ACADEMIC CURRICULA 2022 - 2023

# BACHELOR'S DEGREE PROGRAMME

# B. Tech in

# Mechanical Engineering

## Curricula & Syllabi


Kalinga Institute of Industrial Technology (KIIT)

Deemed to be University U/S 3 of UGC Act, 1956

B h u b a n e s w a r , O d i s h a , I n d i a

# ACADEMIC CURRICULA
# 2022 - 2023

## B. TECH
## MECHANICAL ENGINEERING

**Course Structure and Detailed Syllabi**
**for students admitted in**
**2022 - 23**
**Academic Session**

Kalinga Institute of Industrial Technology (KIIT)
Deemed to be University U/S 3 of UGC Act, 1956
Bhubaneswar, Odisha, India

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# SCHOOL OF MECHANICAL ENGINEERING

## VISION OF THE SCHOOL

To deliver world-class education and research in Mechanical Engineering, with particular regard to their application in industry, healthcare and commerce in a diverse society.

## MISSION OF THE SCHOOL

**MS-1:** To prepare students for professional career, higher studies or entrepreneurship.

**MS-2:** To facilitate students to utilize fundamental technical knowledge and skills in Mechanical engineering, to analyze and solve problems, and apply these abilities to generate new knowledge, ideas or products in academia, industry or government.

**MS-3:** To encourage and facilitate students, to involve themselves in high end research work through continuous learning, to build skills beyond curriculum.

**MS-4:** To integrate training in engineering principles, critical thinking, hands-on projects, open-ended problem solving to build up creative abilities and research spirit.

**MS-5:** To impart the essential skills of leadership, teamwork, communication and ethics so that they can interact and communicate effectively (written and/or oral) with others (e.g., supervisor, client and/or team).

**MS-6:** To engage students with alumni, industry, government, and community partners through outreach activities in order to inculcate global perception.

## B. TECH. PROGRAMMES OFFERED BY THE SCHOOL

- **B. Tech. in Mechanical Engineering**
- **B. Tech. in Mechanical (Automobile) Engineering**
- **B. Tech. in Mechatronics Engineering**
- **B. Tech. in Aerospace Engineering**

# PROGRAMME EDUCATIONAL OBJECTIVES

## B. Tech. in Mechanical Engineering

**PEO1**: To produce graduates who can lead successful career in engineering and technological organizations in the areas associated with the mechanical engineering field while maintaining professional and ethical behaviour in the workplace.

**PEO2**: To prepare the students for higher studies and carry out research and development activities in organizations of national and international repute by providing the knowledge of fundamental basic sciences and engineering applications.

**PEO3**: To develop entrepreneurial skill and self-employment in the adopted mechanical engineering program without compromise in the ethical values and cultural aspects.

## B. Tech. in Mechanical (Automobile) Engineering

**PEO1**: Graduates shall be able to provide solutions to Automobile Engineering problems involving design, manufacturing, heat power, and operational management issues.

**PEO2**: Graduates shall be able to perceive the limitation and impact of engineering solutions in social, legal, environmental, economical, and multidisciplinary contexts.

**PEO3**: Graduates shall demonstrate professional responsibility and thrive to reinforce their knowledge being a part of formal or informal education programs.

## B. Tech. in Mechatronics Engineering

**PEO1**: Graduates shall be able to provide solutions to Mechatronics Engineering problems involving design, manufacturing, and operational management issues.

**PEO2**: Graduates shall be able to perceive the limitation and impact of engineering solutions in social, legal, environmental, economical, and multidisciplinary contexts.

**PEO3**: Graduates shall demonstrate professional responsibility and thrive to reinforce their knowledge being a part of formal or informal education programs.

# B. Tech. in Aerospace Engineering

**PEO1**: Graduates shall be able to provide solutions to Aerospace Engineering problems involving design, manufacturing, and operational management issues.

**PEO2**: Graduates shall be able to perceive the limitation and impact of engineering solutions in social, legal, environmental, economical, and multidisciplinary contexts.

**PEO3**: Graduates shall demonstrate professional responsibility and thrive to reinforce their knowledge being a part of formal or informal education programs.

# PROGRAMME OUTCOMES AND PROGRAMME SPECIFIC OUTCOMES

## B. Tech. in Mechanical Engineering

**Program Outcomes (POs):**

a) **Engineering knowledge:** Ability to apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

b) **Problem analysis:** Ability to identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

c) **Design/Development of solutions:** Ability to design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

d) **Conduct investigations on complex problems:** Ability to use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

e) **Modern tool usage:** Ability to create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

f) **The engineer and society:** Ability to apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

g) **Environment and sustainability:** Ability to understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

h) **Ethics:** Ability to apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

i) **Individual and team:** Ability to function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

j) **Communication:** Ability to communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

k) **Project management and finance:** Ability to demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

l) **Life-long learning:** Ability to recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

**Program Specific Outcomes (PSOs):**

m) Join a technical workforce as successful professionals in a wide range of Mechanical Engineering and related domains.

n) Pursue advanced degrees in engineering, business, or other professional fields.

o) Continuously advance themselves by expanding their technical and professional skills through formal means as well as through informal self-study.

## B. Tech. in Mechanical (Automobile) Engineering

**Program Outcomes (POs):**

a) **Engineering knowledge**: Ability to apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b) **Problem analysis**: Ability to identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c) **Design/Development of solutions**: Ability to design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
d) **Conduct investigations on complex problems**: Ability to use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
e) **Modern tool usage**: Ability to create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

f) **The engineer and society**: Ability to apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
g) **Environment and sustainability**: Ability to understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
h) **Ethics**: Ability to apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
i) **Individual and team**: Ability to function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
j) **Communication**: Ability to communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
k) **Project management and finance**: Ability to demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
l) **Life-long learning**: Ability to recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

**Program Specific Outcomes (PSOs):**

m) Join a technical workforce as successful professionals in a wide range of Automobile Engineering and related domains.
n) Pursue advanced degrees in engineering, business, or other professional fields.
o) Continuously advance themselves by expanding their technical and professional skills through formal means as well as through informal self-study.

## B. Tech. in Mechatronics Engineering

**Program Outcomes (POs):**

a) **Engineering knowledge**: Ability to apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b) **Problem analysis**: Ability to identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c) **Design/Development of solutions**: Ability to design solutions for complex engineering problems and design system components or processes that meet the specified needs with

appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

d) **Conduct investigations on complex problems**: Ability to use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
e) **Modern tool usage**: Ability to create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
f) **The engineer and society**: Ability to apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
g) **Environment and sustainability**: Ability to understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
h) **Ethics**: Ability to apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
i) **Individual and team**: Ability to function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
j) **Communication**: Ability to communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
k) **Project management and finance**: Ability to demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
l) **Life-long learning**: Ability to recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

**Program Specific Outcomes (PSOs):**

m) Join a technical workforce as successful professionals in a wide range of Mechatronics Engineering and related domains.
n) Pursue advanced degrees in engineering, business, or other professional fields.
o) Continuously advance themselves by expanding their technical and professional skills through formal means as well as through informal self-study.

# B. Tech. in Aerospace Engineering

**Program Outcomes (POs):**

a) **Engineering knowledge**: Ability to apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
b) **Problem analysis**: Ability to identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
c) **Design/Development of solutions**: Ability to design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
d) **Conduct investigations on complex problems**: Ability to use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
e) **Modern tool usage**: Ability to create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
f) **The engineer and society**: Ability to apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
g) **Environment and sustainability**: Ability to understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
h) **Ethics**: Ability to apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
i) **Individual and team**: Ability to function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
j) **Communication**: Ability to communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
k) **Project management and finance**: Ability to demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
l) **Life-long learning**: Ability to recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

**Program Specific Outcomes (PSOs):**

m) Join a technical workforce as successful professionals in a wide range of Aerospace Engineering and related domains.
n) Pursue advanced degrees in engineering, business, or other professional fields.
o) Continuously advance themselves by expanding their technical and professional skills through formal means as well as through informal self-study.

# Guidelines for UG Engineering Curriculum – 2022

The curricula for B.Tech. courses have been designed following the general principles of curricular design and developing certain guiding strategies in order to build in the engineering graduate attributes in the courses.

### Principles in Designing the Curricula

The overriding principles in designing the new curricula are that the curricula must (1) Impart specialized and interdisciplinary knowledge and creative problem-solving skills; (2) Reflect aspirations of the society to turn out technology-ready and socially conscious graduates to anticipate and avoid future problems; (3) Leverage the strengths and help making up the weaknesses of the university; (4) Inform the students about new technologies and the emerging social, environmental, and global forces, and (5) Give students the confidence to work in teams and in multi-cultural settings.

### Key Graduate Attributes

Engineers are agents of social change. They interact with the common man to know and define the current and the looming future problems, develop sustainable design solutions using their science and engineering skills, and implement sustainable solutions. Thus, the graduating students must (1) Acquire knowledge and skills—both technical and soft skills such as communication, leadership, and skills of working in multi-cultural, interdisciplinary teams; (2) Develop the mental disposition to understand, conceptualize, and define complex, real-world problems; (3) Be independent, critical thinkers to inquire into the root causes of the problems; (4) Analyse the relevant data and social, economic, and political forces influencing these problems; (5) Synthesize knowledge and diverse perspectives and approaches to find technically and financially viable, sustainable, creative, ethical solutions by evaluating novel alternatives; (6) Use project planning and scheduling methods, establish institutional mechanisms, and communicate the plans and schedules and inspire the concerned individuals to implement the solutions; (7) Imbibe professional values and ethics, and (8) Be life-long learners with empathy for others.

### Strategies for Curriculum Design

Strategies to design the curricula include (1) Understanding the dominant technological and social changes in the world, (2) Incorporating recommendations of the National Education Policy 2020 with respect to design of curricula, (3) Adding the novel features and best curricular practices of leading universities and institutes in India and abroad, (4) Recognizing the UGC and AICTE guidelines and ABET recommendations; (5) Using the opportunities that KIIT offers for multi- and inter-disciplinarity education, and (6) Delivering the key attributes and skills which the graduating students should be equipped with.

## The Structure of the Curricula

The undergraduate engineering curricula are designed to inculcate in the students the graduate attributes indicated above. The curricula include (1) foundational subjects in the fields of humanities, social sciences, science, engineering science, and vocational courses, (2) depth subjects—both core and electives related to the respective disciplines, (3) open electives in diverse fields of humanities, arts, science, engineering, social science, management, law, public policy, media studies, etc., and (4) practice-based subjects. These subjects reflect a mix of theory, hands-on laboratory practice, short- and long-duration projects, field visits, internship, and extra- and co-curricular activities. The Institute has created many avenues for students to organize, lead, and actively participate in social, cultural, and techno-management functions to develop soft social and behavioural skills.

## UG Programmes Offered by the Schools of Technology

The B. Tech. (Hons.) and B. Tech. (Res.) programmes offered by various Schools of Technology are tabulated below.

| Name of the School | B. Tech. (Hons.) and B. Tech. (Res.) Programmess Offered |
|---|---|
| School of Civil Engineering | Civil Engineering |
| School of Computer Engineering | Computer Science and Engineering<br>Information Technology<br>Computer Science and Communication Engineering<br>Computer Science and Systems Engineering |
| School of Electrical Engineering | Electrical Engineering |
| School of Electronics Engineering | Electronics and Telecommunication Engineering<br>Electronics and Computer Science Engineering<br>Electronics and Electrical Engineering |
| School of Mechanical Engineering | Mechanical Engineering<br>Mechanical (Automobile Engineering)<br>Mechatronics Engineering<br>Aerospace Engineering |

## Highlights of the Curricula

1. The curricula allow the students to opt for either a B. Tech. (Hon.) degree or a B. Tech. (Res.) degree.
2. All the B. Tech. curricula have total of 160 – 165 credits.
3. The curricula provide for a Minor in selected areas if students fulfil additional credit requirements.
4. With the inclusion of many Humanities, Arts, and Social Science (HASS) subjects, the curricula are HASS-rich.
5. The curricula provide flexibility in many forms. The students can choose subjects from a large number science, HASS, and engineering electives. They can also choose subjects from lists of professional electives and open electives. The professional electives allow the students to concentrate in selected areas, whereas the open electives allow the students to opt for minors.
6. To ensure an all-round development of students, the curricula have included subjects like Yoga, Universal Human Values, a Community/Environment-based Project, a Vocational Elective, Industry 4.0 Technologies, and K-Explore that consider students' co- and extra-curricular activities for evaluation.
7. The curricula have included subjects like Scientific and Technical Writing and Research Methods and Ethics to instill research and research communication skills in the students.
8. The curricula have also provided for independent projects in the last three semesters to train the students in the art and science of identifying pressing problems and finding their sustainable solutions.

## Notes and Guidelines

### Science Core

Science forms the foundation of engineering. Subjects related to physical, chemical, biological, environmental, and mathematical sciences are covered in the first four semesters in the form core and elective subjects. The core subjects in science are the following:

| | |
|---|---|
| Semester I/II: | Physics, Chemistry, Science of Living Systems, Environmental Science, Differential Equations and Linear Algebra, Transform Calculus and Numerical Analysis, Physics Lab, and Chemistry Lab. |
| Semester III: | Probability & Statistics |
| Semester IV: | Selected Topics in Mathematics (Syllabi to be different for different Schools) |

## Engineering Science Core

Engineering science subjects provide a bridge between science and engineering. The related subjects are included as both core and electives. The semester-wise distribution of the core engineering science subjects is given below.

Semester I/II: Basic Electronics, Programming & Data Structures or Programming Lab, Engineering Drawing & Graphics, Workshop Practice, and Engineering Lab

Half the number of experiments in Engineering Lab will relate to Basic Electronics and the other half to the subject the student picks from the list of Engineering Elective I subjects.

Semester III: Industry 4.0 Technologies

## HASS Core

The curricula include HASS subjects as both core and electives. The HASS subjects that improve the written and rhetoric skills, life skills and research skills of students are included as core subjects. Semester-wise distribution of these courses is given below:

The semester-wise distribution of language- and human values-related subjects is given below:

Semester I/II: English (to develop language skills and skills for making critical analysis of English literature)

Semester I/II: Communication Lab (to develop skills of Listening, Speaking, and Writing)

Semester I/II: Yoga (to bring about unity of mind and body)

Semester III: Scientific and Technical Writing (to develop skills of writing varieties of scientific and technical documents)

Semester VI: Universal Human Values (to develop and respect human values) and Engineering Professional Practice (to understand roles and responsibilities of engineers and the ethical and selected legal issues)

Semester VIII: Research Methods and Ethics (for B. Tech. (Res.) students)

## Professional Core

Professional core subjects form the backbone of an engineering discipline. Every School of Technology decides the list of core subjects that its students must credit. These can be theory and laboratory subjects. These subjects are diffused in Semester III through Semester VI.

Engineering Professional Practice, a professional core subject, is included as a HASS Elective but will be taught by engineering faculty.

## Research Core

Students pursuing B. Tech. (Res.) programme have to go through a course on Research Methods and Ethics, which is offered in Semester VII.

## Science, Engineering Science, and HASS Electives

Options are available to the students to choose subjects from lists of science, engineering science, and HASS electives. Their distributions in the curricula are as under:

| | |
|---|---|
| Semester I/II: | Science Electives, Engineering Electives I and II, and HASS Electives I. |
| Semester IV: | HASS Electives II |
| Semester V: | HASS Electives III |
| Semester VI: | HASS Electives IV |

HASS Elective I includes Community/Environment-based project as one of the subjects. Done as a group work, the subject gives the students an opportunity to connect with the community and the environment, learn and prioritize their problems, and define them in ways that make them amenable to scientific analysis and pragmatic solution.

The lists of Science, Engineering Science, and HASS electives will be available in the ERP. Before a semester begins the Institute will announce the subjects that will be offered in that semester and the students will have to give their choice of electives out of the offered subjects.

## Vocational Elective

Vocational Elective courses provide engineering students a deeper appreciation of the practical aspects of engineering and allow them to relate their theoretical knowledge with practical skills. This subject is included in Semester III. A student must opt for one of the vocational electives which will be announced at the beginning of a semester.

## Open Electives

Open electives allow students to choose subjects from lists of subjects offered by all the Schools. It is through these subjects that a student can pursue his or her latent interests in specific areas and work towards earning a Minor in an area which is outside his (or her) major engineering branch (if the subjects are selected in specific designated areas). These subjects are offered in Semester V through Semester VIII:

| | |
|---|---|
| Semester V: | K-Explore—Practice-based Open Elective I |
| Semester VI – VIII: | Open Electives II, III, and IV |

K-Explore is a 1-Credit Practice-based Open Elective that allows the students to use the scope that the Clubs and the Societies of KIIT University provides to learn the skills of Dance, Music, Photography, etc. and of conducting seminars and conferences through training, practice, and direct involvement.

## Minor

The curricula allow a student to earn a Minor in an area outside the core discipline in which he (or she) has registered. For example, a student doing B. Tech in Mechanical Engineering (his/her parent branch) can choose to have a Minor in Computer Science Engineering. To get a Minor, a student must

(i) Get the fourth semester CGPA of 7.0 or more,

(ii) Successfully fulfill the coursework requirement for at least six theory subjects and two credit Lab/project subjects in an area or discipline other than the one for which he (or she) is registered, and

(iii) Complete at least 20 Credits of coursework in that area.

Thus, if a student has taken three Open Electives in one area other than his (or her) own then he (or she) must choose three theory subjects and two Lab/project subjects in that area in the Fourth year.

If no Lab subject is available in that Minor, then the student must choose an additional theory subject with at least 2 Credits. Students having no backlogs till the end of Semester 4 and a minimum CGPA of 7.0 will only be allowed to opt for the Minor scheme. Students opting for Minor have to mandatorily attend a minimum of 75% Theory and Lab classes (as the case may be) failing which the Minor option will be withdrawn.

## Professional Electives

Professional elective subjects provide the students the opportunity to concentrate in certain specific areas of their interest. These subjects are offered in Semester V through Semester VIII for B. Tech. (Hons.) students (total 15 credits) and in Semester V through Semester VI for B. Tech. (Res.) students (total 9 credits). The distribution of these subjects is given below:

Semester V: Professional Electives (6),
Semester VI: Professional Electives (3),
Semester VII: Professional Electives Theory (3 Credits) for only B. Tech (Hons.) students
Semester VIII: Professional Core Theory (3 Credits) for only B. Tech (Hons.) students

## Research Electives

The students pursuing B. Tech. (Res.) degree may need specialized knowledge in the areas of their theses. For this reason, the curriculum provides for two research electives to be selected in Semester VII and Semester VIII. Every School prepares a list of Research Electives and announces, at the beginning of every semester, the subject which will be offered in that semester. The student is required to select the electives from out of these offered lists.

## Summer Internship

Internship exposes the students to the realities of engineering systems. Every student must go through at least 60 days of internship. It can be taken in an industrial organization or at an institute of higher learning in the summer breaks after the second year and/or after the third year. Internship carries 2 Credits. And the grade secured by a student appears in the Semester VII Grade Sheet of the student.

## Projects

Projects allow the students to work under the supervision of a faculty advisor and apply their acquired knowledge to solve the real-world problems. They define problems, mine information from past works, conceptualize forces and factors that impact the problems, develop design solutions, and demonstrate the effectiveness of the solutions. Semester-wise distribution of this subject is given below:

Semester VI: Mini Project (2 Credits)
Semester VII: Project I (5 Credits)

Semester VIII: Project II (9 Credits for B. Tech. (Hons.) and 12 Credits for B. Tech. (Res.))

## **Semester-away Provision for Project II**

The Institute sometimes allows a student to carry out the fourth-year project (Project II) away from the University campus if the following conditions are satisfied:

- This provision applies to Project II.
- That means a student can avail of this provision in Semester VIII.
- The project must be done either in an industrial unit or in an academic institution.
- The organization in which the student wishes to carry out the project must give in writing that it will provide all facilities (office space, equipment, instrument, data, and travel and stay facilities, if possible) for the student to do the project. In addition, it will also identify a senior and competent employee of the organization to whom the student will report.
- The faculty supervisor must recommend the student's application for availing the semester-away provision.
- A co-supervisor from the organization may be appointed for the project.
- The intending student gives an undertaking that he (or she) will
    - Remain in constant touch with the faculty supervisor,
    - Send monthly progress reports to the supervisor,
    - Give seminar presentations, whenever required.
    - Collect class notes, read books, and prepare for and appear at the examinations (online, if necessary). The student must also do and submit all home assignments given by the teachers and give seminar presentation (online) if necessary.

Since Semester VIII curricula have one theory subject (B. Tech. (Res.)) and two theory subjects (B. Tech. (Hons.)) students, a student applying for this provision will be exempted from attending the lectures on these subjects. But the student must give an undertaking that it will be his (or her) responsibility to collect class notes, read books and other reading materials, submit all home assignments, give seminar presentations (online if required) and prepare for and appear at the examinations.

# COURSE STRUCTURE OF FIRST YEAR

## FIRST SEMESTER

| **Theory** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Sl. No.** | **Course Code** | **Subjects** | **L** | **T** | **P** | **Total** | **Credit** |
| 1 | PH10001 | Physics | 3 | 0 | 0 | 3 | 3 |
| 2 | MA11001 | Differential Equations and Linear Algebra | 3 | 1 | 0 | 4 | 4 |
| 3 | | Science Elective | 2 | 0 | 0 | 2 | 2 |
| 4 | | Engineering Elective-II | 2 | 0 | 0 | 2 | 2 |
| 5 | LS10001 | Science of Living Systems | 2 | 0 | 0 | 2 | 2 |
| 6 | CH10003 | Environmental Science | 2 | 0 | 0 | 2 | 2 |
| **Total Credit (Theory Subjects)** | | | | | | **15** | **15** |
| **Practical** | | | | | | | |
| 1 | PH19001 | Physics Lab | 0 | 0 | 2 | 2 | 1 |
| 2 | CS13001 | Programming Lab | 0 | 2 | 4 | 6 | 4 |
| **Sessional** | | | | | | | |
| 1 | CE18001 | Engineering Drawing & Graphics | 0 | 0 | 2 | 2 | 1 |
| **Total Credit ( Practical & Sessional subject)** | | | | | | **10** | **6** |
| **Total Credit (Semester)** | | | | | | **25** | **21** |

## SECOND SEMESTER

| **Theory** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Sl. No.** | **Course Code** | **Subjects** | **L** | **T** | **P** | **Total** | **Credit** |
| 1 | CH10001 | Chemistry | 3 | 0 | 0 | 3 | 3 |
| 2 | MA11002 | Transform Calculus and Numerical Analysis | 3 | 1 | 0 | 4 | 4 |
| 3 | HS10001 | English | 2 | 0 | 0 | 2 | 2 |
| 4 | EC10001 | Basic Electronics | 2 | 0 | 0 | 2 | 2 |
| 5 | | Engineering Elective I | 2 | 0 | 0 | 2 | 2 |
| 6 | | HASS Elective I | 2 | 0 | 0 | 2 | 2 |
| **Total Credit (Theory Subjects)** | | | | | | **15** | **15** |
| **Practical** | | | | | | | |
| 1 | CH19001 | Chemistry Lab | 0 | 0 | 2 | 2 | 1 |
| 2 | EX19001 | Engineering Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | ME18001 | Workshop | 0 | 0 | 2 | 2 | 1 |
| 2 | YG18001 | Yoga | 0 | 0 | 2 | 2 | 1 |
| 3 | HS18001 | Communication Lab | 0 | 0 | 2 | 2 | 1 |
| **Total Credit (Practical & Sessional Subjects)** | | | | | | **10** | **5** |
| **Total Credit (Semester)** | | | | | | **25** | **20** |

## LIST OF ELECTIVES (FOR FIRST YEAR)

| Engineering Elective I | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Sl. No.** | **Course Code** | **Subjects** | L | T | P | Total | Credit |
| 1 | CE10001 | Basic Civil Engineering | 2 | 0 | 0 | 2 | 2 |
| 2 | ME10003 | Basic Mechanical Engineering | 2 | 0 | 0 | 2 | 2 |
| 3 | EE10002 | Basic Electrical Engineering | 2 | 0 | 0 | 2 | 2 |

| Engineering Elective II | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Sl. No.** | **Course Code** | **Subjects** | L | T | P | Total | Credit |
| 1 | EE10001 | Elements of Machine Learning* | 2 | 0 | 0 | 2 | 2 |
| 2 | ME10001 | Engineering Mechanics | 2 | 0 | 0 | 2 | 2 |
| 3 | EC10003 | Biomedical Engineering | 2 | 0 | 0 | 2 | 2 |
| 4 | EE10003 | Basic Instrumentation | 2 | 0 | 0 | 2 | 2 |

*Not for students of Computer Engineering

| Science Elective | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Sl. No.** | **Course Code** | **Subjects** | **L** | **T** | **P** | **Total** | **Credit** |
| 1 | CH10005 | Nanoscience | 2 | 0 | 0 | 2 | 2 |
| 2 | PH10003 | Smart Materials | 2 | 0 | 0 | 2 | 2 |
| 3 | LS10003 | Molecular Diagnostics | 2 | 0 | 0 | 2 | 2 |
| 4 | PE10002 | Science of Public Health | 2 | 0 | 0 | 2 | 2 |
| 5 | MA 10003 | Optimization Techniques | 2 | 0 | 0 | 2 | 2 |

| HASS Elective-I | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Sl. No.** | **Course Code** | **Subjects** | **L** | **T** | **P** | **Total** | **Credit** |
| 1 | HS10013 | Society, Science, and Technology | 2 | 0 | 0 | 2 | 2 |
| 2 | HS10202 | Essentials of Management | 2 | 0 | 0 | 2 | 2 |
| 3 | HS10121 | Shades of Economics | 2 | 0 | 0 | 2 | 2 |
| 4 | HS10123 | Indian Economy Post Liberalisation | 2 | 0 | 0 | 2 | 2 |
| 5 | SO10043 | Socio-Political Environment | 2 | 0 | 0 | 2 | 2 |
| 6 | PS10043 | Thinking Perspectives | 2 | 0 | 0 | 2 | 2 |
| 7 | PS10045 | Creativity, Innovation and Entrepreneurship | 2 | 0 | 0 | 2 | 2 |
| 8 | EX17001 | Community/Environment-based Project | 2 | 0 | 0 | 2 | 2 |

# COURSE STRUCTURE FOR B. TECH. IN MECHANICAL ENGINEERING

## SEMESTER- III

| Sl. No. | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | EX20003 | Scientific and Technical Writing | 2 | 0 | 0 | 2 | 2 |
| 2 | MA21001 | Probability and Statistics | 3 | 1 | 0 | 4 | 4 |
| 3 | ME21001 | Mechanics of Solids | 3 | 1 | 0 | 4 | 4 |
| 4 | ME20001 | Fluid Mechanics and Hydraulic Machines | 3 | 0 | 0 | 3 | 3 |
| 5 | ME21003 | Manufacturing Technology-I | 3 | 1 | 0 | 4 | 4 |
| 6 | ME20005 | Material Science and Engineering | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **20** | **20** |
| **Practical** | | | | | | | |
| 1 | ME29001 | Fluid Mechanics and Hydraulic Machines Lab | 0 | 0 | 2 | 2 | 1 |
| 2 | ME29003 | Material Testing Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | ME28001 | Manufacturing Practices-I | 0 | 0 | 2 | 2 | 1 |
| 2 | | Vocational Elective | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **8** | **4** |
| **Semester Total** | | | | | | **28** | **24** |

## SEMESTER- IV

| Sl. No. | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | | HASS Elective-2 | 3 | 0 | 0 | 3 | 3 |
| 2 | MA21004 | Vectors, PDE and Complex Analysis | 3 | 1 | 0 | 4 | 4 |
| 3 | EX20001 | Industry 4.0 Technologies | 2 | 0 | 0 | 2 | 2 |
| 4 | ME20002 | Kinematics and Dynamics of Machines | 3 | 0 | 0 | 3 | 3 |
| 5 | ME21002 | Engineering Thermodynamics | 3 | 1 | 0 | 4 | 4 |
| 6 | ME21004 | Manufacturing Technology-II | 3 | 1 | 0 | 4 | 4 |
| **Total of Theory** | | | | | | **20** | **20** |
| **Practical** | | | | | | | |
| 1 | ME29002 | Machine Kinematics and Dynamics Lab | 0 | 0 | 2 | 2 | 1 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2 | ME29004 | Computational Practice Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | ME28004 | Machine Drawing and Solid Modelling | 0 | 0 | 2 | 2 | 1 |
| | ME28002 | Manufacturing Practices-II | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **8** | **4** |
| **Semester Total** | | | | | | **28** | **24** |

## SEMESTER- V

| Sl. No. | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | HS30101 | Engineering Economics | 3 | 0 | 0 | 3 | 3 |
| 2 | | HASS Elective-3 | 3 | 0 | 0 | 3 | 3 |
| 3 | ME30001 | Design of Machine Elements | 3 | 0 | 0 | 3 | 3 |
| 4 | ME30003 | Heat Transfer | 3 | 0 | 0 | 3 | 3 |
| 5 | ME30005 | Industrial Engineering and Operations Research | 3 | 0 | 0 | 3 | 3 |
| 6 | | Professional Elective-I | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **18** | **18** |
| **Practical** | | | | | | | |
| 1 | ME39001 | Heat Transfer Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | ME38001 | Machine Design Sessional-I | 0 | 0 | 2 | 2 | 1 |
| 2 | ME38003 | FEM and CFD | 0 | 0 | 2 | 2 | 1 |
| 3 | | K-Explore Open Elective I | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **8** | **4** |
| **Semester Total** | | | | | | **26** | **22** |

## SEMESTER- VI

| Sl. No. | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | HS30401 | Universal Human Values | 3 | 0 | 0 | 3 | 3 |
| 2 | ME31002 | Applied Thermal Engineering | 3 | 1 | 0 | 4 | 4 |
| 3 | ME30002 | Engineering Metrology and Control | 3 | 0 | 0 | 3 | 3 |
| 4 | | Professional Elective-II | 3 | 0 | 0 | 3 | 3 |
| 5 | | Professional Elective-III | 3 | 0 | 0 | 3 | 3 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 6 | | Open Elective –II/(MI-1) | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **19** | **19** |
| **Practical** | | | | | | | |
| 1 | ME39002 | Metrology and Instrumentation Lab | 0 | 0 | 2 | 2 | 1 |
| 2 | ME39004 | Thermal Engineering Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | ME38002 | Machine Design Sessional-II | 0 | 0 | 2 | 2 | 1 |
| 2 | ME37002 | Mini Project | 0 | 0 | 4 | 4 | 2 |
| **Total of Practical & Sessional** | | | | | | **10** | **5** |
| **Semester Total** | | | | | | **29** | **24** |

## SEMESTER- VII (for B. Tech. (Hons.))

| Sl. No. | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | EX40003 | Engineering Professional Practice | 2 | 0 | 0 | 2 | 2 |
| 2 | | Professional Elective-IV | 3 | 0 | 0 | 3 | 3 |
| 3 | | Open Elective-III/(MI-2) | 3 | 0 | 0 | 3 | 3 |
| (4) | | (MI-3) | (3) | (0) | (0) | (3) | (3) |
| (5) | | (MI-4) | (3) | (0) | (0) | (3) | (3) |
| **Total of Theory** | | | | | | **8** | **8** |
| **Sessional** | | | | | | | |
| 1 | ME48001 | Internship | 0 | 0 | 0 | 0 | 2 |
| 2 | ME47001 | Project-I | 0 | 0 | 10 | 10 | 5 |
| (3) | | (Project-Minor/Lab) | (0) | (0) | (4) | (4) | (2) |
| **Total of Practical & Sessional** | | | | | | **10** | **7** |
| **Semester Total** | | | | | | **18** | **15** |

## SEMESTER- VIII (for B. Tech. (Hons.))

| Sl. No. | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | | Professional Elective-V | 3 | 0 | 0 | 3 | 3 |
| 2 | | Open Elective-IV | 3 | 0 | 0 | 3 | 3 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| (3) | | (MI-5) | (3) | (0) | (0) | (3) | (3) |
| (4) | | (MI-6) | (3) | (0) | (0) | (3) | (3) |
| **Total of Theory** | | | | | | **6** | **6** |
| **Sessional** | | | | | | | |
| 1 | ME47002 | Project-II | 0 | 0 | 18 | 18 | 9 |
| **Total of Practical & Sessional** | | | | | | **18** | **9** |
| **Semester Total** | | | | | | **24** | **15** |

**SEMESTER- VII (for B. Tech. (Res.))**

| Sl. No. | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | | Research Elective-I | 3 | 0 | 0 | 3 | 3 |
| 2 | EX40001 | Research Methods and Ethics | 3 | 0 | 0 | 3 | 3 |
| 3 | EX40003 | Engineering Professional Practice | 2 | 0 | 0 | 2 | 2 |
| **Total of Theory** | | | | | | **8** | **8** |
| **Sessional** | | | | | | | |
| 1 | ME48001 | Internship | 0 | 0 | 0 | 0 | 2 |
| 2 | ME47003 | Research Project-I | 0 | 0 | 10 | 10 | 5 |
| **Total of Practical & Sessional** | | | | | | **10** | **7** |
| **Semester Total** | | | | | | **18** | **15** |

**SEMESTER- VIII (for B. Tech. (Res.))**

| Sl. No. | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | | Research Elective-II | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **3** | **3** |
| **Sessional** | | | | | | | |
| 1 | ME47004 | Research Project-II | 0 | 0 | 24 | 24 | 12 |
| **Total of Practical & Sessional** | | | | | | **24** | **12** |
| **Semester Total** | | | | | | **27** | **15** |

# LIST OF PROFESSIONAL ELECTIVES

**Professional Elective-I**

| | | | |
|---|---|---|---|
| 1. | ME30011 | Advanced Mechanics of Solids | 3 |
| 2. | ME30013 | Finite Element Analysis | 3 |
| 3. | ME30015 | Additive Manufacturing | 3 |
| 4. | ME30017 | Gas Dynamics and Jet Propulsion | 3 |
| 5. | ME30019 | Artificial Intelligence in Mechanical Systems | 3 |
| 6. | ME30021 | Heating, Ventilation, Air Conditioning, and Refrigeration | 3 |

**Professional Elective-II**

| | | | |
|---|---|---|---|
| 1. | ME30012 | Automotive Technology | 3 |
| 2. | ME30014 | Computer Integrated Manufacturing | 3 |
| 3. | ME30016 | Supply Chain Management | 3 |
| 4. | ME30018 | Power Plant Engineering | 3 |
| 5. | ME30020 | Machine Maintenance and Condition Monitoring | 3 |
| 6. | ME30022 | Materials Selection in Mechanical Systems | 3 |

**Professional Elective-III**

| | | | |
|---|---|---|---|
| 1. | ME30024 | Mechanical Vibrations and Noise Engineering | 3 |
| 2. | ME30026 | Robotics and automation | 3 |
| 3. | ME30028 | Computational Fluid Dynamics | 3 |
| 4. | ME30030 | Analysis of Metal Forming Processes | 3 |
| 5. | ME30032 | Theory of Advance Machines and Mechanisms | 3 |
| 6. | ME30034 | Product Design and Development | 3 |

**Professional Elective-IV**

| | | | |
|---|---|---|---|
| 1. | ME40011 | Laser Materials Processing | 3 |
| 2. | ME40013 | Total Quality Management | 3 |
| 3. | ME40015 | Renewable Energy Systems | 3 |
| 4. | ME40017 | Soft Computing Techniques | 3 |
| 5. | ME40019 | Plant Layout and Material Handling | 3 |
| 6. | ME40021 | Cryogenics | 3 |

**Professional Elective-V**

| | | | |
|---|---|---|---|
| 1. | ME40012 | Tribology | 3 |
| 2. | ME40014 | Virtual Reality and Haptics | 3 |
| 3. | ME40016 | Micro-Electro-Mechanical Systems | 3 |
| 4. | ME40018 | Product Lifecycle Management | 3 |
| 5. | ME40020 | Combustion Engineering | 3 |
| 6. | ME40022 | Non Traditional Manufacturing | 3 |

### Combination of Professional Electives (PE-III, PE-IV & PE-V) for Obtaining Track

| Track | Professional Elective-III | Professional Elective-IV | Professional Elective-V |
|---|---|---|---|
| **Production Engineering** | • Analysis of Metal Forming Processes<br>• Robotics and automation | • Laser Material Processing<br>• Plant Layout and Material Handling | • Micro-Electro-Mechanical Systems |
| **Thermal Engineering** | • Computational Fluid Dynamics<br>• Fundamentals of Microfluidics | • Renewable Energy Systems<br>• Cryogenics | • Combustion Engineering<br>• Thermal Design and Management of Electronic Equipment |
| **Design Engineering** | • Mechanical Vibrations and Noise Engineering<br>• Theory of Advance Machines and Mechanisms | • Soft Computing Techniques<br>• Mechanics of Composite Materials | • Tribology<br>• Vehicle Dynamics |
| **Industrial Engineering** | • Product Design and Development<br>• Advance Operations Research | • Total Quality Management<br>• Production, Planning and Control | • Product Lifecycle Management<br>• Work System Design |

### LIST OF RESEARCH ELECTIVES

**Research Elective-I**

| | | | |
|---|---|---|---|
| 1. | ME40031 | Theory of Microfluidics | 3 |
| 2. | ME40033 | Mechanics of Composite Materials | 3 |
| 3. | ME40035 | Material Characterization and Methods | 3 |

**Research Elective-II**

| | | | |
|---|---|---|---|
| 1. | ME40032 | Theory of Advanced Heat and Mass Transfer | 3 |
| 2. | ME40034 | Nano Materials | 3 |
| 3. | ME40036 | Theory of Elasticity and Plasticity | 3 |

| **Semester** | **1st** | **2nd** | **3rd** | **4th** | **5th** | **6th** | **7th** | **8th** | **Total** |
|---|---|---|---|---|---|---|---|---|---|
| **Credit** | 21 | 20 | 24 | 24 | 22 | 24 | 15 | 15 | **165** |
| **Hours** | 25 | 25 | 28 | 28 | 26 | 29 | 18 | 24 | **203** |

## COURSE STRUCTURE FOR B. TECH. IN MECHANICAL (AUTOMOBILE) ENGINEERING

### SEMESTER- III

| Sl. No. | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | EX20003 | Scientific and Technical Writing | 2 | 0 | 0 | 2 | 2 |
| 2 | MA21001 | Probability and Statistics | 3 | 1 | 0 | 4 | 4 |
| 3 | ME21001 | Mechanics of Solids | 3 | 1 | 0 | 4 | 4 |
| 4 | ME20001 | Fluid Mechanics and Hydraulic Machines | 3 | 0 | 0 | 3 | 3 |
| 4 | AE20001 | Machine Kinematics and Dynamics | 3 | 0 | 0 | 3 | 3 |
| 6 | AE20003 | Automotive Mechatronics | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **19** | **19** |
| **Practical** | | | | | | | |
| 1 | ME29001 | Fluid Mechanics and Hydraulic Machines Lab | 0 | 0 | 2 | 2 | 1 |
| 2 | AE29001 | Automotive Electrical and Electronics Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | AE28001 | Automotive Drawing and CAD | 0 | 0 | 2 | 2 | 1 |
| 2 | | Vocational Elective | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **8** | **4** |
| **Semester Total** | | | | | | **27** | **23** |

### SEMESTER- IV

| Sl. No. | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | | HASS Elective-2 | 3 | 0 | 0 | 3 | 3 |
| 2 | MA21004 | Vectors, PDE and Complex Analysis | 3 | 1 | 0 | 4 | 4 |
| 3 | EX20001 | Industry 4.0 Technologies | 2 | 0 | 0 | 2 | 2 |
| 5 | AE20002 | Automotives, Suspension and Transmission System | 3 | 0 | 0 | 3 | 3 |
| 5 | ME21002 | Engineering Thermodynamics | 3 | 1 | 0 | 4 | 4 |
| 6 | AE21002 | Manufacturing Processes for Automotive | 3 | 1 | 0 | 4 | 4 |
| **Total of Theory** | | | | | | **20** | **20** |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Practical** | | | | | | | |
| 1 | ME29002 | Machine Kinematics and Dynamics Lab | 0 | 0 | 2 | 2 | 1 |
| 2 | ME29004 | Computational Practice Lab | 0 | 0 | 2 | 2 | 1 |
| 3 | AE29002 | Automotive Material and Component Testing Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | ME28003 | Manufacturing Practices | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **8** | **4** |
| **Semester Total** | | | | | | **28** | **24** |

**SEMESTER- V**

| Sl. No. | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | HS30101 | Engineering Economics | 3 | 0 | 0 | 3 | 3 |
| 2 | | HASS Elective-3 | 3 | 0 | 0 | 3 | 3 |
| 3 | AE31001 | Design of Automotive components | 3 | 1 | 0 | 4 | 4 |
| 4 | ME30003 | Heat Transfer | 3 | 0 | 0 | 3 | 3 |
| 5 | AE30003 | Electric and Hybrid Vehicle Technology | 3 | 0 | 0 | 3 | 3 |
| 6 | | Professional Elective-I | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **19** | **19** |
| **Practical** | | | | | | | |
| 1 | ME39001 | Heat Transfer Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | AE38001 | Automotive Component Design Sessional | 0 | 0 | 2 | 2 | 1 |
| 2 | ME38003 | FEM and CFD | 0 | 0 | 2 | 2 | 1 |
| 3 | | K-Explore Open Elective I | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **8** | **4** |
| **Semester Total** | | | | | | **27** | **23** |

**SEMESTER- VI**

| Sl. No. | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | HS30401 | Universal Human Values | 3 | 0 | 0 | 3 | 3 |
| 2 | ME31002 | Applied Thermal Engineering | 3 | 1 | 0 | 4 | 4 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 3 | AE30002 | Automotive Engines and Emission | 3 | 0 | 0 | 3 | 3 |
| 4 | | Professional Elective-II | 3 | 0 | 0 | 3 | 3 |
| 5 | | Professional Elective-III | 3 | 0 | 0 | 3 | 3 |
| 6 | | Open Elective –II/(MI-1) | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **19** | **19** |
| **Practical** | | | | | | | |
| 1 | AE39002 | Vehicle Maintenance and Quality Control Lab | 0 | 0 | 2 | 2 | 1 |
| 2 | ME39004 | Thermal Engineering Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | AE37002 | Mini Project | 0 | 0 | 4 | 4 | 2 |
| 2 | AE38002 | Operation Research Sessional | 0 | 0 | 0 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **10** | **5** |
| **Semester Total** | | | | | | **29** | **24** |

**SEMESTER- VII (for B. Tech. (Hons.))**

| Sl. No. | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | | Professional Elective-IV | 3 | 0 | 0 | 3 | 3 |
| 2 | EX40003 | Engineering Professional Practice | 2 | 0 | 0 | 2 | 2 |
| 3 | | Open Elective-III//(MI-2) | 3 | 0 | 0 | 3 | 3 |
| (4) | | (MI-3) | (3) | 0 | 0 | (3) | (3) |
| (5) | | (MI-4) | (3) | 0 | 0 | (3) | (3) |
| **Total of Theory** | | | | | | **8** | **8** |
| **Sessional** | | | | | | | |
| 1 | AE48001 | Internship | 0 | 0 | 0 | 0 | 2 |
| 2 | AE47001 | Project-I | 0 | 0 | 10 | 10 | 5 |
| (3) | | (Project-Minor /Lab) | 0 | 0 | (4) | (4) | (2) |
| **Total of Practical & Sessional** | | | | | | **18** | **7** |
| **Semester Total** | | | | | | **18** | **15** |

**SEMESTER- VIII (for B. Tech. (Hons.))**

| Sl. No. | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | | Professional Elective-V | 3 | 0 | 0 | 3 | 3 |
| 2 | | Open Elective-IV /(MI-5) | 3 | 0 | 0 | 3 | 3 |
| 6 | | (MI-6) | (3) | 0 | 0 | (3) | (3) |
| **Total of Theory** | | | | | | **6** | **6** |
| **Sessional** | | | | | | | |
| 1 | AE47002 | Project-II | 0 | 0 | 18 | 18 | 9 |
| **Total of Practical & Sessional** | | | | | | **18** | **9** |
| **Semester Total** | | | | | | **24** | **15** |

**SEMESTER- VII (for B. Tech. (Res.))**

| Sl. No. | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | | Research Elective-I | 3 | 0 | 0 | 3 | 3 |
| 2 | EX40001 | Research Methods and Ethics | 3 | 0 | 0 | 3 | 3 |
| 3 | EX40003 | Engineering Professional Practice | 2 | 0 | 0 | 2 | 2 |
| **Total of Theory** | | | | | | **8** | **8** |
| **Sessional** | | | | | | | |
| 1 | AE48001 | Internship | 0 | 0 | 0 | 0 | 2 |
| 2 | AE47003 | Research Project-I | 0 | 0 | 10 | 10 | 5 |
| **Total of Practical & Sessional** | | | | | | **18** | **7** |
| **Semester Total** | | | | | | **18** | **15** |

**SEMESTER- VIII (for B. Tech. (Res.))**

| Sl. No. | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | | Research Elective-II | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **3** | **3** |
| **Sessional** | | | | | | | |
| 1 | AE47004 | Research Project-II | 0 | 0 | 24 | 24 | 12 |

| | | |
|---|---|---|
| **Total of Practical & Sessional** | **24** | **12** |
| **Semester Total** | **27** | **15** |

## LIST OF PROFESSIONAL ELECTIVES

**Professional Elective-I**

| | | | |
|---|---|---|---|
| 1. | AE30011 | Two and Three Wheelers | 3 |
| 2. | AE30013 | Automobile Materials | 3 |
| 3. | ME30013 | Finite Element Analysis | 3 |
| 4. | ME30015 | Additive Manufacturing | 3 |
| 5. | ME30021 | Heating, Ventilation, Air Conditioning, and Refrigeration | 3 |

**Professional Elective-II**

| | | | |
|---|---|---|---|
| 1. | AE30012 | Battery Technology | 3 |
| 2. | AE30014 | Tractors and Farm Equipment | 3 |
| 3. | ME30014 | Computer Integrated Manufacturing | 3 |
| 4. | ME30016 | Supply Chain Management | 3 |
| 5. | ME30020 | Machine Maintenance and Condition Monitoring | 3 |

**Professional Elective-III**

| | | | |
|---|---|---|---|
| 1. | AE30018 | Thermal Systems in Automotive | 3 |
| 2. | AE30020 | Vehicle Life Cycle Management | 3 |
| 3. | ME30024 | Mechanical Vibrations and Noise Engineering | 3 |
| 4. | ME30028 | Computational Fluid Dynamics | 3 |
| 5. | ME30034 | Product Design and Development | 3 |

**Professional Elective-IV**

| | | | |
|---|---|---|---|
| 1. | AE40011 | Project Management | 3 |
| 2. | AE40013 | Simulation of IC Engine | 3 |
| 3. | AE40015 | Automotive Quality Management | 3 |
| 4. | ME40015 | Renewable Energy Systems | 3 |
| 5. | ME40017 | Soft Computing Techniques | 3 |

**Professional Elective-V**

| | | | |
|---|---|---|---|
| 1. | AE40012 | Assembly Line Automation | 3 |
| 2. | AE40014 | Fundamentals of Tyre Technology | 3 |
| 3. | AE40016 | Autonomous and connected Vehicle Technology | 3 |
| 4. | AE40018 | Automotive Aerodynamics | 3 |
| 5. | AE40020 | Construction Machines and Vehicles | 3 |

## Combination of Professional Electives (PE-III, PE-IV & PE-V) for Obtaining Track

| Track | Professional Elective-III | Professional Elective-IV | Professional Elective-V |
|---|---|---|---|
| **Mechanical Engineering** | • Mechanical Vibrations and Noise Engineering<br>• Product Design and Development | • Project Management<br>• Renewable Energy Systems | • Assembly Line Automation<br>• Automotive Aerodynamics |
| **Automobile Engineering** | • Thermal Systems in Automotive<br>• Vehicle Life Cycle Management | • Simulation of IC Engine<br>• Automotive Quality Management | • Fundamentals of Tyre Technology<br>• Construction Machines and vehicles<br>• Autonomous and connected Vehicle Technology |

## LIST OF RESEARCH ELECTIVES

**Research Elective-I**

| | | | |
|---|---|---|---|
| 1. | AE40031 | Turbochargers and Superchargers | 3 |
| 2. | AE40033 | Science and Technology of Automotive Engine Material | 3 |
| 3. | ME40012 | Tribology | 3 |

**Research Elective-II**

| | | | |
|---|---|---|---|
| 1. | AE40032 | Fuel cell for Automotives | 3 |
| 2. | AE40034 | Vehicle Dynamics | 3 |
| 3. | ME40020 | Combustion Engineering | 3 |

| **Semester** | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th | 8th | **Total** |
|---|---|---|---|---|---|---|---|---|---|
| **Credit** | 21 | 20 | 24 | 23 | 23 | 24 | 15 | 15 | **165** |
| **Hour** | 25 | 25 | 27 | 28 | 27 | 29 | 18 | **24** | **203** |

## COURSE STRUCTURE FOR B. TECH. IN MECHATRONICS ENGINEERING

### SEMESTER- III

| Sl. No. | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | EX20003 | Scientific and Technical Writing | 2 | 0 | 0 | 2 | 2 |
| 2 | MA21001 | Probability and Statistics | 3 | 1 | 0 | 4 | 4 |
| 3 | MH21001 | ThermoFluids | 3 | 1 | 0 | 4 | 4 |
| 4 | MH20003 | Manufacturing Processes | 3 | 0 | 0 | 3 | 3 |
| 5 | EE20009 | DC, AC and Special Electrical Machines | 3 | 0 | 0 | 3 | 3 |
| 6 | ME20005 | Material Science and Engineering | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **19** | **19** |
| **Practical** | | | | | | | |
| 1 | ME29001 | Fluid Mechanics and Hydraulic M/C Lab | 0 | 0 | 2 | 2 | 1 |
| 2 | EE29007 | DC, AC and Special Machines Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | ME28003 | Manufacturing Practices | 0 | 0 | 2 | 2 | 1 |
| | | Vocational Elective | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **8** | **4** |
| **Semester Total** | | | | | | **27** | **23** |

### SEMESTER- IV

| Sl. No. | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | | HASS Elective-2 | 3 | 0 | 0 | 3 | 3 |
| 2 | MA21004 | Vectors, PDE and Complex Analysis | 3 | 1 | 0 | 4 | 4 |
| 3 | | Industry 4.0 Technologies | 2 | 0 | 0 | 2 | 2 |
| 4 | ME20002 | Kinematics and Dynamics of Machines | 3 | 0 | 0 | 3 | 3 |
| 5 | EC21001 | Electronic Circuits | 3 | 1 | 0 | 4 | 4 |
| 6 | EC20002 | Microprocessors and Embedded Systems | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **19** | **19** |
| **Practical** | | | | | | | |
| 1 | ME29002 | Machine Kinematics and Dynamics Lab | 0 | 0 | 2 | 2 | 1 |
| 2 | EC29001 | Electronic Circuits Lab | 0 | 0 | 2 | 2 | 1 |
| 3 | EC29006 | Microprocessors & Embedded Systems Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | MH28002 | Design and Solid Modelling Lab | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **8** | **4** |
| **Semester Total** | | | | | | **27** | **23** |

**SEMESTER- V**

| Sl. No. | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | HS30101 | Engineering Economics | 3 | 0 | 0 | 3 | 3 |
| 2 | | HASS Elective-3 | 3 | 0 | 0 | 3 | 3 |
| 3 | ME30001 | Design of Machine Elements | 3 | 0 | 0 | 3 | 3 |
| 4 | EE30005 | Power Electronics and Drives | 3 | 0 | 0 | 3 | 3 |
| 5 | EC30003 | Linear and Digital Control System | 3 | 0 | 0 | 3 | 3 |
| 6 | | Professional Elective-I | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **18** | **18** |
| **Practical** | | | | | | | |
| 1 | EE39005 | Power Electronics and Drives Lab | 0 | 0 | 2 | 2 | 1 |
| 2 | MH39001 | PLC and Motion Control Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | ME38001 | Machine Design Sessional-I | 0 | 0 | 2 | 2 | 1 |
| 2 | | K-Explore Open Elective I | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **8** | **4** |
| **Semester Total** | | | | | | **26** | **22** |

**SEMESTER- VI**

| Sl. No. | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | HS30401 | Universal Human Values | 3 | 0 | 0 | 3 | 3 |
| 2 | MH30004 | Industrial Automation and Robotics | 3 | 0 | 0 | 3 | 3 |
| 3 | MH30002 | Design of Mechatronics System | 3 | 0 | 0 | 3 | 3 |
| 4 | | Professional Elective-II | 3 | 0 | 0 | 3 | 3 |
| 5 | | Professional Elective-III | 3 | 0 | 0 | 3 | 3 |
| 6 | | Open Elective –II | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **18** | **18** |
| **Practical** | | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | MH39002 | CIM and Robotics Lab | 0 | 0 | 2 | 2 | 1 |
| 2 | MH39006 | Pneumatics and Hydraulics Lab | 0 | 0 | 2 | 2 | 1 |
| 3 | MH39004 | Mechatronics System Design Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | MH37002 | Mini Project | 0 | 0 | 4 | 4 | 2 |
| **Total of Practical & Sessional** | | | | | | **10** | **5** |
| **Semester Total** | | | | | | **28** | **23** |

**SEMESTER- VII (for B. Tech. (Hons.))**

| Sl. No. | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | EX40003 | Engineering Professional Practice | 2 | 0 | 0 | 2 | 2 |
| 2 | | Professional Elective-IV | 3 | 0 | 0 | 3 | 3 |
| 3 | | Open Elective-III/(MI-2) | 3 | 0 | 0 | 3 | 3 |
| (4) | | (MI-3) | (3) | (0) | (0) | (3) | (3) |
| (5) | | (MI-4) | (3) | (0) | (0) | (3) | (3) |
| **Total of Theory** | | | | | | **8** | **8** |
| **Sessional** | | | | | | | |
| 1 | MH48001 | Internship | 0 | 0 | 0 | 0 | 2 |
| 2 | MH47001 | Project-I | 0 | 0 | 10 | 10 | 5 |
| (3) | | (Project-Minor/Lab) | (0) | (0) | (4) | (4) | (2) |
| **Total of Practical & Sessional** | | | | | | **10** | **7** |
| **Semester Total** | | | | | | **18** | **15** |

**SEMESTER- VIII (for B. Tech. (Hons.))**

| Sl. No. | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | | Professional Elective-V | 3 | 0 | 0 | 3 | 3 |
| 2 | | Open Elective-IV | 3 | 0 | 0 | 3 | 3 |
| (3) | | (MI-5) | (3) | (0) | (0) | (3) | (3) |
| (4) | | (MI-6) | (3) | (0) | (0) | (3) | (3) |
| **Total of Theory** | | | | | | **6** | **6** |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Sessional** | | | | | | | |
| 1 | MH47002 | Project-II | 0 | 0 | 18 | 18 | 9 |
| **Total of Practical & Sessional** | | | | | | **18** | **9** |
| **Semester Total** | | | | | | **24** | **15** |

**SEMESTER- VII (for B. Tech. (Res.))**

| Sl. No. | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | | Research Elective-I | 3 | 0 | 0 | 3 | 3 |
| 2 | EX40001 | Research Methods and Ethics | 3 | 0 | 0 | 3 | 3 |
| 3 | EX40003 | Engineering Professional Practice | 2 | 0 | 0 | 2 | 2 |
| **Total of Theory** | | | | | | **8** | **8** |
| **Sessional** | | | | | | | |
| 1 | MH48001 | Internship | 0 | 0 | 0 | 0 | 2 |
| 2 | MH47003 | Research Project-I | 0 | 0 | 10 | 10 | 5 |
| **Total of Practical & Sessional** | | | | | | **10** | **7** |
| **Semester Total** | | | | | | **18** | **15** |

**SEMESTER- VIII (for B. Tech. (Res.))**

| Sl. No. | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | | Research Elective-II | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **3** | **3** |
| **Sessional** | | | | | | | |
| 1 | MH47004 | Research Project-II | 0 | 0 | 24 | 24 | 12 |
| **Total of Practical & Sessional** | | | | | | **24** | **12** |
| **Semester Total** | | | | | | **27** | **15** |

# LIST OF PROFESSIONAL ELECTIVES

**Professional Elective-I**

| | | | |
|---|---|---|---|
| 1. | MH30011 | IoT and Smart Manufacturing | 3 |
| 2. | MH30013 | Product Design and Development | 3 |
| 3. | EM30003 | Computer Vision | 3 |
| 4. | AE20003 | Automotive Mechatronics | 3 |
| 5. | MH30015 | Micro Electro Mechanical Systems | 3 |

**Professional Elective-II**

| | | | |
|---|---|---|---|
| 1. | ME40014 | Virtual Reality and Haptics | 3 |
| 2. | ME30015 | Additive Manufacturing | 3 |
| 3. | ME30020 | Machine Maintenance and Condition Monitoring | 3 |
| 4. | AE30003 | Electric and Hybrid Vehicle Technology | 3 |
| 5. | MH30014 | Micro and Nano Manufacturing Systems | 3 |

**Professional Elective-III**

| | | | |
|---|---|---|---|
| 1. | MH30016 | Smart Manufacturing with Digital Twin | 3 |
| 2. | ME30014 | Computer Integrated Manufacturing | 3 |
| 3. | MH30018 | Modelling and Simulation of Mechatronics System | 3 |
| 4. | MH30020 | Modelling and Simulation of Automotive Systems | 3 |
| 5. | EC30026 | Bio-Medical Instrumentation | 3 |

**Professional Elective-IV**

| | | | |
|---|---|---|---|
| 1. | MH40011 | Mobile and Autonomous Robots | 3 |
| 2. | ME40022 | Non Traditional Manufacturing | 3 |
| 3. | MH40013 | Intelligent Manufacturing System | 3 |
| 4. | MH40015 | Smart Mobility and Intelligent Vehicles | 3 |
| 5. | MH40017 | Smart Heating, Ventilation, Air Conditioning, and Refrigeration | 3 |

**Professional Elective-V**

| | | | |
|---|---|---|---|
| 1. | MH40018 | Product Lifecycle Management | 3 |
| 2. | MH40020 | Advanced Manufacturing Systems | 3 |
| 3. | MH40022 | Artificial Intelligence for Mechatronics Systems | 3 |
| 4. | MH40024 | Advanced Driver Assistance systems | 3 |
| 5. | ME30016 | Supply Chain Management | 3 |

## Combination of Professional Electives (PE-III, PE-IV & PE-V) for Obtaining Track

| TRACKS | Professional Elective-III | Professional Elective-IV | Professional Elective-V |
|---|---|---|---|
| IOT and Automation | Smart Manufacturing with Digital Twin | Mobile and Autonomous Robots | Product Lifecycle Management |
| Product Design and | Computer Integrated Manufacturing | Non-Traditional Manufacturing | Advance Manufacturing |

| | | | |
|---|---|---|---|
| Manufacturing | | | Systems |
| AI and Intelligent Systems | Modelling and Simulation of Mechatronics System | Intelligent Manufacturing System | Artificial Intelligence for Mechatronics Systems |
| Smart Automotive Mobility | Modeling and Simulation of Automotive Systems | Smart Mobility and Intelligent Vehicles | Advanced Driver Assistance Systems |
| Diversified Technology | Bio-Medical Instrumentation | Smart Heating, Ventilation, Air Conditioning, and Refrigeration | Supply Chain Management |

## LIST OF RESEARCH ELECTIVES

**Research Elective-I**

| | | | |
|---|---|---|---|
| 1. | MH40031 | Mechatronic Sensors and Actuators | 3 |
| 2. | MH40033 | CIM and Robotics | 3 |
| 3. | MH40035 | Industry 4.0 and Smart Manufacturing | 3 |

**Research Elective-II**

| | | | |
|---|---|---|---|
| 1. | MH40032 | MEMS and Microsystems | 3 |
| 2. | MH40034 | Biomechatronic Systems | 3 |
| 3. | MH40036 | Industrial Internet of Things | 3 |

| **Semester** | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th | 8th | **Total** |
|---|---|---|---|---|---|---|---|---|---|
| **Credit** | 21 | 20 | 23 | 23 | 22 | 23 | 15 | 15 | **162** |
| **Total** | 25 | 25 | 27 | 27 | 26 | 28 | 18 | 24 | **200** |

## COURSE STRUCTURE FOR B. TECH. IN AEROSPACE ENGINEERING

### SEMESTER- III

| Sl. No. | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | EX20003 | Scientific and Technical Writing | 2 | 0 | 0 | 2 | 2 |
| 2 | MA21001 | Probability and Statistics | 3 | 1 | 0 | 4 | 4 |
| 3 | AS20001 | Aerodynamics-I | 3 | 0 | 0 | 3 | 3 |
| 4 | AS20003 | Aerospace Structures-I | 3 | 0 | 0 | 3 | 3 |
| 5 | AS21001 | Aerospace Materials and Manufacturing Processes | 3 | 1 | 0 | 4 | 4 |
| 6 | AS21003 | Aerospace Thermodynamics | 3 | 1 | 0 | 4 | 4 |
| **Total of Theory** | | | | | | **20** | **20** |
| **Practical** | | | | | | | |
| 1 | AS29001 | Aerospace Thermodynamics Lab | 0 | 0 | 2 | 2 | 1 |
| 2 | AS29003 | Aerospace Material Testing Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | AS28001 | Machine Drawing and Aero Modeling | 0 | 0 | 2 | 2 | 1 |
| 2 | | Vocational Elective | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **8** | **4** |
| **Semester Total** | | | | | | **28** | **24** |

### SEMESTER- IV

| Sl. No. | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | | HASS Elective-2 | 3 | 0 | 0 | 3 | 3 |
| 2 | MA21004 | Vectors, PDE and Complex Analysis | 3 | 1 | 0 | 4 | 4 |
| 3 | EX20001 | Industry 4.0 Technologies | 2 | 0 | 0 | 2 | 2 |
| 4 | AS21002 | Aircraft Propulsion | 3 | 1 | 0 | 4 | 4 |
| 5 | AS20002 | Aerodynamics-II | 3 | 0 | 0 | 3 | 3 |
| 6 | AS20004 | Aerospace Structures -II | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **19** | **19** |
| **Practical** | | | | | | | |
| 1 | AS29002 | Aerodynamics Lab | 0 | 0 | 2 | 2 | 1 |
| 2 | AS29004 | Aerospace Propulsion Lab | 0 | 0 | 2 | 2 | 1 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 3 | AS29006 | Aerospace Structures Lab | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **6** | **3** |
| **Semester Total** | | | | | | **25** | **22** |

**SEMESTER- V**

| Sl. No. | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | HS30101 | Engineering Economics | 3 | 0 | 0 | 3 | 3 |
| 2 | | HASS Elective-3 | 3 | 0 | 0 | 3 | 3 |
| 3 | AS31001 | Aircraft Performance | 3 | 1 | 0 | 4 | 4 |
| 4 | AS31003 | Aircraft Systems and Instrumentation | 3 | 1 | 0 | 4 | 4 |
| 5 | AS30003 | Space Mechanics | 3 | 0 | 0 | 3 | 3 |
| 6 | | Professional Elective-I | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **20** | **20** |
| **Practical** | | | | | | | |
| 1 | AS39001 | Aerospace Measurement Lab | 0 | 0 | 2 | 2 | 1 |
| 2 | AS39003 | Aircraft Maintenance Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | AS38001 | Aerospace Systems Sessional | 0 | 0 | 2 | 2 | 1 |
| 2 | | K-Explore Open Elective I | 0 | 0 | 2 | 2 | 1 |
| **Total of Practical & Sessional** | | | | | | **8** | **4** |
| **Semester Total** | | | | | | **28** | **24** |

**SEMESTER- VI**

| Sl. No. | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | HS30401 | Universal Human Values | 3 | 0 | 0 | 3 | 3 |
| 2 | AS31002 | Aircraft Design | 3 | 1 | 0 | 4 | 4 |
| 3 | AS30004 | Avionics | 3 | 0 | 0 | 3 | 3 |
| 4 | | Professional Elective-II | 3 | 0 | 0 | 3 | 3 |
| 5 | | Professional Elective-III | 3 | 0 | 0 | 3 | 3 |
| 6 | | Open Elective –II/(MI-1) | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **19** | **19** |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Practical** | | | | | | | |
| 1 | AS39002 | Avionics Lab | 0 | 0 | 2 | 2 | 1 |
| 2 | AS39004 | Instrumentation and Control Systems Lab | 0 | 0 | 2 | 2 | 1 |
| **Sessional** | | | | | | | |
| 1 | AS38002 | FEM and CFD Sessional | 0 | 0 | 2 | 2 | 1 |
| 2 | AS37002 | Mini Project | 0 | 0 | 4 | 4 | 2 |
| **Total of Practical & Sessional** | | | | | | **10** | **5** |
| **Semester Total** | | | | | | **29** | **24** |

**SEMESTER- VII (for B. Tech. (Hons.))**

| **Sl. No.** | **Course Code** | **Course Title** | **L** | **T** | **P** | **Total** | **Credit** |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | EX40003 | Engineering Professional Practice | 2 | 0 | 0 | 2 | 2 |
| 2 | | Professional Elective-IV | 3 | 0 | 0 | 3 | 3 |
| 3 | | Open Elective-III/(MI-2) | 3 | 0 | 0 | 3 | 3 |
| (4) | | (MI-3) | (3) | (0) | (0) | (3) | (3) |
| (5) | | (MI-4) | (3) | (0) | (0) | (3) | (3) |
| **Total of Theory** | | | | | | **8** | **8** |
| **Sessional** | | | | | | | |
| 1 | AS48001 | Internship | 0 | 0 | 0 | 0 | 2 |
| 2 | AS47001 | Project-I | 0 | 0 | 10 | 10 | 5 |
| (3) | | (Project-Minor /Lab) | (0) | (0) | (4) | (4) | (2) |
| **Total of Practical & Sessional** | | | | | | **10** | **7** |
| **Semester Total** | | | | | | **18** | **15** |

**SEMESTER- VIII (for B. Tech. (Hons.))**

| **Sl. No.** | **Course Code** | **Course Title** | **L** | **T** | **P** | **Total** | **Credit** |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | | Professional Elective-V | 3 | 0 | 0 | 3 | 3 |
| 2 | | Open Elective-IV | 3 | 0 | 0 | 3 | 3 |
| (3) | | (MI-5) | (3) | (0) | (0) | (3) | (3) |
| (4) | | (MI-6) | (3) | (0) | (0) | (3) | (3) |
| **Total of Theory** | | | | | | **6** | **6** |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Sessional** | | | | | | | |
| 1 | AS47002 | Project-II | 0 | 0 | 18 | 18 | 9 |
| **Total of Practical & Sessional** | | | | | | **18** | **9** |
| **Semester Total** | | | | | | **24** | **15** |

**SEMESTER- VII (for B. Tech. (Res.))**

| Sl. No. | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | | Research Elective-I | 3 | 0 | 0 | 3 | 3 |
| 2 | EX40001 | Research Methods and Ethics | 3 | 0 | 0 | 3 | 3 |
| 3 | EX40003 | Engineering Professional Practice | 2 | 0 | 0 | 2 | 2 |
| **Total of Theory** | | | | | | **8** | **8** |
| **Sessional** | | | | | | | |
| 1 | AS48001 | Internship | 0 | 0 | 0 | 0 | 2 |
| 2 | AS47003 | Research Project-I | 0 | 0 | 10 | 10 | 5 |
| **Total of Practical & Sessional** | | | | | | **10** | **7** |
| **Semester Total** | | | | | | **18** | **15** |

**SEMESTER- VIII (for B. Tech. (Res.))**

| Sl. No. | Course Code | Course Title | L | T | P | Total | Credit |
|---|---|---|---|---|---|---|---|
| **Theory** | | | | | | | |
| 1 | | Research Elective-II | 3 | 0 | 0 | 3 | 3 |
| **Total of Theory** | | | | | | **3** | **3** |
| **Sessional** | | | | | | | |
| 1 | AS47004 | Research Project-II | 0 | 0 | 24 | 24 | 12 |
| **Total of Practical & Sessional** | | | | | | **24** | **12** |
| **Semester Total** | | | | | | **27** | **15** |

## LIST OF PROFESSIONAL ELECTIVES

**Professional Elective-I**

| | | | |
|---|---|---|---|
| 1. | AS30011 | Computational Aerodynamics | 3 |
| 2. | AS30013 | Rockets and Missiles | 3 |
| 3. | ME30013 | Finite Element Analysis | 3 |
| 4. | ME30015 | Additive Manufacturing | 3 |

**Professional Elective-II**

| | | | |
|---|---|---|---|
| 1. | AS30012 | Aviation Fuel and Combustion | 3 |
| 2. | AS30014 | Fundamentals of Composite Materials | 3 |
| 3. | AS30016 | Introduction to UAV Technology | 3 |
| 4. | ME30016 | Supply Chain Management | 3 |

**Professional Elective-III**

| | | | |
|---|---|---|---|
| 1. | AS30018 | Airport and Airlines Management | 3 |
| 2. | AS30020 | Turbulence in Fluid Flows | 3 |
| 3. | ME30024 | Mechanical Vibrations and Noise Engineering | 3 |
| 4. | ME30028 | Computational Fluid Dynamics | 3 |

**Professional Elective-IV**

| | | | |
|---|---|---|---|
| 1. | AS40011 | Flight Dynamics and Control | 3 |
| 2. | AS40013 | Aircraft Communication, Navigation and Surveillance Systems | 3 |
| 3. | AS40015 | Theory of Aero-elasticity | 3 |
| 4. | ME40013 | Total Quality Management | 3 |

**Professional Elective-V**

| | | | |
|---|---|---|---|
| 1. | AS40012 | Satellite and Space Systems | 3 |
| 2. | AS40014 | Airframe Repair and Maintenance | 3 |
| 3. | AS40016 | Helicopter Aerodynamics | 3 |
| 4. | ME40018 | Product Lifecycle Management | 3 |

## LIST OF RESEARCH ELECTIVES

**Research Elective-I**

| | | | |
|---|---|---|---|
| 1. | AS40031 | Hypersonic Air-breathing Propulsion | 3 |
| 2. | AS40033 | Wind Tunnel Technique | 3 |
| 3. | AS40035 | Advanced Aerospace Structures | 3 |

**Research Elective-II**

| | | | |
|---|---|---|---|
| 1. | AS40032 | High Temperature Gas Dynamics | 3 |
| 2. | AS40034 | Boundary Layer Theory | 3 |
| 3. | AS40036 | Composite Materials and Structures | 3 |

**Total Credit / Hours**

| **Semester** | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th | 8th | **Total** |
|---|---|---|---|---|---|---|---|---|---|
| **Credit** | 21 | 20 | 24 | 22 | 24 | 24 | 15 | 15 | **165** |
| **Hours** | 25 | 25 | 28 | 25 | 28 | 29 | 18 | 24 | **202** |

## LIST OF HASS ELECTIVES

**HASS Elective-II**

| | | | |
|---|---|---|---|
| 1. | HS20220 | Organizational Behaviour | 3 |
| 2. | HS20222 | Human Resource Management | 3 |
| 3. | HS20120 | Economics of Development | 3 |
| | HS20122 | International Economic Cooperation | 3 |

**HASS Elective-III**

| | | | |
|---|---|---|---|
| 1. | HS30223 | Business Ethics and Corporate Governance | 3 |
| 2. | HS30225 | Leadership and Team Effectiveness | 3 |
| 3. | HS30125 | Market Structure and Pricing Policies | 3 |
| 4. | HS30127 | Pragmatic Inquiry | 3 |
| 5. | HS30129 | Economic Analysis of Decision Rules | 3 |
| 6. | HS30131 | Economics of Health and Education | 3 |
| 7. | HS30421 | Gender Studies | 3 |
| 8. | HS30423 | Tribal Resource Management | 3 |
| 9. | HS30425 | Indian Knowledge System | 3 |

## LIST OF K-EXPLORE PRACTICE-BASED ELECTIVES (OPEN ELECTIVE-I)

| Sl. No. | Course Code | Course |
|---|---|---|
| 1 | SA38001 | Robotics |
| 2 | SA38003 | Web Designing |
| 3 | SA38005 | Civil-Tech |
| 4 | SA38007 | Circuit Design & Control |
| 5 | SA38009 | Indian Classical, Folk & Bollywood Dance |
| 6 | SA38011 | Indian Classical & Western Music |
| 7 | SA38013 | Graphic Designing & Editing |
| 8 | SA38015 | Art & Craft |
| 9 | SA38017 | Theatre & Street Play |
| 10 | SA38019 | Film Making |
| 11 | SA38021 | Debating, Public Speaking & Anchoring |
| 12 | SA38023 | Creative Writing |
| 13 | SA38025 | Photography & Videography |
| 14 | SA38027 | Fashion Styling |
| 15 | SA38029 | Culinary Arts |
| 16 | SA38031 | Quiz Activity |
| 17 | SA38033 | Social Outreach |
| 18 | SA38035 | Health & Emergency Care |

## LIST OF VOCATIONAL ELECTIVES OFFERED BY SCHOOL OF MECHANICAL ENGINEERING

| Sl. No | Course Code | Course Title |
|---|---|---|
| 1 | ME28011 | Additive Manufacturing (3D Printing) |
| 2 | ME28013 | Die Development by CNC Milling |
| 3 | ME28015 | Concept Car Manufacturing |
| 4 | ME28017 | Development of Autonomous Wheeled Robots |
| 5 | ME28019 | Modelling of Micro-Wind turbine by 3D CAD Design |

## LIST OF VOCATIONAL ELECTIVES OFFERED BY SCHOOL OF CIVIL ENGINEERING

| Sl. No. | Course Code | Subjects |
|---|---|---|
| 1 | CE28001 | Building Drawing, Estimation & Costing<br>(for Civil Engineering Students) |
| 2 | CE28003 | GIS & GPS Applications<br>(For other branch students) |

## LIST OF VOCATIONAL ELECTIVES OFFERED BY SCHOOL OF COMPUTER SCIENCE ENGINEERING

| Sl. No. | Course Code | Subjects |
|---|---|---|
| 1 | CS28001 | Web Design |

## LIST OF VOCATIONAL ELECTIVES OFFERED BY SCHOOL OF ELECTRICAL ENGINEERING

| Sl. No. | Course Code | Subjects |
|---|---|---|
| 1 | EE28011 | Industrial wiring and control panel design |
| 2 | EE28013 | Installation, operation and maintenance of solar power system |
| 3 | EE28015 | Domestic wiring and home automation |
| 4 | EE28017 | Cyber physics application in industrial IOT |
| 5 | EE28019 | Industrial Control and Remote Monitoring |

## LIST OF VOCATIONAL ELECTIVES OFFERED BY SCHOOL OF ELECTRONICS ENGINEERING

| Sl. No. | Course Code | Subjects |
|---|---|---|
| 1 | EC28001 | Computational Photography |
| 2 | EC28003 | Sound Engineering |
| 3 | EC28005 | Sensors for Automation |
| 4 | EC28007 | PCB Design |

## MACHINE KINEMATICS AND DYNAMICS

**Course Code:** **AE20001**
**Credit:** **3**
**L-T-P:** **3-0-0**
**Prerequisite:** **Nil**

### COURSE OBJECTIVE

Machine Kinematics and Dynamics is an application oriented extension of Engineering Mechanics. This course uses the principles of Statics and Dynamics. Automotive uses a cluster or mechanisms and machines. The main objective of this course is to build the foundational knowledge among the students how to analyze the motions of mechanisms, design mechanisms to have given motions, and analyze forces in machines. This course will cover aspects of analysis of kinematics and dynamics analysis of machine elements including linkages, belt and rope drive, cams and gears, analysis of gyroscopic motion, different types of governors, balancing of rotating and reciprocating parts of engines. Also, students will be able to perform linearized dynamic modeling for vibrational systems within the general machine design context.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Describe simple mechanisms and inversions thereof from perspectives of mobility, displacement, velocity and acceleration,
CO 2: Understand design and prescribe necessary components/systems to smoothen effects of variations in the time-varying forces,
CO 3: Apply static and dynamic forces in reciprocating and rotating devices,
CO 4: obtain cam profiles for required motion profile of the followers and evaluate gyroscopic effects in case of plane discs, automobiles, ships and air crafts,
CO 5: solve motion equations for systems subject to vibration under different excitations at different states of damping, and
CO 6: Design flexible and rigid mechanical components to transmit power.

### COURSE DETAILS

**Simple Mechanism**
Classification of links and pairs, kinematics chains, degrees of freedom, Grashof's law, Grubler's criterion for plane mechanism. Four bar mechanism and its inversions. Single slider crank chain and its inversions, Double slider crank chain and its inversions.

**Velocity Analysis and Acceleration Analysis**
Velocity of a point in a link by relative velocity methods and instantaneous center method, Numbers and types of instantaneous centers in a mechanism, Location of instantaneous centers, Kennedy's theorem, Velocities of four-bar and slider crank mechanisms, Acceleration of point on a link, Acceleration diagram of a link, Acceleration in the slider crank and four bar mechanism, Klein's construction, Coriolis' components of acceleration.

**Force Analysis**
Analytical method of finding acceleration of a piston and connecting rod, Inertia force, Torque, Inertia forces in the Reciprocating Engines, Turning Moment diagrams, Flywheel.

**Belt, Rope and Chain Drive – Analysis and Design**
Velocity ratio, Effect of belt thickness and slip on velocity ratio, Length of belt, Ratio of driving tensions, Power transmitted by belt, Centrifugal tension, Maximum power transmitted by belts, Creep and initial tension, V-belt, Ratio of tensions in rope drive, Chain length, angular speed ratio and Classification of chains.

**Gear and Gear Trains**
Simple, Compound, Riveted and Epicyclic Gear Trains, Calculation of velocity ratio, Theory of shape and action of tooth properties and methods of generation of standard tooth profiles, Standard proportions, Interference and under cutting, methods of elimination of interference, minimum number of teeth to avoid interference.

**Gyroscope and Governors**
Gyroscopic couple of plane disc. Analysis of the forces on bearings due to the forced processing of rotating disc mounted on shafts, Gyroscopic effects on a two wheel and four-wheel vehicle, Gyroscopic stabilization with reference to practical application, Centrifugal Governor, Watt and Porter Governors, Spring loaded Governor-Hartnell Governor, Sensitiveness, Stability, Isochronous, Hunting, Governor Effort and Power, curves of Controlling force.

**Balancing**
Balancing of revolving masses in the same planes and different planes, Partial balance of Locomotives, Variation of tractive efforts, swaying couple, Primary and Secondary balance of multi cylinder engines.

**Cams**
Types of cams and followers, Displacement velocity and acceleration-time curves for uniform velocity, uniform acceleration and deceleration, simple harmonic motion and cycloid motion, Graphical construction of cam profiles for different types of followers.

**Vibration**
Free vibration of single degree system without and with damping, Equilibrium Method, Energy method, stiffness of spring elements, Viscous damping.

**Textbook**

1. Theory of Machines, S. S. Rattan, Tata McGraw-Hill Publication, 4th Edition.

**Reference Books**

1. Theory of Machines, J Shigley, Tata McGraw-Hill Publication 4th Edition.
2. Machines and Mechanisms, David H Myszka, Applied Kinematics Analysis, PHI
3. Kinematics of Machinery through Hyper Works, J.S.Rao, Springer, 1st Edition.
4. Theory of Mechanism and Machines, Sharma & Purohit, PHI.
5. Theory of Machines and Mechanisms, John Joseph Uicker, Gordon R. Pennock, Joselph E.Shigley, Oxford Univ Pr (Sd), 2010.

# AUTOMOTIVES SUSPENSION AND TRANSMISSION SYSTEM

**Course Code:** **AE20002**
**Credit:** **3**
**L-T-P:** **3-0-0**
**Prerequisite:** **Machine Kinematics and Dynamics (AE20001)**

## COURSE OBJECTIVE

This course would encompass a comprehensive study the classification of automobiles according to various parameters such as; types of frames, types of chassis, numbers of road wheels, types of energy sources used, utility etc. Design of transmission system components such as; clutch, gearbox, differential is also included. Types of front axle, constructions details and Materials is also covered. Front wheel geometry viz. Castor, Camber, King Pin inclination, Toe-in. Conditions for true rolling motion of wheels during steering is introduced. Ackerman and Davis steering system and constructional details of steering linkages, different types of steering gear boxes, Steering linkages and layouts are taught with live demo. Differential along with advantages and disadvantages of rigid axle and independent suspension system, working of various independent suspension systems and various types of springs used in suspension are included. Theory of braking, mechanical, hydraulic, pneumatic brakes, Servo brake, power assisted brakes are also taught to make a student understand the safety aspect in regular driving.

## COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Recognize the basic structure, steering brakes and suspension of different automobile,
CO 2: Compare most suitable Drive train, Steering System, Brakes and Suspension System for new automobile,
CO 3: Identify and solve problems related to Steering System,
CO 4: Model and analysis of springs and brakes used in different automobiles,
CO 5: Judge and solve problems related to Brakes, and Suspension, and
CO 6: Design and analysis of gear ratios in transmission system.

## COURSE DETAILS

### Introduction
History of automobile, Classification of automobile: Motor Vehicle Act, Types of chassis layout with reference to power plant locations and drive, Vehicle frames, Various types of frames, Constructional details, Material for different members, Material testing of vehicles frames and components, Loads acting on vehicle frame, Unitized frame body construction.

### Manual Transmission system
Layout of power transmission system, requirement of transmission system Clutch: Need of clutch, Types of clutches, Principle, Construction, Torque capacity, Clutch operating system, Performance curve, Requirement of gearbox, different types of gear box: sliding, constant mesh and synchromesh gear box; Construction details of gear boxes, Gear ratios of vehicle Gear box operation principle, Over drive unit and its operation.

**Automatic transmission**

Fluid coupling, Principle and operation Torque capacity Performance characteristic, Torque converter Construction, principle of operation, Torque capacity multistage torque converter Performance behavior, Electrical drive: Construction and operation Electric drive Ward Leonard control system, Construction and operation, Advantages and disadvantages.

**Front axle and Steering System**

Types of front axle, Constructions details. Materials, Front wheel geometry viz. Castor, Camber, King pin inclination, Toe-in, Conditions for true rolling motion of wheels during steering, Steering geometry, Ackerman and Davis steering system, Constructional details of steering linkages, Different types of steering gear boxes, Steering linkages and layouts, Power and Power assisted Steering.

**Drive Line and rear axle**

Driving thrust and torque reactions, Hotchkiss drive, Torque tube drive and radius rods, Propeller shaft, Universal joint, Constants velocity universal joint, Front wheel drive, Differential, Different types of final drive, Worm and worm wheel, Straight bevel gear, Spiral bevel gear and hypoid gear final drives, Differential principles, Differential locks, Differential housing, Construction of rear axles, Loads acting on rear axle, Rear axle housing, Construction of different types of axle housings, Full floating, Three quarter floating and semi floating rear axles.

**Suspension System**

Need of suspension system, Types of suspension, Suspension springs, Constructional details and characteristics of leaf, Coil and torsion bar springs, Independent suspension, Rubber suspension, Pneumatic suspension, Shock absorbers.

**Braking System**

Classification of brakes, Drum brake & Disc brakes. Constructional details, Theory of braking, Mechanical hydraulic and Pneumatic brakes, Servo brake, Power and power assisted brakes different types of retarders like eddy current and hydraulic retarder.

**Textbook**

1. Automobile Engineering Vol-I, Kripal Singh, Standard Publisher Distributor, 2017.

**Reference Books**

1. Automobile Engineering Vol-II, Kripal Singh, Standard Publisher Distributor, 2017.
2. A Text book of Automobile Engineering, Volume-II. P.S. Gill, S.K. Kataria & Sons, First Edition, 2012
3. Basic automobile Engineering, Nakra C. P., Dhanpat Rai Publication Co. Ltd 7th edition, 2005
4. Automobile Engineering, A. De, Galgotia Publication Pvt. Ltd. 2004.

## AUTOMOTIVE MECHATRONICS

**Course Code: AE20003**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

### COURSE OBJECTIVE

This course is focused on the wide application of electronics in various automotive subsystems to the students of Automobile Engineering who has basic knowledge of electronics engineering. This course emphasizes on microprocessor 8085, sensors and actuators. The significance of the pin diagram and coding required to program a microprocessor can be appreciated. In view of changing emission norms the fuel injection system in IC engine vehicle plays an important role and students will learn about electronic injection control. Students will also learn about electronic chassis control, anti-lock braking system etc.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Describe the functions of a basic microcomputer,
CO 2: Understand appropriate microcomputer to be used in an automobile,
CO 3: Use different sensors and actuators for various automotive systems,
CO 4: Illustrate the electronic engine management systems,
CO 5: Judge and perform ECU diagnostics, and
CO 6: Design the electronic vehicle management and special instrumentation systems.

### COURSE DETAILS

**Introduction to microcomputer**
Microprocessor 8085, Microprocessor architecture, Microcomputer: Buses, memory, timing, CPU registers; Microcontroller, Initialization, operation codes, program counter, branch and jump instructions, subroutine. Analog to digital converters and Digital to analog converters, Sampling, polling and interrupts, Digital filters, Lookup table.

**Sensors and actuators**
Speed sensors, Pressure sensors: Manifold Absolute Pressure sensor, Knock sensor, Temperature sensors, Coolant and Exhaust gas temperature, Exhaust Oxygen level sensor, Position sensors, Throttle position sensor, Accelerator pedal position sensor and crankshaft position sensor, Air mass flow sensor. Solenoids, Stepper motors and relays.

**Electronic engine management system**
Electronic engine control: Input, Output and control strategies, Electronic fuel control system, Fuel control modes: Open loop and closed loop control at various modes, EGR control, Electronic ignition systems; Spark advance correction schemes, Fuel injection timing control.

**Electronic vehicle management system**
Cruise control system, Antilock braking system, Electronic suspension system, Electronic steering control, Traction control system, Transmission control, Safety: Airbags, Collision avoiding system, Low tire pressure warning system.

**Other instrumentation systems**

Input and output signal conversion, Multiplexing, Fuel quantity measurement, Coolant temperature and oil pressure measurement, Display devices- LED, Onboard diagnostics (OBD), OBD-II, Off board diagnostics, Telematics, GPS navigation, The GPS system structure.

**Textbook**

1. Understanding Automotive Electronics, William B. Riddens, Butter worth Heinemann, Woburn, 5th edition 1998

**Reference Books**

1. Embedded System – Architecture, Programming, Design, Rajkamal, Tata McGraw Hill, 2003.
2. Instrumentation Devices and Systems, Raman, C.S., Sharma, G.R., Mani, V.S.V., Tata McGraw Hill, New Delhi, 1983.
3. Understanding Automotive Electronics, Bechhold, SAE- 1998.
Embedded System Design – A Unified hardware & Software Introduction, Frank Vahid, John Wiley

## MANUFACTURING PROCESSES FOR AUTOMOTIVE

**Course Code: AE21002**
**Credit: 4**
**L-T-P: 3-1-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

The main objective of this course is to emphasize the importance manufacturing sciences in the day-to-day life and to study the basic manufacturing processes and tools used. The course is delineated particularly to impart basic knowledge and understanding about the primary manufacturing processes such as casting, joining, forming, powder metallurgy, conventional machining processes and their relevance in current manufacturing industry.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Identify the requirements and complexities associated with different manufacturing processes,
CO 2: Understand the working of various casting processes,
CO 3: Use the concept of metal forming processes,
CO 4: Identify the best welding technique for joining of various components and to produce defect free products,
CO 5: Select an appropriate non-conventional machining technique to machine complex geometry component, and
CO 6: Investigate the role of CNC, robot, and AGV systems in automation.

## COURSE DETAILS

**Foundry Process**

Introduction to Casting, Sand Casting Terminology, Sand- Mould Making Procedure, Pattern Making, Pattern Materials, Pattern Allowances, Types of Patterns, Types of Sand Moulds, Moulding Procedure, Types of Sand, Sand Properties and relevant Testing, Types of Cores, Core Making, Core Sands, Fluidity of Molten Metals and Spiral Fluidity Test, Pouring Time, Casting Yield, Gating System Design, Solidification of Casting, Riser (basic design considerations), Cleaning of Casting, Casting Defects, Special Casting Processes - Die Casting, Permanent Moulds Casting, Precision Investment Casting, Shell Moulding, Centrifugal Casting etc.

**Metal Working Process**

Elastic and Plastic Deformation of Metals, Stress-Strain Relations, Concept of Flow Stress, Strain Hardening, Hot and Cold Working of Metals, Von Mises and Tresca yield criteria, Types of Bulk forming Processes, Rolling: Types of Rolling, Rolling Equipment, Process Variables, Distribution of Roll Pressure, Angle of Bite, Rolling load estimation., Rolling Defects- Causes and Remedies. Forgings: Types of Forging, Basic Forging Operations, Description of Presses and Hammers, Factors affecting Forgeability, Forging load estimation, Forging Defects-Causes and Remedies, Extrusion: Principle and Types, Advantages, Limitations, Applications, Process Variables, Load Calculation, Defects- Causes and Remedies. Drawing: Wire, Rod and Tube Drawing, Process Variables in Drawing, Load Estimation in Rod Drawing, Sheet metal working: – Sheet Metal Operations-Blanking, Punching, Trimming, Shaving, Nibbling, Notching, Hemming, Coining, Embossing, Bending and Spring-back, Stretch Forming, Deep Drawing and Spinning, Types of Sheet Metal Dies, Load Estimation in Sheet Bending and Deep Drawing, Defects in Sheet Metal working, their causes and remedies.

**Fabrication Processes**

Classification of Welding, Types of Weld Joints and Weld Positions, Electric Arc Welding: Principles of Arc Formation, Welding equipment and Electrodes. Gas welding: principles, types of flames, equipment, techniques of gas cutting, Principles of Inert Gas Welding: TIG, MIG, Sub-merged arc welding. Atomic hydrogen welding, Resistance Welding: Principle of spot welding, seam welding, projection welding, Forge welding, Flash welding. Thermit Welding, Electro-slag and Electro-gas welding. Brazing and Soldering. Welding defects (causes and remedies) and inspection.

**Powder Metallurgy**

Metallic Powders: Preparations and Properties, Steps in Processing, advantages, limitations, and applications.

**Conventional Machine Tools & Machining Processes**

Types, Specification, Operations, Tools, Accessories and attachments, Estimation of cutting time of conventional machining processes. Lathe: Types and Principal Parts, Lathe operations – Turning, facing, drilling, boring, chamfering, grooving, parting and thread cutting, Turret & Capstan Lathe, Multi Spindle Automatic Lathe. Shaper: Types and Principal Parts, Shaper Mechanism, Working Principle of Planner and Slotter. Milling: Up and Down milling, and indexing. Grinding; Surface grinding, Centerless grinding, grinding wheel specification, wheel truing and dressing. Finishing Processes: Reaming, Lapping, Honing, Super finishing, Gear Manufacturing.

**Advanced Manufacturing Processes**

Classification, principles, application and limitations of non-conventional machining processes such as Abrasive Jet Machining (AJM), Water Jet Machining (WJM), Abrasive water jet machining, Ultrasonic Machining (USM), Electrical discharge Machining (EDM), Wire electrical discharge machining (WEDM), Electrochemical Machining (ECM), Plasma Arc Machining (PAM), Laser Beam Machining

(LBM) and Electron Beam Machining (EBM), Effect of process parameters on material removal rate, surface roughness and power consumption; Additive manufacturing, Sustainable Manufacturing, Hydroforming.

**Automation in Manufacturing**

Introduction to industrial automation: Elements, Function and levels of Automation, Open and Closed loop control Systems, Automation in machine tools, NC, CNC, & CNC-Part programming, adaptive control, Industrial Robots – configurations, drives and controls, Automated guided vehicles (AGV) system, Automated storage and retrieval systems, CIM, Smart Manufacturing, Intelligent Manufacturing.

**Textbooks**

1. Manufacturing Technology (Vol. I), P.N. Rao (Tata Mc-Graw Hill, Publication. Co.Ltd.)
2. Manufacturing Processes, J. P. Kaushish, PHI
3. Manufacturing Technology (Vol II), P.N. Rao (Tata Mc-Graw Hill, Publication. Co.Ltd.)

**Reference Books**

1. Manufacturing Science: A. Ghosh & A.K. Mallick, EWP
2. Welding& Welding Technology, Richard L.Little, Tata Mc Graw Hill, 1992.
3. A Text book of production Technology, P.C. Sharma, S.Chand and Co. Ltd., 2004.
4. Manufacturing Engineering and Technology, Serope Kalpakjian, Steven R.Schmid, (4 th Edition), Prentice Hall 2000-06-15 ISBN:0201361310.

## AUTOMOTIVE ELECTRICAL AND ELECTRONICS LAB

**Course Code: AE29001**
**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

Students will get to learn about various equipment used in automotive and calibrate various sensor and other system virtually as well as practically. Though the sensors are changing but basic principle remains similar on many occasions. Basic understanding helps the students to identify and troubleshoot various equipment systematically.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Identify the component requirement for circuit building in Lab view,
CO 2: Understand the concept of virtual controller circuit,
CO 3: Articulate battery testing and maintenance for longer life,
CO 4: Analyze various accessory fault pattern in a garage,
CO 5: Evaluate various faults in ignition and starting, and
CO 6: Design a standard automotive sensor calibration process.

**COURSE DETAILS**

**Logic gate**
Logic gate and speedometer, LED blinking and traffic light

**IR sensor**
IR sensor calibration

**Car dashboard**
Car dashboard and testing relay and fuse

**Battery test**
Lead acid battery test, Lithium ion cell test

**Ignition system faults and rectifier circuit**
Diagnosis of ignition system faults and rectifier circuit, Alternator performance test, Alternator voltage regulator test

**Wiring test**
Starter motor test, Wiring of head light, Trafficators, Electric horn check

**Textbook**

1. How to Diagnose and Repair Automotive Electrical Systems, Tracy Martin, Motorbooks International, 2005

**Reference Book**

1. Car Electrical & Electronic Systems, Julian Edgar, Veloce Publishing Ltd., 2020

## AUTOMOTIVE MATERIAL AND COMPONENT TESTING LAB

**Course Code:** **AE29002**
**Credit:** **1**
**L-T-P:** **0-0-2**
**Prerequisite:** **Nil**

**COURSE OBJECTIVE**

In this laboratory students gets to know about the material testing as well as some component testing method. There are various material used in the automotive and steel being on among them and the basic material science knowledge begins with studying steel but later on the students are exposed to several other material and components used in automotive and many other similar machineries.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Identify the machines required for material testing in a laboratory,
CO 2: Understand the concept of tensile strength, compressive strength and hardness,
CO 3: Articulate relevance of three point bending test,
CO 4: Analyze selected sensor fault and diagnosis in a vehicle,
CO 5: Evaluate flow control in Lab view platform, and
CO 6: Design a standard temeprature sensor calibration process in Lab view platform.

**COURSE DETAILS**

**Impact strength of steel**
Determine Impact strength of steel

**Tensile strength and compressive strength**
Tensile strength test, Compressive strength test

**Bending and Hardness**
Three point bending test, Rockwell hardness test, Vickers hardness test

**Sensor calibration**
Lab view introduction, LM35 sensor calibration, Flow sensor calibration

**Thermocouple calibration**
Thermocouple calibration using Labview

**Accelerometer design**
Accelerometer design using Labview

**Textbook**


1. Automobile Mechanical and Electrical Systems Automotive Technology Vehicle Maintenance and Repair, Denton T, Butterworth-Heinemann, 2011


**Reference Book**


1. Modern electronic instrumentation and measurement techniques, Helfrick & Cooper, 2nd edition, PHI.

## AUTOMOTIVE ENGINES AND EMISSION

**Course Code:** **AE30002**
**Credit:** **3**
**L-T-P:** **3-0-0**
**Prerequisite:** **Engineering Thermodynamics (ME21002)**

### COURSE OBJECTIVE

Automobile Engineering students must have sufficient knowledge of internal combustion engine and different fuel being used in the engine. This course emphasizes on conventional and non-conventional fuel for automobile. The significance of the control variables and techniques required to reduce emission. In view of the latest emission norms the measuring techniques of visible and invisible pollutant measurement is challenging and students will learn it with practical demonstration. Students will update their knowledge by tracking all the latest developments introduced to the new modes of power generation in vehicle.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Identify the need of different types of engines in Automobile,
CO 2: Understand different fuel utility in different engine and the mechanism of injection,
CO 3: Solve the performance parameters problems using alternative fuels used in Automobile,
CO 4: Illustrate the efficacy of ignition system and air intake system in different engine,
CO 5: Judge the mechanism of pollutant formation in engines, and
CO 6: Design a suitable exhaust treatment and control technique to curb harmful emission.

### COURSE DETAILS

**Engine**
Petrol engine, Diesel engine, CNG Engine, dual fuel engine, Fuel injection system, Engine modification for Torque and Power.

**Engine Accessories**
Cooling System, Lubrication system, Spark Advance and Ignition advance, Efficiency enhancement, Torque enhancement

**Automotive Fuel**
Calorific value, Bomb calorimeter and Gas calorimeter, Octane and Cetane number, Viscosity, Flash point, Fire point, Cloud point, Pour point, Petrol and diesel additives. Biofuel blend, Biodiesel blend, LPG and CNG combustion.

**Engine Combustion and Pollutant Formation**
General Scenario on automotive Pollution, Pollutant sources; formation, Effects; transient operational effects on pollution; Unburnt hydrocarbon, Carbon monoxide, Oxides of nitrogen, Sulfur dioxide, Particulate Matters, Aldehyde emissions, Effect of operating variables on emission formation.

**Control Techniques for SI and CI Engine**
Design changes, optimization of operating factors, Control of Crankcase emission, Evaporative emission, Exhaust emission - exhaust gas recirculation, Air injector PCV system, Thermal reactors, Catalytic converters.

**Emission Control Efforts**
Emission Standards: Evaluation of Emission Standards – Mandatory Tests for Emission measurement; Type Approval & Production Conformity Tests; Driving Cycles.

**Test Procedure & Instrumentation for Emission Measurement**
Test procedures- Measurements of invisible emissions -ORSAT apparatus, NDIR analyzer, Flame ionization detectors, Chemiluminescent analyzer, Gas analyzer, Measurements of visible emissions – Comparison methods & Obscure methods - Smoke meters, Emission standards

**Textbooks**

1. Internal Combustion Engines, V. Ganesan, Tata McGraw Hill Co., 2004.
2. Automotive Engineering Fuels and Emissions (Classroom & Shop Manual), B. Hollembeak, Delmar CENGAGE Learning (2004)

**Reference Books**

1. Engine Emissions, B.P. Pundir, Narosa Publishing House, 2007.
2. Automobile Engineering, K.K. Ramalingam, Scitech Publications Pvt. Ltd., 2005

## ELECTRIC AND HYBRID VEHICLE TECHNOLOGY

**Course Code:** **AE30003**
**Credit:** **3**
**L-T-P:** **3-0-0**
**Prerequisite:** **Nil**

**COURSE OBJECTIVE**

This Course is structured to expose the students of automobile engineering to then world of electric and hybrid vehicles which are safe, reliable and environment friendly. Starting with Battery pack design the course covers selected component system specially designed for this purpose like DC-DC converters, Traction control etc. Students will have sufficient scope to learn the different series and parallel hybrid systems and the new generation fuel cell vehicles.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Describe electric vehicle technology and hybrid vehicles,
CO 2: Understand the basics of hybrid and electric drive trains,
CO 3: Articulate the standard hybrid vehicle system,
CO 4: Analyze various vehicle power sources systematically used in HEV,

CO 5: Evaluate an energy efficient concept car following international regulations, and
CO 6: Design drive train system and energy storage system of electric and hybrid vehicle.

**COURSE DETAILS**

**Electric Vehicle Power plant and Drives**
Introduction Electric Vehicle Power Plants, Induction Machines, Permanent Magnet Machines, Switch Reluctance Machines, Power Electronic Converters-DC/DC Converters - Buck Boost Converter, Isolated DC/DC Converter, Two Quadrant Chopper And Switching Modes, AC Drives- PWM, Current Control Method, Switch Reluctance Machine Drives - Voltage Control, Current Control.

**Electric and Hybrid Drive Trains**
Introduction Hybrid Electric Vehicles, History and Social Importance, Impact of Modern Drive Trains In Energy Supplies, Hybrid Traction And Electric Traction, Hybrid And Electric Drive Train Topologies, Power Flow Control And Energy Efficiency Analysis, Configuration And Control of DC Motor Drives And Induction Motor Drives, Permanent Magnet Motor Drives, Switch Reluctance Motor Drives, Drive System Efficiency.

**Hybrid Vehicles Combinations**
Parallel Hybrid, Series Hybrid -Charge Sustaining, Charge Depleting, Hybrid Vehicle Case Study – Toyota Prius, Honda Insight, Chevrolet Volt, 42V-72V System for Traction Applications, Lightly Hybridized Vehicles and Low Voltage System, Electric Vehicle Case Study - passenger and commercial vehicles available in India, Hybrid Electric Heavy Duty Vehicles.

**Electric and Hybrid Vehicle Design**
Introduction to Hybrid Vehicle Design, Matching the Electric Machine and the Internal Combustion Engine, Sizing of Propulsion Motor, Power Electronics, Drive System. Selection of Energy Storage Technology, Communications, Supporting Subsystem, Energy Management Strategies in Hybrid and Electric Vehicles - Energy Management Strategies- Classification, Comparison, Implementation; Electric Vehicle Power Source – Battery Charge Capacity, State of Charge and Discharge, Specific Energy, Specific Power, Ragone Plot.

**Battery, charger and charging station**
Battery Pack Design, Battery Modelling - Run Time Battery Model, First Principle Model, Battery Management System- SOC Measurement, Battery Cell Balancing. Traction batteries- Nickel metal hydride Battery, Li-Ion, Li-Polymer Battery. AC Slow and Fast charging, DC fast charging.

**Testing and validation**
Drive cycle, Testing of Motor, Testing of Battery, Testing of Charger, International standards for EV and HEV, National Standard

**Textbook**

1. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, Ehsani, CRC Press 3rd Ed. 2019

**Reference Books**

1. Electric and Hybrid vehicles Design Fundamentals, Iqbal Husain, CRC Press, second edition 2013
2. Hand book of Automotive Power Electronics and Motor Drives, Ali Emadi, CRC Press 2005
3. Introduction to Hybrid Vehicle System Modelling and Control, Wei Liu, Wiley 2015

## TWO AND THREE WHEELERS

**Course Code: AE30011**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

### COURSE OBJECTIVE

This course would encompass a comprehensive study of four stroke SI engine and merits and demerits with respect to two and three wheelers. Types of scavenging processes, merits and demerits, scavenging efficiency, Scavenging pumps, Rotary valve engine are also important in this context. Chassis frame, its types, Single, multiple plates and centrifugal clutches are covered here. Gear box and gear controls, Front and rear suspension systems, Shock absorbers, Panel meters and controls on handle bar are discussed with demonstration. Disc brakes, front and rear brake links layouts, Spoked wheel, Cast wheel are also included here. Stability of two wheelers on straight and curved path or the Chassis dynamometer analysis are most interesting topics here.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Identify best components of two and three wheeled vehicles as per given application,
CO 2: Compare the power transmission system of two wheeler,
CO 3: Solve braking force and stopping distance problem,
CO 4: Evaluate different models of two-wheeler and three-wheeler existing in India,
CO 5: Analyze the drive train of electric scooter and e-rickshaws, and
CO 6: Design the stability criteria for two and three wheelers and race dynamics.

### COURSE DETAILS

**Power Unit**
SI and CI engine, Symmetrical and unsymmetrical valve and port timing diagrams, Fuel system, Lubrication system, Magneto coil and battery coil spark ignition system, Electronic Ignition system, Starting system, Kick starter system.

**Chassis and Sub-Systems**
Mainframe and its types, Chassis and shaft drive, Single and multiple plates and centrifugal clutches, Gear box and gear controls, Front and rear suspension- systems, Shock absorbers, Panel meters and controls on handle bar.

**Brake and Wheels**
Drum brakes, Disc brakes, front and rear brake links layouts, Spoked wheel, Cast wheel, Disc wheel, Disc types. Tyres & tubes.

**Two and Three Wheelers**
Case study of major commercial models of motorcycles, Servicing and maintenance, Troubleshoot common problems, Complex problems diagnostics, Case study passenger and goods three wheelers, Front engine and rear engine, CNG for three wheelers.

**Electric scooters and e-rickshaw**
Latest developments in two and three wheelers, Electric and hybrid three wheeler, E-rickshaw and pick up van.

**Two and three wheeler dynamics**
Stability of two wheelers on straight and curved path, Chassis dynamometer, Stability of three wheelers, Racing bike dynamics, Dirt bike, Cruiser, Bobber bike and Chopper bike.

**Textbook**

1. Two and Three wheeler Technology, D.U. Panchal (PHI) 2022.

**Reference Books**

1. Automobile Engineering vol. I & II, Gupta H M 1st edition Reprint 2006.
2. Automobile Engineering, Gupta R B, Satya Prakashan 2004.
3. Two Wheelers, K. K. Ramlingam, SCITECH 2018.

## BATTERY TECHNOLOGY

**Course Code: AE30012**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

This course is intended to describe the evolution of voltaic cell and various batteries to the students of Automobile Engineering who has sufficient knowledge of engineering chemistry. This course emphasizes on construction, reaction and applications for new batteries. The significance of the safety and reliability required to select a battery can be appreciated. In view of changing battery management systems the electronic circuit of BMS plays an important role and students will have ample knowledge of it. Students will also familiarize with various type of fuel cells and the recent research in membrane, electrode etc.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Identify the difference of fuel cell and battery,
CO 2: Understand the process involved in the inter conversion of electrical energy and chemical energy,
CO 3: Articulate the need to evolve storage as a substitute to conventional IC engine,
CO 4: Analyze the process of battery state estimation,
CO 5: Evaluate the health of a battery pack, and
CO 6: Design a battery pack for an automobile.

**COURSE DETAILS**

**Modern batteries**
Introduction to Energy Storage Systems and Devices, Rechargeable Batteries and their Fundamental Electrochemistry, working and industrial applications of Lead- acid battery, Construction, Working and industrial applications of Zinc-air battery, Nickel metal hydride battery and Li-MnO2 battery.

**Evolution of Battery**
Li-ion Battery Technology and Challenges, Cathode Materials, Anode Materials, Electrolytes, Beyond Li-ion Battery Technologies, Manufacturing Technologies of Batteries, Sustainable Design of Batteries, Capacitors and Super-capacitors.

**Battery Management System**
Introduction and BMS functionality, High-voltage contactor control, Isolation sensing and thermal control, Protection and interface; State-of-charge estimation, Energy and power estimation, Cell Balancing, Causes of imbalance, Design choices when implementing balancing, Passive and Active circuit balancing, Active Capacitive circuit balancing, Active inducing circuit balancing.

**Battery State Estimation**
Estimate state of charge, Overview of vector random (stochastic) processes, Sequential-probabilistic-inference solution, The six-step process.

**Battery Health Estimation**
Lithium-ion aging, Negative electrode, Positive electrode, Sensitivity of voltage to ESR and total capacity.

**Fuel Cells**
Introduction, definition, Construction, working and industrial applications of H2-O2 fuel cell, Methanol-oxygen fuel cell, Differences between battery and fuel cell.

**Textbooks**

1. Battery Technology for Electric Vehicles: Public science and private innovation, Albert N. Link, Alan C. O'Connor, Troy J. Scott, Routledge; 1 edition, 2015.
2. Batteries Demystified, Ramesh Natarajan, Wings Publication (March 18, 2022).

**Reference Book**

1. Lithium-Ion Batteries: Science and Technologies Masaki Yoshio, Ralph J. Brodd, Akiya Kozawa, Springer, 2009.

# AUTOMOBILE MATERIALS

**Course Code: AE30013**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

## COURSE OBJECTIVE

This course would encompass a comprehensive study of different types of materials, their crystal structures and their mechanical properties. Moreover, students will be able to study the corrosion performance and learn to elucidate corrosion protection of the automotive structure. With this knowledge students will be able to select materials for automotive body structures and apply for component manufacture and assembly. Overall students will be able to correlate the structure of different materials with their concerned processing and properties and select the right material in future automobile considering the environmental and safety criteria.

## COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Identify the material requirement for automobile engineering application,
CO 2: Understand the structure and properties of different automobile materials,
CO 3: Articulate component manufacture and assembly using material selection criteria,
CO 4: Analyze the various material joining technology,
CO 5: Evaluate the various corrosion prevention methods, and
CO 6: Design the catalyst structure for pollutant reduction considering environmental and safety considerations.

## COURSE DETAILS

### Introduction
Materials overview, Body architecture, Design and material utilization, Automotive body zones, Early materials and subsequent changes, Materials for Body, Manufacturer's approach to current design, Product requirements, Structural dynamics, Material for static stiffness, Crashworthiness, Weight efficiency, Panel dent resistance and stiffness testing, Material design against fatigue, Alternative body architecture, Unitary aluminium body, Pressed steel space frame, pressed aluminium space frames

### Materials for automotive body structures
Material candidates and selection criteria, Steel reduction and finishing processes, surface topography, Effects in processing, High strength steels, Aluminium, Production process, Alloys for use in body structures, Magnesium alloy

### Metal Forming
Steel formability, Sheet metal press working, Sheet properties and test procedures, Effect of surface topography, Effect of zinc coatings, Tooling Materials, Hydroforming Aluminium formability, Engineering approach to design with aluminium, Superplastic forming, Magnesium formability, Manufacture of components in magnesium, Polymer formability, production of polymer parts, CFRP for EV and the future

**Polymers and composites**
Thermo plastics, Thermosets, Polymer and composite processing, Advanced composites for competition cars, Carbon fiber or CFRP based designs, Integration of materials into designs, Engineering requirements for plastic and composite components, Cost analysis

**Designing hybrid materials**
Material for auto piloting, Manufacturing considerations for various lightweight automotive structures, 3D printing-materials, Processes and applications. Case studies on Li-ion battery, Polymer composites and sensor materials

**Corrosion and protection of the automotive structure**
Corrosion processes, Corrosion of aluminium and other non-ferrous body materials, Mechanism of paint degradation, Effective design principles, Styling, Subassemblies, Panels, Materials used for protection of body structure, Zinc-coated steels –types and use for automotive construction, Paint of the automotive body structure, Environmental improvements in the automotive paint process, Supplementary protective systems, Vehicle assessments, Laboratory tests

**Environmental and safety considerations and future trends**
Effect of body mass and emissions control, Life-cycle analysis, Recycling and ELV considerations, Hygeine, BIW design and safety, Geographic aspects, Quantitative assessment, Factors influencing material change in the future, Influence of environmental controls

**Textbooks**

1. Materials for Automobile bodies, Geoffrey Davies, Elsevier, 1st Edition 2003
2. Automotive Engineering: Lightweight, Functional, and Novel Material, Brian Cantor, P. Grant, C. Johnston, Taylor & Francis

**Reference Books**

1. Fundamentals of Materials Science and Engineering, Callister W. D., Wiley, 4th edition
2. Engineering Materials, S. C. Rangwala, Charotar Publishing House, 2011.
3. Material Science for Engineers, J.F. Shackelford and M.K. Muralidhara, 6th edition, PEARSON
4. Engineering Materials Technology, W. Bolton, 3rd Edition, Butterworth & Heinemann, 2001

## TRACTORS AND FARM EQUIPMENT

**Course Code:** **AE30014**
**Credit:** **3**
**L-T-P:** **3-0-0**
**Prerequisite:** **Nil**

**COURSE OBJECTIVE**

This course is designed to teach about the basic structure of tractors and farm equipment the students of automobile engineering. Special arrangement of Cooling and lubrication system as well as the wheel structure for rough terrain driving will be interesting to the young graduates. Hydraulic and pneumatic system and their maintenance requires special skill for the technicians dealing in this agri-technology sector. Power management is taught practical demonstration. Students exploits various opportunities in trailer design and modifications beneficial to the farmers.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Relate different component and part of tractor and power tiller and Farm Equipment,
CO 2: Identify the best Farm Equipment for land preparation,
CO 3: Illustrate the standard troubleshooting of tractor and power tiller,
CO 4: Examine proper engine and power train for tractor,
CO 5: Construct proper attachment for lifting farm produce with minimum intervention, and
CO 6: Justify the PTO for different applications to suite Indian agriculture.

**COURSE DETAILS**

**General Design of Tractors**
Dimensioning and ergonomics for farm work, Special needs, Industry Standard, Control of the Tractor.

**Fundamentals of Engine Operation**
Engine Frame, Work and Valve Mechanism of Tractor.

**Accessories and Mountings**
Cooling system, Lubrication System and Fuel System of a Tractor, Fuel economy, Fuel blending for Tractor, Performance enhancement, Fuel tanks and filters, Fuel pumps.

**Working attachment of tractors**
Power Take off, Hydraulics and pneumatics, Comparison, advantages and challenges with hydraulic system, advantages and challenges with pneumatic system electro pneumatics, Valves and actuators.

**Farm equipment**
Choice of farm equipment, Heat Treatment of farm equipment, Field Capacity calculation, Field efficiency calculation, Economy of farm tool, Running cost minimization.

**Tillage and plough**
Objectives, methods and terminology, Introduction and classification of primary & secondary tillage, Operation and material of construction, Mould Board Ploughs, Sub soiler, Chiesel Plough.

**Modern farm tools**
Rotary tillage tools, Rotavators, Stirring plough, Auger plough, Rotary hoes, Oscillating tools, Combined harvester.

**Textbook**

1. Farm Tractor-Maintenance and Repair, S.C. Jain and C.R. Rai, McGraw-Hill Education.

**Reference Books**

1. Tractor and Automobiles, Rodichev and G. Rodicheva, Mir Publishers, 1987.
2. Design of Automotive engines for tractor, Kolchin. A., and V. Demidov, Mir Publishers, 1972.

# THERMAL SYSTEMS IN AUTOMOTIVE

**Course Code: AE30018**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

## COURSE OBJECTIVE

This course is intended to describe engine cooling system, compressor and pumps to the students of Automobile Engineering who has sufficient knowledge of heat and mass transfer. This course emphasizes on cooling system in engine space as well as in cabin space. The significance of the heating ventilation and air conditioning system required for passenger comfort can be thoroughly understood. In view of the human comfort of air conditioning plays an important role and students will learn it with practical demonstration. Students will update their learning ability by knowing the design of heat exchangers for automotive which can be extrapolated to the power plants as well.

## COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Identify various thermal systems and its functions,
CO 2: Understand various types of compressors,
CO 3: Solve cooling load calculations and to select different types of fans,
CO 4: Illustrate the concepts to design heat exchangers,
CO 5: Evaluate the applications of different fluid systems, and
CO 6: Develop and simulate one thermal system in computer and validate the result.

## COURSE DETAILS

**Introduction to Thermal Systems**
System boundary and surroundings, Heat transfer, Fluid flow, Heat engines – Functions, Components, Working, Cooling, Properties of coolant, Coolant recirculation and lubrication systems.

**Automotive Air Conditioning**
Psychometrics properties, Use of psychometric chart, Refrigerants, Types of refrigerants, Properties and Selection of refrigerants, Factors affecting the air flow, Types of fans, Axial and Centrifugal fans, Load calculations, Winter air conditioning.

**Air Compressors**
Types and classification of compressors, Working principle, Reciprocating compressors, Single and multistage compressors, Compression with and without clearance, Volumetric, Isothermal and Isentropic efficiency, Rotary compressors, Comparison between reciprocating and rotary compressors, Comparison between centrifugal and axial compressors.

**Fluid Transport**
Incompressibility and expansion of fluids, Transmission of forces through fluids, Multiplication of forces Fluid power, Applications of fluid power, power brakes, Power steering, Shock absorber; Components of hydraulic and pneumatic systems, Reservoir, Pumps, Strainers, filters, Valve types, Actuators, motors,

Accumulators, oil coolers, Cooling fan, Tubing, Piping, Hose; Fluid transport and power systems, Applications of pneumatic and hydraulic systems.

**Heat Exchangers**
Functions of radiator, Compressor, Condenser, Evaporator, expansion valve, Classification of heat exchangers; According to transfer process, Number of fluids, Surface compactness, Construction features, Flow arrangements, Heat transfer mechanisms.

**Design of Heat Exchanger**
Selection and design of heat exchangers based on Types, Heat transfer rate, Cost, Pumping power, Size and weight, Materials, Basic thermal design theory for reciprocators.

**Textbooks**

1. Thermal Engineering, R.K Rajput Laxmi Publications, 8th Edition, New Delhi, 2010.
2. Design and Optimization of Thermal Systems, Yogesh Jaluria, CRC Press; 2nd edition, 2007.

**Reference Books**

1. Fundamentals of Engineering Heat and Mass Transfer", New Age Science Ltd., New Delhi, 2009.
2. Heat and Mass Transfer, Yunus A. Cengel, Afshin J. Ghajar, Tata McGraw Hill, New Delhi, 2013.

## VEHICLE LIFE CYCLE MANAGEMENT

**Course Code: AE30020**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

This course enables the students to understand the womb to grave concept for any automobile component vis-à-vis the modern industry practices. It's important to implement stringent practices to protect the environment as an automobile in general has a lot of potential to damage the environment. Graduates of automobile engineering going through this course is thoroughly aware of ISO 14001 certification of automobile industry and cost effective policy implementation to cope up with a challenging automotive market.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Identify and implement basic components and functionality of a PDM system,
CO 2: Compare the terms PDM and PLM,
CO 3: Solve a PDM system to support and control a product realization process,
CO 4: Illustrate a PDM system to effectively support, follow up and control the project,
CO 5: Evaluate the best waste management technique in recycling old vehicle, and
CO 6: Design an environment friendly scrap management policy.

**COURSE DETAILS**

**Introduction**
Definition of total life cycle (TLC), Concept of TLC-Life cycle impacts-Integrating life cycle technologies, Products and processes within TLC-TLC methodology, TLC assessment data to complex products, Results Improvement for product, Life Cycle Costing (LCC).

**Vehicle End Life**
Design for end of old vehicle management, Problems of old vehicles in emerging markets, Recovery and economic feasibility of materials such as plastics, rubber aluminum, steel, etc.

**Trade off**
Applying life cycle thinking to define trade-offs along the supply, Manufacture, Use and end of life chain, Effect on the customer, Expectation of the customer, Evaluate product cost on fuel consumption, Emissions, Durability, Environment and health.

**Sustainability**
What is sustainability, Use of renewable resources, View to design horizon, Harmonization of Environmental Goals, TLC for emerging vs. developed markets, Rules and regulations to guide designers, International common practices for end of life products.

**Total quality environment (TQE)**
Environmental management system (EMS), product evaluation standards, Requirements of ISO 14001, Environmental policy, Elements of environmental planning: environmental aspects, Legal and other requirements, Objectives and targets, and environmental management programme, Voluntary Vehicle Fleet Modernization Program India, Commercial vehicle, Private vehicle.

**Textbook**

1. Automotive Scrap Recycling: Processes, Prices and Prospects, James. W Sawyer, Routledge, 2015.

**Reference Books**

1. Sustainable Management of Automobile Waste, Forbid George Teke, VDM Verlag, 2010.
2. Automobile Life Cycle Tools and Recycling Technologies, Society of Automotive Engineers, 1993.

## DESIGN OF AUTOMOTIVE COMPONENTS

**Course Code: AE31001**
**Credit: 4**
**L-T-P: 3-1-0**
**Prerequisite: Machine Kinematics and Dynamics (AE20001)**

**COURSE OBJECTIVE**

This course is taught to the graduate students of automobile engineering. Design of components is a core competency expected of the graduates. Advanced level machine component design is taught in this course when the students have already known about mechanics of solids and kinematics of machine. IC engine components like piston, connecting rod are demonstrated and the students are exposed to the concept of factor of safety. Students fine tune their skill by designing components like valve spring and cam.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Understand the basic design requirement and suitable material selection for machine components,
CO 2: Compare and determine geometrical dimensions of a component subjected to complex stress system,
CO 3: Sketch the the engine component as per standards,
CO 4: Analyze the automotive component subjected to static and variable loads,
CO 5: Evaluate the life of component subjected to complex loading, and
CO 6: Design and assemble complex engine parts including bearing.

**COURSE DETAILS**

**Introduction**
Basics of Design principle; Stress concentration, Endurance limit, Low cycle and high cycle fatigue, Soderberg Gerber and Goodman's line, Modified Goodman's diagram, Fracture and Fatigue based design.

**Design of Shaft**
Materials used for shaft, types of shaft, Standard size of transmission shafts, stresses in shafts, Maximum permissible working stresses for transmission for transmission shafts, Design of shaft- shaft subjected to twisting moment only, shaft subjected to bending moment, shaft subjected to combined twisting moment and bending moment, Design of shaft subjected to fluctuating load, axial load in addition to combined torsion and bending loads, Design of shaft on the basis of rigidity.

**Design of Cylinder and Piston**
I.C engines and components design requirement, Materials selection based on engine components and its function, Design of cylinder block and cylinder, Functions of piston in an I.C engines-Design of piston, Description on piston rings-compression ring-oil rings, piston failure

**Design of Connecting Rod**
Introduction - material selection for connecting rod, Design of connecting rod small end, Design of connecting rod big end and shank design, Design of connecting rod-cap bolt design, Design of connecting rod-cap bolt design

**Design of Crankshaft**
Introduction about crank shaft and its function in an I.C Engine; Materials selection for crankshaft, Balancing of I.C. engines, MI of Crankshaft, Significance of firing order, Design of crankshaft under bending and twisting, balancing weight calculations, Development of short and long crank arms.

**Bearing and Valve Actuating Mechanisms**
Design of valve spring and valves, Design of push rod, Sliding contact bearing, Rolling contact bearing.

**Textbooks**

1. Design of Machine Elements– V.B. Bhandari,.(McGrawHill Education Pvt. Ltd.), 4th Ed.
2. Design Data Hand Book, S. Md. Jallaludeen (Anuradha Pub.)

**Reference Books**

1. Machine Design – P.C. Sharma, K. Agarwal S K Kataria and Sons, 2010.
2. Machines Design Data Book - P.S.G. College of Technology, Coimbatore.
3. Mechanical Engineering Design - Shigley J E, Mischiee C. R.; TMH
4. Machine Design, Maleev and Hartman's, CBS; 5th edition, 2011.

## VEHICLE MAINTENANCE AND QUALITY CONTROL LAB

**Course Code: AE39002**
**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

This Laboratory course is to deal with preventive and breakdown maintenance of vehicle. At the same time in the metrology lab students will understand various aspects of quality control done in a standard industry. Quality control knowledge enable a graduate student to appreciate the meaning of accuracy and precision in true sense.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: know the different inspection gauges and its application,
CO 2: Understand the working principal of different measuring instruments and its application,
CO 3: compare the results from different measuring instruments,
CO 4: calculate bore diameter by using four ball and two ball method,
CO 5: Evaluate the tyre and wheel condition of vehicle, and
CO 6: Judge the sensor combustion and emission situation by scanning a vehicle.

**COURSE DETAILS**

**Vehicle Inspection**
Vehicle Inspection and fault detection, OBD Scanning

**Emission**
Emission from engine

**Wheel balance and alignment**
Wheel balance and alignment, Tyre rotation and brake bleeding

** Study of different types of inspection gauges**
Study of different types of inspection gauges and their methods of application, Determination of diameter and length of stepped shaft using Micrometer, Vernier Caliper and Vernier height gauge.

**Determination of angle**
Determination of angle of an angle gauge plate by using sine bar method.

**Determination of bore diameter**
Determination of bore diameter by four ball and two ball method.

**Determination of the included taper angle**
Determination of the included taper angle, Large end, Smaller end diameter (DL and Ds), Check the outer roundness and uniformity of an externally tapered specimen.

**Textbook**

1. Motor Vehicle Mechanic's Textbook, Sully F.K., Butterworth-Heinemann; 5th edition, 2014

**Reference Book**

1. Engineering Metrology, R.K.Jain, Khanna Publishers, 2005.

## PROJECT MANAGEMENT

**Course Code: AE40011**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

### COURSE OBJECTIVE

The purpose of this course is to prepare the students to understand the tools and techniques involved in a project. Moreover, enable them to execute a project to achieve specific goals that will benefit the organizations and society. Without proper planning the students joining a workforce may not add value to the organization from beginning. Therefore this course will make the student gather more managerial skill set in the graduate program.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Identify the important risks facing in a new project,
CO 2: Understand the need for Project Management,
CO 3: Use different techniques of activity planning,
CO 4: Illustrate different environment factor in a simple project execution,
CO 5: Evaluate and select the most desirable projects, and
CO 6: Design a new project and develop project schedule.

### COURSE DETAILS

**Project Management and Project Selection**
Objectives of Project Management, Importance of Project Management, Types of Projects Project Management Life Cycle, Project Selection, Feasibility study: Types of feasibility Steps in feasibility study.

**Project Planning and Implementation**
Project Scope, Estimation of Project cost, Cost of Capital, Project Representation and Preliminary Manipulations, Basic Scheduling Concepts, Resource Levelling, Resource Allocation.

**Project Monitoring and Control**
Setting a base line, Project management Information System, Indices to monitor progress, Importance of Contracts in projects, Teamwork in Project Management, Attributes of a good project team, Formation of effective teams, Stages of team formation.

**Project Closure**
Project evaluation, Project Auditing, Phases of project Audit, Project closure reports Guidelines for closeout reports, Special topics in project management: Computers, E-markets and their role in Project management.

**Risk management**
Type of risk, Risk prioritization, Quantify risk.

**Environmental Impact Assessment**
Compliance with environmental law, Case studies in Project management, Black Swan Events.

**Textbook**

1. Getting Started in Project Management, Tate, Karen (2001), Wiley: New York.

**Reference Books**

1. The Project Management Advisor: 18 Major Project Screw-Ups, and how to Cut them off at the Pass, Pacelli, Lonnie (2004), Prentice Hall: New York.
2. Fundamentals of Project Management, Joseph Heagney (2019), (Fifth Edition), Amacom
3. Project Management and Agile Essentials - A Practical Self-Study Guide, Vibrant Publishers (1 January 2020).

## ASSEMBLY LINE AUTOMATION

**Course Code: AE40012**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

This course is framed to teach the students of automobile engineering about the modern automated industry 4.0. It is important for the automobile professionals to have prior knowledge of PLC programming and dynamic path planning to run a modern industry. Students learn about Pneumatic components, Fluid power actuators, direct and inverse kinematic differential motion and Jacobians. The transition for from industry 3.0 to industry 4.0 is well explained to the students with practical examples.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Identify the applications of PLC applicable to automobile assembly line,
CO 2: Understand PLC programs to solve industrial control problems,
CO 3: Use the best processes for robotics application to reduce cost and increase productivity,
CO 4: Device pneumatics and hydraulic circuit using computer for automated factory,
CO 5: Grade the pneumatic actuator for a given application, and
CO 6: Create a hydraulic link based on load requirements.

**COURSE DETAILS**

**Fundamental of Manufacturing and automation**
Types of production, Functions in manufacturing, Production concepts and mathematical models, Automation strategies.

**PLC (Programmable Logic controller)**
Over view and architecture, PLC programming, Application examples.

**Pneumatics and Hydraulics**
Pneumatic components: Properties of air compressors filter, Regulators, Unit-Air control Valves, Quick Exhaust valves, Pneumatic actuators, Fluid Power, Circuit design, Speed control circuits. Hydraulic system, Sources of hydraulic power, Fluid power actuators, Pumping theory, Direction control valves, Pressure control valves, Types of hydraulic cylinders.

**Robotics and Robot applications**
Robot introduction, Definition, Classification and specification, Mechanism: Kinematic parameters and modeling, Direct and inverse kinematic differential motion and jacobians, Introduction to Dynamics path planning, Trajectory planning and control, Skew, Joint interpolation and straight line motion. Offline programming and simulation.

**Computer Networks for manufacturing**
Hierarchy of computers in manufacturing, Local area networking, Manufacturing automation protocol.

**Future automated Factory**
Introduction to machine learning, Future trends in Trends in manufacturing, Future automated factory.

**Textbooks**

1. Industrial Automation and Robotics, A. K. Gupta and S. K. Arora, Laxmi Publications, New Delhi.
2. Computer-Based Industrial Control, Krishna Kant, Prentice Hall of India Ltd, 1997.

**Reference Books**

1. Fundamentals of Industrial Instrumentation and Process Control", William C. Dunn, TataMcGrawHill, 2009.
2. Oil Hydraulics, Majumdar S.R., Tata McGraw- Hill, 2000.
3. Fluid power with application, Anthony Esposito. Pearson education, 2000.

# SIMULATION OF IC ENGINE

**Course Code: AE40013**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

## COURSE OBJECTIVE

This course would cover a comprehensive study of the fundamental of combustion thermodynamics and chemical reaction that occurs during combustion inside the engine. Differentiation between actual and ideal thermodynamic cycles applied to IC Engine, liquid fuel injection and evaporation principles are very interesting. The effect of throttle operation and supercharging on engine performance, flame propagation can affect the simulation in SI engine as well as heat transfer process simulation. The valve timing and injection timing effect and simulation of unbalanced system for in engines is interesting. Diesel and petrol engine emission simulation is helpful in optimizing its control.

## COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Explain combustion phenomena and measurements of URP and HRP,
CO 2: Summarize the combustion thermodynamics,
CO 3: Simulate the SI engine performance,
CO 4: Analyse the simulated result of SI engine Performance,
CO 5: Reframe and solve problems related to engine computation, and
CO 6: Develop diesel engine simulation.

## COURSE DETAILS

**Introduction to Combustion**
Introduction; Heat of reaction; Measurement of URP, Measurement of HRP, Adiabatic flame temperature, Complete combustion in C/H/O/N Systems.

**Combustion thermodynamics**
Constant volume adiabatic combustion, Constant pressure adiabatic combustion, Calculation of adiabatic flame temperature, Isentropic changes of state.

**SI Engine Simulation with Air as Working Medium**
Deviation between Actual and Ideal Cycle, Problems, SI Engine Simulation with Adiabatic Combustion, SI Engine Temperature drop due to Fuel Vaporization, Full Throttle Operation, Efficiency Calculation, SI Engine Part-Throttle Operation, and Supercharged Operation.

**Progressive Combustion**
SI Engines Simulation with Progressive Combustion, Simulation of Gas Exchange Process, Heat Transfer Process, Friction Calculation, Compression of Simulated Values, Validation of the Computer Code, Engine Performance Simulation, Pressure Crank Angle Diagram And Other Engine Performance.

**Computational method**
Geometry preparation, Mesh generation, Boundary conditions, Model selection, Convergence criteria, Time scale factor.

**Diesel Engine Simulation**
Multi Zone Model For Diesel Combustion, Different Heat Transfer Models For Diesel Engine Simulation, Diesel Engine Equilibrium Calculations, Simulation Of Engine Performance, Diesel Engine Simulation For Pollution Estimation.

**Textbook**

1. Computer Simulation of spark ignition engine process, Ganesan. V. Universities Press (I) Ltd, Hyderabad, 1996.

**Reference Books**

1. Modelling of Internal Combustion Engines Processes, Ramoss. A. L, McGraw Hill Publishing Co., 1992.
2. Computer Simulation of Compression Ignition Engines, Ganesan. V Orient Longman, 2000.

## FUNDAMENTALS OF TYRE TECHNOLOGY

**Course Code: AE40014**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

Tyre technology is a course designed to the most sought after component viz. tyre of automotive. Tyre is the connection between the road and the vehicle subjected to various forces. Vehicle stability in acceleration and braking is dependent on tyre and the tyre may affect the fuel economy of the vehicle. Construction of tyre which involves basic principle of mechanics of solids also requires the attention in composite material. Inspection of tyre requires highly technical skill and hence taught along with laboratory demonstration.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Explain various methods of tyre manufacturing,
CO 2: Understand wear possibilities, their causes and measurements,
CO 3: Solve the forces and moments acting on tyres,
CO 4: Illustrates the safety factors of tyres and its failure analysis,
CO 5: Evaluate the tyre quality through testing methods, and
CO 6: Write logical statement for the optimum tyre selection with respect to load, service life.

**COURSE DETAILS**

**Introduction**
Tyre Basic Functions, Tyre Types: Diagonal, Belted Bias, Radial Bias, Tyre Nomenclature, Tyre Bias Types: Diagonal, Belted Bias, Radial Bias; Radial Tyre Design Process, Tyre Performance Criteria Indoor Test And Outdoor Test, Tyre Manufacturing, Compound Preparation Calendaring, Tyre Assembly, Curing, Inspection, Quality Control Tests.

**Forces and Moments**
Tyre dynamics, Rolling Resistance, The effective rolling radius, Cornering Properties Slip Angle And Cornering Force, Performance Of Tyre On Wet Surface, Ride Properties of Tyres.

**Rubber Abrasion and Tyre Wear**
Sliding Abrasion, Tyre Wear; Influence of Road Surface, Driving Influences; Speed and Load Distributions, Road Wear and Force Distribution; Tire Construction.

**Tyre Noise**
Sound Generation Mechanisms, Sound Enhancement Mechanisms, Analyzing/reducing tyre noise.

**Tyre Safety, Durability and Failure Analysis**
Service, Maintenance Safety, On Vehicle- In-Service Safety, Fundamentals Of Tyre Durability, Nature Of Tyre Durability, Deflection, Heat, Speed, Tyre Structural Failures, Common In-Service Tyre Failure Modes, Run Low/ Flux Break, Tyre Tread Bead Detachment Rapid Air Loss, Over Deflection, Intra-Carcass Pressurization- Cuts And Punctures, Improper Repair, Tyre Defects.

**Non-Destructive Tests**
Inspection Techniques; X-Ray Examination, Shearography, Ultrasound test, Eddy Current test.

**Textbooks**

1. Systematic Review of Tyre Technology, Yasuhiro Ishikawa, National Museum of Nature and Science Vol.16, 2011.
2. US Department of Transportation., The Pneumatic Tire, February 2006.

**Reference Books**

1. Tire and Vehicle Dynamics, Hans B. Pacejka, 3rd Edition, 2002.
2. Vehicle Dynamics: Theory and Application, Reza N. Jazar, Springer 2008.

## AUTOMOTIVE QUALITY MANAGEMENT

**Course Code: AE40015**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

This course gives the automobile engineering students an exposure to quality engineering as practised internationally. System certification is the process followed everywhere and this course teaches the standards ISO 9000 and ISO TS16949. 5s concept, Kizen technique and six sigma changed the scenario of manufacturing quality product all over the world and automotive components carry the quality mark to be relevant in the market. Students fine tune their skill using statistical process control so that they can be industry ready with proper knowledge of quality standards.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Describe the basics of quality engineering and quality management,
CO 2: Understand the evolution of quality assessment in Automobile Industry,
CO 3: Apply the quality concepts in different time frame and different countries,
CO 4: Analyze different Quality Management techniques, system and standards,
CO 5: Solve problems related to Application of management tools and techniques for process improvement, and
CO 6: Design Automotive TS16949 quality system practices.

**COURSE DETAILS**

**Introduction**
Quality, classification of quality and services, Quality systems overview, Product Quality design, Quality engineering in design of production processes, Characteristics, Reliability and Safety, Quality engineering in production, Quality engineering in service.

**Quality Management Systems**
Dimensions of Quality, Costs of Quality, Quality System Standards, ISO 9000 clauses and its interpretations, ISO TS16949 clauses and interpretation.

**Modern Management Tools and Techniques**
5s concepts, Kaizen techniques, Six sigma methodologies, Quality circles, Taguchi loss function, POKE-YOKE Techniques.

**ISO TS16949 Requirements**
Advanced Product Quality Planning (APQP), Design Failure Mode Effects Analysis, Process Failure Mode Effects Analysis, Production Part Approval Process (PPAP), IATF 16949:2016.

**Quality Tools and Measurement Systems**
Statistical process control, SPC detection and SPC prevention, Data collection methods, Statistical Tools, Analysis of variance (ANOVA), Chi-squared test, Correlation, Factor analysis, Mann–Whitney U, Mean square weighted deviation (MSWD), Pearson product-moment correlation coefficient, Regression analysis.

**Measurement systems**
Repeatability, Reproducibility, Variable Gauge R&R, Introduction to Hypothesis Testing.

**Textbook**

1. Automotive quality system Handbook, David Hoyle, Butterworth Heinemann Ltd., Second edition, Oxford, 2000.

**Reference Books**

1. Introduction to statistical control, Montgomery Douglus C., John Wiley and Sons, New Delhi, 2007.
2. Managing for total quality-From Deming to Taguchi and SPC, Logo Thetis N., Prentice Hall of India (P) Ltd., New Delhi, 1997.

## AUTONOMOUS AND CONNECTED VEHICLE TECHNOLOGY

**Course Code: AE40016**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

### COURSE OBJECTIVE

Automobile engineering students learn about the handling of large fleet and traffic on highway by intervention of information technology here. It's important to adapt to the new technology in the transport sector to save time and fuel which have direct impact on environment and human life. Students learn about Data acquisition system, Global position system with the present day demand in amalgamation of Big data analysis and artificial intelligence. So the students with knowledge of this subject can appreciate any Processing System and Control System in broader sense.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Explain the intelligent vision system used in automobiles,
CO 2: Understand the architecture of intelligent transportation system,
CO 3: Model the adaptive control technique for an autonomous vehicle,
CO 4: Predict the reliability of Sensor Based Manoeuvre,
CO 5: Evaluate the scope of intelligent vehicle in Smart city development in India, and
CO 6: Design the successful autonomous vehicle projects.

### COURSE DETAILS

**Vehicle Information System and Intelligent Transport**
Intelligent Transportation System (ITS), Requirements for ITS Communications; Multimedia communication in a car, Current ITS Communication Systems and Services, Vehicle to Vehicle and Road to Vehicle Communication Systems, Inter and Intra Vehicle Communication, VANETS-Devices-Optical Technologies and Millimetre Wave technologies, Global Positioning system.

**Adaptive Control Techniques**
Automatic Control Of Highway Traffic And Moving Vehicles, Adaptive Control Gain Scheduling, Model Reference Adaptive Control, Self Tuning Adaptive Control System Model, System Identification Basics, Recursive Parameter Estimation, Estimator Initialization, Design Of Self tuning Controllers, Generalized Minimum Variance (GMV) Control, Pole Placement Control And Model Predictive Control.

**Decisional Architectures for Autonomous Vehicles**
Control Architectures and Motion Autonomy, Deliberative Architectures, Reactive Architectures, Hybrid Architectures. Overview of Sharp Architecture, Models Of Vehicle; Concepts of Sensor Based Manoeuvre, Reactive Trajectory Following, Parallel Parking, Platooning, Main Approaches To Trajectory Planning, Non-Holonomic, Path Planning.

**Autonomous Vehicle**
DARPA Challenge Case Study, ARGO Prototype Vehicle, The Gold System, The inverse Perspective Mapping, Lane Detection, Obstacle Detection, Vehicle Detection, Pedestrian Detection. Software systems architecture, Computational Performances, ARGO Prototype vehicle Hardware, Functionalities, Data acquisition System, Processing System and Control System.

**Simulation using commercial software**
Fundamental simulation practice using MATLAB, IPG Car maker etc.

**Textbook**

1. Intelligent Vehicle Technologies, Ljubo Vlacic, Michel Parent and Fumio Harashima, Butterworth-Heinemann publications, Oxford, 2001.

**Reference Books**

1. Autonomous Vehicles Intelligent Transport Systems and Smart Technologies, Nicu Bizon, Lucian D Ascalescu And Naser Mahdavit Abatabaei, Nova Publishers-2014.
2. Intelligent Vehicle Technology and Trends, Richard Bishop, Artech House Publishers 2005.

## AUTOMOTIVE AERODYNAMICS

**Course Code: AE40018**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

This course would cover a comprehensive study of the importance of vehicle body, safety aspect in vehicle body design, different types of body according to shape and utility. Vehicle aerodynamics, types of drag and lift/down force, Various Forces and moments influencing drag, Effects of forces and moments are also included. Selected body optimization techniques for minimum drag considering the basic fluid mechanics laws, various governing equations for drag force simulation are explained here. Experimental investigation procedure for drag calculation viz, wind tunnel technology, Flow visualization techniques and the wind tunnel balance is explained with demonstration. Effect of body shapes and its modification to reduce vehicle aerodynamics drag makes the way for body styling.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Identify the fundamentals of various automotive body construction details,
CO 2: Understand the specific body styling of bus and passenger car,
CO 3: Solve the forces and moments acting on car and bus under ideal flow conditions,
CO 4: Illustrate the wind tunnel testing and visualize flow field,
CO 5: Evaluate the optimized cab of a commercial vehicle, and
CO 6: Design of a car body and determine aerodynamic interaction effects between different components attached on top of it.

**COURSE DETAILS**

**Evolution of vehicle body**
Importance of vehicle body, Car Body Terminologies & types of car bodies; Visibility, Forward visibility, Forward vision measurement and Regulations, Driver's Visibility, All round visibility of the vehicle, Sensors and its functions, Methods of improving visibility; Safety aspects in design, Bumper end, Front end, Rear end and, Importance of larger distance, Air bag, Telescopic/Collapsible Steering column.

**Bus Body**
Bus body panels & terminologies; Classification of bus body based on distance travelled by the vehicle, Classification of bus body based on capacity of the vehicle, Classification of bus body based on shape and style of the vehicle, Classification of bus body based on types of metal section used, Bus body regulations & Sequence of bus building operation, Construction of conventional type of bus body, Construction of Integral type of bus body, Comparison of Conventional and Integral type of bus body.

**Passenger Car**
Car Aerodynamics, Types of Aerodynamic drag, Various Forces and moments influencing drag, Effects of forces and moments, Various body optimization techniques for minimum drag.

**Wind tunnel technology**
Basic laws of fluid flow, Continuity, Momentum and energy equations as applied to system and control volume, Concept of flow fields.

**Wind Tunnel**
Principle and Construction details of wind tunnel, Types of wind tunnels; Flow visualization techniques; Testing with wind tunnel balance (scale models).

**Commercial vehicles**
Light commercial vehicles and Heavy commercial vehicles, Dimensions of commercial vehicle driver's seat in relation to various controls, Construction of Tanker and Tipper body, Segmental design of driver's cabin, Effects of rounding sharp front body edges, Effects of various cabs on trailer body, Fore body pressure distribution, Effects of a cab to trailer body, Effects of a cab to trailer body roof height, Effects of a cab to trailer body gab seals, Commercial vehicle drag reduction devices, Cab roof deflectors.

**Textbooks**

1. Aerodynamics of road vehicles, Wolf-Heinrich Hucho, 4th edition, 2000.
2. Modifying the Aerodynamics of Your Road Car: Step-by-step instructions to improve the aerodynamics of road cars, Julian Edgar, Richard H. Barnard, Veloce Publishing, 2019.

**Reference Books**

1. Vehicle Body layout and analysis, Mechanical Engineering Publication Ltd., 1984.
2. Vehicle Aerodynamics: Wind Tunnels, CFD, Aeroacoustics, and Ground Transportation Systems Society of Automotive Engineers, U.S., 1996.
3. Low Speed Aerodynamics, PHI Learning Private Limited, 2017.

## CONSTRUCTION MACHINES AND VEHICLES

**Course Code: AE40020**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

The subject is an elective course designed to give introductory knowledge about different types of off-road vehicles meant for various industrial applications. The course includes the construction, operation and maintenance of vehicles used in construction, road making and other allied industries. The vehicles focused in the course are excavator, shovel, dumper, dozer, grader and drag lines, tractor, power trailer etc. The important components of the vehicles such heavy duty diesel engines, torque converters, braking system, are also included. The course is also emphasizing on the periodic and overall maintenance and troubleshooting of these equipment.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Identify off road vehicles for different constructional and land preparation activities,
CO 2: Understand about various types of off road vehicles and tractors,
CO 3: Apply the prime components' operating principle,
CO 4: Analyze the efficacy of hydraulic systems used in off road vehicles,
CO 5: Evaluate proper maintenance schedule and mechanism of off road vehicles, and
CO 6: Design an optimum model for running cost minimization of construction machinery.

**COURSE DETAILS**

**Introduction**
Classification of off road vehicles and their application, Excavator, Different types of Shovel and Drag-line and their construction, Operating principles, Operating cycles. Production capacity and cost of production.

**Vehicle System**
Brake system and actuation – OCDB and dry disc caliper brakes, Body hoist and bucket operational hydraulics, Hydro-pneumatic suspension cylinders, Power steering system, Articulated steering assembly, Power and capacity of earth moving machines.

**Transport Equipment**
Various types of Dumpers, Main system, components and Carrying capacity of Dumper, Chassis of dumper, Mobility calculation.

**Road making and maintenance Machines**
Different types of Dozer, Grader, and their construction, Operating principles, Production capacity and application mechanism, Other equipment: Scraper and front end loader and their construction and operation.

**Maintenance and Troubleshooting**
Maintenance aspect of Off Road vehicles. Maintenance of hydraulic and pneumatic equipment, Bharat emission standards for diesel construction machinery.

**Heavy Machinery and Handling**
Constructional and working details of Jib crane, Concrete ready mixers, Compactors, vibratory compactors, Forklift, Other utility vehicles, Man lift, scissors, Lift trucks, Material handlers, Power generators.

**Construction Machine choice**
Choice of construction equipment, Maintenance of construction equipment, Field Capacity calculation, Field efficiency calculation, Economy of machinery, Running cost minimization

**Textbook**

1. Latest Development of Heavy Earth Moving Machinery, De, A., Annapurna Publishers, Dhanbad 1995.

**Reference Books**

1. Road Making Machinery, Abrosimov, K. Bran berg, A and Katayer, K. M I R. Publishers Moscow.1971.
2. Moving the Earth, Nichols, Herber L (Jr.), Galgotia Publishing House, New Delhi, 1962.
3. Digging of soils by earthmover with Power Parts, Rudnev, V.K., Oxanian Press Pvt. Ltd., New Delhi, 1985.

## TURBOCHARGERS AND SUPERCHARGERS

**Course Code: AE40031**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

## COURSE OBJECTIVE

This course emphasizes on the improving the power output of engine due to fast combustion by introducing turbocharger or supercharger. This course dissects the basic principle of fluid mechanics and hydraulic machines vis-à-vis a practical application. The significance of utilizing the high grade energy available at exhaust can be appreciated. Incoming turbulent air plays an important role in combustion and the students will have ample knowledge of it. Students will update their technical skill by designing a hydraulic machine like a turbocharger. Principle learnt can be extrapolated in understanding any other hydraulic machine used in industry or power plant.

## COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Explain the purpose of Supercharging,
CO 2: Classify the types of supercharging methods used,
CO 3: Relate the Modern design features of exhaust turbocharger features,
CO 4: Analyze turbocharger thermodynamics,
CO 5: Prioritize the types engines suitable for supercharging, and
CO 6: Design the turbocharger components.

## COURSE DETAILS

**Introduction to turbocharging and turbocharger**
Aim of supercharging, Comparison of naturally aspirated engine with supercharged engine considering same compression ratio and considering same maximum pressure. Basic difference between supercharging and turbo charging, Types of turbocharging processes.

**Constant pressure turbocharging and pulse supercharging**
Introduction, The energy available in the exhaust system, Four-stroke engine with constant pressure turbocharging, Two-stroke engine with constant pressure turbocharging, Advantages and disadvantages of constant pressure turbocharging, Introduction to pulse turbocharging, Four-stroke engine with pulse turbocharging, Two-stroke engine with pulse turbo charging, Advantages and disadvantages of pulse turbocharging, Concept of Pulse converter.

**Difficulties in supercharging for SI Engine**
Causes of knocking and its remedies in SI engine, Methodologies adaption for supercharging in SI engines.

**Supercharging arrangement**
Compound engine, Independent engine, various supercharging methods, and Bearing configurations.

**Thermodynamics of Turbo-charging**
Thermodynamic cycle of turbocharging system, P-V and T-S diagram, P-V-T relations of various thermodynamic processes that construct a thermodynamic cycle of turbocharging system, Compressor and turbine efficiency, Multi-stage compression, Multi-stage compression with intercooling, Analysis of thermodynamic cycles.

**Compressor and turbine**
Compressor classification, Centrifugal compressor and its components with description, Velocity diagram of centrifugal compressor, Slip factor, Energy transfer, and power input factor. Axial flow compressor

and its advantages, Description of axial flow compressor, velocity triangle for axial flow compressor, Energy transfer for axial flow compressor, Axial flow turbine, velocity triangle for single and multi-stage axial flow turbine, Radial flow turbine, Velocity triangle of radial flow turbine, Energy transfer. Dimensional analysis and matching of turbocharger.

**Textbook**

1. Turbocharging the Internal Combustion Engine. N. Watson and M.S. Janota, First published 1982 by THE MACMILLAN PRESS LTD, London

**Reference Books**

2. Turbomachines, A. Valan Arasu, Second Edition, Vikash Publication house Pvt. Ltd., 2012.
3. Charging the Internal Combustion Engine, Hermann Hiereth, Peter Prenninger, Springer 2010.

## FUEL CELL FOR AUTOMOTIVES

**Course Code: AE40032**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

This course is designed for the graduate students at an adavanced stage of engineering. Students will learn about various fuel cell and how they can secure the energy needs of future and sustainable development. Automotives run with zero emission is possible with fuel cell in future and the students will appreciate that while going through the course.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: State the material requirement for a fuel cell,
CO 2: Explain the structure of different fuel cell and their mechanical and electrical properties,
CO 3: Illustrate material selection criteria using the DOE target,
CO 4: Examine the heat treatment principles to change the mechanical properties of bipolar plate,
CO 5: Organize various corrosion prevention methods in fuel cell components, and
CO 6: Justify fuel cell selection to various type of vehicle applications.

**COURSE DETAILS**

**Introduction**
Introduction and overview of fuel cells technology, Low and high temperature fuel cells, Hydrogen oxygen fuel cell, Methanol fuel cell, Phosphoric acid fuel cell, Molten carbonate fuel cell, Solid oxide fuel cell.

**Fuel cell Thermodynamics**
Fuel cell reaction kinetics: Introduction to electrode kinetics, Exchange current and electro-catalysis, Simplified activation kinetics, Voltage efficiency, power density, Ohmic resistance, Membrane, Catalyst electrode design.

**Fuel cell stack**
Fuel cell modeling and system integration, Balance of plant, Cooling plate, Humidifier design.

**Automotive application**
Safety issues and cost expectation and life cycle analysis of fuel cells.

**Fuel tank design**
Hydrogen storage, Methanol storage, Adsorption based storage, Pressurized tank, DOE target.

**Fuel Cell Hybrid Vehicle**
Series and parallel hybrid, Advantages and challenges, Unmanned vehicle.

**Textbook**

1. Fuel Cell Science and Technology, Basu, S., Springer, N.Y. (2007).

**Reference Books**

1. Faulkner, Electrochemical Methods, Bard, A. J. , L. R., Wiley, N.Y. (2004).
2. Principles of fuel cells, Liu, H., Taylor & Francis, N.Y. (2006).
3. Fuel Cells: Principles and Applications, Viswanathan B. Universities Press; First edition (2006).

## SCIENCE AND TECHNOLOGY OF AUTOMOTIVE ENGINE MATERIAL

**Course Code:** **AE40033**
**Credit:** **3**
**L-T-P:** **3-0-0**
**Prerequisite:** **Nil**

**COURSE OBJECTIVE**

This course would encompass a comprehensive study of different types of automotive engine materials. With this knowledge students will be able to apply to solve common economic, environmental and societal issues in automobile engineering with correlation to different type of IC engines. Eventually the students will be able to correlate the structure of different materials with their concerned processing and properties and select the right material in future automotive engine.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: State the material requirement for an IC engine,
CO 2: Explain the structure of different materials and their mechanical and thermal properties,

CO 3: Illustrate material selection criteria using the phase diagram,
CO 4: Examine the heat treatment principles to change the mechanical properties of steel,
CO 5: Organize various corrosion prevention methods in engine components, and
CO 6: Justify material structure properties and apply to various engineering applications.

**COURSE DETAILS**

**Introduction**
Automotive engines, engine components and typical materials, Structures and functions, Cast iron monolithic block, Graphite iron monolithic block, Aluminium block, Al-Si block, Iron and aluminium liner, Improving engine performance by surface modification, Chromium plating, Composite plating, Thermal spray, Cast-in composite, Casting technology for aluminium cylinder blocks, Open and closed deck structures, Use of Si to decrease thermal expansion of aluminium.

**Piston and Piston ring**
Piston design, Heat treatment, Manufacturing process, Reinforcement of piston ring groove, High strength piston, Iron piston. Functions, Suitable shapes for high power put, Ring material, Graphite cast iron, Steel, Surface modification to improve friction and wear.

**The camshaft**
Functions, Improving wear resistance, Chilled cast iron, Finishing, Boring, Grinding, Composite structures, Reducing friction in the valve train.

**Valve and valve spring**
Alloy design of heat resistant steel, Martensitic steel, austenitic steel, Bonded valve using friction welding, Increasing wear resistance, Stellite coating, Ni-based super alloy valve, Lighter valves using ceramics and titanium alloys, Valve seat functions, Steel wires, Coiling a spring, Improving fatigue strength by shot peening, cylinder head.

**The crank shaft and the connecting rod**
Functions and types, Monolithic crankshaft, Assembled crank shaft, Rigidity, Forging, Surface hardening methods, Carburizing, Nitriding, Nitrocarburizing, Carbonitriding, Iron nitriding, Induction hardening, Micro alloyed steel, Strengthening, Monolithic connecting rod, Fatigue failure of bearing, secondary refining after steel making, structure and material of assembled con-rod, The plain bearing, Fracture splitting.

**Turbocharger and exhaust manifold**
Functions, Turbine and compressor designs, Exhaust manifold, Investment castings, Turbine housing, Cast iron, Cast steel.

**The catalyst**
Development of catalysts for petrol engines, Structures and functions, The three-way catalyst, Ceramic and metal honeycomb substrate, Catalyst development to reduce NOx, Controlling pollutants at cold start, Exhaust gas after treatment for diesel engine, Particulate filter, The deNOx catalyst.

**Textbook**

1. The Science and Technology of Materials in Automotive Engines, Hiroshi Yamagata, Woodhead Publishing, 2005.

**Reference Books**

1. An introduction to Modern Vehicle Design, Julian Happian-Smith, Butterworth-Heinemann, Reed Educational and Professional Publishing.
2. Materials Science and Engineering, Willium D. Callister, Jr. John Wiley & Sons publications.
3. Material Science and Engineering, V. Raghavan, Prentice Hall of India, 4th Edition.
4. Jindal U. C., Material Science and Metallurgy, Pearson, 2012.

## VEHICLE DYNAMICS

**Course Code:** **AE40034**
**Credit:** **3**
**L-T-P:** **3-0-0**
**Prerequisite:** **Nil**

### COURSE OBJECTIVE

This course is very important to the students of automobile engineering as it strengthens the design skill set. There are many interesting topics. The students will learn modelling and simulation and will develop expertise to utilize Holzer method for close coupled systems and branched systems. Gough's tyre characteristics plays a very important role in stability of the vehicle and the students will also know directional stability of the vehicle. Calculation of Tractive effort and reactions for different drives is also taught to students to give a holistic idea on vehicle dynamics and control.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Describe the concept of mechanical vibrating system,
CO 2: Understand the modelling of suspension and tyre related vibrations,
CO 3: Simulate and analyze vibrations from vehicles,
CO 4: Analyze the stability and handling characteristics of vehicle at different operating conditions,
CO 5: Write the logical statement to select suitable tyres for a vehicle, and
CO 6: Calculate the roll centre and pitch centre.

### COURSE DETAILS

**Introduction**
Fundamental of vibration, Mechanical vibrating systems, Modelling and Simulation, Model of an automobile, Single, two, multi degrees of freedom systems, Free, forced and damped vibrations, Magnification factor, Transmissibility.

**Multi-degree of freedom systems**
Vibration absorber, Closed coupled system, Eigen value problems, Far coupled Systems, Orthogonality of mode shapes, Modal analysis, and Forced vibration by matrix inversion. Approximate methods for fundamental frequency, Dunkerley's lower bound, Rayleigh's upper bound, Hozler method for close coupled systems and branched systems.

**Suspension and Tyers**
Requirements. Sprung mass frequency. Wheel hop, Wheel wobble, Wheel shimmy. Choice of suspension spring rate. Calculation of effective spring rate. Vehicle suspension in fore and apt directions. Ride characteristics of tyre, Effect of driving and braking torque, Gough's tyre characteristics.

**Vehicle Handling**
Oversteer, Under steer, Steady state cornering. Effect of braking, Driving torques on steering. Effect of camber, Transient effects in cornering.

**Stability of Vehicles**
Directional stability of vehicles. Load distribution. Calculation of Tractive effort and reactions for different drives, Stability of a vehicle on a slope, on a curve and a banked road.

**Textbook**

1. Vehicle handling Dynamics Theory and Application, Masato Abe, Elsevier.

**Reference Books**

1. Vehicle Dynamics Theory and Application, Theory and Application, Reza N. Jazar, Springer.
2. Automotive Chassis, Heldt. P.M., Chilton Co., New York, 1992.
3. Vehicle Dynamics, Ellis. J.R., Business Books Ltd., London, 1991.
4. Steering, Suspension and Tyres, Giles. J.G. Steering, Iliffe Books Ltd, London, 1998.

## AERODYNAMICS - I

**Course Code: AS20001**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Physics (PH10001) and Differential Equations and Linear Algebra (MA11001)**

**COURSE OBJECTIVE**

Aerodynamics-I is a fundamental subject that deals with the basics of low-speed incompressible flow. The objective of this course is to understand the fundamental behavior of viscous flow and boundary layer characteristics. In particular, the course will cover aspects of governing equations for any low speed incompressible flow system and estimation of aerodynamic forces and moments acting on different aerodynamically shaped objects. This subject also highlights the airfoil characteristics of airfoil wing and corresponding flow physics.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Explain fluid properties and the fundamental concept of aerodynamics,
CO 2: Understand the real time viscous flow and boundary layer behavior,
CO 3: Understand the fundamentals of governing equations of aerodynamics,
CO 4: Estimate aerodynamic forces and moments acting on airfoils,
CO 5: Determine the airfoil and wing characteristics, and
CO 6: Interpret the basic concepts of measurement of forces and moments on models during the wind tunnel testing.

**COURSE DETAILS**

**Introduction to Aerodynamics**
Physical properties of Fluid, Fundamental aerodynamic variables, Aerodynamic forces and moments, Centre of Pressure, Dimensional analysis: The Buckingham PI theorem, Flow similarity, Fundamentals of fluid statics, Types of flow: Continuum versus free molecule flow; inviscid versus viscous flow, incompressible versus compressible flow; mach number regimes, Introduction to boundary layer.

**Fundamental Principles and Equations in Aerodynamics**
Models of the fluid: Control volumes and fluid elements, Continuity, momentum and energy equations, Application of the momentum equation: Drag of a two-dimensional body, Pathlines, streaklines and streamlines of a flow, Angular velocity, Vorticity and circulation, Stream function and velocity potential.

**Fundamentals of Inviscid and Incompressible Flow**
Bernoulli's equation, Incompressible flow in a duct: Venturimeter and low-speed wind tunnel, Pitot tube, Pressure coefficient, Governing equation for irrotational incompressible flow: Laplace's equation, Elementary flows: Lifting and non-lifting flows over a circular cylinder, The Kutta-Joukowski Theorem: Generation of lift, d'Alembert paradox.

**Incompressible Flow over Airfoils**
Airfoil nomenclature, Airfoil characteristics, The Kutta condition, Kelvin's circulation theorem and the starting vortex, Classical thin airfoil theory, Aerodynamic center.

**Incompressible Flow over Finite Wings**
Flow past finite wings: Downwash and induced drag, Vortex filament, Biot-Savart's law, Helmholtz's theorem, Prandtl's classical lifting line theory, Applied aerodynamics: The Delta wing.

**Low Speed Wind Tunnels**
Principles of model testing, Types and functions of wind tunnels, Calibration of wind tunnels, Conventional measurement techniques, Special wind tunnel techniques.

**Textbooks**

1. John D. Anderson (Jr.), "Fundamentals of Aerodynamics", Fifth Edition, McGraw Hill Series.
2. Thomson, L.M. Milne., "Theoretical Aerodynamics", Dover India.


**Reference books**

1. S. K. Som, G. Biswas & S. Chakraborty, (2014), "Introduction to Fluid Mechanics and Fluid Machines", McGraw Hill Education (India) Pvt. Ltd, New Delhi, 3rd Edition.
2. Y. Cengel and J. Cimbala, (2010), "Fluid Mechanics", McGraw Hill Education (India) Pvt. Ltd, New Delhi, 2nd Edition.
3. Houghton, E.L., P. W. Carpenter, Steven H. Collicott, Daniel T. Valentine, "Aerodynamics for Engineering Students", Sixth Edition, Elseveir Publishers Ltd.
4. Clancy, L.J (2006), "Aerodynamics", Indian Edition, Sterling Book House Mumbai.
5. Bertin J J. (2002), "Aerodynamics for Engineers", Fourth Edition, , Pearson Education.
6. Wilcox, D. C. (1998). Turbulence modeling for CFD (Vol. 2, pp. 103-217). La Canada, CA: DCW Industries.
7. Rae, W.H. and Pope, A. (2010), "Low Speed Wind Tunnel Testing", John Wiley Publication, 3rd edition, ISBN-13: 978-8126525683.

## AERODYNAMICS-II

**Course Code: AS20002**
**Credit : 3**
**L-T-P: 3-0-0**
**Prerequisite: Aerodynamics-I (AS20001)**

### COURSE OBJECTIVE

Aerodynamics-II is a fundamental subject that deals with the basics of high-speed compressible flow. The objective of this course is to understand the fundamental behaviour of normal and oblique shock characteristics. In particular, the course will cover aspects of mass, momentum, energy equations with ideal gas and calorifically perfect gas laws. This subject also highlights the transonic flow characteristics of airfoil wing and the flow physics involved in hypersonic flows.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to:

CO 1: Understand the energy, momentum and continuity equations,
CO 2: Know the various parameters affecting the normal and oblique shock waves,
CO 3: Know the various theories regarding the steady compressible flow,
CO 4: Know the various parameters of airfoil in high speed flow,
CO 5: Know the various methods for creating supersonic flow in wind tunnels, and
CO 6: Understand transonic flow over wing.

### COURSE DETAILS

**One Dimensional Compressible Flow**
Energy, Momentum, continuity and state equations, velocity of sound, adiabatic steady state flow equations, Flow through converging, diverging passages, Performance under various back pressures.

**Normal and Oblique Shocks**
Prandtl equation and Rankine – Hugonoit relation, Normal shock equations, Pitot static tube, corrections for subsonic and supersonic flows, Oblique shocks and corresponding equations, Prandtl Meyer expansion fan, Hodograph and pressure turning angle, shock polar, flow past wedges and concave corners, strong, weak and detached shocks.

**Expansion Waves, Rayleigh and Fanno Flow**
Flow past convex corners, Expansion hodograph, Reflection and interaction of shocks and expansion, waves. Method of Characteristics Two dimensional supersonic nozzle contours. Rayleigh and Fanno Flow.

**Differential Equations of Motion for Steady Compressible Flow**
Small perturbation potential theory, solutions for supersonic flows, Mach waves and Mach angles, Prandtl-Glauert affine transformation relations for subsonic flows, Linearized two dimensional supersonic flow theory, Lift, drag pitching moment and center of pressure of supersonic profiles.

**Transonic Flow Over Wing**
Lower and upper critical Mach numbers, Lift and drag divergence, shock induced separation,

Characteristics of swept wings, Effects of thickness, camber and aspect ratio of wings, Transonic area rule, Tip effects.

**High Speed Wind Tunnels**
Blow down, indraft and induction tunnel layouts and their design features, Transonic, supersonic and hypersonic tunnels and their peculiarities, Helium and gun tunnels, Shock tubes, Optical methods of flow visualization.

**Textbook**

1. Radhakrishnan, E. (2003), "Gas Dynamics", Prentice Hall of India.


**Reference books**

1. Shapiro, A.H. (1982), "Dynamics and Thermodynamics of Compressible Fluid Flow", Ronold Press.
2. Zucrow, M.J. and Anderson, J.D. (1989), "Elements of gas dynamics", McGraw-Hill Book Co., New York.
3. Mc Cornick. W. (1979), "Aerodynamics, Aeronautics and Flight Mechanics", John Wiley, New York.
4. Anderson Jr., D. (1999), "Modern compressible flows", McGraw-Hill Book Co., New York.


## AEROSPACE STRUCTURES - I

**Course Code: AS20003**
**Credit : 3**
**L-T-P: 3-0-0**
**Prerequisite: Engineering Mechanics (ME10001)**

**COURSE OBJECTIVE**

The objective of this course is to carry out stress analysis for structural members due to tension, compression, bending and torsion. The students will be able to design and analyze aerospace structures. In particular, the course will cover aspects of stress analysis of breams, trusses and frame under the action of forces and failure analysis of joints.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Know structural members and structural behavior,
CO 2: Calculate deflections, stresses and strains,
CO 3: Understand behavior of structural members due to tension, compression, bending and torsion,
CO 4: Carry out stress transformation,
CO 5: Apply failure theories for aircraft stress analysis, and
CO 6: Carry out stress analysis of structures

**COURSE DETAILS**

**Introduction to Aircraft Structures**
Structural System, Type of supports, Types of loads, Types of structural members (Beams, Column, Truss, Frame, Plate and Shells), Tension, Compression, Bending and Torsion, Boundary conditions, Determinate and Indeterminate structures, Aircraft structural components and their functions.

**Stress and Strain**
Concept of Stresses and Strains, Hooke's Law, Poisson's Ratio, Elastic constants, Equilibrium equations, Compatibility equations, Stress–Strain Relations, Normal stress and Shear stress, Transverse shear, Stress Concentration.

**Bending and Torsion**
Theory of simple bending, Shear force and bending moment diagrams, Slope and deflection of beams, bending of plates, Maxwell's and Betti's reciprocal theorems, Torsion in solid and hollow circular shafts, Combined bending and torsion, Clapeyron's three moment equation.

**Stress Transformation**
Distribution of Normal and Shear stresses in different sections, Principal Planes, Principal stresses, Stress Transformation.

**Theories of Failure**
Maximum Principle Stress Theory, Maximum Principle Strain Theory, Maximum Shear Stress Theory, Total Strain Energy Theory, Maximum Distortion Energy Theory, Graphical representation of Theories of Failure.

**Textbook**
1. Lakshmi Narasaiah, G., "Aircraft Structures", BS Publications, Hyderabad.

**Reference books**
1. Timoshenko, S., "Strength of Materials", Vol. I and II, Princeton D. Von Nostrand Co.
2. Donaldson, B.K., "Analysis of Aircraft Structures - An Introduction", McGraw-Hill.
3. Megson, T.M.G., "Aircraft Structures for Engineering Students", Edward Arnold.

## AEROSPACE STRUCTURES - II

**Course Code:** **AS20004**
**Credit :** **3**
**L-T-P:** **3-0-0**
**Prerequisite:** **Aerospace Structures–I (AS20003)**

### COURSE OBJECTIVE

The objective of this course is to carry out design and stress analysis of aerospace structural systems. The students will be able to solve unsymmetrical bending, plate bending, joint analysis and stresses in cylinders. In particular, the course will cover aspects of stress analysis including buckling.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Understand the bending stress analysis in unsymmetrical sections,
CO 2: Analyze stresses in thin and thick cylinders,
CO 3: Analyze shear flow in thin sections,
CO 4: Analyze stresses of aircraft,
CO 5: Analyze the failure of joints, and
CO 6: Carry out buckling analysis.

**COURSE DETAILS**

**Unsymmetrical bending**
Definition of symmetrical and unsymmetrical sections, Principal axis and Neutral axis methods, Bending stresses in beams of symmetrical and unsymmetrical sections, Bending stresses in beams of unsymmetrical sections.

**Buckling of structural members**
Euler's Theory, Critical Load, Slenderness ratio, Effective length of columns, pure tension field beam.

**Stresses in cylinders**
Stresses in thin and thick cylinders.

**Shear flow in thin walled sections**
Concept of shear flow, shear centre and elastic axis, Flexural shear flow in open symmetric and unsymmetrical thin walled sections, Closed single cell and multicell thin walled sections, Combined flexural and torsional shear flow, Warping in open and closed thin walled sections.

**Joints and fittings**
Bolts, rivets and welded connections, bending, shearing and tearing of rivets and plates, bolt shear, tension and bending strength, failure of joints, Strength of joints, Joint efficiency.

**Dynamic Analysis of structures**
Introduction to dynamics of aircraft structures, free and forced vibration.

**Textbook**
1. Timoshenko, S. (1990), "Strength of Materials", Vol. I and II, Princeton D. Von Nostrand Co.

**Reference books**
1. Peery, D.J., and Azar, J.J. (1993), "Aircraft Structures", 2nd edition, McGraw-Hill, N.Y.
2. Megson, T.M.G. (1995), "Aircraft Structures for Engineering Students", Edward Arnold.
3. Donaldson, B.K. (1993), "Analysis of Aircraft Structures - An Introduction", McGraw-Hill.
4. Lakshmi Narasaiah, G. (2010), "Aircraft Structures", BS Publications, Hyderabad.

## AEROSPACE MATERIALS AND MANUFACTURING PROCESSES

**Course Code:** **AS21001**
**Credit:** **4**
**L-T-P:** **3-1-0**
**Prerequisite:** **Nil**

**COURSE OBJECTIVE**

The objective of this course is to introduce various types of engineering materials that are most common to the aeronautical applications in the industry and to develop familiarity with materials' structure, properties. It is aimed at imparting the technical knowhow in the areas of aerospace engineering production techniques using casting, welding, sheet metal operation and various non-conventional manufacturing processes.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Know different material properties and process of heat treatments and understand different phases of iron carbon phase diagram,
CO 2: Understand basics of emerging materials such as composites, smart materials and super alloys used in aerospace structures,
CO 3: Know basics of various material testing and characterization techniques,
CO 4: Know different casting procedures, welding processes and understand different NDT testing procedures for metals and non-metals,
CO 5: Acquire knowledge about the sheet metal processes, various fastening techniques and non-conventional manufacturing processes used for manufacturing aerospace components, and
CO 6: Achieve knowledge on machining processes used for aerospace applications.

**COURSE DETAILS**

**Aerospace Engineering Materials**
Engineering materials: Steels, study of iron and various heat treatment processes - annealing, normalizing, hardening and tempering of Aluminum and steel, Non-Ferrous metals and Alloys: Aluminum and its alloys, Titanium and its alloys, and Corrosion -Types of Corrosions - Prevention – Protective Treatments.

**Emerging Materials for Aerospace Structures**
Aluminium alloys: Non-age-hardenable and Age-hardenable aluminium alloys, Titanium alloys: advantages and disadvantages, types of titanium alloys, titanium aluminides, Shape-memory titanium alloys, Magnesium alloys, Steels: Basic principles of steel metallurgy, Fe-C Phase diagram, Maraging steel, Medium carbon low-alloy steel, stainless steels, Copper and its alloys, Super-alloys: Nickel based super alloys, Iron –nickel super alloys, Cobalt super-alloys, advanced super-alloys for equiaxed, directionally solidified and single crystal castings. Composite materials: Polymer matrix composites, Metal matrix composites, and Ceramic matrix composites.

**Materials Characterization Techniques**
Mechanical methods: tensile test, hardness measurements, impact tests, fatigue test, other mechanical testing methods, Experimental methods: powder diffraction, diffractometers, detectors, interpretation of X-ray diffraction patterns, applications of X-ray diffraction in metallurgical analysis, Electron microscopy: Electron-specimen interactions; Physical principles of scanning electron microscopy (SEM); Transmission electron microscopy (TEM); Energy dispersive X-ray spectrometry (EDS) and wavelength dispersive X-ray spectrometry (WDS), and Thermal analysis: DTA, DSC, TMA, TGA.

**Casting, Welding and Inspection Techniques**
General principles of various casting processes Sand casting, Die-casting, Centrifugal casting, investment casting, Shell molding types; Principles and equipment used in arc welding, Gas welding, Resistance welding, Solid, Laser welding, and electron beam welding, Soldering and brazing techniques. And Need of non-destructive testing (NDT) methods.

**Sheet Metal Processes in Aircraft Industry**
Sheet metal operations: shearing, punching, Super plastic forming; operations in bending like stretch forming spinning drawing. Riveting, Types and techniques, Equipment, fasteners, Integral tanks, Final assembly of aircraft, Jigs and Fixtures, Stages of assembly, and Aircraft tooling concepts.

**Conventional and Non-conventional Machining Processes**

General working principles, Applications and operations of lathe, Shaper, Milling machines, Grinding, Drilling machine, Computer numeric control machining. Working principles and applications of abrasive jet machining, Ultrasonic machining, Electric discharge machining and Electro chemical machining, Laser beam, Electron beam, Plasma arc machining, Additive manufacturing. Introduction to coatings: Chemical Vapor Deposition (CVD), Physical Vapor Deposition (PVD), Epitaxy, and Sputtering.

**Textbooks**


1. S. Kalpakjian, S. R. Schmid (28 March 2018), "Manufacturing Engineering and Technology" Pearson Education; Seventh edition.
2. V. Raghavan (2004), Materials Science & Engineering: A first course, 5th ed., PHI Learning.


**Reference books**


1. D. R. Askeland, P.P. Phule, W.J. Wright (2010), "The Science and Engineering of Materials", 6th ed., Cengage Learning,
2. W. D. Callister, R. Balasubhramanium (2007), "Materials Science and Engineering: An Introduction" John Wiley & Sons,.
3. Adrian P. Mouritz (2012), Introduction to Aerospace Materials, Woodhead Publishing in Materials.
4. P. K. Saha (2020), "Aerospace Manufacturing Processes", CRC Press; 1st edition.
5. P. N. Rao (2009), "Manufacturing Technology", Vol. I and II‖, Tata McGraw Hill Publishing Co., 2nd edition..
6. F. C. Campbell, Manufacturing Technology for Aerospace Structural Materials, Elsevier.


## AIRCRAFT PROPULSION

**Course Code: AS21002**
**Credit: 4**
**L-T-P: 3-1-0**
**Prerequisite: Aerospace Thermodynamics (AS21003)**

**COURSE OBJECTIVE**

This course is designed to teach the principles of modern aircraft propulsion. After a brief introduction on principles of gas turbine engines, this course deals with analysis and design of various components: centrifugal and axial compressors, axial and radial flow turbines, inlets and nozzles, and burners and their performance during different flight conditions.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Understand the working principle, thermodynamic cycles and performance characteristics of gas turbine engines,
CO 2: Understand the internal flow and external characteristics near the inlets, starting problems and different modes of operation in supersonic inlets,
CO 3: Know the types and working principles of axial compressors, its velocity diagrams, blade design and performance characteristics of compressors,
CO 4: Know the types of combustion chambers, the flame stabilization and combustion techniques,
CO 5: Understand flow through nozzle, losses in nozzle, variable area nozzle and thrust vectoring, and
CO 6: Understand the efficiency calculations for over-expanded and under-expanded nozzles.

**COURSE DETAILS**

**Fundamentals of Gas Turbine Engines**

Illustration of working of gas turbine engine – The thrust equation – Factors affecting thrust– Effect of pressure, velocity and temperature changes of air entering compressor –Methods of thrust augmentation – Characteristics of turboprop, turbofan and turbojet –Performance characteristics.

**Subsonic And Supersonic Inlets For Jet Engines**

Internal flow and Stall in subsonic inlets – Boundary layer separation – Major features of external flow near a subsonic inlet – Relation between minimum area ratio and external deceleration ratio – Diffuser performance – Supersonic inlets – Starting problem on supersonic inlets – Shock swallowing by area variation – External declaration – Models of inlet operation.

**Compressors**

Principle of operation of centrifugal compressor – Work done and pressure rise – Velocity diagrams – Diffuser vane design considerations – Concept of prewhirl, rotation stall and surge – Elementary theory of axial flow compressor – Velocity triangles – degree of reaction – Three dimensional – Air angle distributions for free vortex and constant reaction designs – Compressor blade design – Centrifugal and Axial compressor performance characteristics.

**Combustion Chambers**

Classification of combustion chambers – Important factors affecting combustion chamber design – Combustion process – Combustion chamber performance – Effect of operating variables on performance – Flame tube cooling – Flame stabilization – Use of flame holders – Numerical problems.

**Turbines**

Impulse and reaction blading of gas turbines – Velocity triangles and power output – Elementary theory – Vortex theory – Choice of blade profile, pitch and chord – Estimation of stage performance – Limiting factors in gas turbine design- Overall turbine performance – Methods of blade cooling – Matching of turbine and compressor.

**Nozzles**

Theory of flow in isentropic nozzles – nozzles and choking – Nozzle throat conditions – Nozzle efficiency – Losses in nozzles – Over expanded and under – expanded nozzles – Ejector and variable area nozzles – Interaction of nozzle flow with adjacent surfaces – Thrust reversal.

**Textbooks**

1. Hill, P.G. & Peterson, C.R. (1999), "Mechanics & Thermodynamics of Propulsion" Addison – Wesley Longman INC.
2. Mukunda,H.S., "Understanding Aerospace Chemical Propulsion", I.K. International.
3. Ramamurthy, K, (2016), "Rocket propulsion", Laxmi Publications.

**Reference books**

1. Cohen, H. Rogers, G.F.C. and Saravanamuttoo, H.I.H. (1989), "Gas Turbine Theory", Longman.
2. Oates, G.C. (1985), "Aero thermodynamics of Aircraft Engine Components", AIAA Education Series, New York.
3. "Rolls Royce Jet Engine" – Third Edition –1983.
4. Mathur, M.L. and Sharma, R.P. (1999), "Gas Turbine, Jet and Rocket Propulsion", Standard Publishers & Distributors, Delhi.

## AEROSPACE THERMODYNAMICS

**Course Code:** **AS21003**
**Credit:** **4**
**L-T-P:** **3-1-0**
**Prerequisite:** **Physics (PH10001)**

**COURSE OBJECTIVE**

Aerospace Thermodynamics is a specialized need-based extension of Applied Physics comprehending thermal engineering concepts and appreciating the laws of thermodynamics in various applications of day-to-day lives and industries. The objective of this course is to develop the understanding of gas and steam power cycles by the students which is required for the design of complex thermal systems. In particular, the course will cover aspects of analysis of conduction, convection, radiation and heat exchanger principles.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Comprehend terminology related to thermal engineering and recognize the need of learning thermodynamics,
CO 2: Appreciate the $1^{st}$ law in cyclic and acyclic processes,
CO 3: Interpret the $2^{nd}$ law in applications related to heat engine, heat pump and refrigerators,
CO 4: Read and comprehend steam table and Mollier chart in solving complex thermal problems,
CO 5: Understand the applicability of gas and steam power cycles in thermal engineering, and
CO 6: Analyze the mechanism of conduction, convection and radiation and heat exchanger principle.

**COURSE DETAILS**

**Basic Concepts and Definitions**
Scope of thermodynamics, Macroscopic and microscopic approaches, Definition of closed system and open system, Extensive and Intensive Properties, Point and Path function, Reversible and irreversible processes, Thermal, mechanical and chemical equilibrium, thermodynamic equilibrium, Zeroth law of thermodynamics, Forms of energy, energy transfer by heat, forms of work (electrical and mechanical), energy transfer by work.

**First Law of Thermodynamics**
Moving boundary work (PdV work), PdV work for different processes, First law for closed systems (for cyclic and non-cyclic processes), introduction of internal energy as a thermodynamic property, flow work and energy of a flowing fluid, first law for control volumes (open systems) and introduction of enthalpy as a thermodynamic property.

**Second Law and Entropy**
Second law - thermal efficiency of heat engines – Kelvin-Planck statement and Clausius statement - perpetual motion machines - reversible and irreversible processes- Carnot cycle. Entropy: increase of entropy principle- isentropic process - T-ds relations and entropy change of ideal gases – isentropic efficiencies of steady flow devices - Exergy (only introductory information).

**Pure Substances**
Definition of pure substance, p-V and T-v diagrams for pure substances, specific volumes of saturated

liquid, wet vapor and superheated vapour.

**Gas Power Cycles**
The Carnot cycle and its value in engineering - Otto cycle- Diesel cycle- Dual Cycle, Brayton cycle, Gas Turbine cycle with intercooling, reheat and regeneration.

**Heat Transfer**
Three modes of heat transfer-conduction, convection and radiation. Fourier conduction equation, Mechanism of convection and basic concepts: Dimensional analysis for forced and free convection, Nusselt number, Concept of thermal boundary layer, Prandtl number, Radiation properties, emissive power and emissivity, Kirchoff's identity. Planck's relation for monochromatic emissive power of a black body, Stefan-Boltzman law and Wein's displacement law, Radiation shape factor.
**Heat Exchanger**
Types of heat exchangers and heat exchanger configurations. The overall heat transfer coefficient and fouling factor. LMTD and effectiveness-NTU analysis of heat exchangers.

**Textbook**
1. Engineering Thermodynamics, Second Edition, P. Chattopadhyay, Oxford University Press.

**Reference books**
1. Fundamentals of Classical Thermodynamics, Gordon J. Van Wylen , Richard E. Sonntag, Claus Borgnakke, John Wiley, Fifth Edition.
2. Engineering thermodynamics, P. K. Nag, McGraw Hill Education, Fifth Edition.
3. Thermodynamics, An Engineering Approach, Yunus A Cengel and Michael A. Boles, McGraw Hill Education, 7th Edition, 2011 (reprint 2013).

## AEROSPACE THERMODYNMICS LAB

**Course Code: AS29001**
**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Physics (PH10001)**

**COURSE OBJECTIVE**

This laboratory is intended to impart the knowledge on laws of thermodynamics and to provide hands on training to estimate the performance of thermodynamics system. Student can carry out a comparative study of experimental and theoretical results. The experience of performing various experiments will help the students to solve the real life problems related to heat transfer phenomena, refrigeration and air-conditioning and IC engines.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to:

CO 1: Know the process of determining the thermal conductivity of a material,
CO 2: Calculate the heat transfer coefficient for extended surface,
CO 3: Determine the thermal conductivity of castor oil using Gas and Liquid thermal conductivity Experiment Unit,
CO 4: Know about the two stroke and four stroke Petrol and Diesel Engine,
CO 5: Test the Two-stroke and Four-stroke single cylinder Petrol Engine Coupled to Rope Brake

Dynamo-meter Test Rig, and
CO 6: Know the Refrigeration and Air-conditioning system and to determine the Coefficient of performance.

**COURSE DETAILS**

**List of Experiments**

1) To determine the thermal conductivity of the material in a solid bar using the linear heat conduction equipment.
2) To determine the thermal conductivity of the material in a solid disc using the radial heat conduction equipment.
3) To calculate heat transfer coefficient of an extended surface using radiation heat transfer
4) To determine the thermal conductivity of castor oil.
5) To study the vapor compression test rig and determine the theoretical and actual COP of the refrigerator in batch mode with and without load.
6) To study the vapor compression test rig and determine the theoretical and actual COP of the refrigerator in continuous mode with load and without load.
7) To determine the ice making capacity of an ice plant per day and COP of the ice plant.
8) To calculate Coefficient of Performance of the unit when working as Air to Air heat pump and find out cooling capacity for refrigeration cycle.
9) To conduct load test on a 2-stroke, single-cylinder petrol engine and study its performance characteristics.
10) To conduct load test on a 4-stroke, single-cylinder petrol engine and study its performance characteristics.
11) To conduct load test on a 4-stroke, single-cylinder diesel engine and study its performance characteristics.

## AERODYNAMICS LAB

**Course Code:** **AS29002**
**Credit:** **1**
**L-T-P:** **0-0-2**
**Prerequisite:** **Aerodynamics-I (AS20001)**

**COURSE OBJECTIVE**

The aim of this laboratory course work is to explain the fundamental concepts of fluid flow using a low speed wind tunnel. Flow visualization will be carried out using smoke tunnel, tufts and water tunnel over different geometries like circular cylinder, sphere, square and triangular cylinder, symmetric and unsymmetrical airfoils.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to:

CO 1: Know the different components of a wind tunnel and their functionalities,
CO 2: Understand the calibration procedure of a wind tunnel,
CO 3: Analyze the fluid flow patterns based on flow visualization using smoke tunnel, water tunnel and tufts,
CO 4: Estimate the optimized shape of different geometries for better aerodynamic effects,

CO 5: Determine the coefficient of pressure and aerodynamic forces acting over different geometries, and
CO 6: Estimate the boundary layer thickness over flat surfaces.

**List of Experiments**

1) Estimation of the maximum air velocity in the wind tunnel corresponding to rated RPM.
2) Visualization of the flow separation over Aerofoil (NACA-662-015) at different angles of attack.
3) Visualization of the flow separation over different test models (Cylindrical body, Aerofoil, Circular body) at different angles of attack.
4) Verification of Bernoulli's Theorem.
5) Determination of discharge and coefficient of discharge of an orifice meter.
6) Visualization of the flow separation over a car at different angles of attacks.
7) Determination of the pressure distribution around the surface of a cylindrical body.
8) Determination of the pressure distribution around a symmetric airfoil surface.
9) Determination of the pressure distribution around an unsymmetrical airfoil surface.
10) Determination of the lift coefficient acting on the cylindrical body.
11) Determination of the lift coefficient acting on a symmetric airfoil surface.
12) Determination of the lift coefficient acting on an unsymmetrical airfoil surface.

## AEROSPACE MATERIAL TESTING LAB

**Course Code: AS29003**
**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

This lab comprises of various equipment and experiments to provide the exposure to basic mechanical characterization techniques and microstructure analysis. It helps the students to understand the mechanical behaviour of various materials, effect of micro-structural parameters (grain size, boundary fraction, Phase fraction, second phase particle etc.) on their deformation behavior, quality, and performance. The aim of the lab is to demonstrate the students about basic principles in the area of mechanics of materials, structural analysis and strength of materials through a series of experiments with the help of various test equipments.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to:

CO 1: Understand the fundamentals of mechanical properties of various ferrous and nonferrous Metals,
CO 2: Know the different types of mechanical properties of material and their characterization techniques which are used in various fields of engineering,
CO 3: Analyse the mechanical properties of various metals from different thermo-mechanical processing, performance and testing aspects,
CO 4: Develop and change the mechanical properties of steel and its alloys for different structural and automobile applications,
CO 5: Know the fundamentals of microstructure, micro structural characterization of material by using optical microscope, and

CO 6: Analyze the various micro structural parameters, grain size, grain boundaries, inclusions, precipitates phases) and their effect on mechanical properties of material.

**List of Experiments**

1) To determine the impact strength of mild steel by Izod test method.
2) To determine the impact strength of mild steel by Charpy test method.
3) To determine the tensile strength of a mild steel specimen using UTM.
4) To determine the compression strength of a mild steel specimen using UTM.
5) To determine the flexural strength of a mild steel specimen by three point bending test using UTM.
6) To determine the hardness of the given specimen by Rockwell hardness tester.
7) To determine the hardness of the given specimen by Vickers hardness tester.
8) To determine the torsional shear stress, maximum torque of mild steel by Torsion testing equipment.
9) To prepare the metallographic sample (mild steel) and observe the microstructure using an optical microscope.

## AEROSPACE PROPULSION LAB

**Course Code: AS29004**
**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Aerospace Thermodynamics (AS21003)**

**COURSE OBJECTIVE**

The objective of this laboratory is to impart the practical exposure of various phenomena which are related to jet engine propulsion system such as calorific value of fuel, pressure distribution in diffuser and nozzle, propeller performance and propellant preparation method. The students will be able to design compressor and turbine blades using cascade analysis of the blades. The experience of doing various experiments will help the students to solve the real problems related to propellant preparation, propeller performance etc.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to:

CO 1: Determine the calorific value of the given solid or non-volatile liquid fuel using a bomb calorimeter,
CO 2: Calculate the actual heat transfer co-efficient using Natural convective heat apparatus,
CO 3: Examine the pressure distribution over the linear turbine cascade model,
CO 4: Determine the performance of the Diffuser and wall pressure distribution along the diffuser axis,
CO 5: Determine of actual heat transfer co-efficient using natural & forced convective heat transfer apparatus, and
CO 6: Calculate the thrust development of the propeller and find the helical tip speed of the propeller.

**List of Experiments**

1) Determination of the velocity and flow characteristics of wall jet.
2) Determination of the velocity and flow characteristics of free jet.
3) Determination of the velocity and pressure distribution over the linear turbine cascade tunnel.

4) Determination of the heat transfer co-efficient of aerofoil by using natural convection.
5) Determination of the heat transfer co-efficient of aerofoil by using forced convection.
6) Determination of the efficiency of ramjet combustion .
7) Study of the fluid flow through nozzle and determination of wall pressure measurement.
8) Study of the fluid flow through diffuser and determination of wall pressure measurement.
9) Determination of the calorific value of fuel by Bomb Calorimeter.
10) Study of the propellant preparation procedure.
11) Determination of the performance characteristics of a propeller.

## AEROSPACE STRUCTURES LAB

**Course Code: AS29006**
**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Aerospace Structures-I (AS20003)**

### COURSE OBJECTIVE

This laboratory is intended for carrying out experiments to understand the fundamental concepts of stresses and strains of structural members used in aircraft. Students also verify the experimental results with theoretical calculations. The practical significance of various experiments will help them to carryout stress analysis of aerospace structures.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to:

CO 1: Determine the stress and strain in a structure subjected to a combined loading using a strain rosette,
CO 2: Determine the deflection of beam and draw shear force and bending moment diagrams,
CO 3: Visualize and determine stresses with the help of photo elastic apparatus,
CO 4: Evaluate the stresses in a thin and thick cylinder and compare the results analytically,
CO 5: Calculate the impact strength of a material, and
CO 6: Determine the creep strength of a material.

### List of Experiments

1) Drawing of shear force and bending moment diagrams of a simply supported beam.
2) Determination of deflection of simply supported, cantilever, continuous and fixed beams.
3) Determination of stresses and strains in a structure subjected to combined bending and torsion.
4) Determination of deflection of a cantilever beam due to unsymmetrical bending.
5) Verification of Maxwell's reciprocal theorem for a simply supported beam.
6) Measurement of strain in a cantilever beam.
7) Determination of stresses and strains in a Wagner beam.
8) Determination of member forces in a 2D truss structure.
9) Determination of radial and hoop stresses in thin and thick cylindrical vessels.
10) Determination of Euler's buckling load for a column.
11) Determination of impact strength of mild steel by Izod and Charpy impact test.
12) Determination of creep strength of a material.
13) Study of stress distribution pattern using photo-elastic apparatus.

# SPACE MECHANICS

**Course Code: AS30003**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Engineering Mechanics (ME10001)**

## COURSE OBJECTIVE

The objective of this course is to carry out understand space systems, satellite orbits, satellite orbit transfer and missile launching. The students will be able to derive and solve various problems related to various two body problems and orbital equations. In particular, the course will cover spacecraft trajectories between planets and missile trajectories.

## COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Understand solar time solar system and associated basic terms,
CO 2: Understand satellite orbits relation between position and time,
CO 3: Understand satellite orbit transfer, special perturbations,
CO 4: Understand about the various phases in missile launching,
CO 5: Understand about the spacecraft trajectories between planets, and
CO 6: Understand the missile trajectories.

## COURSE DETAILS

**Space and Solar System**
The solar system, Reference frame and coordinate, the celestial sphere, the ecliptic, sidereal time, solar time, standard time, the earth atmosphere.

**N-Body Problem**
The many body problem, circular restricted three body problem, liberation points, two body problem, satellite orbits, relation between position and time, orbital elements.

**Satellite Injection and Satellite Orbit Perturbations**
Introduction to satellite injection , satellite orbit transfer, orbit deviation due to injection errors, special and general perturbations, methods of vibration of orbital elements.

**Ballistic Missile Trajectory**
The boost phase, the ballistic phase, trajectory geometry, optimal flights, time of flight, re-entry phase, the position of the impact point, influence coefficients.

**Interplanetary Trajectories**
Two dimensional interplanetary trajectories, Fast interplanetary trajectories, three dimensional interplanetary trajectories, Launch of Interplanetary spacecraft, Trajectory about the target planet.

**Textbooks**

1. Bate Roger R., Mueller Donald D., White Jerry E., "Fundamentals of Astrodynamics", Dover Publications Inc., New York.
2. Curtis Howard D., "Orbital Mechanics for Engineering Students", Elsevier India.

**Reference books**

1. Sutton, G. P., "Rocket Propulsion Elements", John Wiley.
2. Van de Kamp, P., "Elements of Astromechanics", Pitman.
3. Parker, E. R., "Materials for Missile and Spacecraft", McGraw-Hill Book Co. Inc.
4. Cornelisse, J.W., "Rocket propulsion and space dynamics ", W.H. Freeman & Co.

## AVIONICS

**Course Code: AS30004**
**Credit : 3**
**L-T-P: 3-0-0**
**Prerequisite: Basic Electronics (EC10001)**

**COURSE OBJECTIVE**

Avionics is the aviation-electronic systems used in modern aircraft that uses principles of digital as well as analog system of the communications, navigation, the display and management of multiple systems, and the hundreds of systems to perform individual functions. The objective of this course is to build a conceptual/ foundational knowledge of the students regarding role & importance of avionics systems and its architecture, various operational aspects of integrated modular avionics system and operational based flight display technology.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Build basic conceptual knowledge about role and importance of avionics in civil as well as military aircraft,
CO 2: Analyze different electronics principles used in avionics components, application of digital computer and microprocessor based system,
CO 3: Know the different avionics system architecture, different electrical data systems and different aircraft data networks,
CO 4: Apply the fundamental concept of different display technology and its control in aircraft flight deck and cockpit in modern civil aircraft,
CO 5: Implement various critical aspects of FD/CVR, ELT, operational based avionics systems communication, navigation, automatic flight control system, flight management system and fly-by-wire system, and
CO 6: Understand the phenomena of utility, reliability and maintainability of avionics systems.

**COURSE DETAILS**

**Introduction to Avionics**
Importance and role of Avionics, Need for Avionics in civil/ military aircraft and space vehicles Elements of Avionics, Avionics environment,

**Basic principles of Avionics**
Semiconductor switches-BJT, MOSFET, CMOS,Digital Number system, codes, complementary arithmetic, Digital circuits- combination circuits & Sequential circuits, Analog to digital converter (ADC), Digital to analog converter (DAC), Digital computer-Architecture, representation of data & Instruction, memories, Microprocessor-Architecture of 8085.

**Avionics System Integration**
Integration of avionics sub-systems, Avionics system architecture- Central, Distributed, Federated & Integrated modular Avionics- IMA benefits and system architecture, Aircraft Data Networks-LAN, Ethernet, Avionics Full-Duplex switched network, Electrical data bus system- Data buses, MIL-STD 1553 B, ARINC 429 & 629, Optical data bus system- STANAG 3910.

**Flight Deck and Cockpits**
Control and display technologies- CRT, LED, LCD, EL, plasma panel, Touch screen, Direct voice input (DVI), Civil cockpit and military cockpit- MFDS, HUD, MFK, HOTAS

**Introduction to Avionics system**
Evaluation of avionics system, Categories of avionics system, Core Avionics system- Communication, navigation, Identification & Surveillance, Flight Management & flight control system FMS, Flight Data Recorder (FDR) and Cockpit Voice Recorder (CVR), Emergency Locator Transmitter (ELT).

**Textbooks**
1. Collison RPG, Introduction to Avionics system, Springer International, 2nd edition.
2. Nagabhushana, S. & Prabhu, N., "Principles of Modern Avionics", I.K. International.

**Reference books**
1. Thomas K Eismin, Aircraft electricity & electronics, 5$^{th}$ Edition, GLENCOE, Mcmilan/McGraw Hill.
2. Mike Tooley & David Wyatt (2007), Aircraft Digital electronics and computer system, Principles, maintenance and operation, Butterworth-Heinemann of Elsevier, Published by Elsevier Ltd.

## COMPUTATIONAL AERODYNAMICS

**Course Code: AS30011**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Aerodynamics-I (AS20001) and Aerodynamics-II (AS20002)**

**COURSE OBJECTIVE**

Computational Aerodynamics is a specialized extension of Aerodynamics and Numerical Methods to solve heat transfer and fluid flow problems. The objective of this course is to develop the fundamental understanding of discretization process for numerical calculations. It emphasizes the numerical analysis of lifting and non-lifting bodies. In particular, the course will cover aspects of analyzing various numerical schemes and techniques to compute incompressible and compressible flow conditions.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to:

CO 1: Execute subsonic potential flow computations,
CO 2: Understand the basics of discretization process for numerical calculations,
CO 3: Implement two dimensional panel methods on lifting and non-lifting bodies,
CO 4: Design components which require compressible flow computations,
CO 5: Design convergent - divergent nozzles and diffusers using Euler's equation, and
CO 6: Develop numerical solvers from scratch for two dimensional compressible flow.

**COURSE DETAILS**

**Basic Aspects of Computational Aerodynamics**
Introduction to computational fluid dynamics, CFD as a research tool- as a design tool. Applications in various branches of engineering - Models of fluid flow- Finite Control Volume, Infinitesimal Fluid Element. Substantial derivative- physical meaning of Divergence of velocity.

**Governing Equations and Physical Boundary Conditions**
Derivation of continuity, momentum and energy equations- physical boundary conditions significance of conservation and non-conservation forms and their implication on CFD applications- strong and weak conservation forms- shock capturing and shock fitting approaches.

**Mathematical Behavior of Partial Differential Equations and Their Impact on Computational Aerodynamics**
Classification of quasi linear partial differential equations by Cramer's rule and eigen value method. General behavior of different classes of partial differential equations and their importance in understanding physical and CFD aspects of aerodynamic problems at different Mach numbers involving hyperbolic, parabolic and elliptic equations- domain of dependence and range of influence for hyperbolic equations. Well-posed problems.

**Basic Aspects of Discretization**
Introduction to finite differences- finite difference approximation for first order, second order and mixed derivatives. Pros and cons of higher order difference schemes. Difference equations- explicit and implicit approaches- truncation and round-off errors, consistency, stability, accuracy, convergence, efficiency of numerical solutions-Von Neumann stability analysis. Physical significance of CFL stability condition.

**Finite Volume Methods**
Basis of finite volume method- conditions on the finite volume selections- cell-centered and cell-vertex approaches. Definition of finite volume discretization -general formulation of a numerical scheme- two dimensional finite volume methods with example.

**Grid Types and Characteristics**
Need for grid generation. Structured grids-Cartesian grids, stretched (compressed) grids, body fitted structured grids, H-mesh, Cmesh, O-mesh, I-mesh, Multi-block grids, C-H mesh, H-O-H mesh, overset grids, adaptive grids. Unstructured grids- triangular/ tetrahedral cells, hybrid grids, quadrilateral/hexahedra cells.

**CFD Techniques**
Lax-Wendroff technique, MacCormack's technique-Crank Nicholson technique-Relaxation technique - aspects of numerical dissipation and dispersion. Alternating-Direction-Implicit (ADI) Technique.

Pressure correction technique- application to incompressible viscous flow- need for staggered grid. Philosophy of pressure correction method- pressure correction formula. Numerical procedures- SIMPLE, SIMPLER, SIMPLEC and PISO algorithms. Boundary conditions for pressure correction method.

**Textbooks**


1. Anderson, J.D., Jr. (1995), Computational Fluid Dynamics- The Basics with Applications, McGraw-Hill Inc.
2. Anderson, D.A., Tannehill, J.C.,Pletcher, R.H., Taylor and Francis (1997), Computational Fluid Mechanics and Heat Transfer, Second Edition.


**Reference books**


1. Hirsch, C., Elsevier (2007), Numerical Computation of Internal and External Flows-Fundamentals of Computational Fluid Dynamics, Second Edition.
2. Versteeg, H.K. and Malalasekera, W. (2010), An Introduction to Computational Fluid Dynamics-The Finite Volume Method, Second Edition, Pearson Education Ltd.
3. Tu, J., Yeoh, G.H., Liu, C., Butterworth- Heinemann, (2008), Computational Fluid Dynamics-A Practical Approach.
4. Moukalled, F., Mangani, L., Darwish, M., Moukalled, F., Mangani, L., & Darwish, M. (2016). The finite volume method (pp. 103-135). Springer International Publishing.


## AVIATION FUEL AND COMBUSTION

**Course Code: AS30012**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Aircraft Propulsion (AS21002) & Aerospace Thermodynamics (AS21003)**

**COURSE OBJECTIVE**

This course comprehends the basic properties of commercial fuels used in aircrafts along with their various characteristics. This also includes the knowledge of fuel treatment and understanding the basics of the subsonic and supersonic combustion fundamentals and performance.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to:

CO 1: Understand the concepts in combustion and make combustion calculations,
CO 2: Know the flame temperature of commercial fuels burning in the combustion chambers of various engines,
CO 3: Know the rate of chemical reactions and emission characteristics of hydrocarbon fuels used in power plants and transportation sector,
CO 4: Know the thermodynamic and transport properties of fuels at elevated pressures and temperatures prevalent in the combustion chambers of actual engines,
CO 5: Know the supersonic combustion, and
CO 6: Understand the reaction and mixing processes.

## COURSE DETAILS

**Fundamental Concepts in Combustion**

Thermo - chemical equations - Heat of reaction first order, second order and third order reactions - premixed flames - Diffusion flames

**Chemical Kinetics and Flames**

Measurement of burning velocity - Various methods - Effect of various parameters on burning velocity - Flame stability - Detonation - Deflagration -Rankine – Hugoniot curve - Radiation by flames.

**Combustion in Gas Turbine Engines**

Combustion in gas turbine combustion chambers - Re-circulation – Combustion efficiency - Factors affecting combustion efficiency - Fuels used for gas turbine combustion chambers - Combustion stability - Flame holder types – Numerical problems.

**Combustion in Rockets**

Solid propellant combustion - Double base and composite propellant combustion - Various combustion models - Combustion in liquid rocket engines - Single fuel droplet combustion model - Combustion in hybrid rockets.

**Supersonic Combustion**

Introduction - Supersonic combustion controlled by mixing, diffusion and heat convection - Analysis of reaction and mixing processes - Supersonic burning with detonation shocks.

**Textbooks**

1. Sharma, S.P., and Chandra Mohan, (1987), “Fuels and Combustion”, Tata McGraw Hill Publishing Co., Ltd., New Delhi.
2. Loh, W.H.T. (1982), Jet Rocket, “Nuclear, Ion and Electric Propulsion Theory and Design”, Springer Verlag, New York.

**Reference books**

1. Beer, J.M. and Chigier, N.A. (1981), Combustion Aerodynamics, Applied Science Publishers Ltd., London.
2. Chowdhury, R. (1986), Applied Engineering Thermodynamics, Khanna Publishers, New Delhi.
3. Sutton, G.P., and Biblarz O. (2010), Rocket Propulsion Elements, 7th Edition John Wiley and Sons, Inc., New York.
4. Mathur, M and Sharma, R.P (1988), Gas Turbines and Jet and Rocket Propulsion, Standard Publishers, New Delhi.
5. Turns, S.R. (2000), An Introduction to Combustion Concepts and Applications, 2nd Edition. McGraw Hill, International Editions, New Delhi.

# ROCKETS AND MISSILES

**Course Code: AS30013**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Aircraft Propulsion (AS21002)**

## COURSE OBJECTIVE

Rockets and Missiles is a specialized extension of Space Mechanics and Aircraft Propulsion to compute and analyze the various forces and moments acting on a rocket. The objective of this course is to develop the fundamental understanding of combustion and propulsion systems in rocket. It emphasizes the suitable selection of materials for the rockets and missiles. In particular, the course will cover aspects of design, performance testing and assessment techniques of rockets.

## COURSE OUTCOMES

After successfully completing the course, the students will be able to:

CO 1: Compute and analyze the various forces and moments acting on a rocket,
CO 2: Formulate the equations of motions for flight and separation phases,
CO 3: Understand the combustion and propulsion systems in rocket,
CO 4: Select suitable materials for the rockets and missiles,
CO 5: Understand the design, performance and testing aspects, and
CO 6: Understand the performance evaluation and assessment techniques of rockets.

## COURSE DETAILS

**Rocket Dynamics**
Classification of launch vehicles and missiles – Rocket systems - Airframe components - Forces and moments acting on a rocket – Propulsion, aerodynamics, gravity – inertial and non-inertial frames - coordinate transformation – Equations of motion for three dimensional motion through atmosphere and vacuum, earth's atmosphere, numerical problems

**Solid Propulsion and Pyrotechnics**
Solid propellant rockets - classification, components and their design considerations, propellant grain design - grain mechanical properties, ballistics and burn rate design issues - igniter design - types of nozzles and thrust vector control, pyrotechnic devices and systems-classification, mechanisms and application of pyrotechnic devices in rockets and missiles. Design problems in rocket systems

**Liquid Propulsion and Control Systems**
Liquid propellant rockets – classification and components - thrust chamber, feed systems, propellant tanks, turbo-pumps, types of valves and applications- their design considerations. Different bipropellant systems like cryogenics and their characteristics, pogo and slooh engine gimbal systems and thrusters for control. Spacecraft propulsion and control systems-Design problems.

**Multi-Staging of Rocket and Separation Dynamics**
Navigation and guidance systems in rockets and missiles - aerodynamic control systems of missiles-multi-staging of rockets - vehicle optimization techniques -stage separation system – dynamics, separation techniques - rocket flight dispersion, numerical problems.

**Design, Materials and Testing of Rockets**

Design requirements and selection, performance evaluation and assessment, space environment on the selection of materials for rockets and spacecraft, material selection for specific requirements, advance materials-super alloys and composite materials. Qualification of rocket and missile systems, types of testing and evaluation of design and function.

**Textbooks**


1. Ramamurthi. K. (2010), Rocket Propulsion. Macmillan Publishers India first edition.
2. Sutton. G.P. and Biblarz. O. (2010), Rocket Propulsion Elements.7th edition. Wiley India Pvt Ltd.


**Reference books**


1. Ronald Humble, Henry and Larson (1995), Space Propulsion Analysis and Design. McGraw-Hill.
2. George M. Siouris, (2000), Missile Guidance and Control Systems, Springer-Verlag New York.
3. Cornelisse, J.W, Schoyer H F R, and Wakker K F (1979), "Rocket Propulsion and Space Dynamic", Pitman Publishing Co.


## FUNDAMENTALS OF COMPOSITE MATERIALS

**Course Code:** **AS30014**
**Credit:** **3**
**L-T-P:** **3-0-0**
**Prerequisite:** **Aerospace Materials and Manufacturing Processes (AS21001)**

### COURSE OBJECTIVE

The objective of the course is to define a composite, enumerate the advantages and drawbacks of composites over conventional materials and discuss factors which influence the mechanical properties of a composite, to classify composites, introduce common types of fibers and matrices, and manufacturing, mechanical properties and applications of composites.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to:

CO 1: Identify, describe and evaluate the properties of fibre reinforcements, polymer matrix materials and commercial composites,
CO 2: Develop competency in one or more common composite manufacturing techniques, and select the appropriate technique for manufacture of fibre-reinforced composite products,
CO 3: Understand the manufacturing processes of reinforcement fibers and matrices for composites.
CO 4: Extend knowledge of applications and selection of different composites in consideration of the properties and characteristics.
CO 5: Understand individual constituents in composites, the role of interface between the components, the consequences of joining fiber and matrix to form a unit.
CO 6: Apply knowledge of composite mechanical performance and manufacturing methods to a composite design project.

## COURSE DETAILS

### Introduction

Definition of composite material, Classification based on matrix and topology, Constituents of composites, Interfaces and Interphases, Distribution of constituents, Nano-composites.

### Polymer Matrix Composites

Polymers and polymerization: structure and properties of thermoplastics and thermosets, engineering applications, property modifications -mechanical, thermal behaviour, Processing of polymers.

### Advanced Composite Materials and their Applications

Introduction, Fibers, Matrix materials, Material forms and fabrication methods, Current applications, fabrication of composites.

### Metal Matrix Composites

Fabrication of Metal Matrix Composites: Commonly used Matrices, Basic Requirements in Selection of constituents, solidification processing of composites - XD process, Spray processes - Osprey Process, Rapid solidification processing, Dispersion Processes - Stir-casting & Compocasting, Screw extrusion, Liquidmetal impregnation technique - Squeeze casting, Pressure infiltration, Lanxide process), Principle of molten alloy infiltration, rheological behaviour of melt particle slurry, Synthesis of In situ Composites.

### Ceramic Matrix Composites

Glasses, glass ceramics and fabrication methods, Processing of ceramics: thermal spraying, ion beam machining, laser and electron beam processing.Fabrication of ceramic matrix composites - Various techniques of vapour deposition, Liquid phase method and Hot pressing etc., Fabrication of nano-composites.

### Characterisation of Composites

Control of particle/fibre and porosity content, particle/fibre distribution, Interfacial Reaction of matrix-reinforcing component, Coating of reinforcing component.

### Industrial Application of Composite Materials

Civil constructions of structures/pannels, Aerospace industries, Automobile and other surface transport industries, Packaging industries, Household and sports components etc. Composites in Electrical, Superconducting and Magnetic Applications, Nano-composite devices.

### Textbooks

1. K.K. Chawala (1987), Composite materials, , 2nd ed., Springer-Verlag, New York.
2. V.V. Vasiliev and E.V. Morozov (2001), Mechanics and Analysis of Composite Materials, Elsevier Science Ltd., Oxford.

### Reference books

1. P. M. Ajayan, L. S. Schadler, P. V. Braun (2003), Nano-composite Science and Technology, Wiley VCH Weinheim.
2. K.K. Chawala (1993), Ceramic matrix composites, Chapman & Hall, London.
3. G. Piatti, Advances in composite materials, Applied Science Publishers Ltd., London.

# INTRODUCTION TO UAV TECHNOLOGY

**Course Code: AS30016**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Aerodynamics-I & II (AS20001& AS20002) and Aircraft Propulsion (AS21002)**

## COURSE OBJECTIVE

Introduction to UAV technology is a fundamental subjects to recognize the role of unmanned aerial vehicles (UAVs) in past, present and future society. This subject has the scope to comprehend and explain various components of UAVs.The objective of this course is to understand the basics of flight and flight control systems for UAVs. In particular, the course will describe the basic regulations applicable to UAV flight and understand the concept of aerodynamics and flight performance of UAVs.

## COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Recognize the role of unmanned aerial vehicles (UAVs) in past, present and future society,
CO 2: Describe the need of unmanned aerial vehicles (UAVs) in present and future society,
CO 3: Comprehend and explain various components of UAVs,
CO 4: Comprehend and explain basics of flight and flight control systems,
CO 5: Understand and describe basic regulations applicable to UAV flight, and
CO 6: Understand the concept of aerodynamics and flight performance of UAV.

## COURSE DETAILS

### Overview and Background
Definitions, history of UAVs, classifications of UAVs, contemporary applications, societal impact and future outlook, operational considerations: liability/legal issues, insurance, ethical implications, human factors, LOS/BLOS.

### Unmanned Aerial System (UAS) Components
Configurations, characteristics, applications; propulsion types; on-board flight control; payloads: sensing/surveillance, weaponized, delivery; communications, launch/recovery systems, ground control stations.

### Concepts of Flight
Aerodynamics: lift, weight, thrust, drag; flight performance: climbing vs gliding flight, range/endurance; stability and control: flight axes, flight controls, autopilots.

### Regulatory and Regulations
Homeland regulatory: FCC/FAA; foreign regulatory; regulations: FCC compliance, UAS registration, federal aircraft regulations (FARs); safety considerations

### Textbook
1. Austin, (2010), “Unmanned Aircraft Systems: UAVs Design, Development and Deployment”, Wiley.

### Reference book
1. Beard and Mclain, (2012), “Small Unmanned Aircrfat: Theory and Practice”, Princeton University Press.

## AIRPORT AND AIRLINES MANAGEMENT

**Course Code: AS30018**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

### COURSE OBJECTIVE

Airline and airport management course teaches running of airports and airlines. This provides a broad overview of the airline industry and creates awareness of the underlying publicizing, financial, operative, and other factors influencing airline running. This course offers data on airline commercial and working priorities, along with teaching the key features of aircraft collection and the impact of airport decision creation.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to:

CO 1: Understand the basic management aspect of airport and airlines system such as airport layout, air traffic control, landing procedure,
CO 2: Know the scheduling, flight planning and other economic and commercial activities,
CO 3: Know how government regulation and industry standards affect the cost of operating an Airline,
CO 4: Know the relationship between various airlines, and operational issues affecting airlines and passengers,
CO 5: Understand the economic characteristics of airlines, and
CO 6: Understand the design and development in fleet planning process.

### COURSE DETAILS

**Airports and Airport Systems**
Introduction, Organization and administration.

**Airport Operations Management**
Airfield, Airspace and air traffic management, Airport operations management under FAR Part 139, Airport terminals and ground access, Airport security.

**Airport Administrative Management**
Airport financial management, the economic, political, and social role of airports, Airport planning, Airport capacity and delay.

**Introduction to Airline Planning**
Structure of Airline Industry (Domestic & International)-Growth and Regulation-Deregulation-Major and National Carriers-Regional Carriers-Economic characteristics of the Airlines Airline Planning Process-Airline Terminology and Measures: airline demand, airline supply, average load factor, unit revenue, Airline Planning Decisions: Fleet Planning, Route Evaluation, Schedule Development, Pricing and Revenue Management.

**Fleet Planning and Route Evaluation**
Factors in Fleet Planning-Hub-and-Spoke System-Technical Aspects-Fleet Rationalization-Fleet

Commonality-Long Range Aircraft-Noise Restrictions-Factors in Design and Development-Fleet Planning Process; Route Evaluation in Hub Networks-Route profitability estimation issues-Demand Driven Dispatch.

**Textbooks**


1. Airport Planning and Management 6/E 0006 Edition by Young Seth, Mc GRAW Hills.
2. Airport Management by Ravindran P.C.K, Asian Law House.
3. Alexander T.Wells and John G.Wensveen, Brooks Cole (2003), Air Transportation: A Management Perspective (Fifth Edition).
4. Charles Banfe, Prentice-Hall, (1991), Airline Management.


**Reference books**


1. Rechard De Neufville, Airport Systems: Planning, Design and Management, Tata McGraw Hills.
2. Straight and Level (2003), Practical Airline Economics by Stephen Holloway, Ashgate Publishing.
3. Stephen Shaw (2004), Airline Marketing and Management, Ashgate Publishing.
4. William O' Connor (2000), An Introduction to Airline Economics (Sixth Edition), Praeger Publishers.
5. Massoud Bazargan (2004), Airline Operations and Scheduling Ashgate Publishing.


## TURBULENCE IN FLUID FLOWS

**Course Code: AS30020**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Aerodynamics-I (AS20001)**

### COURSE OBJECTIVE

Turbulence in Fluid Flows is a specialized need-based extension of Aerodynamics-I that analyzes fundamentals of turbulence in fluid flows. The objective of this course is to understand the phenomena of turbulent heat transfer and turbulent shear flow. In particular, the course will describe the flow characteristics at the wake of a self-propelled body, the effects of pressure gradient on the flow in surface layers and dispersion of contaminants in turbulent flows.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Understand the fundamentals of turbulence in fluid flows,
CO 2: Understand the phenomena of turbulent heat transfer and turbulent shear flow,
CO 3: Understand the dynamics of temperature fluctuations in turbulent flow,
CO 4: Understand the flow characteristics at the wake of a self-propelled body,
CO 5: Understand the effects of pressure gradient on the flow in surface layers, and
CO 6: Understand the dispersion of contaminants in turbulent flows.

### COURSE DETAILS

**Introduction**

The nature of turbulence, origin of turbulence, methods of analysis, diffusivity of turbulence, length scales in turbulent flows

**Turbulent Transport of Momentum and Heat**
The Reynolds equation, elements of the kinetic theory of gases, estimates of the Reynolds stress, turbulent heat transfer, and turbulent shear flow near a rigid wall

**Dynamics of Turbulence**
Kinetic energy of the mean flow, pure shear flow, the effects of viscosity, kinetic energy of turbulence, vorticity dynamics, the dynamics of temperature fluctuations

**Boundary-Free Shear Flows**
Almost parallel, two-dimensional flows, turbulent wakes, the wake of a self-propelled body, turbulent jets and mixing layers

**Wall-bounded Shear Flows**
Problem of multiple scales, turbulent flows in pipes and channels, planetary boundary layers, effects of a pressure gradient on the flow in surface layers.

**Turbulent Transport**
Transport in stationary homogeneous turbulence, transport in shear flows, dispersion of contaminants, and turbulent transport in evolving flows.

**Textbook**
1. H. Tennekes and J.L. Lumley, (1972), "A First Course in Turbulence", The MIT Press.

**Reference books**
1. U. Frisch (1996), "Turbulence", Cambridge Univ. Press.
2. P.A. Davidson, (2004), "Turbulence: An Introduction to Scientist and Engineers", Oxford Univ. Press.
3. S.B. Pope, (2000), "Turbulent Flows", Cambridge Univ. Press.
4. J. Mathieu and J. Scott (2000), "An Introduction to Turbulent Flow, Cambridge Univ. Press.

## AIRCRAFT PERFORMANCE

**Course Code: AS31001**
**Credit: 4**
**L-T-P: 3-1-0**
**Prerequisite: NIL**

**COURSE OBJECTIVE**

This course is provided to help students to understand the physical principles that determine aircraft performance. The course deals with the calculation of performance of an aircraft for various flight phases (take-off and landing, climb and descent, cruise and turning flight) in realistic conditions, satisfying real world constraints that help to determine the flying strategies that result in optimal aircraft performance.

## COURSE OUTCOMES

After successfully completing the course, the students will be able to:

CO 1: Understand the airplane as a dynamic system, equilibrium conditions,
CO 2: Understand the different types of drag and drag polar,
CO 3: Understand the variation of thrust, power, SFC with velocity and altitude,
CO 4: Understand about performance in level flight, minimum drag and power required, climbing, gliding and turning flight, VN diagram and load factor,
CO 5: Understand the principles and mechanics behind the Helicopter flight, and
CO 6: Understand the ground effect on the performance of helicopter aerodynamics.

## COURSE DETAILS

**Aircraft Properties**
Airplane as a rigid body, Airplane as a dynamic system, Equilibrium conditions, Static stability conditions, Airplane dynamics, Airplane control. Aerodynamic properties of wing and its components.

**Drag Estimation**
Drag aerodynamics - Dimensional Analysis, Potential flow, induced drag, Flow of viscous fluid, parasite drag, and flow of a compressible fluid. Aerodynamic data - section characteristics, planform characteristics, high lift and control devices, Determination of three dimensional wing data. Estimation of airplane drag, low speed drag estimation, high speed drag estimation.

**Performance**
Performance computation, generalized performance method, compressibility speed correction, Range and Endurance, Take - off and landing distances, acceleration in climb, turning performance, design performance.

**Cruising Flight Performance**
International Standard Atmosphere - Forces and moments acting on a flight vehicle -Equation of motion of a rigid flight vehicle - Different types of drag –estimation of parasite drag co-efficient by proper area method- Drag polar of vehicles from low speed to high speeds - Variation of thrust, power with velocity and altitudes for air breathing engines. Performance of airplane in level flight - Power available and power required curves. Maximum speed in level flight - Conditions for minimum drag and power required.

**Maneuvering Flight Performance**
Range and endurance - Climbing and gliding flight (Maximum rate of climb and steepest angle of climb, minimum rate of sink and shallowest angle of glide) -Turning performance (Turning rate turn radius). Bank angle and load factor – limitations on turn - V-n diagram and load factor.

**Textbooks**
1. Eshelby, E. Martin (2000), “Aircraft Performance : Theory and Practice”, Elsevier India.
2. Russell, J.B., “Performance and Stability of Aircraft.”, Elsevier India.

**Reference books**
1. Etkin, B. (1982), "Dynamics of Flight Stability and Control", Edn. 2, John Wiley, New York.
2. Babister, A.W. (1980), "Aircraft Dynamic Stability and Response", Pergamon Press, Oxford.
3. Kermode, A.C., “Mechanics of Flight, Pearson.
4. Nelson, R.C. (1998), "Flight Stability and Automatic Control", McGraw-Hill Book Co.

# AIRCRAFT DESIGN

**Course Code: AS31002**
**Credit: 4**
**L-T-P: 3-1-0**
**Prerequisite: Aerodynamics-I & II (AS20001 & AS20002), Aircraft Propulsion (AS21002) and Aerospace Structures-I &II (AS20003& AS20004)**

## COURSE OBJECTIVE

Aircraft Design is a specialized extension of Aerodynamics, Aircraft Propulsion, Aerospace Structure and associated fundamentals to comprehend aircraft design principles. The objective of this course is to develop the understanding of selection process of different configurations and aircraft preliminary design process. In particular, the course will cover aspects of wing design steps and propulsion system design steps.

## COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Understand the fundamentals of aircraft design,
CO 2: Understand the function of aircraft components,
CO 3: Understand the selection process of different configurations and trade-off analysis,
CO 4: Understand the aircraft preliminary design process,
CO 5: Understand the wing design steps, and
CO 6: Understand the propulsion system design steps.

## COURSE DETAILS

**Aircraft Design Fundamentals**
Introduction to design, Engineering design, Design project planning, Decision making, Feasibility analysis, Phases in Design.

**Aircraft Conceptual Design**
Introduction, Primary functions of aircraft components, Aircraft configuration alternatives, Aircraft classification and design constraints, Configuration selection process and trade-off analysis.

**Aircraft Preliminary Design**
Introduction, Design Take-Off weight estimation, Wing area and engine sizing, Constraint Analysis.

**Wing Design**
Introduction, Number of wings, Wing vertical location, Airfoil selection, Wing incidence, Aspect ratio, Taper ratio, The significance of lift and load distributions, Sweep angle, Twist angle, Dihedral angle, High lift device, Sizing of control surfaces.

**Propulsion System Design**
Introduction, Functional analysis and design requirements, Engine type selection, Number of engines, Engine location, Engine installation, Propeller sizing, Engine performance, Engine selection, Propulsion system design steps.

**Textbooks**

1. Raymer, D. P. (2006), Aircraft Design: A Conceptual Approach, 4th ed., AIAA Edu. Series.
2. Sadraey, M. H. (2012), Aircraft Design: A Systems Engineering Approach, Wiley.

**Reference books**

1. Anderson, J. D. (1999), Aircraft Performance and Design, McGraw-Hill.
2. Fielding, J. P. (1999), Introduction to Aircraft Design, Cambridge Univ. Press.

## AIRCRAFT SYSTEMS AND INSTRUMENTATION

**Course Code:** **AS31003**
**Credit:** **4**
**L-T-P:** **3-1-0**
**Prerequisite:** **Aerospace Thermodynamics (AS21003)**

### COURSE OBJECTIVE

The objective of the course is to impart knowledge to the students on various aircraft and engine systems and subsystems which are important for reliable and safe operation of the aircraft. The student will understand various aircraft systems and correctly apply appropriate maintenance procedures to develop essential analytical, troubleshooting and practical skills. The instrumentation system will enable the student to learn the theory of operation, installation considerations and maintenance of a wide range of systems from analog gauges to glass cockpits, for flight, engine, and navigation.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to:

CO 1: Know about Location, visibility and probing of Instrument, Panels, Basic Instrument Elements and Mechanism,
CO 2: Know about basic electrical system in an aircraft,
CO 3: State the ICAO instrumentation requirements and describe instrumentation elements, mechanisms, error sources and temperature compensation,
CO 4: Demonstrate an aircraft control system and its components for both civil and military aircraft,
CO 5: Demonstrate various engine control systems (such as fuel, lubrication and ignition etc.) and its components for both civil and military aircrafts, and
CO 6: Demonstrate the electrical systems (both A.C & D.C) utilizing as an auxiliary power sources in aircraft.

### COURSE DETAILS

**Airplane Control Systems**

Conventional Systems - fully powered flight controls - Power actuated systems – Modern control systems - Digital fly by wire systems - Auto pilot system active control Technology.

**Aircraft Systems**

Hydraulic systems - Study of typical workable system - components - Pneumatic systems - Advantages - Working principles - Typical Air pressure system – Brake system - Typical Pneumatic power system - Components, Landing Gear systems - Classification.

**Air-Conditioning and Pressurizing System**
Vapor Cycle systems, Bootstrap air cycle system - Evaporative vapour cycle systems - Evaporative air cycle systems - Oxygen systems - Fire protection systems, Deicing and anti icing systems- Humidity control. Air distribution systems. Cabin pressurization, tolerance, rain dispersal, antimisting and demisting.

**Engine Systems**
Fuels – Characteristics – Fuel Systems – Lubricant and Lubricant systems – Ignition and starting system – Electronic Engine controls – Full Authority Digital Control (FADEC) – engine Indicating, warning and control systems, Fire protection systems, Deicing and anti icing systems.

**Aircraft Instruments**
Flight Instruments and Navigation Instruments – Gyroscope - Accelerometers, Air speed Indicators – TAS, EAS- Mach Meters - Altimeters - Principles and operation - Study of various types of engine instruments - Tachometers - Temperature gauges - Pressure gauges - Operation and Principles.

**Flight Instruments**
Location, visibility and grouping of Instruments, Panels, Basic Instrument elements and Mechanism, Instruments Panels – Displays – Layouts – Grouping details of: i. Pitot instrument and systems. ii. Primary flight instruments. iii. Heading indicating instruments. iv. Remote indicating systems. v. Synchronous data transmission systems. vi. Flight director and Flight data recording systems. vii. ECAM/EICA/EFIS – Their concepts, detailed description maintenance and practices.

**Aircraft Displays & Lights**
Primary Flight Display (PFD), Navigational display (ND), Multi-functional display (MFD), Head-Up display (HUD), Control display unit (CDU), Electronic Central Aircraft Monitor & Engine Indicator Crew Alert Systems (ECAM/EICAS), Flight compartment lights- Dome light, flood light, Emergency light, Instrument lighting system- Internal & external, Master warning & caution lights, Passenger cabin lights.

**Textbooks**


1. Nagabhushana, S. & Sudha,L.K., “Aircraft Instrumentations & System”, I.K. International
2. Pallet, E.H.J. (2009), “Aircraft Instruments”, Pearson 2$^{nd}$ Ed.


**Reference books**


1. Treager, S. (1997), “Gas Turbine Technology”, McGraw-Hill.
2. McKinley, J.L., and Bent, R.D. (1993), “Aircraft Maintenance & Repair”, McGraw-Hill.
3. “General Hand Books of Airframe and Powerplant Mechanics”(1995), U.S. Dept. of Transportation, Federal Aviation Administration, The English Book Store, New Delhi.
4. Mekinley, J.L. and Bent, R.D. (1993), “Aircraft Power Plants”, McGraw-Hill.

## AEROSPACE SYSTEMS SESSIONAL

**Course Code: AS38001**
**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Aircraft Systems & Instrumentation (AS31003)**

### COURSE OBJECTIVE

The aim of the course is to familiarize the students with aircraft and aero engine systems and subsystems which are important for reliable and safe operation of aircraft. It also includes the functional aspects and troubleshooting of various engine systems and subsystems, Beginning with a review on the historical development of aircraft and aircraft systems, the course presents a comprehensive view on the design and functionality of several systems and system components as well as their interaction.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to:

CO 1: Know about location, visibility and probing of Instrument, Panels, Basic Instrument elements and Mechanism,
CO 2: Know about the basic electrical system, communication and navigating system in aircraft,
CO 3: Describe instrumentation elements, mechanisms, error sources and temperature compensation,
CO 4: Demonstrate an aircraft control system, engine control system (such as fuel control, ignition control, engine indication system, fuel system) and its components for both civil and military aircraft,
CO 5: Demonstrate the electrical systems (both A.C & D.C) with the help of an auxiliary power Sources in aircraft, and
CO 6: Understand the working principles of navigation system.

### COURSE DETAILS

**List of Topics**

1) Aircraft landing gear system
2) Aircraft braking system
3) Aircraft air-conditioning system
4) Engine fuel system
5) Engine lubrication system
6) De-icing system
7) Jet nozzle control system
8) Afterburner system
9) Electrical system
10) Cockpit instrumentation system

## FEM AND CFD SESSIONAL

**Course Code:** **AS38002**
**Credit:** **1**
**L-T-P:** **0-0-2**
**Prerequisite:** **Aerospace Structures-I & II (AS20003 & AS20004) & Aerodynamics-I & II (AS20001 & AS20002)**

### COURSE OBJECTIVE

The aim of the course is to familiarize the students with the working of CFD codes with actual setting up of the problem and solution procedure by extracting the required data, post processing and comparing with available data. This course also provides the knowledge on various structural analysis software packages and imparts the understanding of the stress analysis of different types of structural components as well as the programming for various structural analysis.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to:

CO 1: Define the body shape in a CFD code and create the solution domain and grid generation
CO 2: Apply boundary conditions and generate the solution and validate the aerodynamic quantities from computed data.
CO 3: Perform CFD Analysis over 2D and 3D objects and solve the problems using different turbulence models.
CO 4: Understand the various structural software packages
CO 5: Solve the static structural analysis of one dimensional members, two dimensional & three dimensional problem.
CO6: Understand the various structural programming – open source software packages and programming for various structures problem.

### List of Topics

1) Laminar and Turbulent Pipe Flow
2) Modelling a mixing Elbow (2-D)
3) Flat Plate Boundary Layer
4) Forced Convection over a Flat Plate
5) Steady and Unsteady Flow past a Cylinder
6) Flow Over an Airfoil
7) Flow simulation over an aircraft
8) Compressible Flow in a Nozzle
9) Static stress analysis axial bar
10) Two dimensional (truss) frame with multiple materials and element types
11) Three dimensional truss- Airframe
12) Modal analysis of Aircraft wing
13) Plate buckling analysis
14) Box Beam - Torsional and bending problem
15) Programming of one dimensional bar with single material and axial load
16) Programming of one dimensional step bar, multiple material with different axial load direction
17) Programming for vibration analysis of bar

## AEROSPACE MEASUREMENT LAB

**Course Code:** **AS39001**
**Credit:** **1**
**L-T-P:** **0-0-2**
**Prerequisite:** **Aerospace Thermodynamics (AS21003) & Physics (PH10001)**

### COURSE OBJECTIVE

The objective of this course is to impart knowledge to the students on how to use measurement systems, their calibration procedure for acquiring the correct data. It also provides a means of assessing the suitability of measuring instruments for the quality control of manufactured components. The course helps in understanding the operating procedure of analog and digital devices for measurement and data acquisition.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to:

CO 1: Measure the internal and external features using Vernier caliper, Micrometer, Height gauge, Sin bar, Snap gauge, Plug gauge, Screw pitch gauge, Slip gauge, Feeler gauge,
CO 2: Understand the basics of LABVIEW and NI Instruments,
CO 3: Find the temperature of a body using Thermistor (LM-35) with myDAQ,
CO 4: Estimate the range ( in distance) using IR sensor with myRIO,
CO 5: Measure the flow rate of the flowing fluid using flow-meter with myDAQ, and
CO 6: Determine the acceleration of a body using accelerometer with myRIO.

### List of Experiments

1) Measurement of the Internal and External Features (Length, Width, Thickness, Linear and Angular Measurement) of given component (Nut, Bolt, Washer) Using Vernier Caliper, Micrometer, Height Gauge, Sin Bar, Snap Gauge, Plug Gauge, Screw Pitch Gauge, Slip Gauge, Feeler Gauge.
2) Study of basics of LABVIEW and NI Instruments.
3) Finding of the temperature of a body using Thermistors (LM-35) with myDAQ.
4) Measurement of the Flow Rate of the flowing fluid using Flow-Meter with myDAQ.
5) Finding of the Acceleration of a body using Accelerometer with myRIO.
6) Measurement of the Surface Temperature of an object by using IR Camera.
7) Measurement of the Temperature using Thermocouple with CompactRIO.

## AVIONICS LAB

**Course Code: AS39002**
**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Aircraft Systems & Instrumentation (AS31003)**

### COURSE OBJECTIVE

This laboratory is intended to educate the students to learn about basic digital electronics circuits, programming with microprocessors, design and implementation of data buses in avionics with MIL-STD-1553B and remote terminal configuration and their importance in different applications in the field of Avionics.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to:

CO 1: Evaluate addition and subtraction of binary number,
CO 2: Compare and differentiate the multiplexer and de-multiplexer, encoding and decoding circuits in digital electronics,
CO 3: Evaluate addition and subtraction of 8-bit/16-bit data using microprocessor 8085,
CO 4: Examine storing of 8-bit/16-bit data using microprocessor 8085,
CO 5: Test for the data flow by ascending or descending order using Microprocessor 8085, and
CO 6: Develop interface programming with 4 digit 7 segment Display & Switches & LED‘s.

**List of Experiments**

1) Design and hardware implementation of LOGIC GATES.
2) Design and hardware implementation of Half and full Adder circuit.
3) Design and hardware implementation of Subtractor circuit.
4) Design and hardware implementation of Multiplexer / De-mux using logic gates.
5) Familiarization of 8085 microprocessor trainer Kit and its operation.
6) Addition of any two 8-bit numbers by using 8085 Microprocessor.
7) Subtraction of any two 8-bit numbers by using 8085 Microprocessor.
8) Demonstration on Analog communication-Amplitude Modulation &demodulation.
9) Demonstration on Digital communication - ASK or FSK or TDM.
10) Measurement of Radiation and gain of Half-wave dipole antenna.
11) Demonstration on Radar principle or concept- Echo principle.

# AIRCRAFT MAINTENANCE LAB

**Course Code:** **AS39003**
**Credit:** **1**
**L-T-P:** **0-0-2**
**Prerequisite:** **Aircraft Systems & Instrumentation (AS31003)**

## COURSE OBJECTIVE

This course provides the necessary knowledge and experience to work in a variety of aviation maintenance and inspection roles. The activities related to this lab class include structural assembly, blueprint reading, procedures and regulations (safety, weather-related), repairing, modifying and upgrading mechanical and electrical components. This course will also cover the working with various tools for maintenance of components, assemblies and sub-assemblies and defect investigation procedure and practices.

## COURSE OUTCOMES

After successfully completing the course, the students will be able to:

CO 1: Familiarize themselves with welding technology and sheet metal repair works,
CO 2: Know the use of plastic and composite materials in aircraft,
CO 3: Know the operational aspects of hydraulic and pneumatic systems in aircraft,
CO 4: Know the safety practices followed in aviation domain,
CO 5: Understand the inspection and maintenance of auxiliary systems, and
CO 6: Understand the troubleshooting processes.

### List of Experiments

1) Identification of Jet Engine and Piston Engine components.
2) NDT checks followed for aircraft component repair.
3) Checking of Propeller Pitch Balancing.
4) Stripping of Jet Engine.
5) Welding in Aircraft Structural Components.
6) Use of Plastics and Composites in Aircraft.
7) Aircraft Jacking, Assembly and Rigging.
8) Study of various Hydraulic and Pneumatic Systems.
9) Study of various routine maintenance checks.
10) Safety Practices.

# INSTRUMENTATION AND CONTROL SYSTEMS LAB

**Course Code:** **AS39004**
**Credit:** **1**
**L-T-P:** **0-0-2**
**Prerequisite:** **Aircraft Systems & Instrumentation (AS31003)**

## COURSE OBJECTIVE

The objective of the course is to impart the knowledge of aircraft instrumentation and knowledge on sensors and transducers in aerospace application. This course is also designed for knowing the LabVIEW & Matlab programming and providing hands on training to design virtual instrumentation of flight sensors and actuators.

## COURSE OUTCOMES

After successfully completing the course, the students will be able to:

CO 1: Design a virtual instrumentation,
CO 2: Understand the various system and sensors technology,
CO 3: Measure the velocity and three axis acceleration,
CO 4: Design a control system for auto-pilots,
CO 5: Estimate the data transferred in a MIL-STD-1553B data bus, and
CO 6: Determine position in GPS using my RIO.

## COURSE DETAILS

### List of Experiments

1) To develop PID control system through My VTOL (Vertical Take-off and Landing system).
2) To determine the temperature of hot zone using thermocouple with C-DAQ.
3) To determine the Pressure of hot zone using Pressure Transducer with C-DAQ.
4) To determine the acceleration using accelerometer turbine blades (any moving blade).
5) To measure the coefficient of discharge of the flowing fluid using flowmeter.
6) To analyse the mathematical equations related to pressure and density used in aircraft performance with basic loops.
7) To study the variation of lift coefficient with change in density for a given uniform speed (Ex.- 550 km/hr).
8) To extract and analyze data for aircraft equation of motion at different altitudes.
9) To extract and analyze the equation of motion of governed by one degree of freedom (DOF).

# FLIGHT DYNAMICS AND CONTROL

**Course Code: AS40011**
**Credit : 3**
**L-T-P: 3-0-0**
**Prerequisite: Aerodynamics-I (AS20001) and Aircraft Performance (AS31001)**

## COURSE OBJECTIVE

This course provides an introduction to the flight dynamics, modelling and fundamental stability and control aspects of aircraft. The course covers aircraft roll, pitch and yaw static stability and control basics and develops the full nonlinear equations of motion.

## COURSE OUTCOMES

After successfully completing the course, the students will be able to :

CO 1: Know about degrees of stability, stability criteria, effect of fuselage and CG location, stick forces, aerodynamic balancing. (stick fixed),
CO 2: Know about degrees of stability, stability criteria, effect of fuselage and CG location, stick forces, aerodynamic balancing. (stick free condition),
CO 3: Understand the lateral control, rolling and yawing moments, static directional stability, rudder and aileron control requirements and rudder lock,
CO 4: Understand about dynamic longitudinal stability, stability derivatives, modes and stability criterion, lateral and directional dynamic stability,
CO 5: Understand three dimensional rigid body dynamics, and
CO 6: Understand flight handling qualities.

## COURSE DETAILS

**Static Longitudinal Stability and Control - Stick Fixed**
Introduction to Static and dynamic stability - Degree of freedom of rigid bodies in space - Purpose of controls in airplanes - Static Longitudinal stability, Stick fixed stability - Stability criterion - Effects of fuselage and nacelle - Influence of CG location - Power effects - Stick fixed neutral point.

**Static Longitudinal Stability and Control - Stick Free**
Stick free stability-Hinge moment coefficient - Stick free neutral points-Symmetric maneuvers - Stick force gradients - Stick _ force per 'g' - Aerodynamic balancing. Determination of neutral points and maneuver points from flight test.

**Static Lateral and Directional Stability**
Dihedral effect - Lateral control - Coupling between rolling and yawing moments - Adverse yaw effects - Aileron reversal - Static directional stability - Weather cocking effect - Rudder requirements - One engine inoperative condition - Rudder lock.

**Dynamic Stability**
Dynamic longitudinal stability: Equations of motion - Stability derivatives - Characteristic equation of stick fixed case - Modes and stability criterion - Effect of freeing-the stick - Brief description of lateral and directional. Dynamic stability - Spiral, divergence, Dutch roll, auto rotation and spin.

**Aircraft Equation of Motion**
Body Axis, Stability Axis, Earth Axis – Euler Angles – Transformation between Axis – Advantages of Axis – Aircraft Equations of Motion – Kinematic Equations.

**Linearization**
Small Perturbation Theory: Linear Equations of Motion, Stability Derivatives, Longitudinal and Lateral Modes – Concept and Physics – Characteristic Equation – Transfer Function Approach – State Space Modeling and Application to Modes.

**Flying & Handing Qualities**
Flying and Handling Qualities – Autopilots – Stability - Augmentation System (Longitudinal and Lateral Control) – Fly-By-Wire Aircraft – Active Control System – Control Configured Vehicles – Introduction to Relaxed Static Stability – Gust Load Alleviation – Smart Airplanes – Introduction to Digital Control and Stability

**Textbooks**

1. Etkin, B. (1982), "Dynamics of Flight Stability and Control", Edn. 2, John Wiley, New York.
2. J. Seddon, (1990), "Basic Helicopter Aerodynamics", AIAA Series.


**Reference books**

1. Babister, A.W. (1980), "Aircraft Dynamic Stability and Response", Pergamon Press, Oxford.
2. Dommasch, D.O., Shelby, S.S., and Connolly, T.F. (1981), "Aeroplane Aerodynamics", Third Edition, Issac Pitman, London.
3. Perkins, C.D., and Hage, R.E. (1988), "Airplane Performance stability and Control", John Wiley & Son:, Inc, New York.


## SATELLITE AND SPACE SYSTEMS

**Course Code: AS40012**
**Credit: 3-0-0 3**
**L-T-P: 3-0-0**
**Prerequisite: Space Mechanics (AS30003)**

**COURSE OBJECTIVE**

The purpose of this course in is to provide the student with an introduction to the design of satellite and space systems. This includes subsystem functions and performance measures. In this syllabus, tradeoffs of performance among alternative designs that may satisfy the required subsystem function and optimize higher-level system performance or cost requirements are also discussed.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to:

CO 1: Know about the Payloads and missions, system view of spacecraft propulsion system, launch vehicles, and spacecraft mechanisms,
CO 2: Know about the about Preoperational spacecraft environment, operational spacecraft environment, Environmental effects on design, the sun, the earth, and spacecraft effects, spacecraft structure and thermal control,
CO 3: Know about the various Attitude control, Electrical power systems, telecommunications, telemetry command, data handling and process,
CO 4: Know about the various Failures, Reliability, material and process, safety, configuration control, build and verification, system engineering, case studies,

CO 5: Know about the Satellite design philosophy, satellite system design, COTS components in the space environment, Micro satellites, mini satellites and nano-satellites in orbit operation, and
CO 6: Know about the satellite application for meteorology, navigation, communication, geo observation and space environmental studies.

**COURSE DETAILS**

**Space System Design**
Payloads and missions, system view of spacecraft propulsion system, launch vehicles, spacecraft mechanisms.

**Spacecraft Environment and Its Effects on Design**
Preoperational spacecraft environment, operational spacecraft environments, Environmental effects on design, the sun, the earth, and spacecraft effects, spacecraft structure, thermal control.

**Spacecraft Systems**
Attitude control, Electrical power systems, Telecommunications, telemetry command, data handling and process.

**Product Assurance**
Failures, Reliability, material and process, safety, configuration control, build and verification, system engineering, case studies

**Satellite Engineering and Applications**
Satellite design philosophy, satellite system design, COTS components in the space environment. Micro satellites, mini satellites and nano satellites, in orbit operation, satellite application for meteorology, navigation, communication, geo observation, and space environment study.

**Textbook**
1. P. Fortescue J. Stark, and G. Swinerd, (2002), "Spcaecraft systems engineering", John Wiley and sons.

## Reference book
**1.** NASA Project Gemini Familiarization Manual Manned Satellite Spacecraft, Periscope Film LLC, 2011.

## AIRCRAFT COMMUNICATION, NAVIGATION AND SURVEILLANCE SYSTEMS

**Course Code: AS40013**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Avionics (AS30004)**

**COURSE OBJECTIVE**

The course aims at understanding and analyzing the aircraft communication navigation surveillance systems of aircraft and particularly their operation, their role on the aircraft and their interconnection. The course focuses on all means of communication (audio, visual, video, information, data) and their transmission (HF, VHF, UHF, satellite). Also it enhances the detail knowledge of different Radio navigation and surveillance systems used in aircraft.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to:

CO 1: Know various communication systems of the aircraft and understand their function and principle of operation,
CO 2: Familiarize with various navigation systems of the aircraft and understand their functions and principle of operation,
CO 3: Apply radio navigation principles to different civil and military aircraft avionics systems,
CO 4: Analyze the role and operation of aircraft flight control system,
CO 5: Acquire knowledge about aircraft surveillance system, weather radar and electronic warfare, and
CO 6: Understand the working principle and need of collision avoidance system.

**COURSE DETAILS**

**Aircraft Communication system**
Fundamentals of Communication-Types of Communication- HF/VHF/UHF Communication, Analog & digital, Modulation- Analog Modulation-AM, FM, Phase, Pulse modulation, Digital Modulation-ASK, FSK, PSK. Different Multiplexing technique- FDM, TDM & CDM, Fundamental of radio wave propagation, role of antenna in communication, Types of antenna used for aircraft, Communication Transmitter & receiver, Transceiver.

**Aircraft Navigation system**
Fundamental of Navigation-Basic principle, Navigation Coordination frame, Categorization of navigation system, Principle and working operation of Navigation systems- Radio navigation system, Identification Friend or Foe (IFF), Hyperbolic Navigation system-LORAN, OMEGA, Doppler navigation System (DNS) & Radio Altimeter, Inertial Navigation system (INS), Global Positioning system (GPS), Global Navigation Satellite System (GNSS).

**Aircraft Navigational Aid (NAVAID) System**
Automatic direction finder (ADF),VHF Omni direction range (VOR), Distance Measuring Equipment (DME), Instrument landing system (ILS), Microwave Landing Systems (MLS).

**Aircraft Flight Control System**
Flight control system-fly by wire system, Role of AFCS system, Principle, Basic components of AFCS, Operation of Autopilot, Interlocks, Types of AFCS.

**Aircraft Surveillance & Collision avoidance system**
ATC Transponder, Primary Surveillance radar (PSR), Secondary Surveillance Radar (SSR), Traffic alert & Collision Avoidance system (TCAS), Terrain Awareness and Warning system (TAWS)-GPWS & EGPWS, Weather Avoidance radar, Electronic Warfare **-** ESM, ECM & ECCM.

**Textbooks**

1. M Keyton and W R Fied, Avionics Navigation system,2$^{nd}$ edition, Wiley publication.
2. Ian Moir and Allan G. Seabridge (2006) Civil Avionics Systems, John Wiley & Sons, Ltd. ISBN: 0-470-01632-9.


**Reference books**

1. Powel J. (1981), Aircraft Radio system, The English book store, Himalayan book distributor Edition.
2. Kennedy Davis, Electronics Communication system, Fourth edition, Tata MacGraw-Hill, Fourth Edition.

## AIRFRAME REPAIR AND MAINTENANCE

**Course Code:** **AS40014**
**Credit:** **3**
**L-T-P:** **3-0-0**
**Prerequisite:** **Aerospace Materials and Manufacturing Processes (AS21001)**

### COURSE OBJECTIVE

The aim of the course is to introduce aircraft component disassembly, reassembly and troubleshooting procedures with reference to maintenance and repair and impart knowledge on operation of various systems of aircraft and safety practices.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to:

CO 1: Familiarize in welding technology and sheet metal repair works,
CO 2: Know the use of plastic and composite materials in Aircraft,
CO 3: Know the Hydraulic and Pneumatic systems in Aircraft,
CO 4: Know the Safety Practices,
CO 5: Understand the inspection and maintenance of auxiliary system, and
CO 6: Understand the troubleshooting processes.

### COURSE DETAILS

**Welding in Aircraft Structural Components**
Equipments used in welding shop and their maintenance - Ensuring quality welds - Welding jigs and fixtures - Soldering and brazing. Sheet metal Repair and Maintenance: Inspection of damage Classification - Repair or replacement - Sheet metal inspection - N.D.T. testing, riveted repair design, Damage investigation – Reverse technology.

**Plastics and Composites in Aircraft**
Plastics in Aircraft: Review of types of plastics used in airplanes -Maintenance and repair of plastic components - Repair of cracks, holes etc., various repair schemes - Scopes. Advanced composites in Aircraft: Inspection - Repair of composite components - Special precautions - Autoclaves.

**Aircraft Jacking, Assembly and Rigging**
Airplane jacking and weighing and C.G. Location. Balancing of control surfaces–Inspection and maintenance. Helicopter flight controls. Tracking and balancing of main rotor.

**Review of Hydraulic and Pneumatic System**
Trouble shooting and maintenance practices - Service and inspection -Inspection and maintenance of landing gear systems. - Inspection and maintenance of air - conditioning and pressurization system, water and waste system. Installation and maintenance of Instruments - handling - Testing -Inspection. Inspection and maintenance of auxiliary systems - Fire protection systems - Ice protection system - Rain removal system - Position and warning system - Auxiliary Power Units (APUs).

**Safety Practices**
Hazardous materials storage and handling, aircraft furnishing practices -Equipments. Troubleshooting - theory and practices.

**Textbook**
1. Kroes, Watkins, Delp. (1992), “Aircraft Maintenance and Repair”, McGraw Hill, New York.

**Reference books**
1. Larry Reithmeir. (1992), “Aircraft Repair Manual”, Palamar Books, Marquette.
2. Brimm, D. J., Bogges R. E. (1940), “Aircraft Maintenance”, Pitman Publishing corp., New York.

## THEORY OF AEROELASTICITY

**Course Code:** **AS40015**
**Credit :** **3**
**L-T-P:** **3-0-0**
**Prerequisite:** **Aerodynamics-I (AS20001)**

**COURSE OBJECTIVE**

The objective of this course is to make the students familiarize with aero-elastic nature of the materials used on an aircraft, its effect on the aerodynamic forces, stability and performance of the aircraft; analytical study of effects like flutter.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to:

CO 1: Understand the phenomenon of aero elasticity,
CO 2: Solve problem related to single degree of freedom,
CO 3: Solve problems using the theorems of multiple degrees of freedom,
CO 4: Solve problems by analyzing the systems which undergo static aero elasticity problems,
CO 5: Solve problems in aero elasticity using MATLAB, and
CO 6: Use MATLAB for solving systems having multi-degrees of freedom.

**COURSE DETAILS**

**Introduction**
Aero elasticity phenomena, flutter, divergence, control reversal, flexibility effects on stability and control.

**Single Degree of Freedom**
Introduction to degrees of freedom, Response of single degree of freedom, system, Laplace transform, Harmonic excitation virtual work, Lagrange's equation.

**Multiple Degrees of Freedom**
Classical theories of multi degree freedom system, Undamped mode and frequencies.

**Static Aero-elasticity**
Static problem, divergence of wind tunnel models, wall - sting and strut - mounted models, control reversal, classical flutter analysis, one and two - degree of freedom flutter, flutter boundary characteristics.

**MATLAB**
Introduction to MATLAB, Application of MATLAB for solving aero elastic problem, Design of spline - MATLAB coding.

**Textbook**
1. Y.C. Fung (2002), "An Introduction to the Theory of Aero elasticity", John Wiley & Sons.

**Reference book**
1. Bisplinghoff R.L., Ashley H and Hoffman R.L (1983), “Aeroelasticity”–Addision Wesley Publication, New York.

## HELICOPTER AERODYNAMICS

**Course Code: AS40016**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Aerodynamics-I (AS20001) and Aerodynamics-II (AS20002)**

### COURSE OBJECTIVE

Helicopter aerodynamics provides understanding the elements of helicopter aerodynamics and ground effect machines, their components and methods of control. This subject includes the formulation of mathematical model using simple blade element theory, analyze its figure of merit and evaluate power estimations and application of the aerodynamics, propulsion and control concepts for various VTOL and STOL aircraft and ground effect machines.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to:

CO 1: Know the major helicopter components, characteristics and configurations,
CO 2: Analyse the performance of a helicopter in forward flight,
CO 3: Identify conditions that affect the performance of the helicopter,
CO 4: Analyse the rotor and aircraft performance under hovering and axial flight conditions,
CO 5: Use simplified aerodynamic theory as it applies to helicopter flight to perform preliminary aerodynamic design of a helicopter rotor, and
CO 6: Estimate of the special power required for helicopter flights.

### COURSE DETAILS

**Elements of Helicopter Aerodynamics**
Configurations based on torque reaction-Jet rotors and compound helicopters-Methods of control - Collective and cyclic pitch changes - Lead - Lag and flapping hinges

**Ideal Rotor Theory**
Hovering performance - Momentum and simple blade element theories - Figure of merit - Profile and induced power estimation - Constant chord and ideal twist rotors.

**Power Estimates**
Induced, profile and parasite power requirements in forward flight-Performance curves with effects of

altitude- Preliminary ideas on helicopter stability.

**Lift, Propulsion and Control of Vistol Aircraft**
Various configuration - Propeller, rotor, ducted fan and jet lift - Tilt wing and vectored thrust - Performance of VTOL and STOL aircraft in hover, transition and forward motion.

**Ground Effect Machines**
Types - Hover height, lift augmentation and power calculations for plenum chamber and peripheral jet machine - Drag of hovercraft on land and water, Applications of hovercraft.

**Textbook**

1. Gessow, A., and Myers, G, C. (1987), "Aerodynamics of Helicopter", Macmillan & Co., N.Y.
2. McCormick, B, W. (1987), "Aerodynamics of V/STOL Flight", Academic Press.


**Reference books**

1. Johnson, W. (1980), "Helicopter Theory," Princeton University Press.
2. McCormick, B, W. (1995), "Aerodynamics, Aeronautics and Flight Mechanics"John Wiley.
3. Gupta, L. (1996), "Helicopter Engineering", Himalayan Books.


## HYPERSONIC AIR-BREATHING PROPULSION

**Course Code: AS40031**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Aircraft Propulsion (AS21002)**

### COURSE OBJECTIVE

The objective of the course is to develop knowledge and analysis capabilities for hypersonic propulsion devices including supersonic inlet and exhaust systems, mixing and combustion in high-speed air-breathing engines, turbine-based combined cycle systems, ducted rockets and solid fuel ramjets, ramjets and scramjets and detonation-based approaches using pulsed or rotating detonations.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to:

CO 1: Understand the fundamentals of hypersonic air-breathing propulsion techniques,
CO 2: Know the aerodynamics of combustor/inlet and combustor/nozzle interaction,
CO 3: Analyze the performance of HAP inlets, isolators and nozzles,
CO 4: Evaluate the performance of HAP combustors and fuels,
CO 5: Know the basics of dual mode combustion and dual mode transition, and
CO 6: Determine the characteristics of air-breathing hypersonic vehicles.

### COURSE DETAILS

**Introduction to Hypersonic Air-breathing Propulsion (HAP)**
Definition of hypersonic flight and hypersonic flow, types of hypersonic vehicles, Ram/Scramjet operating principles, Engine-vehicle integration, and hypersonic propulsion challenges

**Aerodynamics of Aircraft Integrated Scramjet**
Propulsion of airframe integration, aerothermodynamics, hypersonic flight environment, vehicle fore body, inlet capture, shock ingestion and spillage, vehicle angle of attack, engine starting, combustor/inlet interaction, combustor flow field, combustor nozzle interaction.

**HAP Inlets, Isolators and Nozzles**
Inlet function and operating modes, inlet types, inlet aerodynamics, performance and operability, isolator, nozzle configurations and nozzle aerodynamics, performance parameters.

**HAP Combustors and Fuels**
Combustion process desired properties, combustor entrance conditions, fuels for hypersonic propulsion, combustion process: reaction rates, stoichiometric fuel/air ratio and equivalence ratio.

**Dual Mode Combustion**
Dual-mode combustion propulsion concept, 1-D ideal flow in burner, Isolator shock-trains, dual mode transition, dual-mode, free jet combustor.

**Combined Cycle Propulsion**
Characteristic earth flight trajectories, air-breathing hypersonic vehicles, challenge of hypersonic air breathing propulsion (HAP), combined cycle definition, requirement for a hap combined cycle propulsion, combined cycle proposed concepts: turbine-based combined cycle (TBCC), rocket-based combined cycle (RBCC), space planes, air-breathing rocket (SABRE).

**Text book**
1. H. W. Heiser and D.T. Pratt, "AIAA Education Series". 5$^{th}$ Edition.

**Reference books**
1. H. Cohen, G.F.C Rogers and H.I.H. Saravanamuttoo, (1989), "Gas Turbine Theory", Longman.
2. M. L. Mathur and R. P. Sharma, (1999), "Gas Turbine, Jet and Rocket Propulsion", Standard Publishers and Distributors, Delhi.

## HIGH TEMPERATURE GAS DYNAMICS

**Course Code:** **AS40032**
**Credit:** **3**
**L-T-P:** **3-0-0**
**Prerequisite:** **Aerospace Thermodynamics (AS21003) & Aerodynamics-II (AS20002)**

**COURSE OBJECTIVE**

The aim of the course is to demonstrate the computational methods appropriate to high speed and/or high temperature flows, the importance and influence of non-equilibrium real-gas effects in high temperature flows, the fundamental features of hypersonic flows and the physical mechanisms causing aerodynamic heating of high speed vehicles.

## COURSE OUTCOMES

After successfully completing the course, the students will be able to:

CO 1: Understand the fundamentals of high temperature gas dynamics,
CO 2: Evaluate the thermodynamic properties in terms of partition function,
CO 3: Know the basics of kinetic theory of gases,
CO 4: Explain the governing equations for inviscid high-temperature equilibrium flow,
CO 5: Analyse the governing equations for inviscid high-temperature non-equilibrium flow, and
CO 6: Know the applications of Navier–Stokes solutions to chemically reacting flows.

## COURSE DETAILS

### Introduction to high temperature gas dynamics
Importance of high-temperature flows, nature of high-temperature flows, chemical effects in air: the velocity-altitude map, definition of real gases and perfect gases, various forms of the perfect-gas equation, composition of equilibrium chemically reacting mixtures: the equilibrium constant, heat of reaction

### Elements of Statistical Thermodynamics
Microscopic description of gases, Boltzmann distribution, evaluation of thermodynamic properties in terms of the partition function, evaluation of the partition function, practical evaluation of thermodynamic properties for a single chemical species, thermodynamic properties of an equilibrium chemically reacting gas, equilibrium properties of high-temperature air

### Elements of Kinetic Theory
Perfect gas equation, collision frequency and mean free path, velocity and speed distribution functions: mean velocities, introduction to chemical and vibrational non-equilibrium, vibrational non-equilibrium: the vibrational rate equation, chemical non-equilibrium

### Inviscid High-Temperature Equilibrium Flows
Governing equations for inviscid high-temperature equilibrium flow, equilibrium normal and oblique shock-wave flows, equilibrium quasi-one-dimensional nozzle flows, equilibrium speed of sound, equilibrium conical flow, blunt-body flows

### Inviscid High-Temperature Non-equilibrium Flows
Governing equations for inviscid, non-equilibrium flows, non-equilibrium normal and oblique shock-wave flows, non-equilibrium quasi-one-dimensional nozzle flows, blunt-body flows, binary scaling

### Viscous High-Temperature Flows
Transport properties in high-temperature gases, definition of transport phenomena, transport coefficients, mechanism of diffusion, energy transport by thermal conduction and diffusion: total thermal conductivity, transport properties for high-temperature air, governing equations for chemically reacting viscous flow, boundary-layer equations for a chemically reacting gas, full and parabolized Navier–Stokes solutions to chemically reacting flows.

### Textbook
1. J.D. Anderson, (2006), “Hypersonic and High-Temperature Gas Dynamics”, 2nd ed., AIAA.

### Reference books
1. W.G. Vincenti and C.H. Kruger, (1975), “Introduction to Physical Gas Dynamics”, Krieger Pub.
2. J.F. Clarke and M. McChesney, (1964), “The Dynamics of Real Gases”, Butterworths.
3. R. Brun, (2009), “Introduction to Reactive Gas Dynamics”, Oxford Univ. Press.

# WIND TUNNEL TECHNIQUE

**Course Code: AS40033**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Aerodynamics-I (AS20001) and Aircraft Systems & Instrumentation (AS31003)**

## COURSE OBJECTIVE

Wind Tunnel Technique is a specialized extension of Aerodynamics and Aircraft System and Instrumentation. The objective of this course is to develop the fundamental principles to estimate aerodynamic forces and visualize the flow past various geometries. It emphasizes the basics of flow measurement techniques practiced in general to calculate surface pressure distribution. In particular, the course will cover the aspects of principles and mechanics to understand component axis balance and internal balances and their measurements in wind tunnel.

## COURSE OUTCOMES

After successfully completing the course, the students will be able to:

CO 1: Solve the Buckingham theory to find the SI unit of a parameter,
CO 2: Know about the testing of wind tunnel in subsonic, transonic and supersonic regimes,
CO 3: Understand the working of Blow down, In-draft tunnels and their specifications,
CO 4: Explain Horizontal buoyancy, checking of flow angularities during calibration,
CO 5: Analyse Component axis balance and internal balance and their measurements in wind tunnel, and
CO 6: Get a clear idea about the smoke and tuft flow visualization procedures in Wind Tunnel testing.

## COURSE DETAILS

**Principles of model testing**
Buckingham Theorem - Non-Dimensional Numbers -Scale Effect, Types of Similarities.

**Wind tunnels**
Classification - Special problems of Testing in Subsonic, Transonic, supersonic and hypersonic speed regions -Layouts - sizing and design parameters.

**Calibration of wind tunnels**
Test section speed - Horizontal buoyancy - Flow angularities - Turbulence measurements - Associated instrumentation - Calibration of supersonic tunnels.

**Wind tunnel measurements**
Pressure and velocity measurements - Force measurements - Three component and six component balances -Internal balances.

**Flow visualization**
Smoke and Tuft grid techniques - Dye injection special techniques - Optical methods of flow visualization.

**Textbook**

1. Rae, W.H. and Pope, A. (1914), "Low Speed Wind Tunnel Testing", John Wiley Publication.

**Reference books**

1. Pope, A., and Goin, L. (1915), "High Speed wind Tunnel Testing", John Wiley.
2. A Pope and J J Harper, Low Speed Wind Tunnel Testing, John Wiley & Sons.
3. Goethert B H, Transonic Wind Tunnel Testing, Pergaman Press.

## BOUNDARY LAYER THEORY

**Course Code: AS40034**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Aerodynamics-I (AS20001)**

### COURSE OBJECTIVE

Boundary Layer Theory is a specialized extension of Aerodynamics. The objective of this course is to develop the fundamentals of boundary layer concept and its development over bluff bodies and streamlined bodies. It emphasizes the boundary layer equations in plane flow and their exact solutions for wedge flow, mixing layer and moving plate. It emphasizes the basics of transition of laminar boundary layers and turbulent boundary layer in application to compressible flow. This course will cover the aspect of different boundary layer controls.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to:

CO 1: Understand the boundary layer phenomenon,
CO 2: Analyse the laminar boundary layer applications and consequences,
CO 3: Understand the transition of laminar boundary layer,
CO 4: Analyze the turbulent boundary layer applications,
CO 5: Solve the boundary layer problems using exact solutions, and
CO 6: Know the different types of boundary layer control.

### COURSE DETAILS

**Fundamentals of Boundary Layer Theory**
Boundary layer concept, laminar and turbulent boundary layer on a flat plate at zero incidence, boundary layer on an airfoil, separation of boundary layer

**Boundary Layer Equations in Plane Flow**
Setting up the boundary layer equations, wall friction, separation and displacement of plate boundary layer, dimensional representation of the boundary layer equations, friction dragand plate boundary layer.

**General Properties and Exact Solutions of the Boundary Layer Equations for Plane Flows**
Compatibility condition at the wall, ordinary differential equation of boundary layers with and without outer flow, similar solutions of the boundary layer equations for wedge flow, mixing layer and moving plate.

**Transition**
Introduction of transition of laminar boundary layers.

**Turbulent boundary layer**
Fundamental of turbulent flow, assumption for calculation of turbulent flow, turbulent flow through pipes, turbulent boundary layer with zero pressure gradient, flat plate, turbulent boundary layer with pressure gradient, turbulent boundary layer in compressible flow, free turbulent flow and jets

**Boundary Layer Controls**
Different kinds of boundary layer controls, continuous suction and blowing, binary boundary layers.

**Textbook**
1. H. Schlichting and K. Gersten, (2001) "Boundary Layer Theory", 8th ed., McGraw-Hill.

**Reference books**
1. G.K. Batchelor, (2000), "Introduction to Fluid Dynamics", 2nd ed., Cambridge Univ. Press.
2. F. M. White, (2006), "Viscous Fluid Flow", 3rd ed., McGraw-Hill.
3. T. Cebeci and A.M.O Smith, (1974), "Analysis of Turbulent Boundary Layers", Academic Press.
4. T. B. Gatski and J.P. Bonnet, (2013), "Compressibility, Turbulence and High Speed Flow", 2nd ed., Academic Press.

## ADVANCED AEROSPACE STRUCTURES

| | |
|---|---|
| **Course Code:** | **AS40035** |
| **Credit:** | **3** |
| **L-T-P:** | **3-0-0** |
| **Prerequisite:** | **Aerospace Structures-I & II (AS20003 & AS20004)** |

**COURSE OBJECTIVE**

The course is structured to provide a thorough understanding of the different design concerns, loads, and analysis techniques that are associated with aerospace structures and to apply principles of mathematics, strength of materials, and structural mechanics to design and analyze aerospace structural components, assemblies and systems.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to:

CO 1: Familiarize with the aircraft structural components,
CO 2: Know the different types of load associated with aircraft,
CO 3: Analyze the open and closed section beams of wings and fuselage,
CO 4: Understand structural loading of aircraft components,
CO 5: Explain the various phases of fatigue and carryout the fatigue analysis of components, and
CO 6: Know about the stress concentration and its calculation procedure.

**COURSE DETAILS**

**Buckling of Structural Members**
Buckling of straight bars, columns, Buckling of thin plates in compression, shear and bending, Torsion-Flexural buckling of thin-walled bars, Column under local crippling, Needham and Gerard methods for determining crippling stresses, Pure and semi-tension field beams, Angles of diagonal tension in web, Inelastic buckling: Introduction, Tangent-modulus theory.

**Stress Analysis in Wing and Fuselage**
Flange type wing beam, Wing sections, Factors affecting wing structural arrangements, Method of stress analysis for wing structures, Basic structure of fuselage, Method of stress analysis for wing structures.

**Fatigue Analysis**
Introduction to fatigue of structures and materials, Different phases of fatigue life, Fatigue mechanism.

**Stress Concentration**
Introduction to stress concentration, Stress concentration factor, Calculation on stress concentration, Effect of notch geometry on stress concentration factor.

**Composite Material for Aircraft Structures**
Introduction, Efficiency of composite materials application, Basic principle of fiber composite materials, Design of aircraft structures using composite materials.

**Dynamic Analysis of Structures**
Introduction to dynamics, Free and forced vibration.

**Textbook**
1. T.H.G. Megson, (2007), "Aircraft Structures for Engineering Students", 4th ed., Butterworth-Heinemann.

**Reference books**
1. S.P Timoshenko and J.N. Goodier, (1970), "Theory of Elasticity, 3rd ed., McGraw-Hill.
2. E.F. Bruhn, (1973), "Analysis and Design of Flight Vehicle Structures", 2nd ed., Jacobs Publishing Inc.

## COMPOSITE MATERIALS AND STRUCTURES

**Course Code: AS40036**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Aerospace Materials and Manufacturing Processes (AS21001) & Aerospace Structures-I (AS20003)**

**COURSE OBJECTIVE**

The course objective is to introduce the design concepts of the composite structures, select composite materials, conduct stress analyses of selected practical applications using laminated plate theories and appropriate strength criteria, and be familiar with the properties and response of composite structures.

## COURSE OUTCOMES

After successfully completing the course, the students will be able to:

CO 1: Understand the fundamentals of structural mechanics,
CO 2: Analyze composite layer and laminates in anisotropic and orthotropic manner,
CO 3: Explain the failure criteria of composite materials,
CO 4: Understand the structural analysis of composite beams and columns,
CO 5: Evaluate allowable stresses for laminates consisting of unidirectional plies, and
CO 6: Know the post-buckling behavior of symmetric plates under axial compression.

## COURSE DETAILS

**Fundamentals of mechanics of solids**
Structural materials, composite materials, equilibrium equations, stress transformation, principal stresses, displacements and strains, transformation of small strains, compatibility equations, admissible static and kinematic fields, constitutive equations for an elastic solid, variational principles.

**Mechanics of a composite layer**
Isotropic layer, unidirectional orthotropic layer, unidirectional anisotropic layer, orthogonally reinforced orthotropic layer, angle-ply orthotropic layer, layer made by angle-ply circumferential winding, fabric layers, lattice layer, spatially reinforced layers and bulk materials

**Mechanics of laminates**
Stiffness coefficients of a non-homogeneous anisotropic layer, stiffness coefficients of a homogeneous layer, stiffness coefficients of a laminate, symmetric laminates, engineering stiffness coefficients of orthotropic laminates, quasi-homogeneous laminates, quasi-isotropic laminates in the plane stress state, anti-symmetric laminates, sandwich structures, coordinate of the reference plane, stresses in laminates

**Failure criteria and strength of laminates**
Failure criteria for an elementary composite layer or ply, practical recommendations, allowable stresses for laminates consisting of unidirectional plies, progressive failure: modeling and analysis.

**Laminated composite beams and columns**
Basic equations, stiffness coefficients, bending of laminated beams, nonlinear bending, buckling of composite columns, free vibrations of composite beams, refined theories of beams and plates.

**Laminated composite plates**
Equations of the theory of anisotropic laminated plates, equations for the orthotropic plates with symmetric structure, analysis of the equations of plate theory for transversely isotropic plates, bending of orthotropic symmetric plates, buckling of orthotropic symmetric plates, post-buckling behavior of orthotropic symmetric plates under axial compression.

**Textbook**
1. V.V. Vasiliev and E.V. Morzov, (2007), “Advanced Mechanics of Composite Materials”, 3rd edition, Elsevier.
2. R. F. Gibson, (1994), “Principle of Composite Material Mechanics”, 2nd edition, McGraw-Hill.

**Reference books**
1. R.M. Jones, (1999), “Mechanics of Composite Material”, 2nd edition, Taylor and Francis.

2. I.M. Daniel and O. Ishai, (2005), “Engineering Mechanics of Composite Materials”, 2nd edition, Oxford University Press.
3. T.H. Hong and S.W. Tsai, (1980), “Introduction to Composite Materials”, Techonomic Pub. Co.

## BASIC CIVIL ENGINEERING

**Course Code: CE10001**
**Credit: 2**
**L-T-P: 2-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

To provide an overview on different aspects of civil engineering profession involving surveying, materials and structural, geotechnical, hydraulics and water resources, environmental, and transportation engineering and their roles in the societal development.

**COURSE OUTCOMES**
At the end of the course the students will be able to:

CO 1: Understand the importance and practical applications of different types of surveying,
CO 2: Learn about the different construction materials and understand the philosophy of structural analysis and design,
CO 3: Understand engineering behaviour of soil and types of foundations,
CO 4: Understand different hydraulics, hydrological and water resources engineering applications,
CO 5: Learn about the management strategies of wastewater and solid waste, and
CO 6: Understand the basics of different types of highways, railways, ports and harbours.

**COURSE DETAILS**

**Introduction**
Role of civil engineers in providing infrastructure, improving quality of life and taking major role in Nation Building, different specializations in the civil engineering and its specific role.

**Surveying**
Plans, maps, scales, divisions of surveying, classification of surveying, leveling, advanced methods of surveying.

**Construction Materials & Structural Engineering**
Different construction materials and their uses, **structural analysis and design philosophy.**

**Geotechnical Engineering**
Overview on origin of soil, engineering properties and its classification; soil exploration; Foundations: their importance and purpose; factors to consider in foundation design and stability of slopes; improving site soils for foundation use.

**Hydraulics & Water Resources Engineering**
Overview on fluid properties, open channel flow, surface and groundwater hydrology, irrigation infrastructures.

**Environmental Engineering**
Types of wastewater, principles of wastewater management, Types of solid waste, principles of solid waste management.

**Transportation Engineering**
Classification of highways, typical construction methods of roads, traffic surveys and their applications in traffic planning, Railways, Ports and Harbours.

**Textbooks**

1. Er. Shrikrishna A. Dhale and Er. Kiran M. Tajne, Basics of Civil Engineering, S. Chand & Company Pvt. Ltd., 1st Edition, 2014.
2. Lecture Notes to be provided by the concerned Faculty Members.

**Reference Book**

1. S.S. Bhavikatti, Basic Civil Engineering, New Age International Publisher, 1st Edition, 2021.

## ENGINEERING DRAWING & GRAPHICS

**Course Code: CE18001**
**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

The objective of this course is to provide students with knowledge and abilities to design a 3D object on 2D paper by hand sketching method and by means of computer aided drafting software.

**COURSE OUTCOMES**

At the end of the course, the students will be able to

CO 1: Use common drafting tools properly,
CO 2: Select, construct and interpret appropriate drawing scale as per the situation,
CO 3: Draw orthographic projections of points, lines and planes,
CO 4: Draw orthographic projection of solids like cylinders, cones, prisms and pyramids,
CO 5: Develop the section of solids for practical situations, and
CO 6: Communicate ideas effectively using Computer Aided Drafting.

## COURSE DETAILS

- Introduction to Engineering graphics
- Lettering
- Projection of points & lines
- Line inclined to both the planes
- Projection of planes
- Introduction to Computer Aided Drafting
- Projection of solids
- Section of solids
- Development of surface

### Textbook

1. K. Venugopal, Engineering Drawing + AutoCAD New Age Publishers, 1st Edition, 2011.

### Reference Book

1. S.N. Lal, Engineering Drawing with an Introduction to AutoCAD, Cengage India Private Limited, 1st Edition, 2017.

# GIS & GPS APPLICATIONS

**Course Code: CE28003**
**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Nil**

## COURSE OBJECTIVE

The objective of the course is to understand the GIS principles, applications, preparation of study maps, creation of interpolation maps, delineation of watershed, explain the functions of GPS and operation of GPS.

## COURSE OUTCOMES

At the end of the course, the students will be able to

CO 1: Explain the fundamentals of GIS,
CO 2: Understand the operations of ArcGIS tools and prepare the layout of study area,
CO 3: Create interpolation maps,
CO 4: Delineate watershed using ArcGIS,
CO 5: Describe the principles and functions of GPS, and
CO 6: Operate GPS in the field for navigation.

**COURSE DETAILS**

- Overview of Geographic Information System (GIS)
- Familiarization to ArcGIS Interface
- Layout of study area
- Preparation of interpolation map
- Watershed delineation
- Remote sensing satellites
- Basics of Global position system
- Basic operations of GPS Handset
- GPS field surveying and data processing

**Reference Books**


1. Principles of geographical information systems by P.A. Burrough and R. A. McDonnell, Oxford University Press, UK.
2. Geographic information systems and science by M.F. Goodchild, P.A. Longley, D.J. Maguire and D.W. Rhind, John Wiley & Sons Ltd., England.
3. Global Positioning system: Principles and Applications by Satheesh Gopi, McGraw Hill Education.


## CHEMISTRY

**Course Code:** **CH10001**
**Credit:** **3**
**L-T-P:** **3-0-0**
**Prerequisite:** **Nil**

**COURSE OBJECTIVE**

This course is designed to enrich the students with the basic concepts in Chemistry and to strengthen their fundamentals which will support them to pursue education and research in engineering. The course will help the students to conceptualize alternative sources of energy by electrochemical means and use the instrumental techniques to explore chemical products.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Rationalize bulk properties and processes using thermodynamic consideration and apply the knowledge to decide the feasibility of a given process,
CO 2: Analyze the kinetics of multistep reactions as well as the theories of reaction rates,

CO 3: Understand the importance of catalysis and their mechanism of action and applications,
CO 4: Apply the principles of electrochemistry to evaluate properties, such as pH, solubility product, etc. and understand the working principle of modern batteries,
CO 5: Apply different spectroscopic techniques, such as UV-Vis, IR and NMR, for structural elucidation, and
CO 6: Differentiate between smart and intelligent materials.

**COURSE DETAILS**

**Chemical Equilibrium and Thermodynamics**
Introduction, Internal energy, Enthalpy, Entropy and free energy, Dependence of free energy on temperature and pressure, Gibbs-Helmholtz equation, Free energy change and equilibrium constants, Van't Hoff isotherm and isochore, Clapeyron- Clausius equation, Partial molar properties, Chemical potential, and Gibbs-Duhem equation.

**Chemical Kinetics**
Rate of reaction and rate laws of multiple reactions (steady-state approximation), and of parallel, opposing and consecutive reactions; Theories of reaction rate: Collision theory, Lindemann modification, Absolute reaction rate; Catalysis: Types, theories, and kinetics of enzyme catalysis (Michaelis-Menten mechanism).

**Spectroscopy**
UV-Vis spectroscopy: Beer-Lamberts law, Types of transition, Concept of auxochrome and chromophores, Factors affecting $\lambda_{max}$ and, Woodward-Fieser rules for calculation of $\lambda_{max}$ in diene systems; IR spectroscopy: Types of vibration, Hooks law, detection of functional groups like C=C, -OH, -$NH_2$ and -C=O**.**

**NMR Spectroscopy**
Basics of NMR Spectroscopy: Theory, Chemical shift, Shielding-deshielding effect, Structural elucidation of simple compounds.

**Electrochemical Energy Systems**
Types of electrodes, electrode/cell potential; Nernst equation and application to: find electrode and cell potential, equilibrium constant, solubility product and pH; Modern batteries: Fuel cells (AFCs, PEMFs, SOFCs, MCFCs), Zn-air battery, Li-ion battery, Na-ion battery, Ni-MH battery.

**Smart and Intelligent Materials**
Introduction to smart materials, Properties and types of smart materials, Structures, System intelligence-components and classification of smart structures, Common smart materials and associated stimulus-response, Application areas of smart systems.

**Textbook**

1. S Chawala, Engineering Chemistry, Dhanpat Rai and Co, $4^{th}$ Edition, ISBN: 9788177001938.

**Reference Books**

1. S Agarwal, Engineering Chemistry: Fundamentals and Applications, Cambridge University Press, ISBN: 9781107476417.

2. S. Chakroborty, S. Sen, and S. Mittal, Engineering Chemistry, Cengage Learning India Pvt. Ltd., ISBN: 9386668645.
3. B.R. Puri, L.R Sharma, and M. S. Pathania, Principles of Physical Chemistry, Vishal Publishing Co., 47th Edition, ISBN: 978-9382956013.
4. R.M. Silverstein, Fransis X, Webster, D.J. Kiemle, Spectrometric Identification of Organic compounds, -Jhon Wiley& Sons, INC, 7th Edition.
5. S. Glasstone, Elements of Physical chemistry-, Macmillan publishers, 2nd Edition ISBN: 978-0333038437.
6. D.J. Leo, Engineering Analysis of Smart Material Systems, Wiley 2007, 1st Edition ISBN: 978-0471684770.


## ENVIRONMENTAL SCIENCE

**Course Code: CH10003**
**Credit: 2**
**L-T-P: 2-0-0**
**Prerequisite: Nil**

### COURSE OBJECTIVE

This course is designed to create awareness in the students on monitoring, assessment, and management of environmental pollutants. The course will also make the students aware of more benign chemistry, i.e., green chemistry, and help them to understand the implementation of Environmental Impact Assessment (EIA).

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Understand the components and composition of the environment along with the radiation balance model,
CO 2: Rationalize the different types of pollutants, their sources, effects, and control measures,
CO 3: Develop the idea of water purification strategies,
CO 4: Identify toxic wastes and conceptualize the principles of solid waste management,
CO 5: Conceptualize the principles of green chemistry and implement them in the synthesis of advanced material, to reduce pollution, and
CO 6: Provide for Environmental Impact Assessment (EIA) requirements before planning a project.

### COURSE DETAILS

**Overview of the Environment**
Overview of the environment, terminologies, Components of Earth: Lithosphere, atmosphere, hydrosphere and biosphere, Concept of black body radiation and albedo, eZro-dimensional energy balance model.

**Air Pollution and Control**
Primary and secondary air pollutants, CFC, Smog (oxidizing and reducing), Important environmental issues: Depletion of the ozone layer, Acid Rain, Greenhouse effect and global warming, Control measures: Baghouse filter, Cyclone separator, Electrostatic precipitator, Catalytic converter, and Scrubber.

**Water Pollution and Control**
Types and sources of water pollutants, wastewater treatment techniques: Ultrafiltration, aerobic and anaerobic treatment, Reverse osmosis, Electrodialysis, Disinfection by chlorination, Ozonation, Modern water purification system, Water quality parameters like hardness, Water softening process (permutit), WHO guidelines for drinking water.

**Soil Pollution and Solid Waste Management**
Soil pollution: Sources of pollutants and mitigation measures. Types of solid wastes: Heavy metal, bio-medical and radioactive wastes, Toxic and biochemical effects of solid wastes, Solid waste management (landfilling, incineration, and composting).

**Green Chemistry and EIA**
Basic principles of green chemistry with examples, Matrices to explain greenness, $R^4M^4$ model, life cycle analysis. Importance, scope and principles of EIA with a case study.

**Textbook**

1. A.K. De, Environmental Chemistry, New Age International Publishers, 9th Edition.

**Reference Books**


1. S. Chakraborty, D. Dave, and S.S. Katewa, Environmental Chemistry-, Cengage Learning India Pvt. Ltd., 1st Edition.
2. Aloka Debi, Environment Science and Engineering, Universities Press, 2nd Edition.
3. Erach Bharucha, Textbook of Environment studies for undergraduate courses, Universities Press, 2nd Edition.
4. D. De and D. De, Fundamentals of Environment and Ecology, S. Chand & Co, 2013.
5. Jain and Jain, Engineering Chemistry, Dhanpat Rai Publishing Company.
6. S.C. Santra, Environmental Science, New Central Book Agency, ISBN: 9788173814044.


## NANOSCIENCE

**Course Code: CH10005**
**Credit: 2**
**L-T-P: 2-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

This course is designed to educate, inspire, and motivate young students about nanoscience, nanotechnology, and their applications. The course provides information on the latest innovations in this field to get insights into the nanomaterials synthesis/fabrication and applications that can be achieved at a nanoscale.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Learn fundamental aspects of nanoscience,
CO 2: Classify different types of nanomaterials based on their dimension and composition
CO 3: Understand different synthesis techniques to grow nanomaterials,
CO 4: Analyse nanomaterials using different characterization techniques,
CO 5: Apply the acquired knowledge to design new materials, and
CO 6: Evaluate the importance of nanoscience in engineering applications.

**COURSE DETAILS**

**Introduction**
Concept and Classifications based on dimensions and compositions, Significance of nano-size: Surface area to volume changes; Properties changing with size (reactivity, melting point, catalytic, electrical, optical), Nanoscience in nature, and Quantum dots as data storage.

**Synthesis of nanomaterials**
Top-down synthesis (Mechanical method-ball milling, Photolithography, Laser ablation, sputtering), Bottom up (pyrolysis, sol-gel, CVD, self-assembly), Green synthesis (metallic nanoparticles, metal oxides), Biosynthesis.

**Characterization**
XRD-X-ray generation, Working principle (Bragg's law), Peak broadening in nanomaterials (Scherrer formula), Electron microscopy (SEM, TEM)—high energy electron generation, electron optics, Scanning Electron Microscopy (SEM)—secondary, back scattered, EDX, Transmission Electron Microscopy (TEM)—bright field imaging, dark field imaging, and Selected area diffraction pattern.

**Applications**
Cosmetics—ZnO, $SiO_2$, $TiO_2$ Nanoparticles in cosmetics, $SiO_2$ $TiO_2$ in toothpaste, silver, gold, copper nanoparticles in skin care product; Medical Fields—MRI, CT scan contrast enhancement agent, Drug and gene delivery system, Magnetic hyperthermia treatment; Agriculture—Nano-pesticides, herbicides, and fungicides, Food packaging; Aerospace and Aviation Industries—Carbon nanotubes (CNT) nanocomposites, Metal Nanoparticle-Polymer composites, SiC Nanoparticle reinforced alumina (high temperature strength, creep resistance); and Nanomaterials for Environmental Remediation—Degradation/removal of pollutants.

**Textbook**


1. B.S. Murty, P. Shankar, Baldev Raj, B.B. Rath and James Murday, Textbook of Nanoscience and Nanotechnology, 1st Edition, 2012, ISBN-13: 978-8173717383.


**Reference Books**

1. Luisa Filipponi and Duncan Sutherland.,Nanotechnologies: Principles, Applications, Implications and Hands-on Activities, Edited by the European Commission Directorate-General for Research and Innovation Industrial technologies (NMP) program, 2012, ISBN: 978-92-79-21437-0.
2. Charles P. Poole Jr., Frank J. Owens., Introduction to Nanoscience and Nanotechnology, An Indian Adaptation, 3rd Edition, 2020, ISBN-13: 978-9354240201.
3. P.I. Varghese, T. Pradeep. A Textbook of Nanoscience and Nanotechnology, Tata McGraw Hill Education, 2017, ISBN: 9781259007323.

## CHEMISTRY LAB

**Course Code: CH19001**
**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Nil**

### COURSE OBJECTIVE

This lab course covers different types of chemical experiments ranging from volumetric analysis to spectroscopic techniques. This course provides the students with hands-on training in many of the advanced spectroscopic and analytical techniques in chemistry. The experiments in the course span over diverse applications in chemistry. It contains experiments dealing with environmental chemistry, volumetric analysis, organic and inorganic synthesis, electrochemistry, and spectroscopy**.**

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Handle different chemicals with proper safety protocols in an advanced Chemistry laboratory,
CO 2: Learn and apply basic techniques used in Chemistry laboratory for preparation, purification and identification,
CO 3: Analyze the kinetics of 1st order reactions and estimate the rate constant,
CO 4: Use different instrumental techniques such as Conductometry, pH-metry, Potentiometry and Colorimetry,
CO 5: Analyse basic water quality parameters like hardness, dissolved oxygen, alkalinity, chloride, ferrous iron contents etc, and
CO 6: Rationalize and learn the spectroscopic and synthesis techniques in chemistry.

### COURSE DETAILS

- Estimation of total hardness in a given water sample in terms of calcium and magnesium hardness by EDTA method
- Estimation of the amount of NaOH and $Na_2CO$ 3 present in a given mixture solution

- (a) Determination of the strength of $KMnO_4$ solution by using standard sodium oxalate solution. (b) Determination of the amount of Ferrous ($Fe^{2+}$) ions present in the Mohr's salt solution by using standard $KMnO_4$ solution
- Determination of the amount of dissolved oxygen present in a given water sample by Winkler's method
- Finding the strength of $Fe^{2+}$ present in the supplied Mohr's salt solution by potentiometric titration
- Determination of the rate constant of acid-catalyzed hydrolysis of ethyl acetate
- Determination of the chloride ion ($Cl^-$) present in a given water sample by the argentometric method
- Finding the strength of supplied acid by pH-metric titration against a standard alkali
- Finding the strength of a given hydrochloric acid solution by titrating it against standard sodium hydroxide solution conducto-metrically
- Verification of Beer Lambert's Law and application of this law to determine the unknown concentration of a given solution
- Determination of the concentration of ferric ions ($Fe^{3+}$) in a given water sample by a spectrometric method using KCNS as color developing agent
- Determination of the Isoelectric point (pI) of glycine amino acid
- Synthesis of transition metal complexes and characterization by using IR and $^1$H-NMR. (Open ended)
- Determination of the concentration of different ions (cations and anions) in a given water sample by colorimetry. (Open ended)
- Application of potentiometric titrations (Open ended)

**Reference Books**


1. Chemistry laboratory Instruction manual, School of Applied Sciences, KIIT Deemed to be University.
2. Vogel's Quantitative Chemical Analysis, J. Mendham, R.C. Denney J. D. Barnes, M.J.K. Thomas, 6th Edition, Longman.
3. Standard methods for examination of water and wastewater, 23rd Edition, APHA.


## PROGRAMMING LAB

**Course Code: CS13001**
**Credit: 4**
**L-T-P: 0-2-4**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

The course aims to provide exposure to problem-solving through programming. It aims to train the student to the basic concepts of the C-programming language. This course involves lab component which is designed to give the student hands-on experience with the concepts.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Have fundamental knowledge of computers hardware and number systems with commands in Linux,
CO 2: Write, compile and debug programs in C language.
CO 3: Design programs involving decision structures, loops, and functions.
CO 4: Construct arrays to store, manipulate, search and display data.
CO 5: Apply the dynamics of memory by the use of pointers, and
CO 6: Use different data structures and create/update basic data files.

**COURSE DETAILS**

- Basic Linux commands
- Operators and Expressions
- Branching statements (if-else, switch).
- Control statements (looping - for, while, do-while).
- Arrays
- Character Arrays (strings).
- Functions.
- Pointers and Dynamic Memory Allocation.
- Structures and Unions
- File Handling

## WEB DESIGN

**Course Code: CS28001**
**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

Web design and programming is a large field, with different types of technologies implemented by different tools. HTML, CSS, and JavaScript are known to be the three pillars of client-side web programming. After finishing this course, a student should be prepared to write nicely formatted, interactive web pages, with no dependencies on server-side technologies.

**COURSE OUTCOMES**

At the end of the course, the students will be able to

CO1: Understand the basics of web page design,
CO2: Use formatting instructions of HTML,

CO3: Apply the style formats using CSS,
CO4: Write basic scripts using JavaScript,
CO5: Apply DOM in web pages, and
CO6: Create dynamic web pages using HTML and JavaScript.

**COURSE DETAILS**

**HTML Fundamentals**
HTML: Structure of a program, various tags and their roles in HTML programs, Lists: ordered, unordered, definition, Table.

**More with HTML**
Form design, Frames, link and it's types, Images.

**CSS Essentials**
Style sheets: Inline, Internal, External.

**JavaScript Basics**
Introduction, characteristics, Variables, Data types, Type casting and conversion Functions. Primitives, operators, Control statements, Array, Function, Function – Parameter Passing and dynamic argument and return statement

**More with JavaScript**
DOM - browser, window, document, image and form object, Properties and Methods of different objects, Predefined Java Script Object - Array, String and Date Object and their methods, Event handling – Link, Body, Image and events associated with different HTML tags

**Textbook**

1. MASTERING HTML, CSS & Java Script Web Publishing, Laura Lemay, Rafe Colburn and Jennifer Kyrnin, BPB Publications.

**Reference Books**

1. HTML, CSS and JavaScript All in One, Sams Teach Yourself, Julie C. Meloni and Jennifer Kyrnin, Pearson Education.
2. HTML 5 Black Book, DT Editorial Services, Dreamtech Press.

## BASIC ELECTRONICS

**Course Code: EC10001**
**Credit: 2**
**L-T-P: 2-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

The course is designed to familiarize students of all branches to the all-pervasive field of Electronics, enable them to carry out research in interdisciplinary fields involving semiconductor devices, and utilize the knowledge in solving practical problems in real life in today's age of electronics.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Understand the properties of semiconductor and current conduction mechanism,
CO 2: Comprehend the working of P-N junction diodes; identify different diode circuits and analyze them,
CO 3: Understand the working of different types of transistors,
CO 4: Know about OP-AMP and its applications,
CO 5: Analyze the working of op-amp using either inverting or non-inverting configurations, timing circuit, regulated power supply ICs, and their applications, and
CO 6: Realize the importance of various analog and digital electronic systems and electronic devices.

**COURSE DETAILS**

**Semiconductors, Diodes and Transistors**
Properties of semiconductor materials, Applications of semiconductors as p-n junction diode, Diode characteristics and breakdown mechanisms, Half-wave and full-wave rectifiers with filters, Zener diode, Transistor constructions, operations and their characteristics. Transistor biasing, amplifiers, and load line analysis, Concepts of JFET and MOSFET.

**Operational Amplifier (Op-amp) and applications**
Introduction to Op-amp and its Characteristics. Application of Op-Amp as Inverting amplifier, Non-inverting Amplifier, Summing, Difference amplifier and comparator.

**Introduction to Digital Electronics**
Different number systems and its conversions, Logic gates and truth tables of OR, AND, NAND, EX-OR. Combinational circuit and Sequential circuit.

**Miscellaneous Electronic Devices**
SCR, Opto-electronic devices and fiber techniques, Introduction and description of sensor performance, Fundamentals of analog communication techniques (AM and FM).

**Textbook**

1. J. Millman, Christos C. Halkias & C.D. Parikh, Integrated Electronics: Analog and digital circuits and Systems, 9$^{th}$ Edition, 2021.

**Reference Books**

1. R.L. Boylestad & L. Nashelsky, Electronic Devices & Circuits, PHI, 7$^{th}$ Edition, 2021.
2. D.A. Bell. Electronic Devices and Circuits (Oxford), 5$^{th}$ Edition,2021.
3. D. Chattopadhyay and P. C. Rakshit. Fundamentals & Applications, New Age International, 15$^{th}$ Edition 2021.

## BIOMEDICAL ENGINEERING

**Course Code: EC10003**
**Credit: 2**
**L-T-P: 2-0-0**
**Prerequisite: Nil**

### COURSE OBJECTIVE

Biomedical Engineering is a multidisciplinary field that combines knowledge available in a wide range of disciplines such as engineering, medicine, and societal science. The course focuses on innovating newer equipment and technologies to improve human health and enhance health care facilities in a holistic manner.

### COURSE OUTCOMES

At the end of this course, the students will be able to

CO 1: Apply knowledge of basic engineering and biology to solve the problems,
CO 2: Acquire knowledge of human body about cell, potential and organs of body,
CO 3: Develop a thorough understanding on principles of bio-instrumentation,
CO 4: Explain the role of bio-potential electrodes, and design of sensors,
CO 5: Differentiate and analyse the biomedical signal sources, and
CO 6: Acquire knowledge about imaging techniques used in hospital.

### COURSE DETAILS

**Introduction and Overview**
Introduction to biomedical engineering, Applications of biomedical engineering.

**The Human Body**
cCll-structure and function, Tissue & organs, Bio-potentials, Action potential, Major human systems (musculoskeletal, circulatory, nervous, and respiratory system).

**Bio-instrumentation**
Instruments in medical practice, Man-instrumentation system, Basic components, Linear network analysis, Bioelectric amplifier (OpAmp, isolation amplifier, instrumentation amplifier), Bio-instrumentation design, and Intelligent medical instrumentation.

**Biomedical Electrodes and Sensors**
Ssignal acquisition, Bio-potential measurements, Active and passive sensors, and Electrodes for biophysical sensing (Ag-AgCl, surface electrodes, microelectrodes), transducers, sensors.

**Biomedical Signals, Imaging and Informatics**
Bioelectric phenomena, Sources of biomedical signals, Origin of biopotentials, Basics of bio-signal processing, noise, Interference, Electrical safety issues, Principle of medical imaging techniques, such as X-ray, US, MRI, CT scan, and nuclear imaging, and Fundamentals of bio-informatics.

**Textbook**

1. John D. Enderle & Joseph D. Bronzino Introduction to Biomedical Engineering, Academic press, 3rd Edition, 2012.

**Reference Books**

1. Joseph D. Bronzino, Donald R. Peterson, The Biomedical Engineering Handbook, CRC press, 4th Edition 2015.
2. G.S. Sawhney, Fundamentals of Biomedical Engineering, New Age International (P) Ltd, 2011.

## MICROPROCESSOR AND EMBEDDED SYSTEMS

**Course Code: EC20002**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: EC21001**

**COURSE OBJECTIVE**

Objective is to provide an overview of 16-bit Microprocessor, and its interfacing to solve design-based problems. Also is to acquaint students with insight of Embedded Systems, design perspective and applications.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to:

CO 1: Analyse the architecture of a 16-bit Microprocessor like 8086, its instructions and programming.
CO 2: Design Memory Interfacing using memory chips with proper decoder circuits with a 16-bit processor and analyze the interrupt structure of 8086 Microprocessor.
CO 3: Design an interface with proper decoder circuits to establish communication between 8086 and I/O to solve real-time applications.
CO 4: Apply different design constraints and communication protocols for Embedded systems.
CO 5: Analyze 8-bit Microcontroller (like 8051), its instructions, timers & counters and serial operation, and also analyze ARM processor.
CO 6: Develop skill for writing Assembly and/or Embedded C programs for interfacing various devices.

**COURSE DETAILS**

**Intel 8086 Microprocessor**
Architecture, Pins, 8086 Instructions, Sample programs, and Interrupts.

**Memory and I/O Interfacing**
Memory Interfacing, Programmable Peripheral Interface (PPI 8255), Programmable Interrupt Controller

(8259), and USART (8251).

**Fundamentals of Embedded Systems**
Embedded Processor in System, Components of Embedded System, Brief introduction to Embedded software in system, Design Process in Embedded System, Programming methods for Embedded System case study, Communication Protocols - I2C, and SPI/CAN.

**Mmicrocontrollers & Interfacing**
Overview of MCS-51 Family of Microcontrollers, Memory Organization, Pins, Addressing Modes, Interrupts, Timers & Counters, Serial Communication, 8051 Instruction Set & Interfacing with ADC, LCD, and DC motor.

**Brief on RISC philosophy and ARM Principles**

**Textbooks**


1. Ray, A. K., Bhurchandi, K.M. Advanced Microprocessor and Peripherals - Architecture, Programming and Interfacing, McGraw Hill Education Pvt Ltd. 3rd Edition.
2. Muhammad Ali Mazidi, Janice Gillispie Mazidi, Rolin McKinlay. The 8051 Microcontroller and Embedded Systems: Using Assembly and C, Pearson Education India - 2nd edition.


**Reference books**


1. Douglas V. Hall Microprocessors and Interfacing, Programming & Hardware, McGraw Hill Education Pvt Ltd., 3rd Edition.
2. Mazidi, M. A., & others. ARM Assembly Language Programming & Architecture.
3. Deshmukh. Microcontroller Theory & Applications, McGraw Hill Education Pvt Ltd.
4. Raj Kamal. Embedded Systems: Architecture, Programming & amp, Design, TMH, 2011.


## ELECTRONIC CIRCUITS

**Course Code: EC21001**
**Credit: 4**
**L-T-P: 3-1-0**
**Prerequisite: EC10001**

**COURSE OBJECTIVE**

This course will prepare students to perform analysis of analog and digital electronics circuits. Empower them to understand working of transistor and design amplifiers, filters, oscillators etc using transistors. Students will learn to design various combinational and sequential circuits. They will acquire elementary knowledge of various other domains of electronics like communication systems, VLSI design, Internet of Things etc.

## COURSE OUTCOMES

After successfully completing the course, the students will be able to:

CO 1: Understand, analyze and design BJT amplifiers.
CO 2: Understand, analyze and design FET amplifiers.
CO 3: Simplify and realize Boolean expressions and design various combinational circuits.
CO 4: Analyze and comprehend circuits using op-amps.
CO 5: Design and analyze circuits using op-amp like instrumentation amplifier, filter, oscillator, differentiator, and integrator.
CO 6: Analyze and design various sequential circuits using flip-flops and multivibrators using 555 timers.

## COURSE DETAILS

**Introduction to Network Theorems**

**Transistor Amplifier**

Requirement of biasing, Different types of biasing circuits for BJT & FET, Small signal model for BJT (simplified hybrid model), Low frequency small signal analysis of CE and CC configurations (without feedback), Small signal model for FETs (JFET and MOSFET), Low frequency small signal analysis of CS and CD configurations, Frequency response of amplifier, Classification of amplifier, and Class B Push Pull Amplifier.

**Boolean Algebra and K-maps**

Representation of Boolean Function, Minterms & Maxterms, K-map representation, and Simplification and realization with logic gates.

**Analysis & design of Combinational Circuits**

Introduction to combinational circuits, Adders (Full adders, parallel binary adders, 4-bit Adder/ Subtractor), Decoders and Encoders and its application, and Multiplexer.

**Operational amplifiers**

Block diagram representation, Op-amp parameters, Feedback concept, General characteristics of negative feedback amplifier, Op-amp circuits using negative feedback (voltage series feedback & voltage shunt feedback), Differential amplifier, Op-amp applications, Instrumentation amplifier, Voltage to current converter and vice versa, Integrator, Differentiator, Active filter, and Op-amp with positive feedback.

**Analysis & design of Sequential Circuits**

Overview of various Flip-flops (inter-conversion of FFs), Concepts of level and edge triggering, Counter (synchronous and asynchronous) & application, and Multivibrator using IC555.

**Textbooks**

1. Millman, J., Halkias, Parikh. Millman's Integrated Electronics - Analog and Digital Circuit and Systems, MGH, 2nd Ed.
2. Gayakwad, R.K. Op-Amps and Linear Integrated Circuits, Pearson, 4th Ed.
3. Morris Mano, M. (2016). Digital Logic and Computer Design, Pearson.

**Reference books**

1. Boylestad, Robert L., Nashelsky, Lewis. Electronics Devices and Circuits, Pearson, 11th Ed.
2. Choudhury, D. Ray., Jain, Shail. Linear Integrated Circuits, New Age, 5th Ed.
3. Kumar, Anand. Fundamentals of Digital logic, PH. 4th Ed.

## COMPUTATIONAL PHOTOGRAPHY

**Course Code:** **EC28001**
**Credit:** **1**
**L-T-P:** **0-0-2**
**Prerequisite:** **Differential Equations and Linear Algebra (MA11001)**

### COURSE OBJECTIVE

Computational photography (CP) is the fusion of computer graphics, computer vision, optics and imaging. The role of CP is to overcome the limitations of traditional cameras by combining imaging and computing to enable new and improved ways to capture, represent and interact with the physical world. The course provides and overview of elements photography, which includes digital image capturing mechanisms, lighting controls, effect of focal length and aperture and various lossy and lossless image storage mechanisms. Objective is to briefly explain computational methods used to enhance photographs.

### COURSE OUTCOMES

At the end of this course, the students will be able to

CO 1: Appreciate concept of photography, and digital camera technology,
CO 2: Understand types of cameras and their mechanisms,
CO 3: Demonstrate computational image processing,
CO 4: Apply computational photography methods for photo composition and panoramic,
CO 5: Apply computational image processing for photography quality enhancement, and
CO 6: Explain various image filtering techniques.

**COURSE DETAILS**

**Introduction to Computational Photography**

History of Photography and Computational Photography, Digital Representation of Images, Cameras, Difference between Full frame, APSC and Medium format sensors, scaling, crop sensor advantages/disadvantages.

**Digital photography**

Principle of Operation of DSLR camera, Aperture, ISO, Shutter speed and Angle Control, Camera Calibration and Tethering, Computational Cameras, Image Storage formats: Compressed vs uncompressed formats, Basics of Lenses: Wide angle, Telephoto, Prime lenses, Macro lenses. Difference in angle, Depth of field control.

**Computational Techniques**

Concept of Color, color models, noise, its types, image histogram, Image Processing software: Licensed and Open Source.

**Training on Computational Photography**

Shooting with wide angle lenses, Shooting with Telephoto lens, zooming, changes in angle, Shooting with Prime lenses and constant aperture lenses, Shooting with Macro lenses, microscopic photography.

**Training on Digital Imaging-I**

Photography Genres, Scene Composition, Dynamic Range improvement, Portraits, Photographing scenes, crowd and people, Shooting Portraits, group photos and events.

**Training on Digital Imaging-II**

Long exposure, Brenizer's Method, Sports High Shutter speed, Burst, fisheye, architecture photography, Macro, Basics of Long exposures, using polarizing filters Shooting panorama, Brenizer's method and other photographing techniques, Shooting sports, high shutter speed.

**Training on Digital Imaging-III:**

Use of lights, soft box and flashes, guide number etc., product photography, computational photography, E-commerce photography, Use of Lights, Flash, wireless flash, Basics of product photography, photography for e-commerce and computational photography.

**Training on Post Processing-I:**

RAW image processing, Basic adjustments and correction, Lens Distortion and color correction using Adobe Photoshop, Monochrome image processing, color image processing batch processing using Light-room.

**Training on Post Processing-II**

Image enhancement operations, noise removal, Artistic filtering, cosmetic filtering, and other post processing methods. Post Processing III: Background removal, artificial coloring.

**Training on Post Processing-III:**

Open Source and free software for image post processing and computational photography, their usage and capabilities.

**Photography Ethics**

Photography ethics: empathy, consent, integrity, ethical decision making, privacy.

**Textbook**

1. Richard Szeliski, Computer Vision: Algorithms and Applications, 2nd Edition.

**Reference Books**

1. Ayush Bansai, Achuta Kadambi, and Ramesh Raskar, Computational Imaging Book.
2. Richard Hartley and Andrew Zisserman, Multiple View Geometry in Computer Vision.
3. David Forsyth and Jean Ponce, Computer Vision: A Modern Approach.
4. Steven Gortler, Foundations of 3D Computer Graphics.
5. Rafael Gonzalez and Richard Woods, Digital Image Processing.
6. Barbara London and John Upton, Photography.

## SOUND ENGINEERING

**Course Code: EC28003**
**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

It elaborately covers in various aspects of sound (physical and mechanical behavior), equipment used for recording/ reproducing and basic idea for the preparation of final sound track in film or television production.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Recognize, define, and explain the principles of sound engineering related to signal flow, microphones, recording, mixing, production, and mastering, CO 2: Demonstrate practical, imaginative understanding and fluency on sound engineering technologies and procedures,

CO 3: Solve problems independently, imaginatively, and creatively in the field of sound engineering will be demonstrated by students,

CO 4: Learn how to conduct research and have a critical comprehension of sound engineering and its related fields,

CO 5: Understand the basic techniques of sound recording, and

CO 6: Understand the working of different types microphone and loudspeakers and their applications in industry.

**COURSE DETAILS**

- Introduction to technology of sound
- Analysis of pre-recorded speech, music and effects
- Observation of the installation of PA System in a large auditorium
- Study and analysis of different microphones
- Study the feature of 2 channel digital sound recorder
- Study about the effect of loudness in relation with the distance from source to the listener
- Sound recording and reproduction practice by using recorder in PA system chain
- Study of sound in different environmental situation
- Study and analysis on Modulated Radio wave AM and FM in Live streaming radio stations
- Study the effect of Bass and Treble (Concept of Equalization)

**Textbook**

1. Glyn Alkin, Sound Recording and Reproduction.

**Reference Book**

1. Michael Talbot Smith, Sound Assistance.

## SENSORS FOR AUTOMATION

**Course Code:** **EC28005**
**Credit:** **1**
**L-T-P:** **0-0-2**
**Prerequisite:** **Nil**

**COURSE OBJECTIVE**

Sensors and automation are revolutionizing the technology in the areas like consumer electronics, automotive industry, healthcare, and in other settings. The course will provide an opportunity for students to learn different sensors and its application in real world problems. It will empower the students to develop their knowledge regarding operation, application and integration of sensors to enable the design and realization a complete systems.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Learn about the microcontroller, its hardware interfacing and programming,
CO 2: Understand the working principle and characteristics of different types of sensor,
CO 3: Interface various sensor interfacing with microcontroller and display devices,
CO 4: Understand the basic principles of analog to digital conversion and its application with different sensors,
CO 5: Gain knowledge about various types of automation system, and
CO 6: Develop and implement sensor for final products in real time applications.

**COURSE DETAILS**

- Introduction to microcontroller, platform of operations with basic programming techniques
- Interfacing of serial and parallel device with microcontroller
- Interfacing of microcontroller with display devices
- Use of ADC to interface various analog sensors with microcontroller
- Introduction to sensor, measurement of physical parameters like temperature and humidity
- Application of ultrasonic and proximity sensor
- Application of gas and pressure sensor
- Application of IR sensor and RFID
- Interfacing actuators to drive DC motor (application of touch switch as actuators)
- Implement sensor in final products for real time solution

**Textbook**

1. T. Karvinen, and K. Karvinen, Getting started with sensors, Shroff Publishers, 2014.

**Reference Books**

1. J.S. Katre, Sensors in Automation, Tech Knowledge Publications, 1st Edition, 2023
2. D. Patranabis, Sensors and Transducers, PHI Learning, 2nd Edition, 2003.

## PCB DESIGN

**Course Code: EC28007**
**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Basic Electronics (EC10001)**

**COURSE OBJECTIVE**

Over the years, printed circuit board manufacturing has continued to grow in order to keep up with the increasing demands of newer, faster, and more complex electronic circuitry. This course will familiarize students to design, simulate electronics circuit and fabricate PCB for prototyping using CAD tool. This program is designed to provide a balanced foundation of theoretical knowledge and practical skills in printed circuit board design.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Understand and evaluate different electronics components,
CO 2: Create schematic and simulate the circuit using OrCAD or any other CAD tools,
CO 3: Understand single- and double-layer PCB,
CO 4: Create and fabricate PCB and analyze the PCB using screen printing method,
CO 5: Understand assembly of electronics component by soldering, and
CO 6: Analyze and test the circuit for any error.

**COURSE DETAILS**

**Description of different Electronics Component and their Identification:**
Passive and active components, component identification, Color code for resistor and disc capacitors, Inductor and their types, simple air core and iron core inductor design.

**Circuit Design and Simulation using CAD tool (OrCAD):** Design of a simple electronics circuit using data sheet and circuit schematic and simulation.

**Schematic to PCB transfer and routing:**
Schematic to PCB transfer (assigning foot prints to various components, transfer to PCB), routing, DRC, ERC, EMC.

**Screen Printing Procedure**
Preparation of screen, mask transfer

**PCB preparation and Checking of Routing**
transfer of layout to PCB using screen printing methods, etching, cleaning, error checking of routing, component mounting, soldering

**Testing and Verification**
Testing the circuit with the help of multi-meter and CRO

**Textbooks**

1. Chris Robertson, Printed Circuit Board, PHI, 2003.
2. Elaine Rhodes, Developing Printed Circuit Assemblies: From Specifications to Mass Production, 2008, ISBN: 978-1435718760.

**Reference Books**

1. Douglas Brooks, Signal Integrity Issues and Printed Circuit Board Design, PHI, 2003.
2. Kraig Mitzner, Complete PCB Design Using OrCAD Capture and PCB Editor, Newnes, 2009.
3. Open source EDA Tool KiCad Tutorial: http://kicad-pcb.org/help/tutorials/

## ELECTRONIC CIRCUITS LAB

**Course Code: EC29001**
**Credit: 1**
**L-T-P: 0-0-1**
**Prerequisite: EC10001**

### COURSE OBJECTIVE

Students will be able to gain knowledge and implement as well as simulate basic analog and digital electronic circuits (amplifier, oscillator, voltage regulator, decoder, multiplexer, counter) using discrete components and ICs. Students will have the ability to analyse, and resolve engineering problems associated with component selection, assembly and testing and get familiarization to PCB designing.

### COURSE OUTCOMES

Upon completion of this course, the students will be able to:

CO 1: Design and simulate amplifier circuit using BJT/FET and ICs.
CO 2: Design and simulate oscillator circuit using BJT/FET and ICs.
CO 3: Design and simulate filter circuit using discrete components/ICs.
CO 4: Design and simulate voltage regulator circuit using discrete components/ICs.
CO 5: Simulate and design combinational logic circuits like adders, decoders and multiplexers in Xilinx ISE and logic gate ICs.
CO 6: Simulate and design sequential logic circuits like Synchronous type counters and Asynchronous type counters in Xilinx ISE and Flip-flop ICs.

## MICROPROCESSORS & EMBEDDED SYSTEM LAB

**Course Code: EC29006**
**Credit: 1**
**L-T-P: 0-0-1**
**Prerequisite: EC21001**

### COURSE OBJECTIVE

This course aims to develop assembly level and high-level language programming skills on 8086 Microprocessor and 8051 Micro-controllers. Also, to develop the skill of designing embedded systems using ARM for various general purpose and sensing applications.

### COURSE OUTCOMES

Upon completion of this course, the students will be able to:

CO 1: Develop Assembly language programming skills on 8086 Microprocessor and 8051 Micro-controller trainer kit.

CO 2: Develop Assembly language programming skills on 8086 Microprocessor and 8051 Micro-controller using software to execute programs and interfacing circuits.
CO 3: Understand the basic hardware components and their selection method based on the characteristics and attributes of an embedded system.
CO 4: Develop the hardware software co-design and firmware design approach.
CO 5: Understand the architectural features, develop programs using instructions of ARM and C language for different applications
CO 6: Understand the need of real-time operating system for embedded system applications.

## LINEAR AND DIGITAL CONTROL SYSTEM

**Course Code: EC30003**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: EC20001**

### COURSE OBJECTIVE

This course covers concepts of open- and closed-loop systems, mathematical modeling of physical system, transfer functions, signal flow graphs, feedback theory, time domain analysis, design specifications & performance indices. This course also deals with time response of 2nd order systems, stability analysis using Routh-Hurwitz criteria and root-locus methods, frequency responses, Proportional, PI, PID controllers and Z-transform as applied to discrete-time systems with transformation from the s plane to the z-plane, Discrete state space modelling, state and output feedback designing.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Determine the transfer function and calculate the effect of feedback on gain, time constant, bandwidth, noise etc.
CO 2: Understand and analyze the working and importance of control components in a control loop.
CO 3: Apply the knowledge of performance characteristics and able to draw the response of system to different standard inputs.
CO 4: Define type and order and then calculate rise time, peak time, steady state error for standard test inputs.
CO 5: Determine the stability from characteristic equation using Routh stability criterion and Root Locus analysis and frequency response with bode plot.
CO 6: Apply the knowledge of discrete system to find the state space model and pulse transfer function and their stability.

### COURSE DETAILS

#### Introduction

Open-loop Vs Closed-loop Control Systems, Mathematical Representation of Systems, Basic understanding of systems, and transfer function using signal flow graph.

**Time Domain Analysis and Performance Criteria**

Stability Definitions and Conditions, Negative Feedback Analysis and Stability Testing, Transient Time Response: The Effect of Pole Locations, Second Order Time Response Characteristics, Steady State Response, and System Type and PID controller design

**Concept of stability**

Routh stability criterion, Root locus concept and checking stability, Frequency response bode plot, and lead lag compensator

**Sampled data control system**

Z-transform, pulse transfer function (z-transfer function), stability analysis of sampled data control systems, and Discrete state space modelling with stability analysis.

**Textbooks**


1. Nagrath, I.J., Gopal, M. (1996). Control System Engg, New Age International (P) Ltd, 2nd Ed.
2. Benjamin C. Kuo. Automatic Control Systems, Prentice Hall.


**Reference books**


1. Ogata, K. Modern Control Engg, PHI. 3rd Edn.
2. Norman Nise. Control Systems Engineering, Wiley, 3rd Edition.


## BIO-MEDICAL INSTRUMENTATION

**Course Code: EC30026**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: EC21001**

**COURSE OBJECTIVE**

This course focuses on the use of multiple sensors to monitor physiological characteristics of a human or animal. It involves measurement of biological signals like ECG, EMG, or any electrical signals generated in the human body.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to:

CO 1: Identify various bio-medical signals and instruments.
CO 2: Analyze various bio-medical transducers, sensors and their brief performance specifications.
CO 3: Analyze the principle of various bio-medical instruments, transducers used to measure temperature, pressure.
CO 4: Analyze the principle of various bio-medical instruments used to measure heart rate.

CO 5: Differentiate between various bio-medical instruments.
CO 6: Analyze applications of various bio-medical instruments in medical purposes.

**COURSE DETAILS**

**Fundamentals of Biomedical Instrumentation**
Sources of Biomedical Signals, Basic Medical Instrumentation System, Intelligent Medical Instrumentation Systems, PC Based Medical Instrumentation Systems, General Constraints & Regulations of Medical Devices.

**Biomedical Signals & Electrodes**
Origin of Bioelectric Signals-Repolarization, Depolarization, Resting Potential Recording Electrodes – Ag- AgCl Electrodes, Electrodes for ECG, EEG, EMG, Microelectrodes, Skin Contact Impedance, Motion Artifacts, Transducers used in biomedical applications.

**Blood pressure measurements**
Manual / automatic systems, invasive and non-invasive types, Sphygmomanometer, Blood flow measurements using ultrasonic and electromagnetic flowmeters.

**Heart**
Engineering analog of heart, model of heart, electrocardiograph-principle of instrument, detail instrumentation, noises and interference in the measurement, its solutions, other systems of diagnosing the heart. Pacemaker – general description and instrumentation details, Defibrillator.

**X-ray imaging**
Range for medical use, Principle of X-ray generation, Instrumentation of X- ray image.

**Computer aided tomography (CAT)**
Basic principle, Image acquisition, Mathematical modeling for reconstruction of image, Block diagram representation of the instrument and detailing of some parts.

**Surgical Diathermy**
Principle of surgical diathermy, Surgical diathermy machine, Surgical diathermy analyser.

**Patient Safety**
Electric Shock Hazards, Leakage Currents, Safety Codes for Biomedical Equipment.

**Textbooks**

1. Khandpur, R. S. Hand Book of Biomedical Instrumentation, 2nd Edition, Tata McGraw Hill.
2. Cromwell, Leslie., Weibell, Fred J., Pfeiffer, Erich A. Biomedical Instrumentation and Measurements , 2nd Edition, PHI learning Pvt. Ltd.

**Reference Book**

1. Joseph, J. Carr., John, M. Introduction to Biomedical Equipment Technology Brown, 4th Edition. Pearson Education.

## ELEMENTS OF MACHINE LEARNING

**Course Code: EE10001**
**Credit: 2**
**L-T-P: 2-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

Today, we have access to massive data which get generated through information and computer technology in our connected world. Most of these data lie unused and often overwhelm us due to their size and variety. The objective of this course is to introduce to the students to the field of learning from data, discovering data patterns, converting them into knowledge, and applying it to solve real-world problems.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Demonstrate fundamentals of machine learning,
CO 2: Identify data types, apply suitable processing and visualize using suitable methods,
CO 3: Describe Unsupervised Learning and apply clustering techniques,
CO 4: Describe Supervised Learning and apply classification techniques,
CO 5: Demonstrate perceptron and Multi-layer Perceptron models, and
CO 6: Apply machine learning techniques for real world requirement.

**COURSE DETAILS**

**Introduction**
Importance and Applications of Machine Learning, Supervised, Unsupervised, Reinforcement Learning and Evolutionary Learning.

**Data Analysis**
Measurement Scales and Data Types; Visualization, Pre-processing and Transformation of Data; Dimensionality Reduction; and Data (Dis)Similarity.

**Unsupervised Learning**
K-means and Density-based, Clustering Methods.

**Supervised Learning**
K-Nearest Neighbour, Decision Tree by Qualitative and Quantitative (information Gain method); Evaluation by Confusion Matrix of Supervised Learning Methods.

**Learning with Neural Networks**
Perceptron, Multi-layer Perceptron and, Error Backpropagation Learning.

**Textbooks**


1. Gopal, M., Applied Machine Learning, McGraw Hill Education, 2018.
2. Pradhan, M. and U. D. Kumar, Machine Learning Using Python, Wiley India Pvt. Ltd, 2019.


**Reference Books**


1. Alpaydin, E., Introduction to Machine Learning, 3rd Edition, The MIT Press, 2014.
2. Bishop. C M, Pattern Recognition and Machine Learning, Springer, 2006.
3. Jain, V. K., Big Data Science Analytics and Machine Learning, Khanna Publishers, 2021
4. Mitchell, T. M.,Machine Learning, McGraw Hill, 1997.
5. Müller, A. C.,Introduction to Machine Learning with Python, O'Reilly Media, Inc, 2016
6. Raschka, S. and V. Mirjalili, Python Machine Learning, 3rd Edition, Packt Publishing, 2019.
7. Shalev-Shwartz, S. and S. Ben-David, Understanding Machine Learning: From Theory to Algorithms, Cambridge University Press, 2014.


## BASIC ELECTRICAL ENGINEERING

**Course Code: EE10002**
**Credit: 2**
**L-T-P: 2-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

The course is designed to provide to the students a comprehensive overview of the basics of the electrical engineering discipline. In particular, the course includes fundamental aspects of DC, AC and magnetic circuit analysis, working principles and applications of machines, and safety measures used in various electrical apparatus and appliances.

**COURSE OUTCOMES**

At the end of the course the students will be able to

CO 1: analyze the concept of DC circuit,
CO 2: understand the concepts of AC circuits,
CO 3: analyze the three phase circuit,
CO 4: interpret the behavior of magnetic circuits,
CO 5: remember the principles and operation of electrical machines, and
CO 6: know the concepts of electrical safety and protection systems.

**COURSE DETAILS**

**D. C. Circuits**
Kirchhoff’s law, Source transformation, Star-delta transformation and equivalent resistance of the circuits, Mesh and Nodal analysis, Superposition theorem.

**A.C. Circuits**

Peak, average, R.M.S. values of sinusoidal quantities, Peak factor, Form factor, Phase difference, Phasor representation, AC through R, L, C, AC Series Circuit (RL, RC, RLC), Three-phase AC circuits: Voltage, current and power in star and delta connections.

**Electromagnetic Circuits**

Magnetizing Force, Reluctance, Permeance, Magnetic field, Magnetic permeability, Analogy between Electric Circuits and Magnetic Circuits. Series magnetic circuit, BH curve.

**Scope and Safety Measures**

Electrical Energy Scenario in India, Application of Transformer, Three-phase and single-phase induction Motors, Power ratings of air conditioners, PCs, laptops, printers, refrigerator, washing machine, different lamps, electricity tariff, calculation of electricity bill for domestic consumer.

**Personal Safety Measures**

Electric Shock, Earthing and its types, Safety Precautions to avoid shock.

**Equipment Safety Measures**

Working principles of fuse and miniature circuit breaker (MCB), Residual Current Circuit Breaker (RCCB).

**Textbooks**


1. V.K. Mehta, Rohit Mehta, Principles of Electrical Engineering and Electronics S. Chand and Company, New Delhi, Revised Edition 2013.
2. D.C. Kulshreshtha, Basic Electrical Engineering, Tata McGraw publication, 1st Edition 2011.
3. T.K. Nagasarkar and M.S. Sukhija, Basic Electrical Engineering, , Oxford University press, 3rd Edition 2017.


**Reference Book**


1. Sanjeev Sharma, Basics of Electrical Engineering, I.K. International, New Delhi, 3rd Reprint 2010.


## BASIC INSTRUMENTATION

**Course Code: EE10003**
**Credit: 2**
**L-T-P: 2-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

The course is designed to impart, to the students, the principles of analog and digital measuring instruments which include the working mechanisms of sensors and transducers and their applications in industrial and biomedical systems.

**Course Outcome**

At the end of this course, the students will be able to

CO 1: Know the basics of measuring instruments,
CO 2: Measure different electrical quantities,
CO 3: Understand the working principles of optical and electrical transducers and sensors,
CO 4: Understand the working of electrical transducers and sensors,
CO 5: Apply the transducers in industrial applications, and
CO 6: Use instruments in biomedical applications.

**COURSE DETAILS**

**Analog and Digital Instruments**
Basics of measuring instruments, Types of analog instruments, Measurement of voltage, current, power and energy in single and three phase circuits; Digital Instruments: Digital voltmeter, Digital multimeter, Timer/counter, and Time, phase and frequency measurements in oscilloscope.

**Sensors and Transducers**
Optical sources and detectors: LED, photo-diode, light dependent resistor; Basics of fiber optic sensing, IR Sensors. Resistive, capacitive, inductive, piezoelectric, and Hall effect sensors, Temperature transducers: Thermocouple, RTD, and thermistor.

**Transducers in Industrial Applications**
Measurement of displacement (linear and angular), velocity, acceleration, force, torque, vibration, shock, pressure, flow, liquid level, pH, conductivity and viscosity.

**Instruments in biomedical applications**
ECG, Blood Pressure measurement, CT scan, and Sonography

**Textbook**


1. R.K. Rajput, Electrical and Electronic Measurements and Instruments, S. Chand Publication, 4$^{th}$ Edition, 2015, William David Cooper, Electronic Instrumentation and Measurement Techniques, by PHI, 2010.


**Reference Books**


1. R.K. Jain, Mechanical and Industrial Measurements (Process Instrumentation and Control), Khanna Publishers, 1995.
2. A.K. Sawhney, A course in Electrical and Electronics Measurements and Instrumentation Dhanpat Rai Publication, 10$^{th}$ Edition, 2012.
3. D. Patranabis, Sensors and Transducers, PHI Publication, 2$^{nd}$ Edition, 2017.

## DC, AC AND SPECIAL ELECTRICAL MACHINES

**Course Code: EE20009**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite(s): Nil**

### COURSE OBJECTIVE

To understand construction, working principles, testing and control of different electrical machines and their industrial and domestic applications.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to:

CO 1: Analyse the construction, basic principle, types, characteristics and applications of DC Machines.
CO 2: Estimate the performance of Transformer.
CO 3: Measure the emf generated, voltage regulation of an alternator
CO 4. Outline the construction, principle of operation, types, speed control, starting and applications of three phase induction motor
CO 5: Discuss the principle, types and application of single-phase Induction Motor.
CO 6: Prioritize the performance of various special electrical machines with their Industrial applications.

### COURSE DETAILS

**DC machines**
DC Generator: Principle of Operation, Different Parts, Emf equation, Different types and their characteristics, and Applications.
DC Motor: Principle, Concepts of back emf, Voltage and power equation, Types and their characteristics, Armature and shaft torque, Different methods of speed control of DC shunt motor, Applications. Necessity of starter, 3-point starter. Losses and eefficiency of DC machines

**Transformer**
Single phase transformer: Principle of operation, Types, Emf equation, Ideal and practical transformer, Transformer without and with load, Exact equivalent circuit and phasor diagram, Open circuit and short circuit test, Losses, Efficiency and regulation, and Applications.
Three phase transformer: Principle, Connections, and Applications.

**Three-phase AC machines**

**Three-phase synchronous machine**
Alternator: Principles, Construction, Types, EMF equation of alternator, Voltage regulation by synchronous impedance method, Synchronous Motor: Construction, Principle of operation, Applications.

**Three-phase induction motor**

Principle of operation, Construction, Types, Torque equation, Torque slip characteristics, Starting torque and maximum torque, Losses and efficiency, Different methods of speed control and method of starting, and Applications.

**Single phase induction motors and special motors**

**Single phase induction motors**

Operating Principle, Types and Applications

**Special motors**

Principle, Operation and applications of stepper motor, Shaded pole motor, Repulsion motor, Universal motor, Reluctance motor, and Hysteresis motor,

**Textbooks**


1. Theraja, B. L. (2010). Electrical Technology, Volume -II. S. Chand Publications.
2. Mukherjee, P. K., Chakravorti, S. (2013). Electrical Machines, Dhanpat Rai Publication.


**Reference books**


1. Hussain, A. (2008). Electrical Machines, Dhanpat Rai, Delhi, 2nd Edition.
2. Bimbhra, P. S. (2008). Electrical Machinery, 7th Edition, Khanna Publishers.
3. Hubert, C. I. (2003). Electric Machines, Pearson Education, 2nd Edition.
4. Kothari, D.P., Nagrath, I. J. (2004). Electric Machines, 3rd Edition., Tata McGraw-Hill, New Delhi.


## INDUSTRIAL WIRING AND CONTROL PANEL DESIGN

**Course Code: EE28011**
**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

This vocational course will provide an overview of electrical occupations, including the training and the employment options available in electrical industry. It is also designed to provide related training in the electrical trade that will give students the proper coursework in installation and designing of control panel.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Realise the purpose and general principles of control components and circuits,

CO 2: Install Industrial wiring circuits according to given specification and plan, CO 3: Analyze circuit operations on basic motors (3ø induction Motor),

CO 4: Interpret and install circuits according to rules and regulations of the National Electrical Codebook,

CO 5: Connect motor controllers for specific applications with emphasis on safety practices and in accordance with National Electrical Code (NEC) requirements, and

CO 6: Select and size contactors, relays and timing relays and overload relays both physically and schematically and describe their operating principles.

**COURSE DETAILS**

- Design multiwire circuit for a direct motor starter (DoL) with one operating (forward) direction using QElectrotech software.
- Design multiwire circuit for a direct motor starter (DoL) with two operating (forward & reverse) direction using QElectrotech software.
- Design multiwire circuit for a Star – Delta motor stator with one operating (forward) direction using QElectrotech software.
- Design multiwire circuit for a Star – Delta motor stator with two operating (forward & reverse) direction using QElectrotech software.
- Design & connect for a direct motor starter (DoL) with one operating (forward) direction in modular set up.
- Design & connect for a direct motor starter (DoL) with two operating (forward & reverse) direction in modular setup.
- Design & connect for a Star – Delta motor stator with one operating (forward) direction in modular set up.
- Design & connect for a Star – Delta motor stator with two operating (forward& reverse) direction in modular set up.
- Install & wire for a direct motor starter (DoL) with one operating (forward) direction in Industrial Control Panel.
- Install & wire for a direct motor starter (DoL) with two operating (forward & reverse) direction in Industrial Control Panel.
- Install & wire for a Star – Delta motor stator with one operating (forward) direction in Industrial Control Panel.
- Install & wire for a Star – Delta motor stator with two operating (forward & reverse) direction in Industrial Control Panel.

**Reference Books**


1. Tarlok Singh, Installation, commissioning and maintenance of electrical equipment.
2. B.P. Patel and M.A. Chaudhari, Industrial Electrical Systems.

# INSTALLATION, OPERATION AND MAINTENANCE OF SOLAR POWER SYSTEM

**Course Code: EE28013**
**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

To impart job-oriented training to students and make them well convergent on Installation, operation & maintenance of solar PV system. This vocational course is based on study of solar photovoltaic (PV) cells, modules, and system components; electrical circuits; PV system design and sizing for use on homes, commercial building etc., understanding energy conversion from sunlight to electricity, and working with solar conversion equipment. This Course will give students the book knowledge and hands on experience needed to become entrepreneur / self-employed.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Demonstrate and apply the knowledge of solar electric systems terms and concepts,
CO 2: Size and design a photo voltaic system,
CO 3: Mount, ground, position, install, wire and connect a photo voltaic system,
CO 4: Test voltage generated by photo voltaic system,
CO 5: Learn different types of solar PV modules and batteries used in solar PV plant, and
CO 6: Design of solar PV plant based on estimated loads.

**COURSE DETAILS**

- To demonstrate the I-V and P-V Characteristics of PV module with varying radiation and temperature level.
- To demonstrate the I-V and P-V characteristics of series and parallel combination of PV modules.
- To show the effect of variation in tilt angle on PV module power.
- To demonstrate the effect of shading on module output power.
- To demonstrate the working of diode as bypass diode and blocking diode.
- To draw the charging and discharging characteristics of battery.
- Observe the output waveform of the inverter in auto mode.
- Workout power flow calculations of standalone PV system of AC load with battery.
- Workout power flow calculations of standalone PV system of DC load with battery.
- Find the MPP manually by varying the resistive load across the PV panel.

**Reference Books**


1. Chetan Singh Solanki, Solar Photo Voltaic Technology and Systems.
2. B.H. Khan, Non-Conventional Energy Resources.
3. P. Sukhatme, Solar Energy - Principles of Thermal Collection and Storage.
4. G.N. Tiwari, Solar Energy: Fundamentals, Design, Modelling and Applications.

# DOMESTIC WIRING AND HOME AUTOMATION

**Course Code: EE28015**
**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Nil**

## COURSE OBJECTIVE

This vocational course will provide an overview of electrical occupations, including the training and the employment options available in electrical consultancy. It is also designed to provide related training in the electrical wing that will give students the proper coursework in installation and designing of domestic wiring and home automation.To develop electrical wiring skills in students through systematic training that would enable the students to construct and test various electrical circuits using appropriate electrician tools, wires, protective devices and wiring accessories as per IS standards.

## COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Use appropriate electrician tools, wires, protective devices and wiring accessories,
CO 2: Rig up wiring diagrams using conduit system of wiring,
CO 3: Apply IS standards for electrical wiring,
CO 4: Prepare different types of wiring joints,
CO 5: Well convergent in drawing electrical wiring circuit, and
CO 6: Enhancement of knowledge regarding specification and application of different electrical devices.

## COURSE DETAILS

- Perform the assembly, wiring and implementation of a single switch (SPST Switch) in circuit.
- Perform the assembly, wiring and implementation of a Double switch (SPST Switch) in circuit.
- Perform the assembly, wiring and implementation of a power socket in circuit.
- Perform the assembly, wiring and implementation of a controlled power socket circuit in housing.
- Perform the assembly, wiring and implementation of a two ways switches (SPDT Switch) in circuit.
- Perform the assembly, wiring and implementation of a impulse relay in circuit.
- Perform the assembly, wiring and implementation of a time switch in circuit
- Perform the assembly, the wiring and the implementation of a timer lighting in circuit.
- Perform the assembly, the wiring and the implementation of a twilight switch in circuit in house or in a shop.
- Perform the assembly, wiring and implementation of a controlled lighting in circuit (time switch, timer, twilight switch).
- Perform the assembly, the wiring and the implementation of a water heater in circuit.
- Perform the assembly, wiring and implementation of a central impulse relay in circuit.
- Study and implementation of Light sensitive switch.
- Perform the assembly, wiring and implementation of a fan in circuit.
- Perform the assembly, wiring and implementation of a distribution panel.
- Home automation using KNX technology.
- Application of Load shedding contactor and programmable time switch.

**Reference Books**


1. Frederic Marsh, Home Automation - A Smart Home Guide: The Beginner’s Manual Including Google Home, Echo Dot and Amazon Alexa. Easy Instructions, Directions and Commands ... and Home Automation Guide Series Book 1, Kindle Edition.
2. James Gerhart, Home Automation and Wiring.


## CYBER PHYSICS APPLICATION IN INDUSTRIAL IOT

**Course Code: EE28017**
**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

The students will utilize the principles of Cyber-Physical Systems (CPS) and Internet of Things (IoT) to develop applications, implement IoT applications by selecting appropriate hardware and software platform and also Develop IoT applications using open-source platforms.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Basics of cyber physics components,

CO 2: Understanding of sensors and actuators,

CO 3: Layout diagram of open source microcontroller board,

CO 4: Understanding of analog and digital I/O for cyber-physics,

CO 5: Understanding of different protocols for IoT connectivity, and

CO 6: Basic architecture for IoT enabled Cyber Physics.

**COURSE DETAILS**

**1. CYBER PHYSICAL SYSTEM (THEORY)**

- CPS Realworld.
- Design and Validation of CPS.
- Smart city application CPS.
- CPS Hardware Platforms (Process, Sensors and Actuators).

**2. Industry 4.0**

- IOT Fundamentals and protocols including layers.
- Sensor and Interfacing.

**Hands on Practice**

- Architecture and pin diagram of Arduino UNO/MEGA and ESP8266
- IDE installation for open source C++ or Phython

- Analog and Digital voltage sensing and processing through Firmware
- Analog and Digital voltage based actuator through Firmware
- Display OLED/Seven segment integration through IDE
- PCB Design Concept and implementation with uC.
- Implementation of UI/UX through RestAPI based Thing speak
- DATA logging and Generating CSV through Rest API
- Writing a Firmware for ESP-8266 or NODEMCU (programming based knowledge)
- IoT based transformer / condition monitoring system

**Reference Books**


1. Adrian McEwen, Hakim Cassimally, Designing the Internet of Things.
2. Asoke K Talukder and Roopa R Yavagal, Mobile Computing, Tata McGraw Hill, 2010.
3. Tanenbaum, Andrew S, Computer Networks, Pearson Education Pte. Ltd., Delhi, 4th Edition
4. Stallings, William, Data and Computer Communications, Pearson Education Pte. Ltd., Delhi, 6th Edition.
5. F. Adelstein and S.K.S. Gupta, "Fundamentals of Mobile and Pervasive Computing," McGraw Hill, 2009.


## INDUSTRIAL CONTROL AND REMOTE MONITORING

**Course Code: EE28019**
**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

To provide hands on experience in developing Industrial Control and remote monitoring by using PLC (Programmable logic Controller), thus by utilizing it in Process control applications.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Know about typical components of a Programmable Logic Controller,
CO 2: Know the concept of Electrical ladder logic and its relationship to PLC instructions,
CO 3: Understand the concept of digital electronics and data acquisition,
CO 4: Program PLC logical switching circuits for industrial applications,
CO 5: Choose and utilize Timer, Counter, and other intermediate programming functions, and
CO 6: Design and program automated industrial production line.

**COURSE DETAILS**

**1. Programmable logic Controller SYSTEM. (THEORY)**

- Introduction to Industrial Automation.
- Introduction to PLC programmable logic controller

- PLCs & related software and its major Components
- Relay logic Hardware Platforms (Switches, Sensors and Actuators).
- Study of Contactors, Timers, Counter and Comparator

**2. Human Machine interface**

- Introduction to HMI Communication with PLC
- HMI tags and Assignments
- Project on Industrial load sequential feedback control Using PLC HMI

**Hands on Practice**

- Introduction of PLC SOFTWARE as TIA Portal
- Ladder Programming for Basic gates logics by using SPST Contacts
- Ladder Programming on SPDT
- Latching Concept and related Latching program
- Study of program memory and Programming on Memory Bits
- Study of TIMER BLOCKs and its Programming
- Introduction to COMPARATOR BLOCK and its Programming
- Introduction to COUNTER BLOCK and its Types with Programming
- Project on Industrial Load OFF/ON control Using PLC and HMI
- Introduction to analog Logic in PLC and its Programming

**Reference Books**


1. Vijay R. Jadhav, Programmable logic Controller, KHANNA PUBLISHERS, 2nd Edition, 2012.
2. R.G Jamkar, Industrial Automation Using PLC, SCADA and DCS, Laxmi Publications Private Limited.
3. PLC and SCADA by Prof Rajesh Mehra and Er. Vikrant Vij Published by University Science Press.
4. John R Hackworth and Frederick D. Hackworth Jr., Programmable logic Controller: Programming methods and Applications, PEARSON Edition: 1st Edition, 2006.


## DC, AC AND SPECIAL MACHINES LAB

**Course Code: EE29007**
**Credit: 1**
**L-T-P: 0-0-1**
**Prerequisite: EE20009**

**COURSE DESCRIPTION**

The main objective of this laboratory is to provide the practical exposure to the student regarding operation of various electrical machines like DC generators, DC Motors, Alternators, Synchronous motors, Induction Motors, Special Motors and Transformers. Students are allowed to conduct various experiments for the validation of performance characteristics of all the machines. From this laboratory courses student will gain the skill to select correct machine for a specific application.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to:

CO 1: Memorize the working principle and applications of different electrical machines.
CO 2: Discuss the problems in industrial applications of electric motors.
CO 3: Demonstrate of different electrical machines.
CO 4: Distinguish between the different electrical machine according to the requirement in the industrialapplications.
CO 5: Learn about the safety precautions to be taken while using electrical equipment.
CO 6: Design the equivalent circuit of the transformer and construct the circle diagram of an induction motor.

**TOPICS**

- No Load and Load Characteristics of a (i) D.C Shunt Generator and (ii) Separately ExcitedGenerator
- Calculate the efficiency and losses of a single-phase transformer by the open circuit and shortcircuit test
- Design of the circle diagram using the No load and Block rotor test on three-phase inductionmotor
- Determine the load characteristics of Stepper motor

**Textbooks**


1. Bimbhra, P. S. (2008). Electrical Machinery, 7th Edition, Khanna Publishers.
2. Mukherjee, P. K., Chakravorti, S. (2013). Electrical Machines, Dhanpat Rai Publication.


**Reference books**


1. Hussain, A. (2008). Electrical Machines, Dhanpat Rai, Delhi, 2$^{nd}$ Edition.
2. Theraja, B. L. (2010). Electrical Technology, Volume (II). S. Chand Publications.
3. Hubert, C. I. (2003). Electric Machines, Pearson Education, 2$^{nd}$ Edition.
4. Kothari, D.P., Nagrath, I. J. (2004). Electric Machines, 3$^{rd}$ Edn., Tata McGraw-Hill, New Delhi.

# POWER ELECTRONICS AND DRIVES

**Course Code: EE30005**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: EE20009**

## COURSE OBJECTIVE

It aims to familiarize readers with switching devices, power converters, and their uses in different power industrial drive systems.

## COURSE OUTCOMES

After successfully completing the course, the students will be able to:

CO 1: Understand the working principles of different power electronics devices.
CO 2: Analyze the concepts of single phase and three phase controlled rectifiers.
CO 3: Compare different topologies of DC to DC converters.
CO 4: Analyze the control of single phase and three phase Inverters
CO 5: Explain the operation of power factor correction circuit and MLI
CO 6: Discuss the different industrial drive system.

## COURSE DETAILS

**Introduction to Power Electronics**
Comparison of power devices operating in the switch mode to those operating in the active region.

**Power Electronic Devices**
Thyristor characteristics, Turn ON methods, Dynamic Characteristics of thyristors, Two Transistor Model of thyristor, Characteristics and construction of Power MOSFETS, Characteristics construction of IGBT, and SiC based power devices and applications.

**AC to DC Converters**
Single Phase Converters – Half Wave with R, RL, RLE load and effect of free Wheeling diode, Single Phase half and full controlled full Wave converters with R and RLE Load, 3 Phase half and fully controlled rectifiers, and Power factor correction circuit.

**DC to DC Converters**
Step up and Step Down choppers, basic concepts of bi-directional converter, and Forward and Flyback converters.

**Inverters**
Single Phase Half Bridge and Full Bridge Inverters, 3 Phase Inverters, 180° and $120^0$ conduction, Voltage Control of inverters, Sinusoidal Pulse Width Modulation, and Concept of multi-level inverters.

**Electric Drives**

Different loading and operating points of speed torque characteristics, Selection of motors, Steady state stability, load Equalization, D.C. Motor Speed control, 4 quadrant choppers for control of DC motor, and A.C. Drives: variable frequency drives.

**Textbooks**

1. Rashid, M. H. (2017). Power Electronics, Devices, Circuits & Applications, Pearson Education, 4th Edition.
2. Bhimbra, P.S. (2022). Power Electronics, by, Khanna Publishers, 7th Edition.
3. Dubey, G.K. (2010). Electrical Drives, Narosa Publishing House Pvt Ltd, Second Edition.

**Reference books**

1. Singh, M.D., Khanchandani, K.B. (2007). Power Electronics, Tata McGraw-Hill publishers, Second Edition.
2. Mohan, N., Undeland & Robbins. (2009). Power Electronics, Converters, Applications and Design, John Wiley and Sons, Third Edition.
3. Krishnan, R. (2015). Electric Motor Drives: Modeling, Analysis and Control, Pearson Education India, 1st Edition.

## POWER ELECTRONICS AND DRIVES LAB

**Course Code: EE39005**
**Credit: 1**
**L-T-P: 0-0-1**
**Prerequisite: Nil**

**COURSE DESCRIPTION**

This course utilizes the knowledge of Power Electronic to verify AC-DC converters, which are examined in details with R and RL loads. Analysis of DC-DC converters are done so that experimental verification can be facilitated. The waveforms and the output voltage equation of SMPS are experimentally verified. It also imparts knowledge on performance of the fundamental control practices associated with AC and DC machines (starting, reversing, braking, plugging, etc.) using power electronics. Students will perform experiments related to topics studied in electric drives like various DC and AC motor drives and their control.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to:

CO 1: Choose an appropriate converter for variety of needs.
CO 2: Comprehend the principles of operation of various converters.

CO 3: Apply AC-DC converters for rectification.
CO 4: Analyze the parameters and the waveforms of the output of the converters.
CO 5: Evaluate the electrical and mechanical parameters of a given motor.
CO 6: Design different DC and AC motor drives electric drive industrial and domestic applications.

**TOPICS**

- Study of output voltage waveforms and parameters of three phase uncontrolled rectifier.
- Study of single phase fully controlled AC-DC converter with R and RL laod.
- Verify the performance of DC-DC converters.
- Speed control of separately excited DC motor by armature voltage control method using singlephase fully controlled AC to DC converter with and without load.
- Speed control of 3 phase squirrel cage induction motor using V/F control method.

**Textbooks**

1. Dubey, G.K. (2007). Fundamentals of Electric Drives, Second Edition, Narosa Publishers.
2. Pillai, S.K. (2007). A First Course on Electrical Drives, New Age International Publishers, 2nd Ed.

**Reference books**

1. Bose, Bimal. K. (2006). Power Electronics and Motor Drives: Advances and Trends, Academic Press.
2. De, N.K., Sen, P.K. (2004). Electric Drives, PHI Learning Pvt. Ltd., 7th Edition.
3. Bose, Bimal. K. (2013). Modern Power Electronics and AC Drives, PHI Publisher, 1st Ed.
4. Nasar, S.A., Boldea. (2006). Electrical Drives, CRC Press, Second Edition.
5. El-Sharkawi, M.A. (2000). Fundamentals of Electrical Drives, Thomson Learning, 1st Ed.
6. Krishnan, R. (2003). Electrical Motor Drives, PHI.

## COMPUTER VISION

**Course Code: EM30003**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite(s): MA11001, MA11002**

**COURSE OBJECTIVE**

The challenge of computer vision is to develop a computer based system with the capabilities of the human eye-brain system. It is therefore primarily concerned with the problem of capturing and making sense of digital images. The field draws heavily on many subjects including digital image processing, artificial intelligence, computer graphics and psychology. The objectives are to develop students' understanding of the basic principles and techniques of image processing, image understanding, and to develop skillsets in the design and implementation of computer vision techniques.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Explain the image formation and camera technologies.
CO 2: Perform feature extraction using different image processing techniques.
CO 3: Differentiate between image formats.
CO 4: Perform image transformation based on different types of transformation techniques.
CO 5: Design filters to perform image analysis using spatial and frequency domain methods.
CO 6: Design systems to detect and track various objects.

**COURSE DETAILS**

**Digital Image Fundamentals**
Elements of visual perception, A simple image model, Sampling and quantization, Relationship between pixels, Image geometry: Translation, Rotation.

**Image Analysis**
Introduction spatial domain methods, Frequency domain method, Enhancement by point processing: Histogram equalization, Spatial filtering: Mean & Median filter, Sharpening filter, High boost filters, derivative filters, Enhancement in frequency domain, Homomorphic filtering.

**Image Transform Review of mathematical preliminaries**
Toeplitz and circulant matrices, Orthogonal and unitary matrices, Block matrices and Kronecker products, Separable operators, Introduction to image transforms, Two dimensional orthogonal and unitary transforms, Properties of unitary transforms, 2-D DFT, Walsh Transforms, Hadamard transform, Discrete Cosine Transform (DCT), Karhunan-Lauve (K-L) Transform, SVD Transform.

**Feature Extraction**
Edges Canny, Sobel, Line detectors (Hough Transform), Corners -Harris and Hessian Affine, Orientation Histogram, SIFT, SURF, Feature analysis, Feature vectors, distance/similarity measures.

**Object Representation and Tracking**
Object detection, Face detection, Pedestrian detection, Face recognition: Eigen faces, Active appearance and 3D shape models. Object representation, Motion detection and tracking, Background Subtraction and Modelling, Optical Flow. Point tracking, Kernel tracking, Introduction to Yolo.

**Machine Learning for Computer Vision**
Neural Architecture, deep learning use cases, datasets for Machine perception, Training Pipeline, building sequential model using Keras and CV2, Transfer learning.

**Textbooks**

1. Szeliski, Richard. (2011). Computer Vision: Algorithms and Applications, Springer-Verlag London Limited.
2. Lakshmanan, Valliappa., Görner, Martin., Gillard, Ryan. (2021). Practical Machine Learning for Computer Vision, Publisher(s): O'Reilly Media, Inc., ISBN: 9781098102364.
3. Forsyth, D. A., Ponce, J. (2003). Computer Vision: A Modern Approach, Pearson Education.

**Reference books**

1. Davis, E.R. Computer and Machine Vision Theory, Algorithms, Practicalities, Academic Press,4th Edition.
2. Gonzalez, R.C., Woods, R.E. (1992). Digital Image Processing, Addison- Wesley.
3. Bradski, G., & Kaehler, A. (2008). Learning Open CV: Computer vision with the OpenCV library. " O'Reilly Media, Inc."
4. Hartley, R., & Zisserman, A. (2003). Multiple view geometry in computer vision. Cambridge university press.

## COMMUNITY/ENVIRONMENT-BASED GROUP PROJECT

**Course Code: EX17001**
**Credit: 2**
**L-T-P: 0-0-4**
**Prerequisite: Nil**

### COURSE OBJECTIVE

This course is offered to give the students an opportunity to connect with the community and the environment, learn and prioritize their problems, and define the problems in ways that make them amenable to scientific analysis and pragmatic solution. Appreciating the community problems, visualizing and experiencing them in person, self-learning, applying to realities, searching for and finding implementable solutions are the primary benefits of this project-based course.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Identify need of the community,
CO 2: Formulate objective of a project,
CO 3: Communicate orally and through formal technical write-ups,
CO 4: Analyze and interpret data wherever essential,
CO 5: Provide an implementable solution to the problem, and
CO 6: Work in team following ethical manners.

## COURSE DETAILS

The projects will be applied to problems uppermost in the minds of the community regarding the problems that they confront regularly. The problems may range from social inequality and social justice to lack of common services such as health, education, water, power, banking, and from lack of access to government subsidies and policies to deforestation and environmental problems.

# INDUSTRY 4.0 TECHNOLOGIES

**Course Code: EX20001**
**Credit: 2**
**L-T-P: 2-0-0**
**Prerequisite: Nil**

### COURSE OBJECTIVE

The current manufacturing industries and businesses are moving from the third industrial revolution of the computers and automation to the fourth where the automation becomes even smarter fueled by data analytic and artificial intelligence. This course is designed to offer learners an introduction to use of Internet and Digital technology for better manufacturing and business. Learners will gain deep insights into how smartness is being harnessed from data and appreciate what needs to be done in order to overcome some of the challenges.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

- CO 1: Understand the key components and enablers of Industry 4.0 Technology,
- CO 2: Appreciate the smartness in Smart Factories, smart products and smart Services,
- CO 3: Outline Smart Factory technologies and their role in an Industry 4.0 world,
- CO 4: Outline IoT technology and scope of implementing IoT in Industries and businesses,
- CO 5: Comprehend distributed cyber-physical and digital manufacturing system, and
- CO 6: Demonstrate the opportunities, challenges brought about by Industry 4.0 and how organizations and individuals should prepare to reap the benefits.

### COURSE DETAILS

**Introduction**
The Fourth Industrial Revolution, Difference between conventional automation and Industry 4.0, Case Studies: Health, Agriculture, Manufacturing.

**Industry 4.0 and its components**
Internet of Things (IoT) & Industrial Internet of Things (IIoT), Internet of Services, Value chains in manufacturing companies, Digital Twins.

**Digital Manufacturing and Design**
Cyber Physical Systems and Next Generation sensors, Collaborative Platform and Product Life-cycle Management, Robotics and Automation.

**Industrial IoT**
Cloud Computing, Big Data Analytic, AI & ML, Virtual and Augmented Reality, Block-chain.

**Challenges & Opportunities in Industry 4.0**
A Digital Strategy alongside Resource Scarcity, Standards and Data security, Financing conditions, availability of skilled workers, Comprehensive broadband infra- structure, Legal framework, protection of corporate data, liability, handling personal data.

**Textbooks**


1. D. Pyo, J. Hwang, and Y. Yoon, Tech Trends of the 4th Industrial Revolution, Mercury Learning & Information publisher, 2021.
2. Bruno S. Sergi, Elena G. Popkova, Aleksei V. Bogoviz, and Tatiana N. Litvinova Understanding Industry 4.0: AI, the Internet of Things, and the Future of Work, Pub: Emerald Publishing Limited, 2019.


**Reference Books**


1. S. Misra, A. Mukherjee, and A. Roy, Introduction to IoT. Cambridge University Press, 1st Edition, 2021.
2. Dac-Nhuong Le, Chung Van Le, Jolanda G. Tromp, Gia Nhu Nguyen, Emerging Technologies for Health and Medicine: Virtual Reality, Augmented Reality, Artificial Intelligence, Internet of Things, Robotics, Industry 4.0, John Wiley publisher, 2018.
3. Alasdair Gilchrist, Industry 4.0: The Industrial Internet of Things, Apress Berkeley publisher, CA 1st Edition, 2016.


## SCIENTIFIC AND TECHNICAL WRITING

**Course Code: EX20003**
**Credit: 2**
**L-T-P: 2-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

Technical documents take many forms depending on their purpose and the audience. A technical document can be a project proposal, minutes of a meeting, an advertisement in a newspaper, or even a research paper. A scientific document is a form of technical document where both the author and the audience are experts. The writing styles and the document density of technical documents depend on the nature of the document. The objective of this course is to train the students in the art and science of writing a range of scientific and technical documents.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Realize the need to articulate the purpose of the document, identify its audience, and decide the density of information to be included in scientific and technical documents,
CO 2: Internalize the art and science of scientific and technical writing,
CO 4: Make appropriate use of crisp language, illustrations, and symbols,
CO 4: Distinguish between bad and good writing (Analyze and Evaluate),
CO 5: Prepare a variety of scientific and technical documents, including laboratory and project reports,
CO 6: Write these documents in an accurate, clear, concise, coherent, appropriate, and readable manner.

**COURSE DETAILS**

**Introduction**
Forms and features of creative, technical, scientific, and science writing; Audience types (general and specific experts, technicians, managers, laypersons, and mixed audience); Examples of documents for technical, professional, and scientific communications; Characteristics of effective technical writing: Accuracy, clarity, conciseness, coherence, appropriateness, and readability.

**Language Issues**
Revisiting English grammar; Punctuation (period, comma, colon, semicolon, question mark, exclamatory mark, apostrophe, quotation marks, hyphen, dash, parentheses, and brackets); Mechanics (capitalization, italics, abbreviations, acronyms); Latin terms used popularly in English texts; Informal and colloquial English; Dangling modifiers, Faulty parallelism, Judicious use of common words and phrases; Active and passive voice; Nominalization; Common English errors; Pitfalls in writing; Adapting texts to issues of gender, race, and ethnicity; and Guarding against Plagiarism.

**Paragraphing**
Unity of idea, topic sentence, logical and verbal bridges through use of signposts, transitions, and link words; Patterns of development of an idea; and Lists.

**Structure of Scientific Documents**

Prefatory Materials: Title, Copyright Notice, Declaration and Certificates, Abstract, Keywords, Acknowledgements and Conflict of Interest Statement, Symbols and Abbreviations, and Table of Contents.
Body of Scientific Documents: Introductory Materials—Context, problem and current response, research questions, hypotheses, and objectives and scope; Literature Review—Presentation styles, citations and referencing systems, quoting, paraphrasing, and summarizing; Materials and Methods—Mathematical Materials: Methodology, methods, tools, and techniques; Quantitative, qualitative, experimental, and mixed methods; Numbers and numerals, engineering and scientific notations of numbers, mathematical operators, equations, flowcharts, algorithms, SI units, significant digits and order of magnitude, figures, tables, and photographs; Experimental apparatus, materials, specifications, measuring instruments, procedure, data analysis; Concluding Materials—Conclusions, implications, generalization, limitations, scope for further work, and contributions of the work.

End Matters: References, Appendixes, and Supplementary materials.

**Structure of Selected Technical Documents**
PowerPoint presentation, Abstract of a paper, Laboratory reports, Progress report, Project proposal, Minutes of a meeting, Brochure, and News items.

**Reference Books**


1. Lecture notes on Scientific and Technical Writing.
2. Alred, G. J., C. T. Brusaw, and W. E. Oliu (2008), *Handbook of Technical Writing*, St. Martin's Press, New York, 9th Edition.
3. Angelika H. Hofmann (2014), Scientific Writing and Communication, Papers, Proposals, and Presentations, Oxford: Oxford University Press.
4. Duke Graduate School Scientific Writing Resource (https://sites.duke.edu/scientificwriting/).
5. Gerald. J. Alred, Charles. T. Brusaw, and Walter. E. Oliu (2008), *Handbook of Technical Writing*, St. Martin's Press, New York, Ninth Edition.
6. OWL, The Purdue Online Writing Laboratory, https://owl.english.purdue.edu/owl/.
7. Perelman, L. C., J. Paradis, and E. Barrett (1998), The Mayfield Handbook of Technical and Scientific Writing, Mayfield Publishing (ed.), Available free at http://www.mhhe.com/mayfieldpub/tsw/toc.htm, Mayfield Publishing Company, Inc., 1280 Villa Street, Mountain View, CA 94041, 415.960.3222, <http://www.mayfieldpub.com>, <mailto:hypertext@mayfieldpub.com>.
8. Rubens, P. (2001), Science and Technical Writing: A Manual of Style, 2nd Edition, Routledge, New York.


## RESEARCH METHODS AND ETHICS

**Course Code: EX40001**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

The objective of this course is to introduce to the undergraduate students the various elements and methods of ethically conducting a piece of scientific research.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Select research topics and formulate research questions,
CO 2: Conduct a literature search and make a review of literature,
CO 3: Get acquainted with a range of qualitative, quantitative, experimental, and theoretical methods of research,
CO 4: Become familiar with the techniques of data collection, analysis, and interpretation,
CO 5: Understand the importance of research ethics and the implications of the broader impact of research, and
CO 6: Conduct research with honesty and integrity.

**COURSE DETAILS**

**Introduction to research**
Structure of research: Scientific method and Engineering design cycle, Defining and scoping Research problems, Formulating research objectives and research questions.

**Literature Review**
Searching for literature; Narrative and systematic literature review; Summarizing, paraphrasing, and quoting; and Referencing styles.

**Design of Experiments**
Basic Principles of randomization, replication, and Blocking; Factors and Responses; Analysis of variance, Experiments with blocking factors, and Factorial designs.

**Data Analytics**
Data pre-processing; Data visualization; Tests of hypothesis; Decision trees; and Artificial neural networks.

**Theoretical Models**
Typology of models; Optimization models, forecasting models, and control models; Monte Carlo simulation; Genetic Algorithm; Model verification and validation; and Measurement and uncertainty analysis.

**Drawing Inferences**
Drawing inferences, Generalizing, Finding potential applications, Imagining future scope, and Highlighting novelty of research.

**Research Ethics**
Ethics and morality; Utilitarian and deontological theories of ethics; Fabrication, falsification, plagiarism, and questionable research practices; Issues related to privacy and confidentiality; and Ethical issues related to publications.

**Reference Books**


1. Dunn, P. K. (2021), Scientific Research and Methodology: Tutorials, An Introduction to Quantitative Research and Statistics in Science, Engineering, and Health: Tutorials, Available free at https://bookdown.org/pkaldunn/SRM-tutorials/.
2. Dunn, P. K. (2021), Scientific Research and Methodology: Software, An Introduction to Quantitative Research and Statistics in Science, Engineering, and Health: Using Software, Available free at https://bookdown.org/pkaldunn/SRM-software/. (Uses Jamovi and SPSS Software, Jamovi is a freely downable software)
3. Lectures note on Research Methods and Ethics provide by Concerned faculty members.

# ENGINEERING PROFESSIONAL PRACTICE

**Course Code: EX40003**
**Credit: 2**
**L-T-P: 2-0-0**
**Prerequisite: Nil**

## COURSE OBJECTIVE

Engineers are expected to perform their tasks responsibly and ethically, following professional standards and guidelines. This course allows the students to understand the roles and responsibilities of engineers in society, learn professional standards, codes of ethics, issues concerning employment contracts and other legal matters, and skills of working in teams, and to effectively communicate.

## COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Know (a) the features of engineering as a profession, (b) the roles and responsibilities of engineers in society, and (c) the skills for working in teams,
CO 2: Realize the use of professional standards, codes of ethics, legal provisions surrounding engineering functions,
CO 3: Apply the above-stated standards, codes, legal provisions, and group communication skills in their decision-making situations,
CO 4: Break down a complex problem into smaller manageable tasks,
CO 5: Compare among alternatives in situations of uncertainty, risk, and ambiguity, and
CO 6: Design engineering solutions to industrial environmental and social problems.

## COURSE DETAILS

**Engineering and Engineer**
Engineering as a discipline and a profession; Attributes and functions of a practicing engineer; and Engineer as a problem solver, designer, and change agent.

**Selected Functions of Engineering**
Designing for safety and reliability; Quality and productivity management; Dealing with problem complexity, uncertainty, risk, and ambiguity; Project management; and Managerial functions such as planning, organizing, motivating, and controlling; Costing and accounting.

**Professional Aspects of Engineering**
Accreditation, certification, and licensing; Ethical issues: Ethics and morality, ethical dilemmas, codes of ethics, professional conduct, nature and role of professional societies, engineering standards; Legal issues—Legal forms of business organizations, employment contracts, trademarks, patents, copyrights, trade secrets, professional liability, contractual agreements, environment and information technology laws, and international legal framework such as WTO.

**Group Dynamics**

Individual cognition; Dynamics of working in teams/groups; Interacting with stakeholders; Dealing with multicultural environments; Team and group communication; and Negotiation and conflict resolution.

**Textbook**

1. Shrestha, R. K. and Shrestha, S. K., Textbook of Engineering Professional Practice, 3rd Edition, Heritage Publishers and Distributors Pvt. Ltd, 2020.

**Reference Books**

1. Habash, R. Professional Practice in Engineering and Computing: Preparing for Future Careers, 1st Edition, Boca Raton: CRC Press, 2019.
2. Walesh, S.G., Engineering Your Future: The Professional Practice of Engineering, 3rd Edition, Wiley, 2012.
3. Subramaniam, R., Professional Ethics, 2nd Edition, Oxford University Press, 2017.
4. Lectures note on Engineering Professional Practice provide by Concerned faculty members.

## ENGLISH

**Course Code: HS10001**
**Credit: 2**
**L-T-P: 2-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

The objective of the course is to develop and improve, in the students, the skills of active listening, speaking, reading, and writing in English, through lecture classes and practice sessions, and improve their professional communication abilities. The course will help the students to enhance their critical thinking and situational communicative skills through the study of contemporary social issues depicted in literature.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Apply verbal and non-verbal modes of communication effectively in practical situations,
CO 2: Retain a grammatically correct and logical flow while drafting reports and other technical pieces of writing,
CO 3 : Develop competence in reading and comprehension,
CO 4 : Implement active listening responses in professional practice,
CO 5: Utilize neutral accent in English pronunciation successfully, and
CO 6 : Understand situational and conversational English used for different purposes and contents.

## COURSE DETAILS

### Professional Communication

Process of Communication: Definition, Explanation & Diagram, Difference Between General and Technical Communication; Methods of Communication (Verbal & Non-Verbal); Non-Verbal Communication (Kinesics, Proxemics, Chronemics, Oculesics, Olfactics, Gustorics, Haptics, and Iconics); Paralanguage; Flow of Communication (Formal & Informal); Levels of Communication; and Barriers of Communication (Intrapersonal, Interpersonal, and Organizational).

### Basics of Grammar and Writing Skills

Error Detection in Sentences: Articles, Prepositions, Tense, Subject-Verb Agreement, Active and Passive Voice; Use of Punctuation: Full Stop, Comma, Colon, Semi-colon, Single & Double Inverted Commas, Exclamation & Interrogation Marks, Hyphens and Dashes, and Ampersand.
Paragraph Writing – Components; Writing Bias-free English; Business Letters: Enquiry, Claim/Complaint, and Order; Technical Reports: Formats, Style & Referencing; and Reading Techniques: Skimming, Scanning, Intensive & Extensive Reading.

### Basic Sounds of English

Hearing & Listening: Types of Listening – Appreciative, Empathetic, Critical, Comprehensive, Superficial, Differences between Listening & Hearing; Introduction to Basic Sounds of IPA: Symbols of IPA, Types of Vowels & Consonants; and Problem Sounds & Mother Tongue Influence: Concept of MTI with Examples.

### English Literature

Short Story – O. Henry: 'Gift of the Magi;'Short Story – Ismat Chughtai: 'Sacred Duty;'; Poem – Robert Frost: 'Stopping by Woods on a Snowy Evening; Poem – Tennessee Williams: 'We Have Not Long to Love' and Drama: William Shakespeare: Merchant of Venice.

### Textbook

1. M. Ashraf Rizvi, Effective Technical Communication, Tata McGraw Hill Education Publication, 2005.

### Reference Books


1. Sidney Greenbaum. The Oxford Grammar (English). Oxford University Press, 1st Edition. 2005.
2. S. Verma, Technical Communication for Engineers, Vikas Publishing House,2015.
3. R Dove,The Penguin Anthology of 20th Century American Poetry,Penguin Books. 2013.
4. The Merchant of Venice (The New Cambridge Shakespeare). Mahood & Lockwood eds. CUP. 2018.

## SOCIETY, SCIENCE, AND TECHNOLOGY

**Course Code: HS10013**
**Credit: 2**
**L-T-P: 2-0-0**
**Prerequisite: Nil**

### COURSE OBJECTIVE

There is a circular relationship between society, science, and technology. Society creates a need and an ambience to develop science and technology, and science and technology create means to meet societal needs and new opportunities to make human life better. Studying this relationship is the objective of this course. The course will expose, before the students, the past developments of science and technology and the social forces that played a dominant role in making these developments possible and the way these were used in the society. The course will also present the ethical principles that underlie the development and use of science and technology in the society**.**

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Understand the forces that shape the development of science and technology,
CO 2: Understand the major milestones of scientific discoveries have impacted human thought processes,
CO 3: Understand the effect of technological developments in societal transformation,
CO 4: Analyse the contribution of Science and Technology in solving societal and Environmental problems,
CO 5: Evaluate the ethical issues related to abuse of science and technology, and
CO 6: Apply the skills learned to suggest solutions to global problems linked to science and technology.

### COURSE DETAILS

**Introduction**
Human Curiosity to Know the Truth of Nature, Need to Improve Quality of Life, Emergence of Science and Technology, Characteristics of Society, Science, and Technology, and Impact of Science and Technology on the Society.

**Scientific Discoveries**
Milestone Scientific Discoveries of the Past and the Ways They Impacted Human Thought Process and Culture; Scientific Method, Developing a Theory, and Making of a Discovery; Discoveries in the Physical, Biological, and Mathematical Sciences; Normal Science, Paradigms, Anomalies, Crisis and Emergence of Scientific Theories, and Scientific Revolutions.

**Technological Developments**
Milestone Developments of Technologies and the Ways They Transformed the Society. Stories of Technological Developments such as Steam Engines, Electricity, Semiconductors, and IoT.

**Science and Technology in the Service of the Society**
Contributions of Science and Technology to Solving Societal, Environmental, and Global Problems.
Successes and Limitations, and Abuses and Control of Science and Technology; Ethical Considerations.

**Textbook**

1. Bucchi, M., Science In Society: An Introduction to Social Studies of Science, Routledge Publication, 1st Edition,2004.

**Reference Books**

1. Collins, H. and T. Pinch, The Golem: What You Should Know about Science, 2nd Edition, New York: Cambridge University Press,1998.
2. Collins, H. and T. Pinch,The Golem: What You Should Know about Technology, 2nd Edition. New York: Cambridge University Press, 2014.
3. Kuhn, T. S.,The Structure of Scientific Revolutions, 4th Edition, Chicago University Press, 2012.
4. Hatton, J. and P. B. Plouffe, Eds., Science and Its Ways of Knowing, New Jersey: Prentice Hall,1997.
5. Moskovites, M., Ed., Science and Society, Ontario: House of Anansi Press Limited,1997
6. Sismondo, S. An Introduction to Science and Technology Studies, 2nd Edition. Maldon, MA: Blackwell Publishing, 2009.
7. Sarukkai, S. What Is Science?, New Delhi: National Book Trust, India, 2012.
8. USSR Academy of Sciences Science and Society, Moscow: Nauka Publishers, 1989.

## SHADES OF ECONOMICS

**Course Code: HS10121**
**Credit: 2**
**L-T-P: 2-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

This course will provide technical students with knowledge in concepts of environmental economics, resource economics, and circular economy, allowing prosperity for present and future generations. The course will equip future engineers with skill to handle resources efficiently and effectively. Acquaint them with the contemporary trends in business settings and thereby innovate novel solutions to existing problems.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Understand the economic drivers that shape the future of India,
CO 2: Understand sustainability issues related to usage of factor endowment,
CO 3: Create linkage between Economics, Science and Technology,
CO 4: Apply knowledge, reasons and the need for regulating circular economy,
CO 5: Assess and analyses scope for global market opportunities, and
CO 6: Explore yet to be unearthed employment opportunities.

## COURSE DETAILS

**Purple Economy: Economics of Glocalization**
Introduction to colours and world of economics (including White, Blue, Black, Green, Purple, Grey, Red, Pink, Silver); Concept and definition of purple economy; Cultural footprint; Local and global cultural economy; Culture and well being; Rethinking employment and training in the purple economy; Vocal for Local; Make in India.

**Grey Economy: Economics of Informal Sector**
Concept and definition of grey economy; Introduction to formal and informal Sector; Formal and informal sector linkage; Labour absorption and dualism in economy; Theoretical and policy issues; Migration in informal sector.

**Green Economy: Economics of Reduce, Reuse, and Recycle**
Concept and definition of green economy; Green investment and green bond; Green technology and renewable resources; Carbon footprint; Waste management.

**Blue Economy: Economics of Ocean Resources**
Concept and definition of blue economy; The marine environment; Fisheries and aquaculture; Tourism; Ocean-based renewable sources of energy; Transportation and the blue economy; ; Pollution of water resources; Water resource management.

**Black Economy: Economics of Unsanctioned Sector**
Concept and definition of black money; Causes and consequences of black economy; Global black income generation; Extent of black money in India. Government measures to curb black money.

**Textbook**


1. S.K Mishra and V. K. Puri, Indian Economy. Himalaya Publishing House,2022, ISBN: 978-93-5596-423-6


**Reference Books**


1. Uma Kapila. Indian Economy: Economic Development and Policy. Academic Foundation ISBN-10: 9332705550 and ISBN-13: 978-9332705555,2022.
2. Taneja and Myer: Economics of development and Planning, Vishal Publishing Co. ISBN-13: 978-9382956068.
3. Datt Gaurav & Mahajan Ashwani , Indian Economy, S Chand & Company Limited. 2017.
4. Adrian C. Newton, Elena Cantarello, An Introduction to the Green Economy. Science, Systems and Sustainability,2014
5. Shalini Goyal Bhalla. Circular Economy- (Re) Emerging Movement, 2020.
6. Somnath Hazra & Anindya Bhukta, The Blue Economy. An Asian Perspective.
7. The Informal Economy: an Employer's Approach. The Informal Economy: an Employer's Approach. 2021.
8. The Purple Economy: An Objective, An Opportunity, 2013.
9. Tom Tietenberg, Lynne Lewis, Environmental and Natural Resource Economics. 2018.

# INDIAN ECONOMY POST LIBERALISATION

**Course Code: HS10123**
**Credit: 2**
**L-T-P: 2-0-0**
**Prerequisite: Nil**

## COURSE OBJECTIVE

Study of this course provides an extensive understanding of changing structure of Indian economy over time. This course targets to put emphasis on inclusive growth, reducing poverty, inequality and creating decent employment in the economy. This course will give an understanding about the issues faced by an economy in achieving sustainable development.

## COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Interpret the changing structure of Indian economy,
CO 2: Perceive the issues and challenges faced by Indian economy,
CO 3: Evaluate the policies and programmes required to achieve inclusive growth,
CO 4: Realise the importance of human capital in triggering economic development,
CO 5: Comprehend the state and role of external sector in strengthening Indian economy, and
CO 6: Help in achieving sustainable development for the economy.

**Introduction and features**
Changing structure of the Indian economy Changing paradigms of Development Strategies and Economic Reforms.

**Poverty, Inequality and Employment**
Various concepts and estimates of poverty; Income inequality; Problem of unemployment; Interface among growth, poverty and employment; Inclusive growth and Human Development; Sustainable Development Goals—Targets for reduction in Poverty, Inequality and Decent Employment.

**Demographic Issues**
Demographic trends, size and structure of population; Health and Education; Skill challenges and demographic dividends; Sustainable Development Goals—Targets forGreater Wellbeing and Better Human Capital.

**Perspectives in Agriculture, Industry and Services**
Agricultural growth performance and food security; Growth, trends and changing pattern of Indian industries, industrial reforms and policies; Services in India’s growth process; Sustainable Development Goals—Targets for Inclusive and Sustainable Growth.

**External Sector and Issues in Indian Public Finance**
Foreign trade and trade policy; fiscal devolution, Indian Union Budget and Tax System

**Textbook**

1. Uma Kapila, Indian Economy Performance and Policies, academic foundation, 2020, ISBN:978-933270545.

**Reference Books**

1. S.K. Mishra, and V. K. Puri, Indian Economy, Himalaya Publishing House,2022, ISBN: 978-93-5596-423-6.
2. Gaurav Datt and Ashwani Mahajan, Indian Economy, GENERIC. Classic Edition, 2022, ISBN-10: 9352531299, ISBN-13: 978-9352531295.

## ESSENTIALS OF MANAGEMENT

**Course Code: HS10202**
**Credit: 2**
**L-T-P: 2-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

This course explores the basic concepts and processes of management. Students will learn the importance of management in their professional life from the stories on the evolution and practices of management. Students will examine the fundamental roles and processes of planning, organizing, staffing, directing and controlling that comprise the managers' role. This course also examines the fundamentals of marketing and financial management for the success of the organization. This course will make an attempt to introduce students to the business environment and strategic management process to understand the nuances of business. Students will develop skills related to the manager's function as required in today's competitive environment.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Learn different approaches, theories and stories of various practitioners of management and know how such knowledge could be applied to achieve goals of Organizations within the changing environment,
CO 2: Understand the core functions of management in order to facilitate efficient and effective decision making both at individual and organizational level,
CO 3: Identify the human resource requirement of the organization for achieving its objective effectively,
CO 4: Synthesize various marketing and financial skills and techniques in order to be successful in corporate world,
CO 5: Assess the business environment and understand the importance of various types of business environment for better decision making, and
CO 6: Acquire the lesson learnt in strategic management process for strategic decision making by leveraging the core competencies of the organization.

## COURSE DETAILS

**Evolution of Management Thoughts**
Concept, Scope and Significance of Management; Classical Approach; Scientific, Bureaucratic & Administrative theory of Management; Neo-classical and Modern Approach; Contribution of Management Practitioners.

**Functions of Management (Part I)**
Nature, scope and significance of Planning; Types of Planning; Process of Planning; Barriers to effective planning; Decision making: concept, types and process; Organizing: concept and significance; Delegation of authority; Authority vs. Responsibility; Structure of Organization: departmentalization, Centralization vs. Decentralization.

**Functions of Management (Part II)**
Concept of Staffing, Manpower planning and Job design; Recruitment and selection; Training and development; Performance Appraisal; Directing: Concept, Direction and Supervision; Controlling: Concept, Importance and levels; Process and types of controlling.

**Marketing and Financial Management**
Marketing Mix (Product, place, price, Promotion); Market Segmentation; Introduction, scope, importance and functions of Financial management; Introduction to Financial statements: Profit and loss account; balance sheet.

**Business Environment and Strategic Management**
Business environment: concept, importance, elements; Types of business environment; Strategic Management: Concept, Importance and levels of strategy; Process of Strategic Management.

**Textbooks**


1. S.A. Sherlekar & V.S. Sherlekar, Modern Business Organization & Management (Systems Approach) by Himalya Publishing House, 2018.
2. Harold Koontz and Heinz Weihrich, Essentials of Management: an International Perspective, McGraw Hills, 2020.


**Reference Books**


1. K. Ashwathappa, Essentials of Business Environment, Himalaya Publishing House, 2017.
2. Joseph L. Massie, Essentials of Management, Pearson Education India, 4$^{th}$ Edition, 2015.
3. Azhar Kazmi and Adela Kazmi, Strategic Management, Mc-GrawHill, 5$^{th}$ Edition 2020.


## COMMUNICATION LAB

**Course Code:** **HS18001**
**Credit:** **1**
**L-T-P:** **0-0-2**
**Prerequisite:** **Nil**

## COURSE OBJECTIVE

This course is designed to enrich the basic knowledge of engineering students in the field of communication and to support the engineering and research programs.

## COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Use English grammar correctly and unambiguously in technical writing,
CO 2: Apply verbal and non-verbal modes of communication effectively in practical situations,
CO 3: Have a basic understanding of the communication process and to know the practical implementations in the workplace,
CO 4: Retain a logical flow while drafting reports and other technical pieces of writing,
CO 5: Develop competence in reading and comprehension, and
CO 6: Be familiar with English pronunciation and use neutral accent successfully.

## COURSE DETAILS

**Reading Comprehension**
Understanding meaning and sequence of ideas in written language.
Activity based on matching, multiple choice questions, open close, appropriate headings.

**Time & Tense + Subject-Verb Agreement**
Applying correct grammar in everyday writings.

**Vocabulary Building (Mind Mapping/Phrasal Verbs)**
Developing vocabulary through associating key ideas, and learning idioms and phrases.

**Listening Comprehension**
Interpreting meaning and syntax in spoken language.

**E-mail Writing**
Formulating appropriate e-mails with relevant salutation, language & conclusion.

**Resume Writing/ Video Resume**
Creating suitable, job-oriented resume.

**Thematic Speaking**
Practising and implementing theme-based individual speaking skills.

**PowerPoint Presentation**
Developing skills to design and deliver engaging, informative and impactful presentations, and Class Participation.

## ECONOMICS OF DEVELOPMENT

**Course Code: HS20120**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

### COURSE OBJECTIVE

The objective of this course is to provide students with the essential tools and concepts of development economics, to prepare them to understand what makes underdevelopment persist and what helps development succeed.Students will explore diverse dimension and measures of development, as well as the application of microeconomic analysis to issues of development in poor countries, including the study of household decisions and the analysis of institutions and norms influencing development.And To enhance students understanding of the SDGs to create a better- informed citizenry, which will lead to a more sustainable action by all and for all.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Understand key factors and issues in the process of economic development,
CO 2: Enhance their ability in applying economic models to study development problems,
CO 3: Learning the role of the three basic components of ecosystems and environment and underlying causes of their degradation,
CO 4: Understand the policy scenario and the existing environmental conventions/regulations/ laws,
CO 5: Development of sustainable planning for sustainable development of environment, economy and firms, and
CO 6: Select and apply appropriate economic techniques to solve environmental problems and measure the value of environmental goods.

### COURSE DETAILS

**Economic Growth and Development**
Meaning of development and Economic growth, Characteristics of less developed countries. Factors in Economic development, Measuring development and development gap — per capita income, inequality of income and wealth, Gini coefficient, Human Development Index, Physical Quality of Life Index, and other indices of development.

**Theories of Economic Growth and Development**
Theories of Economic Development: Classical (Smith, Ricardo, Malthus), Marxian – Theory of Social change, immutable laws, Crisis in capitalism, Schumpeter and capitalist development, Rostow's stages of growth. Partial theories of growth and development: Vicious circle of Poverty, Big push, balanced growth, unbalanced growth.

**International aspects of Economic Development**
International trade as an engine of growth; Static and dynamic gains from trade; Prebisch, Singer and Myrdal theses vs. free trade; Export-led growth; Tariffs and effective protection; WTO and developing countries. External resources; FDI; Aid vs. trade.

**Development and Environment**
Economy linkage; Environment as a necessity and luxury; Population environment linkage. Allocation problem; Market failure for environmental goods; environment as a public good.

**Sustainable Development**
Concept and indicators of sustainable development. Common Property Resources, Property right approach to environmental problem-property rights approach, property rights and environmental problems, Externalities and Pigovian tax, Coase theorem, Coase theorem and transaction cost. Prevention, control, and abatement of pollution.

**Textbooks**

1. S. Ghatak, An Introduction to Development Economics, Allen and Unwin, London, 2003.
2. Kindleberger, C. P. Economic Development, McGraw Hill, New York, 1958.
3. Todaro, M. P. Economic Development, Longman, London.

**References Books**

1. Thirwal, A. P. Growth and Development, Macmillan, UK, 2017.
2. Adelman, I. Theories of Economic Growth and Development. Stanford University Press, Stanford, 1966.
3. Chenery, H. and T.N. Srinivasan (Eds) Handbook of Development Economics, Vols 1, 2, Elsevier, Amsterdam, 2002.
4. Myint, H. Economic Theory and Underdeveloped Countries, Oxford University Press, New York, 1971.

## INTERNATIONAL ECONOMIC COOPERATION

**Course Code: HS20122**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

This objective of this course is to equip students with knowledge of both the theoretical concepts and the actual procedures involved in international trade. The specific purpose is to increase the knowledge of importing and exporting essentials and to offer the with the skills for understanding the international trading process.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Learn theories of international trade,
CO 2: Understand free trade, protection, and BOP,
CO 3: Analyse the role of international organisations,
CO 4: Understand the working of foreign exchange,
CO 5: Study the EXIM policies, and
CO 6: Analyse secondary data relating to international trade.

## COURSE DETAILS

**Theories of International Trade**
Classical Theories of International Trade- Mercantilism, Absolute Advantage, Comparative advantage Theory, Gains from international trade; Terms of trade; Theory of Reciprocal Demand; Modern Theories of International Trade-Heckscher-Ohlin theory.

**Free Trade, Protection and Balance of Payment**
Free trade and protection in developing countries; Forms, methods and effects of protection; Introduction of BoP, Structure of BoP, Disequilibrium in BoP, Measures to overcome disequilibrium in BoP, Tariff, Trade creation vs Trade diversion.

**International Organizations**
International Monetary Fund; World Trade Organization; Regional Trade Agreements; Trade Blocs.

**Foreign Exchange**
Foreign Exchange Market; Theories of foreign exchange; Factors affecting exchange rate; Fixed and flexible exchange rate; FERA and FEMA.

**EXIM Policies**
Recent budgetary policies and programs relating to inequality; Analysis of Economic Survey data.

**Textbooks**

1. R.R. Paul, Money Banking and International Trade, Kalyani Publishers, 12th Edition,2015, ISBN-10:932725774X, ISBN-13: 978-932725774.
2. Bo Södersten and Geoffrey Reed, Palgrave Macmillan, International Economics. 1994, ISBN-10: 0333612167, ISBN-13: 978-0333612163.

**Reference Books**

1. Dominick Salvatore, International Economics: Trade and Finance, Wiley; 11th Edition, 2017, ISBN-10: 8126552344 ISBN-13: 978-8126552344.
2. Paul R. Krugman, Maurice Obstfeld, Marc Melitz, International Trade: Theory and Policy, 2017, ISBN-10: 9789332585768, ISBN-13: 978-9332585768.

## ORGANIZATIONAL BEHAVIOUR

**Course Code:** **HS20220**
**Credit:** **3**
**L-T-P:** **3-0-0**
**Prerequisite:** **Nil**

## COURSE OBJECTIVE

This course shall guide the students to learn the basic concepts of Organizational Behaviour and its applications in contemporary organizations. Further, it help them to describe how people behave under different conditions and understand why people behave as they do. The students would be in a position to synthesize related information and evaluate options for the most logical and optimal solution such that they would be able to predict and control human behaviour and improve results. Lastly, this course would help the students to understand how individual, groups and structure have impacts on the organizational effectiveness and efficiency.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Know about organization, organizational behaviour, it's nature, scope and significance,
CO 2: Develop their personality as per industry requirement,
CO 3: Apply motivational techniques to make the employees work with confidence and satisfaction,
CO 4: Develop different leadership styles to adjust themselves in different organizational situations,
CO 5: Improve the knowledge of group behaviour and techniques of group decision making, and
CO 6: Apply the concepts for managing changes in organization as well as the development of an organization's human resources.

**COURSE DETAILS**

**Introduction to Organizational Behaviour**
Organizational Behaviour- nature and scope; Need for studying OB; contributing disciplines to OB; evolution of OB; OB approaches and models; OB opportunities and disruptions.

**Individual Perspective**
Introduction to Individual behaviour; Personality- concept, determinants, types and theories/models; Personality and OB; Perception- meaning, perceptual process, factors affecting perception; perception and its application in OB; Attitude- nature, components, formation and types; Values- concepts, types and formation; attitude, values and behaviour.

**Individual Perspective**
Learning- meaning, determinants, theories and principles; learning and behaviour; Motivation- nature, importance, process and theories; managerial implication of motivation- job design, quality of work life and employee engagement; organizational citizenship behaviour- meaning, theoretical perspective, determinants and predictors.

**Group Perspective**
Foundation of group behaviour; meaning and characteristics of group; why do people form and join groups; types and groups; stages of group development; group decision making; Team building- meaning and types of team; team building process; Meaning, sources and types of conflict; conflict management and negotiation strategies; Leadership- meaning and importance; differentiating between leader and manager; leadership styles; leadership theories.

**Organizational Perspective**
Organizational structure- meaning and elements; Organizational culture- meaning, types and functions of culture; creating, sustaining and changing a culture; Organizational change- meaning and need; managing resistance to change; Organizational development- meaning, objectives, models and interventions.

**Textbooks**

1. S.S. Khanka, Organizational behaviour texts and cases Sultan Chand, OB text and cases S.S. Khanka, S. Chand, 2022.
2. Stephen P. Robbins, Timothy A. Judg, Neharika Vohra Organizational Behaviour, Pearson, 18th Edition, 2018.

**Reference Books**

1. Fiona M. Wilson, Organizational Behaviour and Work, Oxford University Press, 2014.
2. K. Aswathappa, Organizational Behaviour, Himalaya Publishing House, 2013.

## HUMAN RESOURCE MANAGEMENT

**Course Code: HS20222**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

This course aims at providing conceptual knowledge on human resource management that will be useful for a manager of an organization. It also understands employer and employee relationship in order to achieve organizational objectives effectively. It starts with hiring and continues till retention. It also focuses on enabling the students to integrate the understanding of various HR concepts along with the domain concept in order to take correct business decisions.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Learn the various functions of management, personal and professional qualities of a manager in order to manage human resource of an organization effectively,
CO 2: Understand the process of acquiring human resource through effective planning, recruitment and selection process,
CO 3: Apply different training and development methods for organizational effectiveness,
CO 4: Analyse the importance of performance appraisal and equitable pay for the growth of both individual and organization,
CO 5: Inculcate the sense of inter personal relation required in professional front in handling employer-employee relation effectively for achievement of organizational objectives, and
CO 6: Know the technique of managing and being managed by the organization.

**COURSE DETAILS**

**Introduction to HRM**

Introduction, scope, objectives; Managerial and operational functions of Management; HRM as a source of competitive advantage; Qualities and role of HR managers.

**Planning and Acquiring Manpower**

Human resource planning- Introduction, objectives, need, importance; Factors, Process and barriers of HRP; Job analysis- concept, objective and Process; Meaning, process and sources of recruitment; Factors of effective recruitment; Meaning and process of selection; Competency mapping for selection decision; Induction and socialization; recent trends in recruitment and selection.

**Developing Manpower**

Training- nature, need, objectives, importance; areas of training; training process- identifying training need, designing a training program; methods and techniques of training; evaluating training effectiveness; Role specific and competency-based training; career planning and development- meaning, objective and process.

**Managing Performance and Compensation**

Performance appraisal- concept, objectives and importance of performance appraisal; Process of performance appraisal; Methods of performance appraisal; Problems in performance appraisal; Potential Appraisal; Components of compensation; objectives and factors affective Wage and salary administration; methods of wage payment; process of wage determination; Pay band compensation system.

**Maintaining and Retaining Human Resources**

Industrial Relation- concept, objective and approaches: Reasons for poor industrial relation; Measures for improving industrial relation; Industrial Dispute- nature, causes, prevention and settlement; meaning, objectives, importance and conditions for successful collective bargaining; Workers Participation in management- concept, objectives, forms and measures; Discipline and Grievance- Statutory provisions concerning discipline; causes and machinery for redressal of grievances.

**Textbooks**

1. P. Jyoti & D. N. Venkatesh, Human Resource Management, Oxford Publication.
2. Gary Dessler and Biju Varkkey, Human Resource Management, Pearson Education, 2020.

**Reference Books**

1. S.S. Khanka, Human Resource Management Text and Cases by, S. Chand and company Limited, 2022.
2. K. Aswathappa, Human Resource Management. Mc-Graw Hill Education, 2013.
3. P. Subba Rao Personnel and Human Resource Management., Himalaya Publishing House, 2022.

## ENGINEERING ECONOMICS

**Course Code: HS30101**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

### COURSE OBJECTIVE

The objective of Engineering Economics is to aidi n decision-making by focusing on the economic implications of technical analysis. It is committed to making operational level decisions and solving problems.

### COURSE OUTCOME

At the end of the Course the student will be able to

CO 1: Comprehend the significance of different components of Engineering Economics,
CO 2: Analyze the basic economic concepts required for engineers and managers,
CO 3: Develop the problem solving aptitude in the students through practical and case problems,
CO 4: Decide the feasibility of a particular project by the application of different project evaluation Techniques,
CO 5: Use the economic tools in the decision making process, and
CO 6: Survey the current macroeconomic situations in the economy.

### COURSE DETAILS

**Introduction to Economics and Engineering Economics**
Basic concepts of Engineering Economics: Demand Analysis, Supply Analysis, Market Equilibrium. Revenue Analysis. Demand Forecasting- Quantitative Methods, Consumer's Equilibrium.

**Production and Cost Analysis**
Short Run and Long Run Production Functions, Producer's Equilibrium condition.Cobb-Douglas Production Function.
Cost Concepts: Short Run and Long Run Cost analyses. Break-Even Analysis.
Market: Concepts and Types; Perfect Competition, Monopoly.

**Time Value of Money**
Interest Formulae and their applications with cash flow diagram. Evaluation of Investment Proposals - Present Worth, Future worth and Annual Equivalent Method of comparison

**Economic Appraisal Techniques**
Net Present Value (NPV), Internal Rate of Return(IRR) ,Cost Benefit analysis.Depreciation calculation; Meaning and Definition, Methods.

**Macroeconomic policies**
Functions of commercial banks and central bank, Fundamentals of Business cycle, Macroeconomic policies for stabilization.

**Textbooks**

1. Dominick Salvatore, Siddartha K. Rastogi, Managerial Economics: Principles and Worldwide Applications, Oxford University Press, ISBN: 9780199467068, 9th Edition, 2020.
2. D N Dwivedi, H L Bhatia, & S N Maheswari, Engineering Economics, Vikas Publishing House, Noida, ISBN:978-93-5674-625-1, 2nd Edition 2023.
3. James Riggs, David D. Bedworth and Sabah U. Randhawa, Engineering Economics, 4th Edition, McGraw Hill Education (India) Private Limited, New Delhi, 2016.

**Reference Books**

1. William A. McEachern and Simrit Kaur Micro ECON-A South-Asian Perspective-, Cengage Learning, 2013.
2. Yogesh Maheshwari, Managerial Economics- 3rdEdition, PHI Learning Private Limited,2014.
3. A. Khan, Arshad Noor Siddiquee, Brajesh Kumar, Engineering Economy-Zahid Pearson Publication, 2012.
4. R. Panneerselvam Engineering Economics, Pub: PHI Learning Private Limited, New Delhi, 9thEdition, 2008.
5. G.S Gupta Managerial Economics, Tata McGraw Hill Education Private Limited, 2nd Edition, 2011.
6. D.M. Mithani, Managerial Economics – Theory and Applications –Himalaya Publication, New Delhi, 6th Edition, 2009.
7. S.B. Gupta, R7. Monetary Economics-Institutions, Theory and Policy, S. Chand, 1995.
8. R.D. Gupta R8. Macro – Economics, Publication: Kalyani Publication, 1994.

## MARKET STRUCTURE AND PRICING POLICIES

**Course Code: HS30125**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

Develop the ability for getting conceptual clarity about the various types of markets along with their functions and understand the pricing policy operations in the different markets.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Comprehend the significance of different components of market,
CO 2: Analyze the basic economic concepts required for various types of market and their policies,
CO 3: Develop the problem-solving aptitude through practical and case study problems faced by the economy,
CO 4: Use the economic tools in the decision-making process of fixing prices and quantities in different Market,
CO 5: Differentiate between different markets and the policy measures to regulate it, and

CO 6: Survey and map the impact of the current micro and macro-economic situations in the economy.

**COURSE DETAILS**

**Cost and Revenue Analysis**
Concepts of cost (economic cost, production cost, real cost, opportunity cost, private & social cost), cost function, Output maximisation and cost minimisation, Derivation of cost function, traditional and modern theories of costs. Concepts of revenue (total, average, marginal revenue), relationship between TR, AR and MR.

**Market Structures and Perfect Competition**
Meaning of market, characteristics of market, and types of market. Perfectly competitive market and features, equilibrium of the firm and industry under perfect competition (short run and long run).

**Monopoly Market**
Meaning, concepts and characteristics of monopoly market. Equilibrium price and output determination under monopoly market in short and long run. Monopoly price discrimination. Degree of monopoly power and its measure. Control and regulation of monopoly power.

**Duopoly and Oligopoly Market**
Non-collusive oligopoly: Cournot's duopoly and Kinked-Demand Model. Collusive oligopoly: Cartel; Cartels aiming at joint profit maximization and market sharing cartels. Price leadership; low-cost price leadership, dominant firm price leadership and barometric price leadership.

**Monopolistic Competition**
Meaning, price determination of a firm under monopolistic competition; Chamberlin's group equilibrium; theory of excess capacity; selling costs; difference between perfect competition and monopolistic competition; difference between monopoly and monopolistic competition.

**Textbooks**


1. Koutsoyiannis, Modern Microeconomics, St. Martin's Press, New York,2nd Edition 1979, ISBN 978-0-333-25349-6.
2. G. S. Maddala, Ellen M. Miller, Microeconomics: Theory and Applications, McGraw-Hill Inc., US-Publisher, 1989, 0070394156-ISBN.
3. H.L. Ahuja, Modern Microeconomics: Theory & Applications, S. Chand Publishing, 2022, ISBN: 9789355011015.


**Reference Books**


1. Robert Pindyck, Daniel Rubinfeld, Microeconomics, 8th Edition, 2017, 9789332585096-ISBN, Pearson Education Publication.
2. G. Fransico Stigler, Theory of Price, Prentice Hall of India, New Delhi, 4th Edition, 1996.
3. H. Gravelle and R. Rees, Microeconomics, Person Education U.K. 3rd Edition 2007, 2007ISBN: 9788131716557, 8131716554.
4. H.R. Varian, Micro Economic Analysis, W.W. Norton & Company; New York, 3rd edition 2019, ISBN-13: 978-8130908632.

# PRAGMATIC INQUIRY

**Course Code: HS30127**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

## COURSE OBJECTIVE

As a foundation for lifelong inquiry, this course introduces students to research techniques and how they are used in both liberal arts, technical and professional courses.

## COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Understand the meaning and importance of research in behavioral science,
CO 2: Describe in detail different types of research methodologies,
CO 3: Identify the strengths and weaknesses of the different study designs,
CO 4: Assess whether research studies are using the most appropriate study design,
CO 5: Discuss why various approaches may be appropriate/ inappropriate for their work-based research question, and
CO 6: Apply the concepts in research related activity.

## COURSE DETAILS

**Pragmatic Inquiry**
Meaning, characteristics, need, type, and approaches.

**Research Problem**
Meaning, definition, selection, and framing of problem statement.

**Research Design**
Meaning, characteristics, need, type, approaches, and problems of research design.

**Sampling Design**
Meaning, characteristics, need, type, approaches, and problems.

**Data Collection Method and Analysis**
Types of data, Source of data, Methods of data collection, data analysis.

**Textbook**

1. Deepak Chawla & Neena Sodhi, Research Methodology: Concepts and Cases, Vikas Publishing House,2018, ISBN-10: 9325982390, ISBN-13: 978-9325982390.

**Reference Books**

1. C.R. Kothari and Gaurav Garg, Research Methodology, New Age International Publishers,2019, ISBN-10 9386649225, ISBN-13- 978-9386649225.
2. S.K. Mangal, Research Methodology in Behavioural Sciences, Prentice Hall India Learning Private Limited, 2013, ISBN-10: 9788120348080, ISBN-13: 978-8120348080.
3. Sameer S. Phanse, Research Methodology-Logic, Methods, and Cases, OUP, Sameer S. Phanse,2016 ISBN: 9780199453788.

## ECONOMIC ANALYSIS OF DECISION RULES

**Course Code: HS30129**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

### COURSE OBJECTIVE

Analyze and understand investment decisions under the conditions of risk and uncertainty. Particular economic models are not the ends, but the means for illustrating the method of applying mathematical techniques to economic theory in general.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Analyze and understand investment decisions under the conditions of risk and uncertainty,
CO 2: Explain how game theory brings out the strategy used by the oligopoly firms to determine the best possible action to maximize profit-maximizing objective,
CO 3: Understand functional formulation of the problem and application of linear programming,
CO 4: Describes different concepts used in analysing the national income and the different methods applied to measure the national income,
CO 5: Describe and explain the main channels of the monetary transmission mechanism through monetary and fiscal policy, and
CO 6: Describe managerial decisions through the application of some economic concepts, theories and principles.

### COURSE DETAILS

**Investment Decisions under Risk and Uncertainty**
Concepts of Risk and Uncertainty; Investment Decisions under Risk: The Pay-Off Matrix Method, Risk-Adjusted Discount Rate Method, Certainty-Equivalent Approach, Probability Theory Approach, Decision Tree Method, Simulation, Sensitivity Analysis.

**Game Theory and Strategic behaviour of Firms**
Basics of Game Theory, Prisoners' Dilemma: The Problem of Oligopoly Firms; Application of Game Theory to Oligopolistic Strategy; Nash Equilibrium: Pure and Mixed Strategy.

**Optimization: Constrained & Extrema**
Free and constrained optimization, extrema of a function of two variables: graphical analysis, Lagrange method. Utility maximization & Cost minimization.

**Linear and Non-Linear Programming for Business Decisions**
Conditions for Application of Linear Programming; Concept of Feasible Solution; Assumptions of Linear Programming Application of Linear Programming Technique: Profit Maximization Problem, Formulation of Profit Maximization Problem in Linear Programming Mode; Graphical Method of Solving Linear Programming Problems; Simplex Method: Algebraic Solution, Simplex Tableau Method. Introduction to Non-Linear Programming.

**Input-Output Analysis**
Input-output model, its structure and its derivation. The use of input output model in Economics.

**Textbook**

1. D.N. Dwivedi, H.L. Bhatia, S.N. Maheshwari, Vikas Publishing Pvt. Ltd., 2022.

**Reference Books**

1. C. Chiang and K. Wainwright, Fundamental Methods of Mathematical Economics, McGraw Hill International Edition, 2017.
2. K. Sydsaeter and P. J. Hammond, Mathematics for Economic Analysis, Pearson Educational Asia, 2002.

## ECONOMICS OF HEALTH AND EDUCATION

**Course Code: HS30131**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

The United Nations member states' adoption of the Millennium Development Goals, which include among other objectives achieving universal primary education, reducing child mortality, enhancing maternal health, and combating diseases, reflects the significance of education and health in enhancing wellbeing. This course offers a microeconomic framework to examine, among other things, individual preference in the demand for health and education, governmental involvement, and elements of inequality and discrimination in both sectors. An outline of India's health and education system is also provided.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Understanding role of health and education in human development,
CO 2: Analysing microeconomic foundations of health economics,
CO 3: Assessing the growth of health sector in India,

CO 4: Appraising the benefits of investment in human capital,
CO 5: Assessing the growth of education health sector in India, and
CO 6: Examining the underling discrepancies in both sectors.

**COURSE DETAILS**

**Role of Health and Education in Human Development**
Importance of health and education outcomes and their relationship with macroeconomic performance.

**Health Economics Market**
Demand for health; uncertainty and health insurance market; alternative insurance mechanisms; market failure and rationale for public intervention; equity and inequality.

**Education: Investment in Human Capital**
Rate of return to education: private and social; quality of education; signaling or human capital; theories of discrimination; gender and caste discrimination in India.

**Health and Education Sectors in India: An Overview**
Health outcomes; health systems; health financing. Cost effectiveness and cost-benefit analysis; burden of disease. Literacy rates, school participation, school quality measures.

**Trend in Health and Education Sector in India**
Secondary data analysis pertaining to health and education sector. Trend analysis and forecasting using time series data. Simple growth rate calculations.

**Textbook**

1. S.K. Mishra, and V.K. Puri, *Indian Economy*, Himalaya Publishing House,2022, ISBN: 978-93-5596-423-6.

**Reference Books**

1. William, Jack, Principles of Health Economics for Developing Countries, World Bank Institute Development Studies, 1999.
2. World Development Report, Investing in Health, The World Bank, 1993.
3. G. Ronald, Ehrenberg and S. Robert, Smith, Modern Labor Economics: Theory and Public Policy, Addison Wesley, 2005.

## BUSINESS ETHICS AND CORPORATE GOVERNANCE

**Course Code:** **HS30223**
**Credit:** **3**
**L-T-P:** **3-0-0**
**Prerequisite:** **Nil**

**COURSE OBJECTIVE**

This course focuses upon the fundamental principles and standards that should govern the business organizations. The objective of this paper is to make the students aware about the importance of ethics, corporate governance and role of CSR & sustainable development goals in the business to encourage moral practices and sensitivity towards the ethical dimension of managerial problems.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Familiarize the learners with the concept and relevance of Business Ethics in the modern era,
CO 2: Understand the value of business ethics which will guide them in maintaining firm moral values while taking managerial decision,
CO 3: Make moral judgments in dilemmatic situations across the work domains,
CO 4: Analyse the application of management practices by adhering to corporate law and ethics,
CO 5: Evaluate the scope, opportunity and complexity of Corporate Social responsibility in the global and Indian context, and
CO 6: Create an opportunity to understand the sustainable development goals in maintaining a balance between the economic, environmental and social needs.

**COURSE DETAILS**

**Business Ethics: Concept, Principles & Theories**
Meaning, objective and types of Ethics; Business ethics- concept, need, scope, objectives and importance; factors influencing business ethics; Principles of Business ethics; Relationship between ethics and business ethics; theories of business ethics; Ethical dilemma and ethical decision making.

**Ethics in Practice across the domain**
Ethics in marketing- introduction, ethical dilemma in marketing, unethical marketing practices, measures to stop unethical practices in marketing; Ethics in Finance- introduction, code of ethics in finance, unethical practices in finance or frauds, measures to stop unethical practices in finance; Ethics in HRM- introduction, ethical issues in HRM (job discrimination, sexual harassment, employee privacy, whistle blowing, affirmative action); importance of workplace ethics and employee code of conduct.

**Corporate Governance**
Corporate Governance- concept, objective and need. Role of law in corporate governance; important issues in corporate governance; Corporate governance in India-past, present and Future; Importance and principles of Corporate Governance.

**Introduction to Corporate Social Responsibility**
CSR- Concept, evolution and development; Why CSR; Apprehensions against CSR; Forms and dimensions of CSR; making business corporations socially responsible; CSR in India.

**Sustainable Development**
Introduction, meaning, history, features, objectives of sustainable development; The pillars and principles of sustainable development; SDG and its relevance in business.

**Textbooks**

1. K. Nirmala, Dr. B.A. Karunakara Reddy & N. Aruna Rani, Business Ethics and Corporate Governance, Himalaya Publication House
2. C.S.V. Murthy, Business Ethics and Corporate Governance, Himalaya Publishing, 2022.

**Reference Books**


1. Prabhakaran Paleri, Corporate Social Responsibility (concept, cases and trends Cengage Learning India Pvt. Limited, 2020.
2. S.S. Khanka, Business Ethics and Corporate Governance, Sultan Chand, 2019.
3. C.U. Saraf, Corporate Social Responsibility (CSR), Corporate Governance, Sustainable Development and Corporate Ethics/Business Ethics Himalaya Publishing House 2017.


## LEADERSHIP AND TEAM EFFECTIVENESS

**Course Code: HS30225**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

An effective leader understands the team dynamics, stimulates the morale of the followers and always aims at creating a participative workforce by enhancing team work. This course mainly focuses on individual, group and organization factors associated with leadership. There is a strong connection between emotional intelligence and leadership because the technical skills and knowledge will definitely help the students to fulfil the entry level requirements. Similarly, understanding employee empowerment would assist the students in acquiring the desirable professional skills.

**COURSE OUTCOMES**

At the end the course, student will able to

CO 1: Learn the characteristics and need of an effective leader,
CO 2: Understand the effectiveness of different leadership styles in different contexts from an instrumental, political, and ethical perspective,
CO 3: Apply leadership theories to the real business scenario,
CO 4: Analyse group dynamics and importance of team work,
CO 5: Evaluate the ways to handle emotions and stress and manage work-life flexibility, and
CO 6: Create organizational environment that is psychologically safe and make the employees feel empowered.

**COURSE DETAILS**

**Leadership: concepts and practices**
Meaning, Definition and understanding of leadership; the role and functions of a leader; Differentiation between leadership and management; what makes a leader effective; characteristics of an effective leader; leadership in Indian organization.

**Leadership Perspectives**

Trait perspective of leadership (Great man theory and trait theory); Behavioural perspective of leadership (mangerial grid and likert system - four management); Studies on leadership (Hawthorne, IOWA, Michigan and Ohio); Contingency perspective of leadership (fiedler's contingency theory, path goal, hersey blanchard situational theory); contemporary perspective to leadership (transformational, transactional, charismatic, servant and Nurturant-task leadership style).

**Team effectiveness and Leadership**
Characteristics and types of teams; types and functions of group; Group vs team; understanding an effective team; who is a team leader; tuckman's team development stages; team development and team building; team meetings and leadership; team effectiveness leadership model; high-performance teams and leadership; team cohesiveness; common threats to groups.

**Emotional Intelligence and Leadership**
What are emotions; Meaning, type and source of emotions; Concept and competencies of emotional intelligence; Elements of emotional intelligence; importance of EI; EI at workplace; Emotional intelligence and leadership; Significance of EI for leaders; strategies to enhance EQ in our jobs; EQ vs. IQ; developing EQ; obstacles to the development of EQ.

**Leadership and empowerment**
Employee empowerment- concept, need and importance; approaches to empowerment; advantages and disadvantages of empowerment; empowerment skills of a leader; Empowering vs. Dis-empowering; leader as a coach (coaching skill); delegation (advantages and levels of delegation, steps and principles of effective delegation); empowering interpersonal skills.

**Textbook**

1. Ranjana Mittal, Leadership Personal effectiveness and Team Building, Vikas Publishing House Pvt Ltd, 2015.

**Reference Book**

1. S. Bhargava and Gourav Bhargava, Team Building and Leadership, Neelam Himalaya Publishing House, 2015.

## UNIVERSAL HUMAN VALUES

**Course Code: HS30401**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

The objective of the course is to develop a holistic perspective based on self-exploration, understand the harmony in the human being, strengthen self-reflection, and develop commitment and courage to act.

**COURSE OUTCOME**

After successfully completing the course, the students will be able to

CO 1: Understand the concept of value education and its need,
CO 2: Apply their knowledge on value education for apt self-assessment,
CO 3: Comprehend human-human relationship,
CO 4: Build holistic perception of harmony at all levels of existence,
CO 5: Develop the sense of natural acceptance of human values, and
CO 6: Create people friendly and eco-friendly environment.

**COURSE DETAILS**

**Need, Basic Guidelines, Content and Process for Value Education**

Purpose and motivation for the course, recapitulation from Universal Human Values-I. Self-Exploration–what is it? - Its content and process; 'Natural Acceptance' and Experiential Validation- as the process for self-exploration. Continuous Happiness and Prosperity- A look at basic Human Aspirations. Right understanding, Relationship and Physical Facility- the basic requirements for fulfillment of aspirations of every human being with their correct priority. Understanding Happiness and Prosperity correctly- A critical appraisal of the current scenario. Method to fulfil the above human aspirations: understanding and living in harmony at various levels. Include practice sessions to discuss natural acceptance in human being as the innate acceptance for living with responsibility (living in relationship, harmony and co-existence) rather than as arbitrariness in choice based on liking-disliking.

**Understanding Harmony in the Human Being - Harmony in Myself!**

Understanding human being as a co-existence of the sentient 'I' and the material 'Body'. Understanding the needs of Self ('I') and 'Body' - happiness and physical facility. Understanding the Body as an instrument of 'I' (I being the doer, seer and enjoyer). Understanding the characteristics and activities of 'I' and harmony in 'I'. Understanding the harmony of I with the Body: Sanyam and Health; correct appraisal of Physical needs, meaning of Prosperity in detail. Programs to ensure Sanyam and Health. Include practice sessions to discuss the role others have played in making material goods available to me. Identifying from one's own life. Differentiate between prosperity and accumulation. Discuss program for ensuring health vs dealing with disease

**Understanding Harmony in the Family and Society- Harmony in HumanHuman Relationship**

Understanding values in human-human relationship; meaning of Justice (nine universal values in relationships) and program for its fulfillment to ensure mutual happiness; Trust and Respect as the foundational values of relationship. Understanding the meaning of Trust; Difference between intention and competence. Understanding the meaning of Respect, Difference between respect and differentiation; the other salient values in relationship. Understanding the harmony in the society (society being an extension of family): Resolution, Prosperity, fearlessness (trust) and co-existence as comprehensive Human Goals. Visualizing a universal harmonious order in society- Undivided Society, Universal Order- from family to world family. Include practice sessions to reflect on relationships in family, hostel and institute as extended family, real life examples, teacher-student relationship, goal of education etc. Gratitude as a universal value in relationships. Discuss with scenarios. Elicit examples from students' lives.

**Understanding Harmony in the Nature and Existence - Whole existence as Coexistence**
Understanding the harmony in the Nature. Interconnectedness and mutual fulfilment among the four orders of naturerecyclability and self-regulation in nature. Understanding Existence as Co-existence of mutually interacting units in allpervasive space. Holistic perception of harmony at all levels of existence. Include practice sessions to discuss human being as cause of imbalance in nature (film "Home" can be used), pollution, depletion of resources and role of technology etc.

**Implications of the above Holistic Understanding of Harmony on Professional Ethics**
Natural acceptance of human values. Definitiveness of Ethical Human Conduct. Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order. Competence in professional ethics: a) Ability to utilize the professional competence for augmenting universal human order b) Ability to identify the scope and characteristics of people friendly and eco-friendly production systems, c) Ability to identify and develop appropriate technologies and management patterns for above production systems. Case studies of typical holistic technologies, management models and production systems. Strategy for transition from the present state to Universal Human Order: a) At the level of individual: as socially and ecologically responsible engineers, technologists and managers b) At the level of society: as mutually enriching institutions and organizations . Sum up. Include practice Exercises and Case Studies will be taken up in Practice (tutorial) Sessions eg. To discuss the conduct as an engineer or scientist etc.

**Textbook**

1. Human Values and Professional Ethics by R R Gaur, R Sangal, G P Bagaria, Excel Books, New Delhi, 2010.

**Reference Books**

1. Jeevan Vidya: Ek Parichaya, A Nagaraj, Jeevan Vidya Prakashan, Amarkantak, 1999.
2. A.N. Tripathi, Human Values, New Age Intl. Publishers, New Delhi, 2004.
3. The Story of Stuff (Book).
4. Mohandas Karamchand Gandhi, The Story of My Experiments with Truth.
5. E. F Schumacher, Small is Beautiful.
6. Cecile Andrews, Slow is Beautiful.
7. J.C. Kumarappa, Economy of Permanence.
8. Pandit Sunderlal, Bharat Mein Angreji Raj.
9. Dharampal, Rediscovering India.

10. Mohandas K. Gandhi, Hind Swaraj or Indian Home Rule.
11. Maulana Abdul Kalam Azad, India Wins Freedom.
12. Romain Rolland (English), Vivekananda.
13. Romain Rolland (English), Gandhi.

## GENDER STUDIES

**Course Code: HS30421**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

### COURSE OBJECTIVE

The objective of this course is to make student understand the concepts of masculinity and femininity as analytical categories via analysing the role of communalism, patriarchy, violence as major hurdles to women's rights globally. Further, this course will enhance their understanding over the current health and education status of women to analyze impact of government health policy on women. Additionally, it will bring greater understanding over the integration of gender concerns and perspectives in policies and programmes for sustenance of environment at international, national, regional levels.

### COURSE OUTCOME

At successfully completing the course,the student will be able to

CO 1: Familiarise the students with the concepts of sex, gender and sexuality commonly used in gender studies,
CO 2: Identifying major human rights violations faced by women worldwide,

CO 3: Learn about women's health movements and government health policies,
CO 4: Develop an insight into policy perspective issues, and concerns of girl's education in India,
CO 5: Delineate the characteristics and the issues of environment and the involvement of women in balancing ecosystem,and
CO 6: Understand on sustainable development, millennium development goal, and other global level development initiatives taken for uplifting women status in society.

### COURSE DETAILS

**Understanding Basic Concepts in Gender Studies**

Concepts: Sex, Gender, Sexuality, Femininities, Masculinities and other sexualities, Patriarchy; WID: Women in Development; WAD: Women and Development; GAD: Gender and Development

**Gender and Human Rights Discourse**

Women's Rights as Human Rights (FGM, FF, Rape, Honour Killing, IVP, Witch Hunting, Virginity Test, Communalism, Trafficking, Immigration); National Commission for Women and other State Commissions, Ministry and Department of Women and Child.

**Gender and Health**

Sexual and reproductive health (ICPD, B.P.A. Family planning and Abortion); Impact of violence on women's health; Women's health movement: National and International; National health and population policy; National Family Health Survey (NFHS)

**Gender and Education**

Women's Education in Free India: Gender Disparity in Enrolment; Constraints of Women's Education: Social, Economic, Cultural, Geographical, other Factors; Important Committees and Commissions on Women's Education: Radhakrishnan Commission (1948), Mudaliar commission (1952), Kothari Commission (1964-1966), Ramamurthy Commission (1991).

**Gender and Environment**

Role of women in environment conservation; Role of Women in Waste Management; Women's Resistance to Environmental Destruction: Joint Forest Management – CHIPKO Movement – Narmada Bachao Aandolan

**Reading Materials**


1. Gerda Lerner, Creation of Patriarchy, Oxford University Press,1985
2. Menon, Nivedita. ed. 2007. Sexualities. Women Unlimited. New Delhi.
3. Gnew, Sneja, A Reader in Feminist Knowledge, Routledge, New York,1991
4. Marjorie Agosin (ed.), Women, Gender and Human Rights: A Global Perspective, Rawat Publications, 2000
5. Monica Chawla, Gender Justice: women and law in India, Deep and Deep pub., New Delhi, 2006, 2013
6. P D Kaushik, Women's rights; access to justice, Bookwell Publications, New Delhi, 2007
7. Paola Monzini, Sex Traffic, Prostitution, Crime and Exploitation, Zed Pub., 2005
8. Chloe E. Bird, Patricia P. Rieker, Gender and Health, Cambridge University Press, 2008.
9. Jasmine Gideon, Ed., Handbook on Gender and Health (International Handbooks on Gender series), Development Studies, Birkbeck, University of London, UK, 2016.
10. Nelson E, Zimmerman C. Household survey on domestic violence in Cambodia. Ministry of Women's Affairs, Project Against Domestic Violence, Cambodia,1996.
11. Parker B, McFarlane J, Soeken K. Abuse during pregnancy: effects on maternal complications and birth weight in adult and teenage women. Obstetrics and gynaecology, 1994, 84(3):323-328.
12. Madeleine Arnot and Mairtin Mac, An Ghaill, (2006) "Gender and Education" Routledge, New York
13. Aruna Goel, (2004) "Education and Socio-Economic Perspective of Women Development and Empowerment" Deep and Deep Publications, New Delhi

14. Eileen M. Byrne, (1978) “Women and Education” Tevi Stock Publications, Michigan
15. Payal Mago and Isha Gunwal, (2019). Role of Women in Environment Conservation.
16. M.S Swaminathan. (1998). “Gender Dimensions in Biodiversity management”. Konark Publisher’s Pvt. Ltd, New Delhi.
17. P.K.Rao. (2000). “Sustainable Development – Economics and Policy”. Blackwell, New Delhi.
18. Swarup, Hemlata and Rajput, Pam. (2000). “Gender Dimensions of Environmental and Development Debate: The Indian Experience” in Stuart S. Nagel, (ed.) “India’s Development and Public Policy”. Ashgate, Burlington.

## TRIBAL RESOURCE MANAGEMENT

**Course Code: HS30423**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

### COURSE OBJECTIVE

The course intends to impart a comprehensive knowledge about the reality, pertaining to economic alleviation of the poor and downtrodden. It is inter-disciplinary and based on utilization of natural resources employing traditional means of approach, conducive for societal growth and development. This shall hone socioeconomic environmental development for uplifting the condition of tribal population for igniting new ideas in the new economy.

### COURSE OUTCOME

At successfully completing the course, the student will be able to

CO 1: Identify the concept of sustainable natural resource management,
CO 2: Recognize agribusiness management, its opportunities and risks,
CO 3: Discuss adequate skills to prepare and implement integrated development plan & projects for the optimal use of tribal renewable resources for the sustainable development of the environment,
CO 4: Illustrate the nuances of environmental policies and Laws in India and understand the core competencies required for resource mobilization and policy formulation based on the research insight,
CO 5: Prioritize the role of health and education for the development of tribal community, considering tribal people as resources,and
CO 6: Develop trainees or volunteers as competent change agent in the field of tribal resource management.

### COURSE DETAILS

**Natural Resource Management**

Introduction to Natural Resources and their management: Natural Resource Management (NRM): Concept, Issue and Approaches; Need for developing extension strategies for NRM; Issues in management of NRM; Problems encountered while advocating strategies for NRM; Monitoring and auditing in Natural Resource Management (NRM); Triple Bottom Line (TBL) and concept of Sustainable Natural Resource Management; NRM of Water, land and forests: Water resources and their management, Overview of irrigation management, Integrated Watershed management and rainwater harvesting, River Basin management; Scope of market mechanism in NRM

**Agribusiness Management**

Agricultural value chains and their relevance; Managerial Insights: Identifying agribusiness opportunities; Assessing feasibility – technical, commercial and financial and thereby identify feasible opportunities for projects; Analyzing influences of external environment factors and associated risks; Discussions on illustrative agribusiness projects; select models and opportunities of agribusiness opportunities and ventures.

**Environmental Resource Management of Tribals**

Environment and Development-Theories of optimal use of exhaustible and renewable resources; Sustainable Development - The concept of sustainable development; strong and weak sustainability; Mechanism for environment regulation in India; environmental laws and their implementation; Environmental Policy in India-Policy instruments for controlling water and air pollution and forestry policy; Institution for forest Management- The institutions of joint forest management , social foresty-rationale and benefits

**Tribal Health and Education Management**

Role of Health and Education in Tribal Development: Importance in poverty alleviation; health and education outcomes and their relationship with macroeconomic performance; Tribal Health in India: An Overview Health outcomes; health systems; health; Evaluation of Health Programs for tribals: Costing, cost-effectiveness and cost benefit analysis; burden of disease; Tribal Education in India: An Overview Literacy rates, school participation, school quality measures

**Agro forestry Management**

Multiplicity of Agroforestry products and services- ecological and economic and cultural considerations-gender equality- preservation of indigenous knowledge. Socioeconomic benefits of agroforestry; Smallholder livelihood and the role of agroforestry- Food and nutritional security Fulfillment of food, fodder, fuelwood and shelter based needs- income generation vs. subsistence production; Adoption of AF-Determinants of adoption: feasibility, profitability, and acceptability; . Self-efficacy in farmer decision-making - policy aspects.

**Text Books**


1. Madhusudan Bandi ,Tribals and Community Forest Management , Rawat Publication, 2013
2. Jumyir Basar,Indigenous Knowledge and Resource Management Shipra Publications, 2014
3. Laishram Herojit, Rethinking Resource Management: Sustainability and Indigenous Peoples, A.K. Publications, 2012.


**Reference Book**

1. G.K. Bera, Tribal India's Traditional Wisdom and Indigenous Resource Management by, Abhjeet Publishers.

## INDIAN KNOWLEDGE SYSTEM

**Course Code: HS30425**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

### COURSE OBJECTIVE

The objective of the course is to promote interdisciplinary study on all aspects of the Indian Knowledge System (IKS), preserve and disseminate IKS for further study and societal applications. It will actively help students to engage in spreading the rich heritage of our country and traditional knowledge in the field of Liberal Arts, Literature, Basic Sciences, Engineering and Technology, Economics, mental and physical well being etc.

### COURSE OUTCOME

At successfully completing the course,the student will be able to

CO 1: Understand the concept of Indian traditional knowledge and its importance,
CO 2: Know the need and importance of protecting traditional knowledge,
CO 3: Develop an appreciation among the students for ancient scriptures,
CO 4: Contrast and compare characteristics and important kinds of traditional knowledge,
CO 5: Evaluate social change on traditional knowledge,and
CO 6: Create innovative ways of bringing forward ancient knowledge to the forefront.

### COURSE DETAILS

**Meaning of Traditional Knowledge System**

Overview of the Vedas, the Upanishads, the Puranas, and the Itihasas. Main Schools of Darshana/ Philosophy: Astika (Vedanta, Nyaya, Vaisheshika, Sankhya, Mimamsa, Yoga) and Nastika (Buddhist, Jainist, Lokayata). Types of Shastra (Vyakarana, Kavya, Alamkara, Shilpa, Vastu, Natya and Sangita). Types of Kavya (Drishya, Shravya, Chitra). Theory of Rasa: Natyashastra by Bharata (Chapter 6). Applied Traditional Knowledge: Myths, Rituals, Taboos and Superstitions, Folktales, Proverbs. Fundamental Concept of Dharma and Its Role in Various Streams of Indian Knowledge System

**Yoga and Spiritualism**

Definition and Origin of Yoga. Significance of spirituality in Yoga, Historical development of Yoga; Yogic philosophy: The eight limbs of yoga according to Patanjali, Mind, body & spirit connection in yoga; Relevance of Asana, Pranayama & Dhyana in Yoga: Physical posture for physical, mental and spiritual development, Breathing techniques for energy restoration & consciousness, Meditation for inner stillness and mindfulness, Meditation for spiritual growth & self-discovery; Ethics & Moral Values in Yoga: Exploring the ethical principles Yama and Niyama, Application of yogic principles to daily life for spiritual growth; Yoga & Spirituality in modern life.

**Fun with mathematics without calculator**

**Arithmetic-** Quick calculation with 11 and 12, Multiplication with 99999 in seconds, multiplication with numbers near the bases, vertical and cross multiplication, Magic squares and square roots, cubes, fractions, divisions, HCF and LMC in ancient style. Algebra- Factorising quadratic expressions, One variable linear equation, Simultaneous linear equations. Implementation of Vedic mathematics tools during competitive examinations.

**Ancient Indian Science and Technology**

Technological development in India: Agriculture (Origin and development, ancient crops, Traditional practices), Water management (Overview, Harappan water management, other case studies, Medieval Water structures), Pottery (Overview, Technical aspects), Silpasastra (Architecture and Construction· An introduction to Silpasastra, Construction Technology), Metallurgy (Copper/Bronze/Zinc, Iron and Steel Technology in India).

**Trade and Commerce in Ancient India**

Internal, External, Trade routes Indo-Roman contacts and Maritime Trade of South India; Silk and Cotton Textiles, the Principal Maritime Trade Commodities of Ancient India; Trade routes in Ancient India: Silk Route and Spice Route.

**Reading Materials**


1. Dasgupta, Surendranath. A History of Sanskrit Literature, Motilal Banarsidass
2. Banerji, Suresh Chandra. A Companion to Sanskrit Literature, Motilal Banrasidass
3. Chatterjee, Satischandra. An Introduction to Indian Philosophy, Motilal Banarsidass
4. Sharma, Chandradhar. A Critical Survey of Indian Philosophy, Motilal Banarsidass
5. A Text Book on Yoga and Health by Dr. Sajib Kumar Bhowmik, Sports Publication, 2020.
6. Light on the Yoga Sutras of Patanjali, B.K.S Iyengar, Element, 2005.
7. The Complete Book of Yoga: Karma Yoga, Bhakti Yoga, Raja Yoga, Jnana Yoga by Swami Vivekananda, Fingerprint Publishing, 2019.
8. Singhal, Aditi. How to Become A Human Calculator. ISBN : 9789352836543. S Chand Publishing
9. M. Tyra and K Kundan. Magical Book on Quicker Maths . ASIN : B07X93W2FC. BSC Publishing Co Pvt Ltd.
10. Singh, Balram. Science and Technology in Ancient texts. DK Print World ltd, 2012. ISSN 9788124606322.
11. Chandra Moti, Trade and Trade Routes in Ancient India. New Delhi: Abhinav Publications, 1977
12. Textiles in Ancient India: From Indus Valley Civilization to Maurya Period. Vishwavidyalaya Prakashan, 1994.

13. Duraiswamy, D. Silk and Cotton Textiles, the Principal Maritime Trade Commodities of Ancient India. ACTA VIA SERICA, Vol. 6, No. 2, Dec. 2021: 91-116, 6(2), 91–116.

## ECONOMIC INEQUALITY

**Course Code:** **HS40162**
**Credit:** **3**
**L-T-P:** **3-0-0**
**Prerequisite:** **Nil**

### COURSE OBJECTIVE

This course studies inequality from the economic perspective.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Learn about various aspects of inequality,
CO 2: Analyse and Measuring Inequality,
CO 3: Understand food security and inequality,
CO 4: Understand about health and educational disparity,
CO 5: Learn about effectiveness of current government programs, and
CO 6: Analyze the data on economic inequality.

### COURSE DETAILS

**Introduction to inequality**
Meaning of inequality; Global versus within-country inequality, growth and inequality; indicators of regional imbalance; cause of regional inequality; policy measures to remove regional inequality.

**Measuring Inequality**
Income Inequality, causes of income inequality; Axioms of inequality, Lorenz curve and Kuznets' inverted U hypothesis, Gini Coefficient, Decile dispersion ratio, Palma ratio, Gary S. Fields's Prediction.

**Inequality and Food Security**
Food and nutritional value; Global Hunger Index; Concept of food security, Global food security index; food self-sufficiency; Public Distribution System (PDS); Steps to reform PDS.

**Inequality and Human Resource Development**
Essential components of Human development, Human development Index (HDI), HDI ranking vs Income ranking, Inequality adjusted human development index, Gender inequality, Gender inequality index; Population stabilization; Health care infrastructure; Development of education sector in India, Equity and inclusion in education, policy measures to remove inequality.

**Current Status of Inequality**
Recent budgetary policies and programs relating to inequality; Analysis of Economic Survey data.

### Textbook

1. Gaurav Datt and Ashwani Mahajan, Indian Economy, GENERIC. Classic Edition, 2022, ISBN-10: 9352531299, ISBN-13: 978-9352531295.

**Reference Book**

1. S.K. Mishra, and V.K. Puri, Indian Economy, Himalaya Publishing House,2022, ISBN: 978-93-5596-423-6.
2. Inequality Re-Examined. Amartya Sen. Oxford University Press. ISBN-10: 0198289286, ISBN-13: 978-0198289289.
3. Uma Kapila, Indian Economy: Economic Development and Policy, Academic Foundation, ISBN-10: 9332705550 and ISBN-13: 978-9332705555.

## SCIENCE OF LIVING SYSTEMS

**Course Code: LS10001**
**Credit: 2**
**L-T-P: 2-0-0**
**Prerequisite: Nil**

### COURSE OBJECTIVE

The objective of the course is to enrich the basic knowledge of students in the field of biology and use that knowledge to support the engineering and research programs. Besides, the course also helps to learn methodology to establish models for various biological phenomena and apply the aforementioned models to predict/analyse the functionality of various systems.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to
CO 1: Learn the typical characteristics that distinguish life forms and analyze life process at cellular level,
CO 2: Apply concepts on structure and function of simple biomolecules in life processes
CO 3: Understand different process involved in life and analyse their effects,
CO 4: Analyse different biological phenomena and relate them to engineering applications,
CO 5: Comprehend different physiological functions and relate them to computer-based techniques, and
CO 6: Implement concepts of biology and their relevance to engineering and technology.

### COURSE DETAILS

**Cellular Organization of a Living Organism**
Biology in engineering, The Living World: Biodiversity of living world, Microorganisms, Cell as the basic unit of life, Cell theory, Structure and function of Prokaryotic and Eukaryotic cells, Cell growth and reproduction, Homeostasis, Concept of gene, Basic structure and function of chromosomes.

**Molecular and Biochemical Basis of an Organism**
Chemical Context of Life: Water, Carbon, Structure and Function, Types of bonding, Bio-macromolecules (Carbohydrates, Proteins, Amino acids, Lipids and Nucleic acids), Protein synthesis, Cell differentiation, Stem cells and their applications.

**Enzymes, Photosynthesis, Metabolism and Bioenergetics**
Enzymes: Introduction, structure, properties, Classification, Mechanism of enzyme actions, Factors affecting enzyme action, Strategies utilized by enzymes to affect catalysis. Photosynthesis: Introduction, pigments, process of photosynthesis, Mechanism of photosynthesis (light reaction and dark reaction). Metabolism and Bioenergetics: Anabolism and catabolism.

**Nervous system, Immune system and Cell Signaling**
Nervous system: Introduction, History of neuroscience, Types of glial cells, Nerve cells - Neurons, Organization of the nervous system, Action potential, Diseases of the nervous system, Computer-based Neural Networks. Immune system: Introduction, Innate Immunity, Adaptive or acquired immunity, Diseases of the immune system, Immune engineering. Cell signaling: General principles of cell signaling.

**Molecular Machines, Biosensor and Bioremediation**
Molecular Machines: Introduction, Molecular motors and Machines, F0F1-ATP synthase motors, Cytoskeleton associated motors. Biosensors: Concept of biosensor, Working principle, Types of biosensors, Glucose biosensors, Bio-detectors: DNA detection biosensor, Detection of pollutants, Biosensor in food industry. Bioremediation: Introduction, Role of microorganisms, Factors determining bioremediation, Types – *in situ/ex situ*, Advantages and disadvantages, Biofuel.

**Textbook**

1. S. Thyagarajan, N. Selvamurugan, M.P Rajesh, R.A Nazeer, Richard W. Thilagarajan, S. Bharathi and M.K. Jaganathan, Biology for Engineers, McGraw Hill Education (India),7$^{th}$ Edition, 2022.

**Reference Books**


1. P.H. Raven and G.B. Johnson. Biology (Indian Edition), Tata McGraw Hill Education Publication,13$^{th}$ Edition, 2023.
2. E.D. Enger, Feederick C, Ross and David B. Bailey. Concepts of Biology,Tata McGraw-Hill Publication, 14$^{th}$ Edition, 2011.
3. Neil A. Campbell and Jane B. Recee, Biology, Pearson Education, 8$^{th}$ Edition , December 2007.
4. Cecie Starr, Biology Concepts and Application, Thomson Books, 6$^{th}$ Edition, January 2006.


## MOLECULAR DIAGNOSTICS

**Course Code: LS10003**
**Credit: 2**
**L-T-P: 2-0-0**
**Prerequisite: Nil**

## COURSE OBJECTIVE

The objective of the course is to understand methods and techniques that are used to study biological processes in living beings. They include experimental and methodological approaches, protocols and tools for biological research.

## COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Learn the basics of Genes, Chromosomes, DNA, RNA and proteins along with their Aberrations,

CO 2: Understand the principles and working mechanisms of various instruments used in the study of biological processes in living things,

CO 3: Apply the knowledge of different diagnostics methods for quantitative estimation of xenobiotics (drugs and their metabolites) and biotics (proteins, DNA, metabolites) in biological systems,

CO 4: Analyze the recent developed techniques which are required for gene editing and their Applications,

CO 5: Evaluate the role of various bio-analytical techniques in environmental studies, biomedical sciences, life sciences, molecular biology, and biotechnological research, and

CO 6: Implement the knowledge of diagnostics in designing point-of-care instruments for different diseases.

## COURSE DETAILS

**Biomolecules**

Overview of DNA, RNA, and Proteins, Chromosomal structure & mutations, DNA polymorphisms; and Gene and Genetic errors.

**Molecular Basis of Diseases**

Infectious, non-infectious; Diagnosis- traditional, modern tools, Concepts of molecular diagnostics.

**Molecular Diagnosis and Techniques**

DNA fingerprinting, Auto-antibody fingerprinting, Southern blotting, PCR, Real-time PCR and variations; Nucleic acid sequencing: New generations of automated sequencers, CRISPR technology and its use in diagnostics and gene editing.

**Protein Diagnostics Techniques**

Antigen-antibody reactions, ELISA, variations of ELISA; Western blotting.

**Point-of-Care Devices**

Biosensors and nano-biosensors for disease and metabolites detection.

**Textbook**


1. M K. Campbell, S O. Farrell, O M. McDougal, AE Biochemistry, Cengage Publisher, 9th Edition, 2017, ISBN-13: 9789814846448.

**Reference Books**


1. N. Rifai, Andrea Rita Horvath and Carl T. Wittwer, Principles and Applications of Molecular Diagnostics, 2018, Elsevier Publisher, 1st Edition, 2018.
2. K.G. Ramawat & Shaily Goyal, Molecular Biology and Biotechnology, Publisher S. Chand & Co., 2nd Edition, 2010, ISBN: 9788121935128.
3. H. Lodish, Arnold Ber, Molecular Cell Biology, WH Freeman Publisher, 8th Edition, 2016, ISBN-10 9781464187445.


## OPTIMIZATION TECHNIQUES

**Course Code: MA10003**
**Credit: 2**
**L-T-P: 2-0-0**
**Prerequisite: Nil**

### COURSE OBJECTIVE

To familiarize the students with a few rudimentary and popular optimization techniques to enable them to solve resource-constrained real-world problems.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Know the concept of Linear programming problem (LPP) and will able to formulate linear programming problem,
CO 2: Understand the basic terminology and concepts of solving LPP,
CO 3: Solve LPP by simplex method,
CO 4: Know the concept of duality in Optimization technique,
CO 5: Apply optimization technique to solve transportation problem, and
CO 6: Solve assignment problem.

### COURSE DETAILS

**Linear Programming**
Mathematical foundations and basic definitions, Linear optimization: Formulation and graphical solution of linear programming problems, Simplex method, Duality.

**Transportation**
General structure of a transportation problem, Finding initial basic feasible solution by North-West corner rule, Least-Cost method and Vogel's Approximation Method, and Testing for optimality.

**Assignment Problem**
Hungarian assignment method, Unbalanced assignment problems, Restrictions in assignment, Travelling Salesman model.

**Textbook**


1. H.A. Taha, Operation Research, An Introduction, Pearson Education, 10th Edition.

**Reference Books**

1. K. Gupta, Kanti Swarup, and Man Mohan, Operations Research, P., S. Chand & Co, 2004.
2. N.S. Kambo, Mathematical Programming Techniques, East West Press, 1997.
3. R. Fletcher, Practical Methods of Optimization, 2nd Edition, John Wiley, 1987.
4. Hanif D, Sherali, M. S. Bazarra & J.J. Jarvis, Linear Programming and Network Flows, Wiley Publication, 2nd Edition.

## DIFFERENTIAL EQUATIONS AND LINEAR ALGEBRA

**Course Code: MA11001**
**Credit: 4**
**L-T-P: 3-1-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

The objective of this course is to familiarize the prospective engineers with techniques in ordinary differential equations and linear algebra. It aims to equip the students to tackle advanced level of mathematics and applications that they would find useful in their disciplines.
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**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Understand the concept of modelling and formulation of Differential equation of physical problems,
CO 2: Apply different methods to solve ODE problems involving growth-decay, cooling effects and electrical circuits etc,
CO 3: Solve 2nd and higher order ODEs,
CO 4: Apply the knowledge of special function in engineering problems,
CO 5: Use the essential tool of matrices and linear algebra in a comprehensive manner, and
CO 6: Apply the knowledge of Eigen value and Eigen vector in the field of engineering and also get the concept of complex matrices.

**COURSE DETAILS**

**Ordinary Differential Equations of First Order**
Introduction and formation of differential equations, Overview: Variable separable, homogeneous, equations reducible to homogeneous form. Exact differential equations, equations reducible to exact form, linear differential equations, equations reducible to linear form

(Bernoulli's equation). Applications of differential equations: Growth-Decay Problem, Newton's Law of Cooling, Mixing problem, Orthogonal trajectories.

**Linear Differential Equations of second order**

Second order linear homogeneous equations with constant coefficients; differential operators; solutions of homogeneous equations; Euler-Cauchy equation; linear dependence and independence; Wronskian; Solutions of non-homogeneous equations: general solution, complementary function, particular integral; solution by variation of parameters; undetermined coefficients. Applications of 2nd order differential equations in Electric circuit.

**Special Functions**

Improper Integrals for one variable, some test for convergence of improper integrals, Gamma function, Properties, Beta function, Relation between Gamma and Beta functions. Radius of convergence of power series, Legendre equation. Legendre polynomial. Recurrence relations and Orthogonality property of Legendre polynomial. Bessel's equation, Bessel's function, Recurrence relation.

**System of Linear Equations and Vector Space**

Linear system of equations; rank of matrix; consistency of linear systems; Solution of system of linear equations: Gauss elimination, inverse of a matrix by Gauss Jordan method, Vector Space, Sub-space, Basis and dimension, linear dependence and independence, Linear transformation.

**Matrix-Eigen value problems**

Eigen values, Eigen vectors, Eigen basis, quadratic form; Hermitian, Skew-Hermitian forms; similar matrices; Diagonalization of matrices.

**Textbook**

1. Erwin Kreyszig, Advanced Engineering Mathematics, Wiley INC, 10th Edition, 2011.

**Reference Books**

1. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 44th Edition.
2. H.K. Das, Introduction to Engineering Mathematics, S. Chand & Co Ltd, 11th Edition.
3. B.V. Ramana, Higher Engineering Mathematics, Tata McGraw-Hill Publications 2007.
4. J. Sinha Roy and S. Padhy, A course on ordinary & partial differential Equation, Kalyani Publication, 3rd Edition.

## TRANSFORM CALCULUS AND NUMERICAL ANALYSIS

**Course Code: MA11002**
**Credit: 4**
**L-T-P: 3-1-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

The objective of this course is to familiarize the students with the methods of Laplace and Fourier transformation and various numerical techniques to solve engineering problems.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Apply Laplace Transform to problems in the field of science and engineering,
CO 2: Use Fourier series and Transform as a tool to solve differential equations,
CO 3: Estimate the error in the results obtained in the numerical methods,
CO 4: Solve nonlinear equations that arise in engineering problems and interpolation,
CO 5: Know various numerical methods of differentiation and integration, and
CO 6: Apply numerical solution of differential equations and systems of linear equations.

**COURSE DETAILS**

**Laplace Transforms**
Laplace Transform, Inverse Laplace Transform, Linearity, Transform of derivatives and integrals, Unit Step function, Dirac delta function, Second shifting theorem, Differentiation and integration of transforms, Convolution, Solution of ODEs and integral equation by Laplace transform.

**Fourier Series and Transform**
Fourier series, Arbitrary periods, Even and odd functions, Half range expansions, Fourier integral, Cosine and sine transforms, Fourier Transform, Inverse Fourier Transform, Linearity, Fourier Transform of derivative, Convolution.

**Approximations & Errors**
Approximation of numbers by truncation and rounding-off, Types of errors.
Numerical solution of Nonlinear equations: Solutions by Bisection Method, Fixed Point Iteration Method, Newton-Raphson Method, Regula-Falsi and Secant Method, Rate of Convergence of Secant & Newton-Raphson Method.

**Interpolation & Approximation**
Finite Differences, Operators and Relation between them. Interpolation: Newton's forward and backward difference interpolation, Newton's divided difference interpolation and Lagrange interpolation.

**Numerical Differentiation & Integration**
Numerical differentiation of first- and second-order equations using difference table. Trapezoidal rule, Simpson's 1/3$^{rd}$ and 3/8$^{th}$ rules, Gauss-Legendre's two-point and three -point formulae. Error in Numerical Integration.

**Numerical Solution to ODE**
Taylor's (OK?) series Method, Euler's Method, Modified Euler's Method, Runge-Kutta Methods of order 2 and 4, Reduction of second-order ODE to system of first-order ODEs and its solution by R-K method of order four. Solution of System of Linear Equations, Solutions by Gauss-Seidel and Gauss-Jacobi methods.

**Textbooks**

1. E Kreyszig, Advanced Engineering Mathematics by Wiley, INC, 10th Edition.
2. Jain, Iyenger and Jain, Numerical Methods for Scientific and Engineering Computation, New age International (P) Ltd., 6th Edition.

**Reference Books**

1. B.S. Grewal, Khanna, Higher Engineering Mathematics, Publishers, 44th Edition.
2. B.V. Ramana, Higher Engineering Mathematics, Tata McGraw-Hill Publications, 2007.
3. A, Thangapandi and Somasundaram, Numerical Methods, Scitech Publishers, 2nd Edition.

## PROBABILITY AND STATISTICS

**Course Code: MA21001**
**Credit: 4**
**L-T-P: 3-1-0**
**Prerequisite: Nil**

### COURSE OBJECTIVE

The objective of this course is to familiarize the students with the foundation of probability and statistics and to use it in solving the problems arises in engineering and real-life applications.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Understand basic probability and its applications,
CO 2: ~~S~~tudy probability distributions and can use it in real life data analysis,
CO 3: Have a knowledge on univariate and bivariate distributions and their properties,
CO 4: Measure the central tendency and dispersion of a data set to draw conclusion from the data and interpret the data with the appropriate pictorial representation,
CO 5: Have good understanding of the Central Limit Theorem and its applications, and
CO 6: Analyze the statistical inference.

### COURSE DETAILS

**Probability and random variables**
Basic concepts of sample space, events (with example), Axiom of Probability, Conditional Probability, Bayes' Theorem and its applications. Discrete random variable, probability mass function, cumulative distribution function and Moment Generating function for discrete random variable, some special distributions like Uniform distribution, Geometric distribution, Binomial distribution, Negative Binomial distribution, Poisson distribution, Hypergeometric distribution, mean and variance. Continuous random variable, density function, cumulative distribution function and Moment Generating function. Uniform distribution, normal distribution, mean, variance, percentile and critical value of normal distribution, normal approximation of the binomial distribution and exponential distribution.

**Joint probability and distributions**
Joint probability mass function and marginal probability mass function, joint probability density function and marginal probability density function, concept of independent random variable (joint probability),

conditional probability mass function and conditional probability density function. Expected value, covariance and correlation for jointly distributed random variable (both continuous and discrete).

**Descriptive Statistics**

Frequency distribution, pictorial and tabular representation of data, stem and leaf display, dot plots, histogram, box plots and comparative box plots. Basic concepts on mean, median and mode, Skewness, Kurtosis, Correlation, Coefficient of Correlation, rank correlation, Regression Analysis: Least square method.

**Inferential Statistics**

Population, sample, random sample, sampling distribution, distribution of sample mean, central limit theorem, point estimator, point estimation of parameter using method of maximum likelihood estimation, confidence interval, confidence interval for the mean of a normal population with known and unknown variance, confidence interval for the variance of a normal population, hypothesis testing, one sided and two sided alternatives, Tests for mean of the normal distribution with known variance, Tests for mean of the normal distribution with unknown variance, tests for variance of the normal distribution.

**Textbooks**

1. J. L. Devore, Probability and Statistics for Engineers and Sciences, CENGAGE Learning, 9th Edition
2. Erwin Kreyszig, Advanced Engineering Mathematics, Wiley Inc., 10th Edition.

**Reference Books**

1. S.M. Ross, Introduction to Probability and Statistics for Engineers and Scientists, Elsevier/AP, 6th Edition.
2. J.S. Milton & J.C. Arnold, Introduction to Probability and Statistics, Mc Graw Hill, 4th Edition.

## VECTORS, PDE AND COMPLEX ANALYSIS

**Course code:** **MA21004**
**Credit:** **4**
**L-T-P:** **3-1-0**
**Prerequisite:** **Differential Equations and Linear Algebra (MA11001), Transform Calculus and Numerical Analysis (MA11002)**

**COURSE OBJECTIVE**

The objective of this course is to empower the students to design and solve branch prospective problems by the use of Vector calculus, Complex variables, partial differential equations and its numerical solutions.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Understand the physical significance of the concepts like divergence, curl and gradient,
CO 2: Apply vector integration theorems like Gauss divergence, Stokes and Greens theorem in different engineering applications like work done by force, evaluation of flux etc.,

CO 3: Know the basic analytical techniques for solving the classical wave, heat and Laplace equation,
CO 4: Find the numerical solution of wave, heat and Laplace equation using finite difference method,
CO 5: Understand the fundamental concepts of complex variable and skill of contour integration to evaluate complicated real integrals via residue calculus, and
CO 6: Apply the techniques of vector integration and complex integration to diverse situations in engineering and other mathematical contexts.

**COURSE DETAILS**

**Vector Calculus**

Brief concepts of vectors, gradient of a scalar field, directional derivatives, divergence and curl of a vector field. Vector line integral, surface integral, Green's theorem, Gauss divergence theorem, Stoke's theorem, engineering applications of above integral theorems like work done by force, flux integration, independence of path etc.

**Partial Differential Equations (PDE)**

Basic concepts of PDE like order, degree, linear, nonlinear, homogeneous and non-homogeneous PDE. Solution of PDE by Variable Separable method. Classification of PDE and their reduction to normal form. One dimensional Wave equation, D'Alembert and Fourier series solution of 1-D wave equation. Solution of 1-D heat conduction equation by Fourier series method. Solution of 2-D Laplace equation and 2-D heat conduction equations (steady state) with boundary conditions using Fourier series. Laplace equation in polar co-ordinates and its application to find the electrostatic potential/steady state temperature in a disk with appropriate boundary conditions. Solution of PDE by Laplace Transform.

**Numerical Solution of PDE**

Basics of finite difference approximation, forward, backward and central difference approximation of derivatives. Brief concepts of discretization for time and space derivatives. Numerical solution of 1-D wave equation (hyperbolic) using explicit and Crank-Nicholson scheme, 1-D heat equation (parabolic) explicit and Crank-Nicholson method and 2-D Laplace equation (elliptic) using the Liebmanns method and ADI method .

**Complex Analysis**

Basic concepts of complex number. Complex functions, derivatives, analytic function, Cauchy Riemann equations, harmonic functions, harmonic conjugate, elementary functions like exponential, trigonometric, hyperbolic, logarithmic functions and general powers. Curves in complex plane and their parametric representation. Line integrals, Cauchy integral theorem, Cauchy integral formula, Derivatives of analytic function. Power series, Taylor's series, Maclaurin's series, Laurent's series, singularities, Residues, Residue Integration, Real Integrals and Cauchy's Principal Value integrals.

**Textbooks**

1. Erwin Kreyszig, Advanced Engineering Mathematics, Wiley Inc., 10$^{th}$ Edition.
2. Jain, Iyenger and Jain, Numerical Methods for Scientific and Engineering Computation, New age International (P) Ltd., 6$^{th}$ Edition.

**Reference books**

1. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36th Edition.
2. B.V. Ramana, Higher Engineering Mathematics, TMH, 2017 Edition.
3. H.K. Dass, Advanced Engineering Mathematics, S. Chand, 2007 Edition.

## ENGINEERING MECHANICS

**Course Code: ME10001**
**Credit: 2**
**L-T-P: 2-0-0**
**Prerequisite: Nil**

### COURSE OBJECTIVE

Engineering Mechanics is a specialized need-based extension of Applied Physics and uses the principles of Statics and Dynamics. The objective of this course is to build the foundational knowledge of the students which is required for the design of mechanical systems. In particular, the course will cover aspects of analysis of rigid body, frame and machine under the action of force system, and analysis of free body diagram of a system whether at rest or in motion

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Draw complete and correct free-body diagrams and write the appropriate equations from the free-body diagram,
CO 2: Use scalar analytical techniques for analyzing forces and moments in mechanical systems,
CO 3: Analyze forces in statically determinate structures such as trusses, frames and problems related to friction,
CO 4: Determine the centroid and second moment of area,
CO 5: Apply fundamental concepts of kinematics and kinetics of particles to the analysis of simple and practical problems, and
CO 6: Solve real life problems by using mathematics, physical laws and theorems.

### COURSE DETAILS

**Concurrent Forces in a Plane**
Introduction to Engineering Mechanics, Free-body diagrams, Composition and resolution of forces, Methods of moments. Friction: Concept of friction, Wedge friction.

**Force Analysis of Plane Trusses**
Methods of joints, Method of Sections, ~~-~~Centroid: Parallel forces in a plane, Centroid of plane figures, Theorem of Pappus, and Centroid of composite plane figures.

**Moment of Inertia**
Moment of Inertia of plane figures, Parallel axis theorem, Perpendicular axis theorem, and Moment of Inertia of composite figures.

**Principle of Virtual Work**
Equilibrium of Ideal Systems, Virtual work.

**Dynamics of Particles**
Differential equations of rectilinear motion, Free vibration, D'Alembert's Principle, Momentum and Impulse, Work & Energy, Conservation of energy, Impact.

**Curvilinear Motion**
Normal and tangential acceleration, Motion of a projectile, Work and Energy in curvilinear motion.

**Rotation of a Rigid Body**
Kinematics of rotation, Rotation under the action of a constant moment.

**Textbook**

1. S. Timoshenko, D.H. Young and J.V. Rao, Engineering Mechanics, Tata McGraw-Hill Publication 5$^{th}$ Edition, 2017.

**Reference Books**

1. I.H. Shames, Engineering Mechanics (Statics and Dynamics), Prentice Hall, 4$^{th}$ Edition, 2005.
2. S.S. Bhavikatti, Engineering Mechanics –New Age International, 8$^{th}$ Edition, 2021.
3. S. Rajasekaran and G. Sankarasubramanian, Engineering Mechanics (Statics and Dynamics), Vikas publishing House, 3$^{rd}$ Edition, 2017.

## BASIC MECHANICAL ENGINEERING

**Course Code:** **ME10003**
**Credit:** **2**
**L-T-P:** **2-0-0**
**Prerequisite:** **Nil**

**COURSE OBJECTIVE**

The course is designed to give an overview of the fundamental aspects of mechanical engineering so that a student pursuing any branch of engineering will realize the possibilities that the branch of mechanical engineering offers.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: understand the basic principles of thermodynamics,
CO 2: develop an understanding of fluid machines like turbine and pump,
CO 3: determine stress and strains in a component subject to a load,
CO 4: understand the working and design aspect of power drives,
CO 5: recognize appropriate material for a particular engineering application, and
CO 6: understand the fundamentals of manufacturing processes.

**COURSE DETAILS**

**Concepts of Thermodynamics**
Systems, properties, state, and cycle, Thermodynamic equilibrium and quasi-static process, First law of thermodynamics for closed system, First law of thermodynamics for open/flow systems, Second law of thermodynamics, Kelvin Plank statement, Clausius statement, and Basic concept of entropy.

**Fluid Mechanics and Hydraulic Machines**
Introduction to fluids, Properties of fluids, Pressure variation with depth, Bernoulli's equation and its applications, and Introduction to hydraulic turbines and pumps.

**Mechanics of Materials**
Stress, Strain, Stress-Strain diagrams for ductile and brittle materials, Elastic constants, Hooks Law, Factor of Safety, One-dDimensional loading of members of varying cross sections.

**Power Transmission**
Gear, Belt, and Chain Drives, Shaft under varying loading conditions, Introduction to robots, Applications of robotics, Basic robot motions, Sensors and Actuators.

**Manufacturing Processes**
Introduction to engineering materials, Types and classification of materials, Properties of materials, Introduction to casting, forming, forging, rolling, extrusion and welding, Introduction to machine tools, NC, CNC, and 3-D Printing.

**Textbook**

1. P. Kumar, Basic Mechanical Engineering, Pearson Education, 2$^{nd}$ Edition, 2018.

**Reference Books**

1. J. K. Kittur and G.D. Gokak, Elements of Mechanical Engineering, Willey, 1$^{st}$ Edition, 2015.
2. B. Agrawal, C. M. Agrawal, Basic Mechanical Engineering, Willey, 1$^{st}$ Edition, 2011.

## WORKSHOP

**Course Code: ME18001**
**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

This workshop practice is designed to impart students the basic knowledge on manufacturing or developing a given object irrespective of their branch of engineering. While furnishing the given object, students will familiar with various mechanical operations and the respective tools or machines. This course involves four different sections namely Fitting, Welding, Turning and Sheet metal which cover both conventional and advanced tools to provide students the updated manufacturing experience. Students are also advised with various safety precautions to be followed during a specific manufacturing practice.

At the end, students will also gain knowledge on different advanced machines such as CNC machine tools and 3D printing.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Practice different operations related to fitting shop,
CO 2: Use different welding tools to prepare a given type of joint,
CO 3: Demonstrate various turning operations including taper turning and knurling using a conventional lathe machine,
CO 4: Design a tray and prepare it using sheet metal equipment involving soldering,
CO 5: Appraise different operations using a CNC machines, and
CO 6: Interpret different advanced machines such as 3D printing/additive manufacturing.

**COURSE DETAILS**

- Turning operations
- Sheet metal operations
- Fitting
- Welding

## FLUID MECHANICS AND HYDRAULIC MACHINES

**Course Code: ME20001**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

1. To introduce the fundamental concepts and principles of fluid mechanics applicable in different fields of engineering design and problem solving.
2. To develop fundamental concept on fluid and its properties, hydrostatic laws for compressible and incompressible fluids, principle buoyancy and stability of floating bodies under different conditions.
3. To indoctrinate the basic concept of kinematics and dynamics of fluid flow and to assimilate the laws and governing equations for different fluid flow cases under dynamic condition.
4. To inculcate the importance of fluid flow measurement and its applications in Industries.
5. To determine the losses in a flow system, flow through pipes, boundary layer flow and flow past immersed bodies.
6. To understand and analyze the performance aspects of fluid machineries specifically hydraulic turbines and pumps.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Describe fluid properties and compute fluid pressure,

CO 2: Explain and compute the hydrostatic forces on the submerged bodies and analyze the condition of stability of floating bodies,
CO 3: Apply fluid kinematics and dynamics principle in incompressible fluid flow,
CO 4: Illustrate Bernoulli's equation on different metering devices and examine energy losses in pipe transitions,
CO 5: Evaluate the performance parameters of hydraulic turbines and pumps, and
CO 6: Develop a set of dimensionless variables for a given flow situation and Compute drag and lift coefficients using the theory of boundary layer flows..

**COURSE DETAILS**

**Introduction**
Definition of a fluid, Concept of continuum, Properties of a fluid, Newton's law of viscosity, Types of fluids, Pressure and stress in the fluid, Absolute, Gauge, and Vacuum pressure.

**Fluid under rest**
Variation of pressure in a fluid, Pascal's law, Manometers, Hydrostatics forces on the submerged surfaces, Buoyancy and flotation, Concept of metacenter, and Metacentric height.

**Kinematics of fluid flow**
Lagrangian and Eulerian approach, Types of fluid flow, Convective, and Local acceleration, Streamline, Pathline, Streakline, Differential form of continuity equation, Stream function, Velocity potential function, Vorticity, Circulation, Flownets.

**Dynamics of fluid flow**
Euler's equation of motion, Bernoulli's equation along a streamline for ideal fluid, Venturimeter, Orificemeter, Pitot tube, Free vortex, and Forced vortex flow, Dynamics of viscous flows, Navier-Stokes equation, Major and minor losses in the pipe, Darcy-Weisbach formula, EGL, HGL, Fully developed laminar flow through pipe.

**Dimensional analysis and Similitude**
Buckingham's pi theorem, Model study, Model laws.

**Flow past immersed bodies**
Concept of boundary layer, Boundary layer thickness, Displacement, Momentum and energy thickness, Von-Karman integral equation, Boundary layer separation, Drag, and lift, Magnus effect.

**Hydraulic turbines**
Types of turbines, Velocity triangle diagram for Pelton wheel, Francis, and Kaplan turbine, Efficiency, Design parameters, Draft tube, Cavitation, Specific speed, Unit quantities, Model study.

**Hydraulic pumps**
Types of pumps, Centrifugal pump, Velocity triangle diagram for centrifugal pump, Multi-staging of centrifugal pumps, NPSH, Specific speed, Cavitation, Model study, Reciprocating pump, Slip, Indicator diagram, Air vessels.

**Textbook**

1. Pati, S. (2013). Fluid mechanics and hydraulic machines. Tata McGraw-Hill Education.

**Reference Books**

1. Kumar, K. L. (2008). Engineering fluid mechanics. S. Chand Publishing.
2. Som, S. K., Biswas, G. & Chakraborty, S. (2003). Introduction to Fluid Mechanics and Fluid Machines, Tata McGraw-Hill Education.
3. Modi, P. N., & Seth, S. M. (2019). Hydraulics and Fluid Mechanics Including Hydraulics Machines. Rajsons Publications Pvt. Ltd.
4. Cimbala, J. M., & Cengel, Y. A. (2006). Fluid mechanics: fundamentals and applications. McGraw-Hill Higher Education.
5. Rajput, R. K. (2004). A textbook of fluid mechanics and hydraulic machines. S. Chand Publishing.

## KINEMATICS AND DYNAMICS OF MACHINES

**Course Code: ME20002**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Mechanics of Solids (ME21001)**

### COURSE OBJECTIVE

Kinematics and Dynamics of Machines is a specialized need-based extension of Engineering Mechanics and uses the principles of Statics and Dynamics. The objective of this course is to build the foundational knowledge of the students how to analyze the motions of mechanisms, design mechanisms to have given motions, and analyze forces in machines. In particular, the course will cover aspects of analysis of kinematics and dynamics analysis of machine elements including linkages, belt and rope drive, cams and gears, analysis of gyroscopic motion, different types of governors, balancing of rotating and reciprocating parts of engines. Also, students will be able to perform linearized dynamic modeling for vibrational systems within the general machine design context.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Discuss different mechanisms from perspectives of mobility, displacement, velocity and acceleration,
CO 2: Understand dynamic forces in reciprocating and rotating devices and perform balancing,
CO 3: Select suitable governor for different applications based on analytical results,
CO 4: Analyze gyroscopic effects in case of plane discs, automobiles, ships and air crafts,
CO 5: Evaluate cam profiles for required motion profile of the followers, and
CO 6: Design flexible and rigid mechanical components to transmit power..

### COURSE DETAILS

**Simple Mechanism**

Classification of links and pairs, Kinematics chains, Degrees of freedom, Grashof's law, Grubler's criterion for plane mechanism. Four bar mechanism, and Its inversions. Single slider crank chain and its inversions. Double slider crank chain, and Its inversions.

**Velocity Analysis**
Velocity of a point in a link by relative velocity methods and instantaneous center method, Numbers and types of instantaneous centers in a mechanism. Location of instantaneous centers. Kennedy's theorem, Velocities of four-bar, and Slider crank mechanisms.

**Acceleration Analysis**
Acceleration of point on a link, Acceleration diagram of a link, Acceleration in the slider crank, and Four bar mechanism. Klein's construction, Coriolis' components of acceleration.

**Force Analysis**
Analytical method of finding acceleration of a piston and connecting rod. Inertia force, Torque. Inertia forces in the Reciprocating Engines, Turning Moment diagrams, Flywheel.

**Belt, Rope and Chain Drive – Analysis and Design**
Velocity ratio, Effect of belt thickness and slip on velocity ratio, Length of belt, Ratio of driving tensions, Power transmitted by belt, Centrifugal tension, Maximum power transmitted by belts, Creep and initial tension, V-belt, Ratio of tensions in rope drive, Chain length, Angular speed ratio, and Classification of chains.

**Gear and Gear Trains**
Simple, Compound, Riveted and Epicyclic Gear Trains, Calculation of velocity ratio, Theory of shape and action of tooth properties and methods of generation of standard tooth profiles, Standard proportions, Interference and under cutting, Methods of elimination of interference, Minimum number of teeth to avoid interference.

**Gyroscope**
Gyroscopic couple of plane disc. Analysis of the forces on bearings due to the forced processing of rotating disc mounted on shafts. Gyroscopic effects on a two wheel and four-wheel vehicle, Gyroscopic stabilization with reference to practical application.

**Governors**
Centrifugal Governor: Watt and Porter Governors, Spring loaded Governor-Hartnell Governor, Sensitiveness, Stability, Isochronous, Hunting, Governor Effort and Power, Curves of Controlling force.

**Balancing, Cams, Vibration**
Balancing of revolving masses in the same planes and different planes, Partial balance of Locomotives, Variation of tractive efforts, swaying couple, Primary, and Secondary balance of multi cylinder engines.
Types of cams and followers, Displacement velocity and acceleration-time curves for uniform velocity, Uniform acceleration and deceleration, Simple harmonic motion and cycloid motion, Graphical construction of cam profiles for different types of followers.
Free vibration of single degree system without and with damping, Equilibrium Method, Energy method, Stiffness of spring elements, Viscous damping.

**Textbook**

1. Rattan, S. S. (2014). Theory of machines. Tata McGraw-Hill Education.

**Reference Books**

1. Shigley, J. E. (1961). Theory of machines. McGraw Hill.
2. Myszka, D. H. (2004). Machines and mechanisms. Prentice Hall.
3. Rao, J. S. (2011). Kinematics of machinery through HyperWorks (Vol. 18). Springer Science & Business Media.
4. Sharma, C. S., & Purohit, K. (2006). Theory of mechanisms and machines. PHI Learning Pvt. Ltd.
5. Uicker, J. J., Pennock, G. R., Shigley, J. E., & Mccarthy, J. M. (2003). Theory of machines and mechanisms (Vol. 768). New York: Oxford University Press.

## MATERIAL SCIENCE AND ENGINEERING

**Course Code: ME20005**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

Material Science and Engineering is a specialized course on the extension of physics and chemistry to solve real life engineering problems in nanotechnology, biotechnology and manufacturing. The objective of the course is to understand the structure of materials, metals in particular and its co-relation with its mechanical, thermal, optical and magnetic properties. In addition, the course will also cover the phase diagram, phase transformation and heat treatment of steel. Application of materials science and engineering in to various functional materials will be covered with the help of case studies.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Understand and identify the structure and defects of materials,
CO 2: Comprehend the concepts of various properties of materials,
CO 3: Analyze and construe the concept of phase and phase diagram in materials,
CO 4: Correlate the application of heat treatment with phase transformation in materials,
CO 5: Evaluate properties of materials with respect to microstructure and phases present, and
CO 6: Create solutions for various engineering problems.

**COURSE DETAILS**

**Introduction and structure of materials**
Classification of engineering materials, Structure of atoms - Atomic bonding in solids, Binding energy, Interatomic spacing, single crystals, Polycrystalline, Non-crystalline solids; Imperfection in solids – Vacancies, interstitials, Schottky, Frenkel defects, Edge, and screw dislocations, Surface imperfection,

Volume imperfections, Importance of defects, Strengthening mechanisms, Microscopic techniques - Grain size determination, and Distribution.

**Properties of Materials**

Mechanical properties - Stress, Strain, Elastic properties, Plastic deformation, and Yield criteria, Fundamentals of hot, and Cold working processes, Hardness, Creep, Fatigue, Fracture, and Failure of materials, Concepts in electronic, Magnetic, and Optical properties of materials.

**Phase diagrams**

Gibbs phase rule, Single component systems, Binary systems, Eutectic, and Peritectic reactions, Lever rule, Application of phase diagram in iron-carbon system.

**Phase Transformation in materials**

Driving force, Homogeneous, and Heterogeneous nucleation, Growth kinetics, Solidification in isomorphous, Eutectic and peritectic systems, Cast structures, and Macrosegregation, Dendritic solidification, and Constitutional supercooling, Coring, and Microsegregation.

**Processing of Materials**

Principles of heat treatment in steel: Isothemal transformation of austenite - CCT and TTT curves, Surface hardening treatments, Annealing, Normalizing, Hardening, Tempering, Martempering, Recovery, Recrystallization, and Grain growth, Heat treatment of cast iron, and Aluminium alloys.

**Testing and Application**

Destructive, and Non-destructive testing of materials, Case studies on nanomaterials, Biomaterials, Smart materials, Energy materials, Other functional materials (Superalloys, Technical ceramics, etc.), Environmental effect on materials.

**Textbooks**

1. Callister, W. D., & Rethwisch, D. G. (2007). Materials science and engineering: an introduction (Vol. 7, pp. 665-715). New York: John wiley & sons.
2. Smith, W. F., Hashemi, J., & Prakash, R. (2019). Materials Science and Engineering, McGraw Hill.

**Reference Books**

1. Raghavan, V. (2015). Materials Science and Engineering: A first course. PHI Learning Pvt. Ltd.
2. Higgins, R. A. (1993). Engineering Metallurgy, Part I: Applied Physical Metallurgy. Chapter IV, 67.
3. NPTEL Introduction to Materials Science and Engineering, IIT Delhi by Prof. Rajesh Prasad https://nptel.ac.in/courses/113102080
4. MIT Open coursewares <https://ocw.mit.edu/courses/materials-science-and-engineering/>

## MECHANICS OF SOLIDS

**Course Code:** **ME21001**
**Credit:** **4**
**L-T-P:** **3-1-0**
**Prerequisite:** **Nil**

**COURSE OBJECTIVE**

The objective of Mechanics of Solids is to provide students with a fundamental understanding of the behavior of solid materials under different types of loads and the ability to analyze simple mechanical structures subjected to different types of loading conditions. This course covers topics such as stress, strain, elastic constants, axial load, bending and torsion, compound stress and strain, shear force and bending moment diagrams, slope and deflection, strain energy, columns, and stresses in cylindrical and spherical shells. The study of Mechanics of Solids provides a foundation for the design and analysis of various structures used in civil, mechanical, and aerospace engineering. It also serves as a prerequisite for advanced courses in the field of solid mechanics and structural engineering.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Understand the fundamental concepts of plain and thermal stresses, strains, and their relationship for different mechanical component under different loadings conditions,
CO 2: Implement the strain energy concept for different types of loading in structures to find slope and deflection,
CO 3: Analyze stress and strain for different mechanical components under uniaxial tension, bending and torsion,
CO 4: Apply graphical and analytical methods to analyze 2D stress and strain system for members under different types of loading conditions,
CO 5: Evaluate shear force, bending moment, slope, and deflection for different types of beams under different loading conditions, and
CO 6: Design mechanical components such as bars, shafts, beams, cylinders, spheres and columns for different types and combinations of loading conditions.

**COURSE DETAILS**

**Fundamentals of Engineering Mechanics**
Free-body diagrams, Composition and resolution of forces, Methods of moments, Parallel forces in a plane, Centroid of plane figures, Moment of Inertia of plane figures, Parallel axis theorem, Perpendicular axis theorem, and Moment of Inertia of composite figures.

**Stress, strain and elastic constants**
Concept of stress: Definition, Types of stresses (normal stress and shear stress), Concept of strain: Definition, Types of strains (Longitudinal, Lateral, Superficial, Volumetric, Shear), Poisson’s ratio, Stress strain diagram for ductile, and brittle materials, Salient features of the diagram, Elastic constants, and relationship thereof, Test instruments for mechanical properties – Stress, Strain, Hardness, Toughness, Impact Strength.

**Stress under axial load**
Expression for stress, and strain for members under axial load, Computation of stress and strain in uniform bars, Stepped bars, Tapered bars under axial load, Statically indeterminate structures,

Computation of stress, and strain due to self-weight of members, Principle of superposition, Computation of stress, and strain in composite rods, Thermal stress.

**Stress under bending and torsion**
Derivation of theory of simple bending, Application of simple bending theory in beams of circular, Rectangular, I-section (solid and hollow as applicable), Torsion in solid and hollow circular shafts, Power-torsion relationship, Derivation, and application of torsional stress expression in solid and hollow shafts, Stress distribution (Normal, and shear stress).

**Compound stress and strain**
Two-dimensional stresses, Principal stress, Principal planes: Analytical method and Mohr's circle method, Principal strains: Derivation, and application, Members under combined bending moment, and torsion.

**Shear force and bending moment diagrams**
Beams: Definition, Boundary conditions at different types of supports, Shear force, and bending moment: Concepts, Derivation, and relation between load, SF and BM, Computation, and representation of shear force, and bending moment in beams (Simply Supported, Cantilever and Overhang) subjected to couples, Concentrated, and uniformly distributed load.

**Slope and deflection**
Slope, and deflection of simply supported beams, Cantilever, and overhang beams under point load, Uniformly distributed load, and couples (Macaulay's method to be followed; hints on other methods to be provided).

**Strain energy**
Concept of strain energy, Concept of toughness, and resilience, Strain energy due to axial load, Bending moment and Twisting moment, Application of strain energy concept: Stress under sudden load, and impact, Castigliano's theorem to find slope, and deflection with applications involving simple structures under point load and uniformly distributed load, Concept of energy of dilation, and energy of distortion.

**Columns, and Stresses in cylindrical and spherical shells**
Members under compression – Concept of columns and struts, Concept of buckling, Euler's theory of buckling, Concept of slenderness ratio, Application in columns with different end conditions, Limitation of Euler's theory, and usefulness of Rankine's theory.
Stresses in thin cylinders, and thin spherical shell under internal pressure, Thick cylinders subjected to internal and external pressures, Application to cylindrical, and spherical shells.

**Textbook**

1. Rattan, S. S. (2011). Strength of materials. Tata McGraw Hill.

**Reference Books**

1. Hibbeler, R. C. (1994). Mechanics of materials. MacMillan Publishing Company.
2. Ryder, G. H. (1965). Strength of materials. Macmillan.
3. Rajput, R. K. (2006). Strength of Materials: Mechanics of Solids. S. Chand.
4. Khurmi, R. S. (2008). Strength of material. S. Chand.
5. Bansal, R. K. (2010). A textbook of strength of materials:(in SI units). Laxmi Publications.

# ENGINEERING THERMODYNAMICS

**Course Code: ME21002**
**Credit: 4**
**L-T-P: 3-1-0**
**Prerequisite: Differential Equations and Linear Algebra (MA11001)**

## COURSE OBJECTIVE

1. To develop an intuitive understanding of thermodynamics.
2. To emphasizing the physics and physical arguments.
3. To be able to use the First Law of Thermodynamics.
4. To know the physical implication of the second law.
5. To understand the entropy, enthalpy and internal energy and establish the relationship.
6. To implement the laws of thermodynamics into practical applications.

## COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Describe energy interaction and thermodynamic properties in close and open systems applying first law of thermodynamics,
CO 2: Understand second law statements in conceptualization of entropy and evaluate performance parameters in thermal machines,
CO 3: Apply the concepts of thermodynamic for pure substances and energy interaction using thermodynamic relations, steam table and Molier chart,
CO 4: Analyse power plant performance using standard and modified vapor cycle,
CO 5: Estimate heat of combustion in open and close systems, and
CO 6: Predict system performance using exergy analysis and thermodynamic relations..

## COURSE DETAILS

### Basic concepts and definitions
Scope of thermodynamics, Macroscopic and microscopic approaches, Thermodynamics systems, Thermodynamics properties, and processes, Thermodynamic equilibrium, Zeroth law of thermodynamics, Measurement of temperature

### First law of thermodynamics
Energy interaction with closed system- Heat, and work transfer, PdV work for different processes, First law for closed systems (for cyclic, and non-cyclic processes), Introduction of internal energy, and enthalpy as thermodynamic properties, Application of first law to different processes of closed system, First law for open systems. control volumes, Flow work and energy of a flowing fluid, Steady flow energy equation.

### Second law of thermodynamics
Kelvin-Planck, and Clausius statements of second law, Reversible and irreversible processes, Irreversibility, Causes of irreversibility, Carnot principles, Clausius inequality, Definition of entropy, and its evaluation for various processes of pure substances, Principle of increase of entropy, Entropy generation.

**Pure substances**
Definition of pure substance, p-v, p-T, T-s and h-s diagrams for pure substances, Dryness fraction, Specific volumes of saturated liquid, wet vapor, and superheated vapor, Use of steam tables in finding internal energy, and enthalpy of steam at different conditions, Measurement of steam quality, Mollier Diagram.

**Thermodynamic properties relations**
Maxwell relations, The Clausius-Clapeyron equation, Tds relations, Isothermal compressibility and volume expansively, The Joule–Thomson coefficient.

**Exergy**
Available energy or Exergy, Useful work, Availability for closed systems.

**Vapour power cycle**
Rankine cycle, Effect of pressure and temperature on Rankine cycle Reheat cycle, Regenerative cycle.

**Introduction to Combustion**
Fuel combustion, Stoichiometric and actual A/F ratio, Enthalpy, and internal energy of reaction, Enthalpy of formation, Calorific value at constant pressure, and constant volume, LCV, HCV, Adiabatic flame temperature, Thermodynamic law for reactive systems.

**Textbook**

1. Cengel, Y. A., Boles, M. A., & Kanoğlu, M. (2011). Thermodynamics: an engineering approach. New York: McGraw-hill.

**Reference Books**

1. Gordon, J., Wylen, V., & Richard, E. S. (1986). Fundamentals of Classical Thermodynamics. John Wiley and Sons.
2. Nag, P. K. (2008). Engineering thermodynamics. New Delhi.
3. Rogers, G. F. G., & Mayhew, Y. R. (1957). Engineering thermodynamics. Longmans, Green & Company.
4. Sherwin, K. (2012). Introduction to Thermodynamics. Springer Science & Business Media.
5. Jones, J. B., Dugan, R. E. (1996). Engineering Thermodynamics. PHI Learning Pvt. Ltd.
6. Mishra, D. P. (2012). Engineering Thermodynamics, Cengage Learning

## MANUFACTURING TECHNOLOGY-I

**Course Code: ME21003**
**Credit: 4**
**L-T-P: 3-1-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

The main objective of this course is to emphasize the importance manufacturing sciences in the day-to-day life and to study the basic manufacturing processes and tools used. The course is delineated particularly to impart basic knowledge and understanding about the primary manufacturing processes such as casting, joining, forming, powder metallurgy, conventional machining processes and their relevance in current manufacturing industry

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Identify basic requirements as well as complexities associated to different basic manufacturing processes,
CO 2: Comprehend the principles of different casting methods to analyze and assess their applicability,
CO 3: Apply load calculation principle and justify scope and limitations in different forming processes,
CO 4: Analyze different welding processes to compute efficiency and realize the source of defects,
CO 5: Judge different operations, principal parts, accessories and mechanism in conventional machine tools and estimate machining time, and
CO 6: Design selected jigs and fixture for machining operation.

**COURSE DETAILS**

**Foundry Process**
Introduction to casting, Sand casting terminology, Sand-Mould making procedure, Pattern making, Pattern materials, Pattern allowances, Types of patterns, Types of sand moulds, Moulding procedure, Types of sand, Sand properties and relevant Testing, Types of cores, Core making, Core sands, Fluidity of molten metals, and spiral fluidity test, Pouring time, Casting yield, Gating system design, Solidification of casting, Riser (basic design considerations), Cleaning of casting, Casting defects, Special casting processes - die casting, Permanent moulds casting, Precision investment casting, Shell moulding, Centrifugal casting etc.

**Metal Working Process**
Elastic and plastic deformation of metals, Stress-Strain relations, Concept of flow stress, Strain hardening, Hot and cold working of metals, Von Mises and Tresca yield criteria, Types of bulk forming Processes - Rolling: Types of rolling, Rolling equipment, Process variables, Distribution of roll pressure, Angle of bite, Rolling load estimation, Rolling defects- causes, and remedies. Forgings: Types of forging, Basic forging operations, Description of presses and hammers, Factors affecting forgeability, Forging load estimation, Forging defects-causes, and remedies, Extrusion: Principle and types, Advantages, Limitations, Applications, Process variables, Load calculation, Defects- causes and remedies. Drawing: Wire, Rod, and Tube Drawing, Process variables in drawing, Load estimation in rod drawing, Sheet metal working: – Sheet metal operations-blanking, Punching, Trimming, Shaving, Nibbling, Notching, Hemming, Coining, Embossing, Bending and Springback, Stretch forming, Deep drawing, and spinning, Types of sheet metal dies, Load estimation in sheet bending and deep drawing, Defects in sheet metal working, Their causes, and remedies.

**Welding Processes**
Classification of welding, Types of weld joints and weld positions, Electric arc welding: Principles of arc formation, Welding equipments, and electrodes. Gas welding: principles, Types of flames, Equipment, Techniques of gas cutting, Principles of inert gas welding: TIG, MIG, Sub-merged arc welding. Atomic hydrogen welding, Resistance welding: Principle of spot welding, Seam welding, Projection welding, Forge welding, Flash welding, Thermit welding, Electro-slag, and Electro-gas welding, Welding defects (causes, and remedies), and inspection.

**Powder Metallurgy**
Metallic powders: Preparations and properties, Steps in processing, Advantages, Limitations, and applications.

**Conventional Machine Tools & Machining Processes**
Types, Specification, Operations, Tools, Accessories and attachments, Estimation of cutting time of conventional machining processes. Lathe: Types and principal parts, Lathe operations – Turning, Facing, Drilling, Boring, Chamfering, Grooving, Parting, and Thread cutting, Turret & Capstan lathe, Multi spindle automatic lathe. Shaper: Types and principal parts, Shaper mechanism, Working principle of planner and slotter. Milling: Up and down milling, and Indexing. Grinding; Surface grinding, Centreless grinding, grinding wheel specification, wheel truing and dressing. Finishing Processes: Reaming, Lapping, Honing, Super finishing

**Jigs and Fixtures**
Functions and differences between jigs, and fixtures, Advantages in mass production, Principles of design and construction. Location: 3-2-1 Principle of location, different types of locating elements. Clamping: Principles of clamping, Types of clamping devices, and power clamping. Drill bushes; Design of simple Jigs for drilling operations, Simple fixtures for milling, and broaching operation.

**Textbooks**

1. Rao, P.N. (2011). Manufacturing Technology Vol-I 3E Volume 1. McGraw-Hill Education (India) Pvt Limited.
2. Rao, P.N. (2009). Manufacturing Technology Vol-II 3E Volume 2. McGraw-Hill Education (India) Pvt Limited.

**Reference Books**

1. Ghosh, A., & Mallik, A. K. (1986). Manufacturing science. Ellis Horwood.
2. Little, R. L. (1973). Welding and welding technology (Book- Welding and welding technology.). New York, McGraw-Hill Book Co.
3. Sharma, P. C. (2004). Production Technology. S. Chand & Co. Ltd. Publications.
4. Kalpakjian, S., & Schmid, S. R. (2009). Manufacturing Engineering. Technology; Prentice Hall.
5. Jindal, U. C. (2012). Material science and metallurgy. Pearson Education India.

## MANUFACTURING TECHNOLOGY-II

**Course Code:** **ME21004**
**Credit:** **4**
**L-T-P:** **3-1-0**
**Prerequisite:** **Material Science and Engineering (ME20005)**

**COURSE OBJECTIVE**

The main objective of this course is to emphasize the importance manufacturing sciences in the day-to-day life. To understand the concept and basic mechanics of metal cutting. To understand the basic concepts of non-traditional machining processes. Learn principles and strategies of automation in manufacturing systems.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Define, represent and transformed the tool geometry parameters in different reference frames,
CO 2: Understand and apply chip formation mechanism to find out effects of process variables on chip flow parameters,
CO 3: Implement appropriate machining conditions to achieve higher machinability at a low cost,
CO 4: Analyze constructional features of CIM system components and do part programming,
CO 5: Select an appropriate non-conventional machining technique to machine complex geometry components, and
CO 6: Design single and multipoint cutting tools in view of strength and deflection..

**COURSE DETAILS**

**Geometry of cutting tools**
Introduction: Machining in manufacturing, Orthogonal and oblique cutting, Types of cutting tools, Tool materials, General configuration of cutting edges of tools, concept of rake and clearance angles, Description of tool geometry: Tool-in-hand system, ASA, ORS, NRS Systems, Geometry of multiple-point cutting tools, and Conversion of tool angles.

**Mechanism and Mechanics of chip formation**
Mechanism of chip formation in machining ductile and brittle materials, Shear deformation and shear plane, Effective rake angle, Chip-tool contact length, Classification and characteristics of chips, Built-up-edge (BUE) formation, Causes of chip flow deviation , Chip reduction coefficient and cutting ratio, Shear angle, Cutting strain, Velocity relationship and Kronenberg relationship, and Effect of cutting variables on chip reduction coefficient.

**Machinability and Economics in machining**
Machinability: Definitions, and Factors affecting machinability, Cutting Force: Purposes of determination of cutting forces, Force system during turning and their significances, Merchant circle diagram-Construction and Development of mathematical expressions for cutting forces, Estimation of stresses, cutting power and cutting energy, Ernst-Merchant angle relationship, Lee-Shaffer's relationship, Experimental Measurement of cutting forces. Tool Wear: Definition, Causes and modes of failure of cutting tools, Mechanism and pattern of cutting tool wear, Tool life: Definition, Estimation and Taylor's tool life equation, Cutting Temperature: Location, causes and measurement, Surface integrity: Surface roughness, residual stress and micro-structure, Cutting Environments: Cutting fluid and its delivery system, Assessment of Machinability, and Economy in machining: Gilbert's model and estimation of economy.

**Tool Design**
Cutting tool design: Design of single point cutting tool; Form tools (Graphical method) and Broach tool. Press tool design: Press working equipment and operations, Press selection, Shearing principle, Stock strip layout, Pressure calculation, Blanking and Piercing die design, Design procedure for progressive and compound dies, Wire drawing and deep drawing.

**Advanced Manufacturing Processes**
Classification, principles, application and limitations of non-conventional machining processes such as Abrasive Jet Machining (AJM), Water Jet Machining (WJM), Abrasive water jet machining, Ultrasonic Machining (USM), Electrical discharge Machining (EDM), Wire electrical discharge machining (WEDM), Electrochemical Machining (ECM), Plasma Arc Machining (PAM), Laser Beam Machining (LBM) and Electron Beam Machining (EBM), Effect of process parameters on material removal rate, surface roughness and power consumption; Additive manufacturing, and Sustainable Manufacturing.

**Automation in Manufacturing**
Introduction to industrial automation: Elements, Function and levels of Automation, Open and Closed loop control Systems, Automation in machine tools, NC, CNC, & CNC-Part programming, adaptive control, Industrial Robots – configurations, drives and controls, Automated guided vehicles (AGV) system, Automated storage and retrieval systems, CIM, Smart Manufacturing, and Intelligent Manufacturing.

**Textbooks**

1. Chattopadhyay, A. B. (2011). Machining and machine tools (With CD). John Wiley & Sons.
2. Pandey, P. C., & Shan, H. S. Modern machining processes. Tata McGraw-Hill Education.
3. Groover, M. P. (3rd edition). Automation, production systems, and computer-integrated manufacturing. Pearson Education India.

**Reference Books**

1. Bhattacharyya, A. (1984). Metal cutting: theory and practice. Jamini Kanta Sen of Central Book Publishers.
2. Juneja, B. L., Sekhon, G.S. & Seth, N. (2005). Fundamentals of metal cutting and machine tools. New Age International Pub.
3. Shaw, M. C., (2002). Metal cutting principles, Oxford Pub.
4. Jain, V. K. (2nd). Advanced machining processes. Allied Publishers Pvt. Ltd.

## ADDITIVE MANUFACTURING THREE DIMENSIONAL PRINTING

**Course Code:** **ME28011**
**Credit:** **1**
**L-T-P:** **0-0-2**
**Prerequisite:** **Nil**

**COURSE OBJECTIVE**

Additive Manufacturing (AM) is a modern manufacturing technology also known as 3D printing process, will provide a clear understanding about the process, acceptability and usability in various field. AM technologies classified on the basis material types will be focused with its real life applications with advantages and disadvantages. Different types of errors associated with AM and CAD technology will be discussed with suitable error minimization processes. Various reverse engineering process will be discussed and practically implemented with its real life applications.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Describe the concept of additive manufacturing, its benefits and applications in various field,
CO 2: Understand various liquid, powder and solid material based technologies in Rapid Prototyping and Rapid Tooling process,
CO 3: Apply reverse engineering process to generate data for fabrication RP part,
CO 4: Design solid models and converting it to 3D printing readable file format required for part fabrication,
CO 5: Evaluate various types errors in the RP parts and errors during CAD file conversion, and
CO 6: Develop the application of AM process in the field of Biomedical.

**COURSE DETAILS**

**Introduction to Additive Manufacturing Technologies**
Need & Development of AM systems, AM process chain, Impact of AM and Tooling on Product Development, Benefits, Applications, Digital prototyping, Virtual prototyping, and Model Preparation using Solid Modelling Software.

**Classification of Additive Manufacturing Technologies**
Classification of AM technologies on the basis of Materials types. Discussion on various AM processes based solid, liquid and semi solid type of materials along with its application, advantages and disadvantages, and Hands on practice for model creation and saving on particular file format.

**Data Processing for AM Technologies**
Process planning for AM, CAD model preparation, data requirements & geometric modelling techniques: Wire frame, surface and solid modelling data formats, and Hands on practice for the fabrication of Single components and Assembly components.

**Rapid Tooling**
Classification: Soft tooling, Production tooling, Bridge tooling; direct and indirect, Fabrication processes, Applications, Rapid tooling techniques such as laminated metallic tooling, direct metal laser sintering, and vacuum casting, and Hands on practice for the fabrication of pattern and mould preparation.

**Reverse Engineering Processes**
Introduction to reverse engineering, Integration of reverse engineering with AM technology and, Hands on practice to generate model data in revere engineering process integrated with AM process.

**Textbook**

1. Choudhary, R.B. (2022) Additive manufacturing, , Khanna Publication.

**Reference Books**

1. Noorani, R. (2006). Rapid prototyping: principles and applications. John Wiley & Sons.
2. Chua, C. K., Leong, K. F., & Lim, C. S. (2010). Rapid prototyping: principles and applications, Yes Dee Publishing Pvt. Ltd, Third edition,
3. Lion, F. W. (2008). Rapid prototyping and engineering applications. CRC Press, Special Indian Edition
4. Liou, F. W. (2007). Rapid prototyping and engineering applications: a toolbox for prototype development. Special Indian Edition

5. Choudhary, R.B. (2022) Additive manufacturing, , Khanna Publication,

## DIE DEVELOPMENT BY CNC MILLING

**Course Code: ME28013**
**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Workshop (ME18001)**

### COURSE OBJECTIVE

The objective of the course is to provide basic knowledge on various tools and precision instruments used during CNC milling operation. It helps in understanding the usage of various machining cycles to reduce the manufacturing lead time. Moreover, it explains the usage of various standards and programming methods to be followed during CNC machining operation. Finally, the students can develop/generate the programs used to produce the geometries with complex contours using CNC milling machine.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Describe the usage of different tools and precautions to be followed during machining,
CO 2: Understand the principle and operation of precision instruments,
CO 3: Apply the technological advancements in NC and aimed to achieve JH pillar,
CO 4: Analyze the programming methods and programming in simulators,
CO 5: Evaluate die contours programming and executing on CNC milling machine, and
CO 6: plan for optimized CNC programming by estimating suitable process parameters.

### COURSE DETAILS

**Tools and Safety**
List of tools used on Milling Machine to perform various operations.
Safety: Introduction to safety equipment, and their uses.

**Measuring instruments**
Vernier caliper, Micrometer, Bevel protractor, Coordinate measuring machine (CMM): Construction, and principle graduation and reading, and least count.

**Introduction to CNC**
Introduction to CNC technology, Conventional Vs. CNC machine tool, CNC clamping system and Implementation of JH for CNC.

**CNC programming**
Introduction to CNC programming, Introduction and demonstration of line programs milling machine using ISO codes into the CNC simulator. Part programming methods, Cutting process parameter selection, Process planning issues and path planning, G & M Codes, Interpolations, and Tool compensations.

**CNC programming-Milling**

Calculations of parameters like speed feed , depth of cut etc. and set a references for the various operations. Prepare & set CNC Milling operations and dry run on the machine. Execute program and inspect simple geometrical forms / standard parts.

**Reference Books**

1. Koren, Y. Computer Control of Manufacturing Systems, Mc Graw-Hill. New York.
2. Groover, P. CAD/CAM
3. Sharma, P.C., Manufacturing Technology-II, S. Chand Publishing.
4. Jain, R.K. Engineering Metrology, Khanna Publishers

## CONCEPT CAR MANUFACTURING

**Course Code: ME28015**
**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

Objective of the course is to give the students hands on experience on building a racing car. Students find it very interesting to develop important parts of a racing car and then assemble and take part in various national and international events. In this process they meet the requirement set by the authorities. Therefore the students learn here how to propose a new car body and prove the feasibility by computational analyisis of the body and other important parts.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Remember the fundamentals of concept car characteristics,
CO 2: Understand the aerodynamic requirements in racing vehicles,
CO 3: Use the concepts of chassis behaviour of concept car,
CO 4: Illustrate the suspension characteristics of the concept car,
CO 5: Evaluate the problems faced in drives and braking systems in motor sports, and
CO 6: Build a concept car body.

**COURSE DETAILS**

**Car Development**
Constraints and specifications, Performance, Handling, Structure, Driver accommodation, and Safety.

**Tyres**

Adjustable features, Preliminary design and analysis, Driver-vehicle relationship, Desirable vehicle characteristics, Fundamentals of track, and Lap.

**Racing Car Aerodynamics**
Aerodynamic force and moment, Race car drag, Spoilers, Dams, Wings, and Effectiveness of wings in steady state cornering.

**Chassis Design**
Conditions for traversing a 90° corner, Effects of high speed braking, Cornering, Combined braking cornering, Steady state cornering, Throttle behaviour, Steering wheel force and kick back, Moving cg position, and Roll centre position changing.

**Suspension System**
Front suspension, General design issues, Camber effects, Sla suspension, Mcpherson struts, Independent rear suspension, Trailing arm types, Instant axis concept, Suspension springs, Torsion springs, and coil springs.

**Textbook**

1. Advanced Race Car Chassis Technology HP1562: Winning Chassis Design and Setup for Circle Track and Road Race Cars Bob Bolles, HP Books; Revised, Updated ed. 2010.

**Reference Books**

1. Race car vehicle dynamics, William F. Milliken and Douglas L. Milliken, 11th edition, SAE, 1995.
2. Formula 1Technology, Peter Wright, Sae Intl; 1st edition 2001.

## DEVELOPMENT OF AUTONOMOUS WHEELED ROBOTS

**Course Code:** **ME28017**
**Credit:** **1**
**L-T-P:** **0-0-2**
**Prerequisite:** **Basic Electronics (EC10001)**

**COURSE OBJECTIVE**

Nowadays, robotics is playing a vital role in industry 4.0, and autonomous wheeled robots are being applied to minimize human efforts and to improve the production rate. This course gives fundamental knowledge about wheeled robotics and its different hardware and software components. Moreover, the subject discusses kinematics equations, which will be implemented to control the motion of wheeled robots through the actuators. Further, the present course also describes the integration of various sensors and their programming, which will be used to make an autonomous control system for a robot.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Describe the fundamentals of wheeled robotics and its different components,
CO 2: Understand locomotion constraint features to travel the wheeled robots in different surface conditions,
CO 3: Apply various sensors integration on wheeled robots for autonomous navigation,
CO 4: Analyze the kinematics of wheeled robots,
CO 5: Evaluate an autonomous sensor-actuator control system with respect to a robot programm, and
CO 6: Design of automation solutions using wheeled robots.

**COURSE DETAILS**

**About Locomotion for Wheeled Robot**
Key issues for locomotion, Wheeled mobile robot’s locomotion, and Legged wheeled robots

**Wheeled Robots Kinematics**
Kinematic models and constraints, Representing robot position, Forward kinematic models, Wheel kinematic constraints, and Degree of freedom

**Sensors for Autonomous Wheeled Robots**
Various sensors for wheeled robots, Sensor classification, Ultrasonic sensor, Infrared sensor, Vision sensor, and Inertial measurement unit (IMU).

**Actuators for Autonomous Wheeled Robots**
Various actuators for wheeled robots, DC motor, Servo motor, Stepper motor, and Motor controller.

**Wheeled Robots Programming**
Robot programming language features, Computer control and robot software (monitor mode, run mode and editor mode), Arduino microcontroller programming, Raspberry Pi programming, and Complete design of an autonomous wheeled robot.

**Reference Books**

1. R. Siegwart, I.R. Nourbakhsh, D. Scaramuzza, Introduction to Autonomous Mobile Robots, MIT Press, 2011.
2. S.G. Tzafestas, Introduction to Mobile Robot Control, Elsevier Science, 2013.
3. G. Dudek, M. Jenkin, Computational Principles of Mobile Robotics, Cambridge University Press, 2010.
4. T. Bräunl, Embedded Robotics Mobile Robot Design and Applications with Embedded Systems, Springer Berlin Heidelberg, 2013.
5. U. Nehmzow, Mobile Robotics A Practical Introduction, Springer London, 2012.

## MODELLING OF MICRO WIND TURBINE

**Course Code:** **ME28019**
**Credit:** **1**
**L-T-P:** **0-0-2**
**Prerequisite:** **Mathematics (MA11001), Fluid Mechanics (ME2021)**

**COURSE OBJECTIVE**

Introduce computer-based solid, parametric, and assembly modeling as a tool for engineering design; enhance critical thinking and design skills. This course introduces the technology and economics of converting wind energy to electricity and other kinds of energy. Both utility scale horizontal axis wind turbines and small-scale horizontal are addressed, as well as the economical and environmental issues associated with wind energy.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Describe the basic concepts of wind energy conversion system,
CO 2: Understand the engineering design process and the implementation of different design phases,
CO 3: Apply concept of standalone, grid-connected, and hybrid operation in renewable energy systems,
CO 4: Illustrate 2D orthographic views from the 3D model for fabrication,
CO 5: Evaluate assembly and associative constraints during analysis, and
CO 6: Create a 3D solid model with high degree of confidence.

**COURSE DETAILS**

**Introduction to Wind Energy and Wind Power**
Introduction to renewable sources, Wind energy, Types of wind turbines, State of the art technology in wind energy, and State of the art technology.

**Design and Development of Small Wind Turbines**
Small wind technology, Blade element momentum theory, Design of tail fin, Wind turbine tower structure design stiffness and strength consideration, Aerodynamics of wind turbine rotor blade design, Angle of attack, and Profile.

**3D Modelling of Wind Turbine Using CAD Tools (SOLIDOWRKS)**
Introduction to 3D modeling, Parametric modeling, Feature-based modeling, Design Intent, Solid modeling commands, Sketching, Extrusion, Revolve, Fillet, Pattern, Solid Modeling, reference geometry, Sweeps, and Lofts.

**Assembling of the 3D Model of the Wind Turbine**
Assembly modeling, Top-down and bottom-up, Mates in assembly, and Exploded view.

**Creation of 2D Drawings for Production/Manufacturing Processes**
Extract 2D orthographic views from the 3D model for fabrication by specifying the proper dimensions, According to industry standards, For parts to be fabricated and to extract section and auxiliary views, Dimensioning standards and conventions, 3D assembly drawing of the wind turbine, Exploded view of the tower, and 3D drawings of all 3D printed parts

**Simulation using SOLIDWORKS and ANSYS**
Engineering analysis with SolidWorks, Stress and deflection of the wind turbine tower, and Simulation of wind turbine using SolidWorks

**Reference Books**

1. Wind Energy Explained: Theory, Design, and Application, By James F. Manwell, Jon G. McGowan, and Anthony L. Rogers, Wiley (2010).
2. Wind Power Plants: Fundamentals, Design, Construction and Operation, Gasch, Robert, Twele, Jochen (Eds.) Springer-Verlag Berlin Heidelberg; 2nd edition (2012).
3. Open source SOLIDWORKS Tutorial : https://my.solidworks.com/training/video/40d7a678-3293-4d7b-ba18-2113ff114b2a

## FLUID MECHANICS AND HYDRAULIC MACHINES LAB

**Course Code: ME29001**
**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Fluid Mechanics and Hydraulic Machines (ME20001)**

### COURSE OBJECTIVE

In this laboratory, the students are introduced to concepts of fluid mechanics and hydraulic machines. This helps the students to understand different means of pressure and flow measurements of fluid. Different devices used for this purpose are: pitot tube, venture meter, orifice meter, rotameter etc. Most common hydraulic machines like turbine and pumps are studied to understand principle of conversion of hydraulic energy to mechanical energy and vice versa. Important principles of fluid properties and effect of their variation in different hydraulic machines help the students to apply these concepts in industry to maximize the performance of such machines.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Recall the principle of Bernoulli's in conservation of head in fluid flow,
CO 2: Explain and use venture meter for flow measurement,
CO 3: Illustrate the flow measurement with the help of orifice meter,
CO 4: Analyze the effect of shape on metacentric height of any floating body,
CO 5: Evaluate performance of centrifugal pump, and
CO 6: Design Pelton wheel for a specific requirement after using characteristic curves.

### COURSE DETAILS

Demonstration of the Bernoulli's principle in conservation of head in fluid flow.
Measurement of fluid flow rate through pipes with the help of venturi meter.
Calculation of the fluid flow through pipe with the help of orifice meter.
Evaluation of the metacentric height of any floating body.
Drawing the characteristic curves for Pelton wheel.
Drawing the characteristic curves for Francis turbine.
Plotting the characteristic curves for reciprocating pump.
Plotting the characteristic curves for centrifugal pump.

## MACHINE KINEMATICS AND DYNAMICS LAB

**Course Code:** **ME29002**
**Credit:** **1**
**L-T-P:** **0-0-2**
**Prerequisite:** **Kinematics and Dynamics of Machines (ME20002)**

### COURSE OBJECTIVE

This laboratory provides the basic and advance knowledge of various kinematics and dynamics machines and their parts like the coefficient of friction calculation setup, screw jack apparatus, flywheel setup, cam and follower analysis, the principle of Hartnell governor, gyroscopic couple calculation setup, damped or undamped with free or forced vibration calculation apparatus. Furthermore, these machines' practical applications in the industry will be discussed briefly during laboratory hours. After completing all the experiments, the students can implement this laboratory's outcome in their project work.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Identify the velocities and accelerations of mechanisms and IC engine parts,
CO 2: Discuss the static and dynamic balancing of high speed rotary and reciprocating machine parts like gear, cam, belt and chain drives,
CO 3: Use of Hook's joint, Davis and Ackerman Steering gears, Compound pendulum, Bifilar and Trifler suspension,
CO 4: Analyse both the free and forced vibrations of machines and structures,
CO 5: Assess the effect of friction on mechanisms and the kinematics of cam and followers, and
CO 6: Predict the effect of the gyroscopic couple on two wheelers, four wheelers, ships, and air-crafts.

### COURSE DETAILS

Determination of the coefficient of friction between different sliding surfaces.

Determination of the Mechanical Advantage (M.A), Velocity Ratio (V.R), Efficiency of a Simple Screw jack, and also verify the Law of machine.

Determination of the moment of inertia of the flywheel, Study of Hartnell Governor, and plot the curve between speed and sleeve displacement.

Study of cam and follower apparatus and draw the curve between follower displacement and angle of a cam rotation for a cam follower pair, and also observe the jump phenomenon.

Comparison between applied couple and theoretical gyroscopic couple, and Study of the longitudinal vibration of helical springs connected in series and parallel.

Study of undamped torsional vibration of two rotor-system, Determination of the natural frequency, Study of damped torsional vibration, and Determination of the damping coefficient.

Determination of forced vibration of an equivalent spring, mass and damper system, and plot the curve between amplitude and frequency.

Determination of the undamped free vibration of an equivalent spring, mass and damper system, and Determination of time period

Study of various types of gears like spur, helical, straight bevel, rack and pinion, and worm gear.

## MATERIAL TESTING LAB

**Course Code: ME29003**
**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Mechanics of Solids (ME21001)**

### COURSE OBJECTIVE

This laboratory would comprise of various equipment and experiments to provide the exposure to basic mechanical characterization techniques and microstructure analysis. This laboratory helps the students to understand the mechanical behavior of various materials, affect of microstructural parameters (grain size, boundary fraction, Phase fraction, second phase particle etc.) on their deformation behavior, quality, and performance. The laboratory is equipped with different destructive testing equipment such as Universal testing machine, Impact testing machine, hardness tester and torsion testing machine along with sample preparation setup and optical microscope. A series of experiments are chosen for undergraduate students to demonstrate the basic principles in the area of mechanics of materials, structural analysis and strength of material. The laboratory also provides support to different research activities carried out by both internal as well as external research scholars (B.Tech, M.Tech and Ph.D.) in terms of finding various mechanical properties (impact strength, tensile strength, compressive strength, shear strength, flexural strength, hardness, etc.) of material as well as microstructural quantification.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Identify the mechanical properties of various ferrous and nonferrous metals,
CO 2: Interpret the different types of mechanical properties of material and their characterization techniques which are used in various fields of engineering,
CO 3: Apply the mechanical properties of various metals from different thermo-mechanical processing, performance and testing aspects,
CO 4: Correlate the mechanical properties of steel and its alloys for different structural and automobile applications,
CO 5: Evaluate the fundamentals of microstructure, microstructural characterization of material by using optical microscope, and
CO 6: Design the various microstructural parameters: grain size, grain boundaries, inclusions, precipitates phases) and their effect on mechanical properties of material.

### COURSE DETAILS

To determine the impact strength of mild steel by Izod test method.

To determine the impact strength of mild steel by Charpy test method.

To determine the tensile strength of a mild steel specimen using UTM.

To determine the compression strength of a mild steel specimen using UTM.

To determine the flexural strength of a mild steel specimen by three point bending test using UTM.

To determine the hardness of the given specimen by Rockwell hardness tester.

To determine the hardness of the given specimen by Vickers hardness tester.

To determine the torsional shear stress, maximum torque of mild steel by Torsion testing equipment.

Metallographically sample (mild steel) preparation and observation of microstructure using an Optical microscope.

## DESIGN OF MACHINE ELEMENTS

**Course Code:** **ME30001**
**Credit:** **3**
**L-T-P:** **3-0-0**
**Prerequisite:** **Materials Science & Engineering (ME 20005), Mechanics of Solids (ME 21001)**

### COURSE OBJECTIVE

This course focuses on various aspects of machine elements, manufacturing considerations and materials used. It enables to determine strength, stiffness and stability of a mechanical component by involving various analytical methodologies. It also deals with design of various joints such as riveted, welded, cotter, knuckle, and design of various types of threaded fasteners. The course will also cover design of various IC engine components and evaluate fatigue life of machine components. At the end of the course, the student will be able to design a mechanical component with proper specifications, least manufacturing cost and high efficiency in operation.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Identify the different loading conditions in machine elements and predict failure criteria,
CO 2: Understand various temporary and permanent fasteners as per industrial requirements and evaluate its strength under various loading,
CO 3: Apply design concept in different IC engine components,
CO 4: Analyze different types of bearing for static and dynamic loads,
CO 5: Evaluate fatigue life of different machine components and estimate endurance strength of different materials, and
CO 6: Design of shafts and gears for industrial applications.

### COURSE DETAILS

**Design considerations**
Basic requirement for machine elements and machines, Design procedure, Design Synthesis, Use of standards in design, Selection of engineering materials, Selection of factor of safety, Manufacturing considerations in design, Various stresses in machine elements, and Theories of failure.

**Design of fastening elements**
Design of riveted joints (Methods of riveting, Application to Boiler Drum), Design of welded joints (strength of butt, transverse and parallel fillet weld, Circular fillet weld subjected to torsion and bending, Axially loaded unsymmetrical, Eccentrically loaded welded joint), Design of bolted joints (types of screw fastening/locking devices), Bolts of uniform strength, and Eccentrically loaded (in-plane, out-plane) bolted joints.

**Design against fatigue load**
Stress concentration and factors, Endurance strength and limit stress, Notch sensitivity, LCF and HCF, Design for a finite life of components and cumulative damage, Design for infinite life, Soderberg and Goodman lines, and modified Goodman's lines, and Evaluation of fatigue life in machine components.

**Design of shafts, gears and bearings**
Design of shafts (types of shaft, shafts subjected to torsion, Bending and combined loading, Design consideration/application as per ASME code), Design of spur gear, Basic modes of lubrication, Viscosity index, Selection of Lubricants, Theory of film (Stribeck's Equation), Static and dynamic load carrying capacity, and Design of journal bearing.

**Design of IC engine components**
Cylinder liners & Piston, and Connecting rod.

**Textbooks**

1. Design of Machine Elements - V. B. Bhandari (TMH), 3rd Ed.
2. Design Data Hand Book, S. Md. Jallaludeen (Anuradha Pub.)

**Reference Books**

1. Machine Design - Sharma/Agarwal (Katson publishing House)
2. Machines Design Data Book - P.S.G. College of Technology, Coimbatore.
3. Mechanical Engineering Design - Shigley J E, Mischiee C. R.; TMH
4. Mechanical Design - of Machines, Maleev/Hartman (CBS)
5. Machine Design - Gupta J. K. and Khurmi R. S. (S. Chand Pub.)

## ENGINEERING METROLOGY AND CONTROL

**Course Code: ME30002**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

Engineering Metrology and Control is an essential course in Mechanical Engineering and its knowledge is compulsorily used in every industry and laboratory. The objective of this course is to develop an intuitive understanding of measurement concepts with a focus on measuring system working procedures and the physics involved behind each. The course covers the knowledge of instrumentation for the measurements of displacement, strain, temperature, pressure, and flow along with metrology techniques. Various advancement in measuring tools such as CMM, SEM, XRD, TEM, AFM and etc. for Metrology and its application in industry can be observed. Different types of control systems are introduced to find the mathematical models of complicated mechanical systems into a more simplified forms in terms of equivalent electrical models for analysis.The content is suitably advanced and oriented to serve as a reference source for the students of undergraduate and postgraduate studies in Mechanical Engineering of all disciplines.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Describe the fundamental knowledge of metrology techniques and their applications,
CO 2: Understand the different instruments used in mechanical measurement and outline their working principles,
CO 3: Apply the concept of metrology accurately for performing measurements in industry,
CO 4: Analyze the basic principles of pressure, temperature and strain measuring devices,
CO 5: Evaluate the different types of control systems, and
CO 6: Develop simplified and equivalent electrical models for analysis of complicated mechanical system.

**COURSE DETAILS**

**Metrology**
Definition, Needs of inspection, principle and methods of measurements, sources of error, precision and accuracy, Standards of measurement, Line, End and Wave length standards.

**Limits, Fits and Tolerances**
Interchangeability and selective assembly, Basic concepts of limit, fit and tolerance, fundamental deviation, hole and shaft basis systems, Limit gauges, and Taylor's principle of limit gauge design.

**Simple measurement tools**
Surface plate, Rules, Callipers, Height gauges, Micrometers, Depth gauges, Dial indicator, Slip gauges, Sine bar, Coordinate measuring machine (CMM) an introduction, Angular and Taper Measurements, Autocollimator, Measurement of straightness, Flatness, Parallelism, Squareness, and Roundness.

**Surface Roughness**
Elements of surface texture, Order of surface irregularity, Evaluation of surface finish, Measurement of surface roughness using Tomlinson surface meter, and Taylor Hobson's Talysurf.

**Screw Thread Measurement**
Standard thread profiles, Errors in threads and pitch errors, Measurement of effective diameter by 2-wires, 3-wires methods, and Best wire size.

**Measurement of Strain**

Mechanical strain gages, theory of strain gage, gage factor, methods of strain measurements, strain gauge bridge arrangement.

**Measurement of Temperature and Pressure**
Methods of measuring temperature, Thermocouples, Law of thermocouples, Thermistor, pyrometry, IR thermography, Methods of pressure measurement, Elastic pressure transducers, Dead weight pressure gauges, Measurement of vacuum, and Measurement of high pressure.

**Modern Measurement Techniques**
Transmission Electron Microscopy (TEM), Scanning Electron Microscopy (SEM), Atomic Force Microscopy (AFM), and X-ray Diffraction Systems (XRD).

**Control Systems**
Introduction, Classification of Control Systems, Feedback and Its Effects, Mathematical Models of Physical Systems, Modelling of Mechanical System Elements (only translational), Electrical Systems, Analogous Systems, and Procedure for Deriving Transfer Functions.
Block Diagram and Signal Flow Graphs
Block Diagram Reduction, and Construction of Signal Flow Graphs.
Time response Analysis
Time Response of First-Order Systems (Only Unit-Step and Unit-Impulse), Second order Systems, Steady-state errors, and error Constants.

**Textbooks**

1. R.K Jain, Engineering Metrology, Khanna Publishers.
2. Thomas G. Beckwith, Roy D. Marangoni, and John H. Lienhard V. Mechanical Measurements, Pearson.
3. Control Systems: By A. Anand Kumar : PHI

**Reference Books**

1. Engineering Metrology and Measurements: By N.V. Raghavendra & L. Krishnamurthy, Oxford Publication
2. A Course in Mechanical Measurement and Instrumentation: By A K Sawhney, P Sawhney : Dhanpat Rai & Co
3. Control Systems Engineering: By J. Nagpal and M. Gopal, New Age International Publishers
4. A Text Book of Metrology: By M Mahajan, Dhanpat Rai & Co

## HEAT TRANSFER

**Course Code: ME30003**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Fluid Mechanics and Hydraulic Machines (ME20001), Engineering Thermodynamics (ME21002**

**COURSE OBJECTIVE**

• To understand the basic principles of heat transfer
• To perceive the transport phenomena of a real engineering application
• To be able to design the heat transfer equipment used for engineering process
• To be able to identify the different parameters effecting the physical process
• To be able to develop experimental techniques and correlations to understand the physical insight of the real life engineering applications
• To develop the necessary background to understand the industry problems

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Identify the different modes of heat transfer in different engineering applications,
CO 2: Discuss the mechanism of conduction heat transfer for implementation in various industrial and scientific systems,
CO 3: Apply the theoretical and experimental correlations of convective heat transfer to different engineering problems,
CO 4: Analyze properties and laws of radiation to estimate the heat transfer rate,
CO 5: Evaluate the thermal performance of various heat transfer applications, and
CO 6: Design an efficient industrial heat exchanger considering three modes of heat transfer.

**COURSE DETAILS**

**Introduction**
Different Modes of heat transfer; conduction, convection and radiation: Fourier's Law
of heat conduction equation, Newton's law of cooling, and Stefan-Boltzmann equation for black body radiation.

**Conduction**
Mechanism of conduction, Derivation of the generalized heat conduction equation in Cartesian coordinates, Cylindrical, and spherical coordinates, Types of boundary conditions, Solution of the one-dimensional steady state heat conduction equation with constant thermal conductivity and without heat generation in Cartesian, Cylindrical, and Spherical coordinates, Extension of the solution to composite walls by electrical analogy, Extension of the solution to composite cylinders and sphere by electrical analogy, Critical thickness of insulation, Heat transfer from fins (only longitudinal fins with the constant cross sectional area), Fin efficiency and effectiveness, Unsteady heat conduction, and Lumped parameter system.

**Convection**
Mechanism of convection and basic concepts, Concept of thermal boundary layer, Conservation equations for mass, Momentum, and energy, Significance of dimensionless numbers in forced and free convection, Expression of local and average values of heat transfer coefficients, Nusselt number for flat plate, Experimental correlations for forced and free convection for various geometries (both laminar and turbulent flow).

**Radiation heat transfer**
Blackbody radiation, Plank's law, Spectral and total emissive power, Wein's displacement law, Spectral and total intensity of radiation, Radiation properties: emissivity, absorptivity, reflectivity and

transmissibility, Kirchoff's law, Radiation shape factor, Relation for shape factor and shape factor algebra, Heat exchange between black bodies through n medium, Grey bodies, and real bodies, Heat exchanges between gray bodies. Radiosity and irradiation, Electrical analogy and radiation network for a 2-surface and 3-surface enclosures in non-absorbing medium, and Radiation shields.

**Heat exchangers**

Types of heat exchangers and heat exchanger configurations. The overall heat transfer coefficient and fouling factor, LMTD and effectiveness-NTU analysis of heat exchangers, and Heat exchanger selection considerations

**Boiling and Condensation**

Introduction, Boiling regimes, Boiling correlations, Types of condensation, use of correlations for condensation on vertical flat surfaces, horizontal tube, and Introduction to heat pipe.

**Textbook**

1. Heat and Mass Transfer, R.K. Rajput, S. Chand & Company, 5th edition.

**Reference Books**

1. Fundamental of Heat and Mass Transfer, Frank P. Incropera, David P. Dewitt, Willey 1996, 4th edition.
2. Heat and Mass Transfer, Y A Cengel and A J Ghajar, McGraw-Hill Publication, 4th edition.
3. Engineering Heat and Mass Transfer, M M Rathore, Laxmi Publications Pvt. Ltd, 3rd edition.
4. Principles of Heat Transfer, Frank Kreith, Raj M. Manglik, M.S. Bohn, Cengage Learning, 7th edition
5. Heat Transfer, J. P. Holman and S. Bhattacharya, McGraw Hill Education, 10th Edition.
6. Introduction to Heat Transfer, S. K. Som, PHI Learning Private Ltd, 2013.

## INDUSTRIAL ENGINEERING AND OPERATIONS RESEARCH

**Course Code: ME30005**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

This course focuses on the understanding of various aspects related to production planning and control which are inevitable for the effective and efficient production of goods and services. Moreover, this course emphasizes on the learning of some of the optimization techniques and their applications, especially linear programming. These techniques are used for decision making and finding the best solution for a given problem.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Describe the forecast of demand, and prepare the aggregate production plan and material requirement plan,
CO 2: Classify the different inventory control problems and calculate the economic order quantity,
CO 3: Solve the different quality control problems using X bar, R, C and P control charts,
CO 4: Analyse the linear programming problems and solve by using simplex method,
CO 5: Evaluate the optimum solution of assignment and transportation problem, and
CO 6: Design the network diagram and calculate the duration of project completion.

**COURSE DETAILS**

**Introduction**
Introduction to Industrial Engineering and Operations Research, Types of Production processes (Project, Job, Batch, Mass/Line, Continuous, Introduction to Production Planning & Control (PPC) and its functions, and Lean Manufacturing

**Production Planning**
Factors influencing facility location, Gravity location problem, Classification of plant layout, Line balancing using rank positional weighted method (RPWM), Forecasting methods: Moving average (Simple and Weighted), Single Exponential smoothing, Linear regression, Aggregate Production Planning (APP), Material Requirement Planning (MRP), Single machine scheduling, Flow shop scheduling using Johnson's algorithm

**Inventory and Quality control**
Inventory costs, Basic EOQ Model without shortages, Model with Quantity discount without shortages, Manufacturing model without shortages, P and Q system of inventory, safety stock, and reorder level, Quality definitions, Quality characteristics for a product, Statistical process control using X Bar, R Chart, p, and c chart, and Introduction to acceptance sampling.

**Linear programming**
Formulation of linear programming problem (LPP), Solution using graphical and simplex method, and Introduction to duality.

**Assignment and Transportation problems**
Feasible solution of transportation problems using Least cost method, North-West corner rule and penalty cost method, VAM, Optimum solution of transportation problems using MODI method, Optimum solution of assignment problems using Hungarian method, and
Queing Model

**Project Scheduling**
Network construction, Critical path method (CPM): Determination of critical path and slack of an activity, program evaluation and review committee (PERT): Determination of the expected duration of a project, and Crashing and Updating.

**Textbooks**

1. R. Paneerselvam, Production and Operation Management, PHI
2. H. A. Taha, Operations Research – An Introduction, Pearson

**Reference Books**

1. A.K. Garg, Production and Operations Management, TMH
2. Hillier et al., Introduction to Operations Research, TMH
3.Gupta and Hira, Operations Research, S. Chand
4.M.T. Telsang, Industrial Engineering and Production Management, S. Chand

## ADVANCED MECHANICS OF SOLIDS

**Course Code: ME30011**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Mechanics of Solids (ME 21001)**

**COURSE OBJECTIVE**

Advanced mechanics of solids is a specialized need-based extension of mechanics of solids and a little bit of machine design. The objective of this course is to build a strong knowledge of the students which is required for the design and analysis of simple and complex mechanical systems. In particular, the course will cover aspects of analysis of stress and strain, generalized Hooke's law, failure theories, general prismatic bar subjected to torsional moment. Further it will cover the analysis of curved beam subjected to bending moment.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Describe the concept of stress, strain at a point and represent the 3D state of stress on Mohr's circle,
CO 2: Recognise stress and strain invariants, principal stresses and strains and their directions,
CO 3: Apply constitutive relationships between stress and strain for linearly elastic solid using generalized Hooke's law,
CO 4: Analyze the prismatic bars with non-circular cross sections subjected to torsional moment,
CO 5: Evaluate the stresses developed in curved beams as well as the beams subjected to asymmetrical bending, and
CO 6: Design the machine components using theories of failure..

**COURSE DETAILS**

**Analysis of stress**
3-D state of stress at a point (in rectangular coordinate), Sign convention for stress, Mohr's circles for 3-D state of stress, Differential equation of equilibrium, Stress invariants, Equilibrium equations for plane stress condition

**Analysis of strain**

Rectangular 3-D strain components, Cubical dilatation, Plane state of strain, Compatibility conditions, Strain deviator and invariants

**General Stress-strain relation**
Generalised Hooke's law, Stress-strain relation for isotropic materials, Relation between different elastic constant.

**Theories of failure**
Different failure theories and their significance, Mohr's theory of failure, Stress space and strain space.

**Unsymmetrical bending**
Straight beams and asymmetrical bending, Shear centre for different sections, Bending of curved beams (Winker-Bach formula).

**Torsion of non-circular sections**
Torsion of general prismatic Bars, Torsion of circular, Elliptical triangular and rectangular bars; Membrane analogy, Centre of twist and Flexural centre.

**Textbook**

1. Srinath, L. S. (2010). Advanced Mechanics of Solids. McGraw Hill Education.

**Reference Books**

1.Boresi, A.P. & Schimdt, R.J. Advanced Mechanics of Materials. Wiley.
2.Singh, S. Strength of Materials. Khanna Publishers.
3.Beer and Johnson (2014). Strength of Materials. McGraw-Hill Education.

## AUTOMOTIVE TECHNOLOGY

**Course Code:** **ME30012**
**Credit:** **3**
**L-T-P:** **3-0-0**
**Prerequisite:** **Nil**

**COURSE OBJECTIVE**

Develop highly skilled automotive engineers with expertise in analyzing and solving challenges related to automobile mechanics, automation, and manufacturing. They should be capable of designing and executing high-quality solutions that prioritize environmental considerations while adhering to ethical and humanistic principles.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Understand the classification of automobiles and their structures,
CO 2: Describe modernised fuel injection systems and improved combustion processes,
CO 3: Analyse gearbox and power train used in a vehicle,
CO 4: Apply suitable steering, suspension, and braking systems for a new vehicle,
CO 5: Evaluate safety features of an automobile, and
CO 6: Acknowledge advanced automobile run on electric, fuel cell or solar energy.

**COURSE DETAILS**

**Introduction**
Evolution of automobiles, Classification of vehicles, Structure of automobile, Types of chassis layout with reference to power plant locations and drive. Vehicle frames. Various types of frames. Constructional details. Materials. Unitised frame body construction, Loads acting on vehicle frame.

**Fuel Injection and Combustion Systems**
Various automobile fuels used in India, Fuel properties- gasoline and diesel fuel properties, Ignition quality, Octane and cetane number, Morden injection systems in SI and CI engines, SPFI, MPFI, GDI, CRDI, Digital twin spark technology, Comparison of knock in SI and CI engines, Supercharging and turbo-charging methods, Types of superchargers and turbocharger, Intercooler, methods of supercharging, Effect of supercharging on engine performance.

**Transmission System**
Different types of clutches, Principle, Construction, torque capacity and design aspects, Fluid drives, Different types of gear boxes – Sliding, Constant and Synchromesh gearbox. Propeller shaft, universal joint, Construction of rear axles. Types of loads acting on axles. Full floating, three-quarter floating and semi-floating rear axles; Differential: construction of differential. Differential locks.

**Steering, Suspension and Braking Systems**
Front wheel geometry: Camber, Castor, King pin inclination, Toe-in and toe-out. Condition for true rolling motion.
Steering geometry: Ackerman and Davis steering system; Constructional details of steering linkages and layouts.
Different types of steering gear levers-construction and operation, power and power assisted steering.

**Suspension System**
Need of suspension system, Types of suspension; Construction details of suspension springs; Leaf springs; Coil springs and torsion bar; Shock absorbers: Telescopic type shock absorber. Independent suspension system. Introduction to pneumatic suspension system.

**Brakes**
Functions of a Brake, Classification of Brakes, Brake Efficiency and Stopping Distance, Hydraulic Braking system, Drum Brakes, Disc Brakes, Self-energized Brakes, Power Assisted brakes.

**Automotive Safety**
Seat belt types and its mounting; Air bags positioning and deployment; Children and pedestrian safety devices; Driver warning system.

**Advanced Automobile**
Combined power source vehicles, Hybrid Vehicle, Electric vehicles and solar powered vehicles, Hydrogen Oxygen fuel cell vehicle.

**Textbook**

1. Jain and Asthana (2002). Automobile Engineering. Tata McGraw Hill, 1st Edition.

**Reference Books**

1. Gupta, S.K. A Textbook for Automobile Engineering. S Chand Publications.
2. H. Crouse, William & L Anglin, Donald (2016). Automotive Mechanics. McGraw Hill.
3. Gupta, K.M. Automobile Engineering. Vol I & II, Umesh Publications.

## FINITE ELEMENT ANALYSIS

**Course Code: ME30013**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Mechanics of Solids (ME21001)**

**COURSE OBJECTIVE**

Finite Element Analysis subject provides the basic and advanced knowledge of various finite element methods starting from the governing differential equation to Lagrange polynomial functions. These methods will be applied to solve different one-dimensional and two-dimensional problems like spring, bar, truss, beam, plane stress/strain, heat and mass transfer, fluid mechanics, etc. Furthermore, the application of FEA software will be discussed, and some complicated engineering problems will be formulated and solved through the software.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Explain the Differences between direct formulation and finite element formulation,
CO 2: Understand the fundamentals of Finite Element Analysis (FEA),
CO 3: Apply the 1D/2D polynomial shape functions and finite elements to solve bar and truss problems,
CO 4: Analyze selected engineering problems using FEA software,
CO 5: Solve the governing equations for various problems using weighted residual methods such as Galerkin's method, and
CO 6: Develop the weak form of the governing finite element equations for 1D and 2D systems..

**COURSE DETAILS**

**Introduction to Finite Element Analysis**
Introduction, Basic concepts of FEA, Brief story of FEA, Need for studying FEA, Comparison of Finite Element and Exact solutions, Applications of FEA.

**Direct Formulation**
Stiffness matrices, Spring and Bar Elements, Linear spring as a finite element, Axial rod problem.

**Finite Element Formulation**
General procedure of FEM, Finite element formulation starting from governing differential equations, Weighted residual method (Galerkin's Technique) and its statement, Weak form of Weighted residual method, Comparison of differential equation, Weighted residual and weak forms.

**One-Dimensional Finite Element Analysis**
Elements and shape functions, Co-ordinate transformations: Global coordinates and natural coordinates, One-dimensional bar/truss finite element, One-dimensional bar under self-weight, One-dimensional heat transfer element.

**Two-Dimensional Finite Element Analysis**
Polynomial shape functions, Pascal triangle for two-dimensional polynomial shape functions, Two-dimensional shape function for three-noded triangular element CST (Constant Strain Triangle), Four-noded rectangular element, Determining shape functions using Lagrange polynomials, Strain displacement matrices.

**FEA Software and its Applications**
Basic of FEA software, Standard procedure of FEA software and its role in engineering field, Application of FEA software.

**Textbook**

1. Seshu, P. (2004). Textbook of Finite Element Analysis, PHI Learning.

**Reference Books**

1. Bhavikatti, S. S. (2005). Finite Element Analysis. New Age International.
2. Hutton, D.V. (2004). Fundamentals of Finite Element Analysis. McGraw-Hill.
3. Reddy, J. N. (2006). An Introduction to the Finite Element Method. McGraw-Hill.

## COMPUTER INTEGRATED MANUFACTURING

**Course Code: ME30014**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

The objective of this Computer Integrated Manufacturing course is to understand the latest developments and the main elements in computer-integrated manufacturing systems. Moreover, students can develop manual and APT part programs for 2D complex profiles, automated tool paths, and G-codes for machining components and test the programs through simulation. Finally, students can predict the future automated benefits and can apply the knowledge in various applications.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Define Automation, CIM, CAD, CAM and explain the differences between these concepts,
CO 2: Understand simple problems of transformations of entities on computer screen,
CO 3: Apply concepts of automated manufacturing industries through mathematical models and analyze different types of automated flow lines,
CO 4: Analyze the automated flow linesto reduce down time and enhance productivity,
CO 5: Evaluate different computer applications in manufacturing and able to prepare part programs for simple jobs on CNC machine tools and robot programming, and
CO 6: Predict the modern trends in Manufacturing like additive manufacturing, Industry 4.0 and applications of Internet of Things leading to Smart Manufacturing..

**COURSE DETAILS**

**Introduction to CIM and Automation**
Automation in Production Systems, Automated manufacturing systems- types of automation, Reasons for automating, Computer Integrated Manufacturing, Computerized elements of a CIM system, CAD/CAM and CIM. Mathematical models and matrices: Production rate, Production capacity, Utilization and Availability, Manufacturing lead time, Work-inprocess, Numerical problems.

**Automated Production Lines and Assembly Systems**
Fundamentals, System configurations, Applications, Automated flow lines, Buffer storage, Control of production line, Analysis of transfer lines, Analysis of flow lines without storage, Partial automation, Analysis of automated flow lines with storage buffer, Fundamentals of automated assembly systems, Numerical problems.

**CAD and Computer Graphics Software**
The design process, applications of computers in design, Software configuration, Functions of graphics package, Constructing the geometry. Transformations: 2D transformations, Translation, rotation and scaling, Homogeneous transformation matrix, Concatenation, Numerical problems on transformations.

**Computerized Manufacture Planning and Control System**
Computer Aided Process Planning, Retrieval and Generative Systems, Benefits of CAPP, Production Planning and Control Systems, Typical activities of PPC System, Computer integrated production management system, Material Requirement Planning, Inputs to MRP system, Working of MRP, Outputs and benefits, Capacity Planning, Computer Aided Quality Control, Shop floor control.

**Computer Numerical Control**
Introduction, Components of CNC, CNC programming, Manual part programming, G Codes, M Codes, Programming of simple components in turning, Drilling and milling systems, Programming with canned cycles. Cutter radius compensations.

**Future of Automated Factory**
Industry 4.0, Functions, Applications and benefits. Components of Industry 4.0, Internet of Things (IOT), IOT applications in manufacturing.

**Textbooks**

1. Groover, Mikell P. (2015). Automation, Production Systems and Computer-Integrated Manufacturing. 4th Edition. Pearson Learning.
2. Rao, P. N. (2015). CAD / CAM Principles and Applications. 3rd Edition. Tata McGraw-Hill.
3. Radhakrishnan, P. CAD/CAM/CIM. 3rd edition. New Age International Pu.

**Reference Books**

1. Zeid, Ibrahim. CAD/CAM. Tata McGraw Hill.
2. Vajpayee, S. Kant (1999). Principles of Computer Integrated Manufacturing. Prentice Hall of India, New Delhi.
3. Groover, M. P. (2007). Work Systems And The Methods, Measurement And Management of Work. Pearson/Prentice Hall, Upper Saddle River, NJ.
4. Boucher, T. O., Chapman & Hall (1996). Computer Automation in Manufacturing. London, UK.

## ADDITIVE MANUFACTURING

**Course Code: ME30015**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

Additive Manufacturing is a modern manufacturing technology also known as 3D printing process, will provide a clear understanding about the process, acceptability and usability in various field. AM technology classified on the basis material types will be focused with it real life applications with advantages and disadvantages. Different types of errors associated with AM and CAD technology will be discussed with suitable error minimization processes. Various reverse engineering process will be discussed with its application.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Know the various liquid, powder and solid material based technologies in Rapid Prototyping and Rapid Tooling process,
CO 2: Understand the concept of additive manufacturing, its benefits and applications in various field,
CO 3: Apply AM process in the field of Biomedical aplliances,
CO 4: Analyse the use of reverse engineering to generate data for fabrication of RP part,
CO 5: Evaluate various types errors in the RP parts and errors during CAD file conversion, and
CO 6: Design solid models and converting it to 3D printing readable file format required for part fabrication..

**COURSE DETAILS**

**Introduction**
Need & Development of RP systems, RP process chain, Impact of Rapid prototyping and Tooling on Product Development, Benefits, Applications, Digital prototyping, Virtual prototyping.

**Liquid and Solid Based Rapid Prototyping Systems**
Stereo lithography Apparatus, Fused Deposition Modelling, Laminated object manufacturing, 3D printing: Working Principles, Details of processes, Products, Materials, Advantages, limitations and applications - Case studies.

**Powder Based Rapid Prototyping Systems**
Selective Laser Sintering (SLS), Direct Metal Laser Sintering (DMLS), 3D Printing (3DP), Laser Engineered Net Shaping (LENS), Selective Laser Melting (SLM), Electron Beam Melting (EBM), Plasma Transferred Arc Additive Manufacturing (PTAAM), Tungsten Inert Gas Additive Manufacturing (TIGAM), Metal Inert Gas Additive Manufacturing (MIGAM): Processes, Materials, Products, Advantages, Applications and Limitations.

**Medical and Bio- Additive Manufacturing**
Customized implants, Orthodontics and human prosthesis: Design and production, Bio additive manufacturing: Computer Aided Tissue Engineering (CATE) followed by case studies.

**Data Processing for Rapid Prototyping**
Process planning for rapid prototyping, CAD model preparation, Data Requirements & geometric modelling techniques: Wire frame, surface and solid modelling data formats - Data interfacing, Tessellation of surfaces, STL file generation Defects in STL files and repairing algorithms, Part orientation and support generation, Support structure design, Model Slicing and contour data organization, Direct and adaptive slicing, Tool path generation.

**Issues of Prototype**
Accuracy issues in Rapid Prototyping, Strength of RP Parts, Surface roughness problem in Rapid Prototyping, Part deposition orientation and issues like accuracy, Surface finish, Build time, Support structure, Cost etc.

**Rapid Tooling**
Classification: Soft tooling, Production tooling, Bridge tooling; direct and indirect, Fabrication processes, Applications, Rapid tooling techniques such as laminated metallic tooling, Direct metal laser sintering, Vacuum casting.

**Reverse Engineering**
Introduction to reverse engineering, Integration of reverse engineering with additive manufacturing technology: Advantages and disadvantages.

**Textbooks**

1.Gibson, I., Rosen, D. W. & Stucker, B. (2015). Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing, Springer.
2.Rafiq, I. Noorani (2006). Rapid Prototyping: Principle and Applications. Wiley & Sons.

**Reference Books**

1.Chua, C. K., Leong, K. F. & Lim, C. S. (2010). Rapid Prototyping: Principles and Applications. Yes Dee Publishing Pvt. Ltd. Third edition.
2.Liou, Frank. W. (2007). Rapid Prototyping And Engineering Applications. CRC Press, Special Indian Edition.
3.Chattopadhyaya, S. (2011). Journey from Rapid Prototyping to Rapid Manufacturing. LAP Lambert Academic Publishing.
4.Cooper, K. G. & Cooper, Cooper. (2001). Rapid Prototyping Technology: Selection and Application. Marcel Dekker Inc. 1st Edition.
5.Roger, N. (2014). Rapid Prototyping of Biomaterials Principles and Applications. ed. Woodhead Publishing.
6.Richard, B., Eggbeer, D. & Paterson, A. (2014). Medical Modelling: The Application of Advanced Design and Rapid Prototyping Techniques in Medicine. Woodhead Publishing.

## SUPPLY CHAIN MANAGEMENT

**Course Code: ME30016**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Industrial Engineering and Operations Research (ME30005)**

### COURSE OBJECTIVE

Supply chain management involves the integration of business processes across organizations, from material sources and suppliers through manufacturing and processing to the final customer. The course provides students with the core knowledge related to a wide variety of supply chain activities, including demand planning, manufacturing planning and control, purchasing, transportation management, warehouse management, inventory control, material handling, product and service support, information technology, and strategic supply chain management.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Describe the fundamental supply chain management concepts,
CO 2: Understand and use fundamental models to make trade-offs between forecasting, inventory, and transportation,
CO 3: Apply core methodologies (probability, statistics, optimization) used in supply chain modeling and analysis,
CO 4: Analyze and improve supply chain processes,
CO 5: Evaluate and manage an effective supply chain, and
CO 6: Design a logistic problem related to transportation and warehousing..

### COURSE DETAILS

**Understanding the Supply Chain and Strategy**
Introduction, Decision phases in supply chain, Process view of supply chain, Supply chain flows. Drivers & Obstacles of Supply Chain Performance, Supply chain performance: Strategic fit and scope.

**Supply Chain Drivers and Designing the distribution network**
Introduction, Supply chain drivers, Obstacles to Achieving Strategic fit, Role of distribution, Factors influencing distribution, Design option for distribution. Network design in the SC, Factors influencing network design.

**Transportation and Sourcing in the supply chain**
Introduction, Factors affecting transportation decisions, Modes of transportation and their performance, Sourcing decision in SC, Supplier selection, Supplier assessment. Coordination in the SC, Lack of coordination and the bullwhip effect.

**Pricing and Information Technology in supply chain**
Introduction, Pricing and revenue management in the SC, Supply chain information system, E-business and supply chain, Warehouse design, Supply chain modelling towards digitisation; case study.
Role of inventory in supply chain. Different analysis of inventory, Different stock limits of inventory, Different models used inventory, Material requirement planning.

**Textbooks**

1. Chopra, Sunil & Meindl, Peter. Supply Chain Management: Strategy, Planning, and Operation. PHI.
2. David, Semchi-Levi & Philip, Kaminsy. Designing and Managing the Supply Chain. TMH.

**Reference Books**

1. Saha, Janat. Supply Chain Management: Text and Cases. Pearson Education.
2. Christoper, Martin. Logistics and Supply Chain Management. Pearson Education.

## GAS DYNAMICS AND JET PROPULSION

**Course Code: ME30017**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Fluid Mechanics and Hydraulic Machines (ME20001), Engineering Thermodynamics (ME21002)**

**COURSE OBJECTIVE**

• To emphasis the difference between compressible and incompressible flow and heat transfer governing mechanisms
• To explain working principles of various essential components, such as turbine blades, nozzles, used in power plants and aerospace industries
• To impart knowledge on identifying key parameters to control the performance of various equipment used in jet and rocket propulsion
• To discuss means for better performance of various components like nozzles, diffusers etc.

• To impart knowledge on design principles of essential equipment used in aerospace industries
• To identify the need of continuous development in the field of various jet and rocket propulsion systems

## COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Identify the relation between thermodynamics, fluid mechanics and heat transfer with the basics of compressible fluid flow and heat transfer,
CO 2: Understand various types of compressible flows, stagnation and critical states, shocks, Fanno flow and Rayleigh flow,
CO 3: Apply the fundamental principles required for calculating stagnation and critical state properties and different performance parameters such as thrust, power, and efficiency of engines,
CO 4: Analyze the effect of various parameters on the performance of nozzles diffusers, and engines,
CO 5: Evaluate the performance of nozzles, diffusers, propellants, jet propulsion and rocket propulsion engines, and
CO 6: Design and analysis of various components such as nozzles, diffusers employed for jet and rocket propulsion system..

## COURSE DETAILS

**Introduction**
Control volume and system approaches, Acoustic waves and sonic velocity, Mach number, classification of fluid flow based on Mach number, Mach cone-compressibility factor, General features of one dimensional flow of a compressible fluid, Continuity, Momentum, and Energy equations for a control volume.

**Isentropic flow of an ideal gas**
Basic equation, Stagnation enthalpy, Stagnation temperature, Stagnation pressure and Stagnation density, Acoustic speed, Critical speed of sound, dimensionless velocity, Governing equations for isentropic flow of a perfect gas, Critical flow area, thrust and impulse function, Steady one dimensional isentropic flow with variable area, Effect of variable area on flow parameters, Chocking, Convergent nozzle, Performance of a nozzle under decreasing back pressure; de Laval nozzle, Optimum area ratio effect of back pressure, Formation of shock in converging-diverging nozzles, Nozzle discharge coefficients, Nozzle efficiency, Shock waves in gases, Governing equations for analysis of shock, Properties of flow across a normal shock, Rankine-Hugoniot equation, and Strength of shocks.

**Fanno Flow**
Adiabatic flow with friction in a constant area duct, Governing equations; Fanno line limiting conditions, Effect of wall friction on flow properties in an Isothermal flow with friction in a constant area duct, Governing equations and limiting conditions.

**Rayleigh Flow**
Steady one dimensional flow with heat transfer in constant area ducts, Governing equations, Rayleigh line, Entropy change caused by heat transfer, Conditions of maximum enthalpy, entropy, Intersection of Fanno, and Rayleigh lines.

**Aircraft propulsion**

Types of jet engines, Energy flow through jet engines, Thrust, Thrust power and propulsive efficiency, Turbojet components, Diffuser, Compressor, Combustion Chamber, Turbines, exhaust systems, Ramjet engines, and Pulse jet engines.

**Rocket propulsion**
Rocket propulsion, Rocket engines, Basic theory of equations, Thrust equation, Effective jet velocity, Specific impulse, Rocket engine performance, Solid and liquid propellant rockets, and Comparison of various propulsion systems.

**Textbook**

Yahya, S. M. (2005). Fundamental of Compressible Flow with Aircraft and Rocket Propulsion. New Age International (p) Ltd., New Delhi.

**Reference Books**

1. Fundamental of Gas Dynamics( 2nd edition).Zucker- Wiley publishers.
2. Liepman & Roshko. Elements of Gas Dynamics.
3. Oosthvizen, P.H., Carscallen, W. E. (1997). Compressible Fluid Flow. McGraw-Hill.
4. Ganesan, V. (1999). Gas Turbines, Tata McGraw-Hill, New Delhi,.
5. Somasundaram, P. R.S.L. (1996). Gas Dynamics and Jet Propulsions. New Age International Publishers.
6. Cohen, H., Rogers, G.E.C., Saravanamutto (1980). Gas Turbine Theory. Longman Group Ltd.

## POWER PLANT ENGINEERING

**Course Code:** **ME30018**
**Credit:** **3**
**L-T-P:** **3-0-0**
**Prerequisite:** **Engineering Thermodynamics (ME21002), Applied Thermal Engineering (ME31002)**

**COURSE OBJECTIVE**

• To understand the principle of power generation
• To gain knowledge for site selection for installing power plants and cost of power generation
• To be able to evaluate the performance characteristics of different components of power plant
• To explore the suitability of power generation method
• To be able to design the optimized equipment for economic power generation
• To select proper method of power generation keeping in view of environmental pollution

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Explain the principle of power generation and sources of energy,
CO 2: Understand the working principles of different components of steam and nuclear power plant,
CO 3: Apply the principles to evaluate the performance of steam power plant,
CO 4: Analyze the combustion mechanisms, steam turbines, nozzles and condenser,
CO 5: Evaluate the performance of boiler, steam turbine, nozzle and condenser, and
CO 6: Design essential components of steam and nuclear power plants.

**COURSE DETAILS**

**Introduction**
Principle of operation(Rankin cycle), Sources of energy: fuel, water, wind, solar and nuclear, Types of power plants, Cost of electrical energy, Fixed cost and operating cost, Types of tariff, and load curves.

**Combustion mechanism, combustion equipment and firing methods**
Fuel bed furnace, Pulverized coal furnace, Cyclone furnace, Fluidized bed combustion, Furnace, Combustion equipment, Air supply systems for combustion, Fuel and ash handling systems, and dust collectors.

**Generation of steam and flow of steam through nozzle**
Boilers and its mountings & accessories, High pressure water tube boiler,. Nozzle shape for different applications, Choked flow and critical pressure ratio, Effect of variations in nozzle back pressures, and Super saturated flow in nozzles.

**Steam Turbines**
Types of steam turbines, Axial variation of pressure and velocity through various types of turbines, Flow through turbine blades, Velocity diagrams of impulse (pressure compounded and velocity compounded) and impulse reaction turbine, Degree of reaction. Parsons turbines, Power, efficiency and other related calculations for simple impulse & reaction turbine, Losses in steam turbines, Reheat factor, and Governing of turbines.

**Steam condensers and cooling tower for power plant application**
Surface condensers, Condenser vacuum and vacuum efficiency, Maintaining vacuum by air pumps, Sources of air leakage into the condenser, Dalton's law of partial pressures applied to steam and air mixtures, Air pump capacity for wet and dry air pumps, Cooling water requirements, and Cooling towers.

**Nuclear power plants**
Nuclear fuels, Chain reaction, Neutron balance, coolants, Reflectors, Moderators, control rods, types of reactors, Boiling water reactors, pressurized water reactors. CANDU Reactor, Gas cooled Reactors, Liquid metal fast breeder Reactor, Heavy water Reactors, Waste disposal, and Safety of Nuclear power plant.

**Textbook**

1. Nag, P. K. (2002). Power Plant Engineering. Tata McGraw-Hill Education.

**Reference Books**

1. Rajput, R. K. Power Plant Engineering (4th Edition). Laxmi Publications (P) Ltd.
2. Gupta, M. K.(2012). Power Plant Engineering. PHI Learning.
3. Sharma, P.C. (2009). Power Plant Engineering, S. K. Kataria & Sons publication.

## ARTIFICIAL INTELLIGENCE IN MECHANICAL SYSTEMS

**Course Code: ME30019**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite(s): Nil**

### COURSE OBJECTIVE

This course covers the basic understanding of organization's ability to produce large volumes of highly integrated, labor intensive or repetitive, customized products by leveraging intelligent design and manufacturing strategies powered by the latest trends in application of artificial intelligence. In this highly interactive course, UG students will form groups of like minded students to explore the latest smart manufacturing strategies and hardware. They will acquire skills to develop machine learning-based design templates, and participate in generative design activities.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Recognize the capabilities and limitations of current advanced manufacturing hardware,
CO 2: Understand the traditional and AI-based geometric representations for digital manufacturing
CO 3: Illustrate mechanical system problem using Dempster Shafer theory.
CO 4: Apply the concept of performance-driven design workflow, as well as principles of generative and inverse design,
CO 5: Evaluate and optimize objects for multiple objectives and across multiple domains
CO 6: Design and build data-driven (machine learning) models that drive design customization.

### COURSE DETAILS

**Introduction to AI and machine learning**
Machine learning methods (including neural networks), Overview of advanced manufacturing processes, Geometry to hardware abstraction languages, AI tools for manufacturing process optimization, Reasoning under uncertainty, review of probability, Baye's probabilistic interferences and dempstershafer theory.

**Designing customizable models for manufacturing**
AI tools for design customization, Deep neural networks, Convolutional neural networks, Generative models, Auto encoders, GANs.

**Predicting performance using ML methods**
Inverse methods performance-driven design, AI methods for inverse methods, Topology optimization, Optimizing design for multiple objectives and multiple domains.

**Logic programming**
Knowledge representation issues, Knowledge engineering, Scope of knowledge, Difficulties in knowledge acquisition methods, Predicate logic, Semantic nets- frames and inheritance, Constraint propagation, Representing knowledge using rules, Rules based deduction systems.

**First order logic**
Inference in first order logic, Propositional inference, First order inference, Unification & lifts forward chaining, Backward chaining, Resolution, Learning from observation, Inductive learning, Decision trees, Explanation based learning, Statistical Learning methods, Reinforcement Learning.

**Expert systems**
Types of expert systems, Human element in expert systems, Problem areas addressed by expert systems, Expert systems success factors, Web based Expert systems.

**Text Book**
1. S. Russel and P. Norvig, "Artificial Intelligence – A Modern Approach", Second Edition, Pearson Education.

**Reference Books**
1. David Poole, Alan Mackworth, Randy Goebel, "Computational Intelligence: a logical approach", Oxford University Press.
2. G. Luger, "Artificial Intelligence: Structures and Strategies for complex problem solving", Fourth Edition, Pearson Education.
3. J. Nilsson, "Artificial Intelligence: A new Synthesis", Elsevier Publishers.

## MACHINE MAINTENANCE AND CONDITION MONITORING

**Course Code:** **ME30020**
**Credit:** **3**
**L-T-P:** **3-0-0**
**Prerequisite:** **Kinematics and Dynamics of Machines (ME20002)**

**COURSE OBJECTIVE**

The aim of this course is to equip students to become instrumental in the increased efficiency of process plan and machinery. By understanding the fundamental principles of condition monitoring and maintenance planning, students can then play key roles in effective preventative maintenance, improved efficiency and increased productivity in their respective industries.

## COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Illustrate the machine maintenance strategies including vibration based condition monitoring and its importance in engineering fields,
CO 2: Understand the working of various transducers used in condition monitoring,
CO 3: Implement data acquisition and signal processing techniques to mechanical components and plants,
CO 4: Analyze the results of wear and debris tests to diagnose faults in the machinery,
CO 5: Formulate monitoring mechanisms using temperature based methods and non-destructive techniques, and
CO 6: Predict the faults in rotating machinery..

## COURSE DETAILS

**Maintenance strategies**
Breakdown, Preventive, Predictive and Proactive maintenance, Plant machinery classification, and Condition based maintenance.

**Transducers for condition monitoring**
Principles and application of accelerometers, Velocity pickups, Eddy current probes, Stroboscopes, Proximity probes, Spike energy detector, Laser vibrometer, Condenser microphones, Thermocouples, Optical pyrometer, Ultrasonic thickness detector, and Acoustic emission transducer.

**Fundamentals of Signal processing**
Fast Fourier Transform (FFT) analysis, Sampling rate, Nyquist sampling theorem, Aliasing, Filters, A/D converter, and Windowing.

**Vibration Monitoring**
Measuring vibration: Signal forms, Phase, Overall and spectral vibration, Measurement point location, and Transducer mountings.

**Rotating machinery fault analysis**
Imbalance, Misalignments, Looseness, Oil whirl, Bent shafts, Coupling problem, Bearing defects, and Gear defects.

**Vibration level classification**
ISO standards, Peak and RMS levels, Time domain averaging, Trending fault data, and Case studies based on vibration data and signature of machines.

**Wear and Debris Analysis**
Principle of Tribology, Industrial and Automotive Lubricants, Lubricants Properties, Lubricants Contamination and Prevention, Lubricants Mechanism and Failures, Sampling of Lubricants, Wear particle size, Ferrography, Particle Counting, Magnetic Plugs, Spectrometric metals analysis and Types of Wear Particles , and Case studies based on oil analysis data of machines.

**Temperature Monitoring**

Infra-red Thermograghy, Principles, Instruments, Thermal imaging, Locating hot spots for maintenance intervention, Ascertaining condition of refractory lining, Identifying faults in cooling system and in electrical Equipments, Plant Heat audit, and Case studies based on thermal images.

**Non Destructive Testing**
Faults that can be detected by NDT, Ultrasonic, Radiography Methods, Eddy Current Method, Acoustic Emission Method, Dye penetrant Method, and Case studies based on available NDT data. Advance Maintenance Practices:Total Productive Maintenance (TPM), Reliability Centered Maintenance (RCM), Computerized Maintenance Management Systems (CMMS), Five Zero Maintenance Concept, Maintenance Planning and Scheduling, Budgeting and Costing.

**Textbook**

Srivastava, S. K. Maintenance Engineering and Management. S.CHAND Publisher.

**Reference Books**

1. Mohanty, A.R. Machinery Condition Monitoring: Principles and Practices (1st Edition). CRC press.
2. Venkataraman, K. Maintenance Engineering and Management(1st Edition), PHI.
3. Raju, N.V.S. Plant Maintenance and Reliability Engineering,( 1st Edition) CENGAGE.

## HEATING, VENTILATION, AIR CONDITIONING AND REFRIGERATION

**Course Code: ME30021**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Applied Thermal Engineering (ME31002)**

**COURSE OBJECTIVE**

• Fundamental information and knowledge of refrigeration and air-conditioning systems
• and their operation
• Knowledge of basic working principles and requirement of different components of the refrigeration and air-conditioning systems.
• Ability to determine necessary sizing and capacity of the refrigeration systems
• Ability to integrate the usage of waste heat energy and other renewable energy into refrigeration systems
• Ability of students to determine the psychometric properties of the air and apply these to different air-conditioning processes.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Describe the fundamentals of refrigeration processes in engineering problems,
CO 2: Classify the different refrigeration and air-conditioning methodologies and the equipment needed,
CO 3: Apply the vapour compression cycle principle to obtain coefficient of performance,

CO 4: Analyze the different conditions of the air in air-conditioning systems through psychometric properties,
CO 5: Evaluate the performance of various refrigeration and air-conditioning systems, and
CO 6: Design the air-conditioning systems based on psychometric properties and processes.

**COURSE DETAILS**

**Vapour Refrigeration System**
Overview of refrigeration and air-conditioning applications, Introduction to Vapour compression refrigeration cycle, P-H chart, Theoretical vapour compression cycle with different combination at the inlet of the condenser (dry-saturated, Superheated and wet mixture), Actual vapour compression cycle, Effect of suction and discharge pressure. Vapour absorption refrigeration system (simple and practical), Advantages of absorption system over compression system and Refrigerants and its properties.

**Air Refrigeration System**
Air refrigerator working on a Bell-Coleman cycle (Reversed Brayton Cycle), Air-refrigeration System, Merits and Demerits of Air-refrigeration Systems, and Simple Air-cooling system.

**Psychometrics**
Properties of air-vapour mixtures, Psychometric chart, Law of air-water vapour mixture, Enthalpy of mixture, Psychometric processes: Simple heating and cooling, Humidification, Dehumidification mixture of air streams, Sensible Heat factor, Cooling and Humidification through water injection (evaporative cooling).

**Air conditioning system**
Introduction, Factors affecting comfort air-conditioning, Air-conditioning systems, Equipment used in an air-conditioning system, Classification of Air-conditioning system; Comfort air-conditioning system, Industrial Air-conditioning system, Winter air-conditioning system, Summer air-conditioning system, Year round Air-conditioning system, and Central air-conditioning system.

**Cooling Load Estimation**
Introduction, Components of cooling load, Sensible heat gain through building structure by conduction, Heat gain from solar radiation, Solar heat gain (sensible) through outside walls and roofs, Sol air temperature, Heat gain due to Sun, Infiltration, Ventilation, Occupants, Appliances, products, Lighting equipment, Power equipment, and Ducts.

**Components In refrigeration and Air-conditioning Systems**
Evaporative condensers, Cooling Towers and Spray Ponds, Natural draft and mechanical draft cooling towers, Bare tube coil evaporators, Finned tube evaporator, Frosting and defrosting evaporator, Capillary tube, Hand operated expansion valve, Automatic expansion valve, Thermostatic expansion valve, Ducts (classification, duct material, Construction, Shape), Duct design, Centrifugal and axial fans, Application of air-conditioning in industry, and Cold storages.

**Textbook**

1. Khurmi, R. S. & Gupta. Refrigeration and Air-conditioning, S. Chand Publication.

**Reference Books**

1. Arora, R. C.(2013). Refrigeration and Air Conditioning. PHI Learning Pvt. Ltd.
2. Arora, S.C. & Domkundwar, S.(2013). A course in Refrigeration and Air Conditioning. Dhanpat Rai & Co (P) Ltd.
3. Prasad, M.(2003) Refrigeration and Air Conditioning. New Age International.
4. Refrigeration and air conditioning - Stocker and Jones.
5. Anantanarayana. Basic refrigeration and Air-conditioning. TMH Publication

## MATERIALS SELECTION IN MECHANICAL SYSTEMS

**Course Code: ME30022**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

### COURSE OBJECTIVE

The choice of materials is essential to mechanical design. The objective of this course is to obtain selection in the Design Process, materials selection with a variety of constraints, shape parameters for various types of loading, and optimal materials selection with and without shape. A variety of issues will be explored that exemplify materials-limited design and the connection between shape, design and materials selection.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Define and comprehend the properties of engineering materials,
CO 2: Understand the different types of engineering materials and correlate their material charts,
CO 3: Apply the materials aspects during designing mechanical systems,
CO 4: Categorize the methodologies for design-led selection of automotive components,
CO 5: Devise strategy for analyzing shape of engineering materials, and
CO 6: Design and selection of materials for recycling.

### COURSE DETAILS

**Engineering materials and their properties**

Materials classes – Engineering Alloys, Engineering polymers, Engineering ceramics, Engineering composites, Glasses, Wood, Definition of materials properties, Density, Modulus, tensile, Modulus-density material properties chart and strength-density chart. Fatigue, Creep strengths, Toughness, Hardness, Fracture toughness, Damping capacity, Fatigue endurance limit, Thermal conductivity, and Wear resistances.

**Processes and their effect on materials properties**

Introduction, Classifying processes, The processes: Shaping, Joining & Finishing, Process-Property Trajectory; Process Selection and Cost- Strategy and Selection Matrices, Limitations and Quality; Selection with multiple constraints, Case Studies (Light Pressure Vehicles, Connecting rods for High Performance Engines, Windings For High Field Magnets); Conflicting objectives, Case Studies (Wafer Thin Casings For Must-Have Electronics, Cost Effective Bumpers, and Materials for a Disk-Brake Caliper).

**Materials selection basis**

The strategy for materials selection on design basis - Design requirements for a components define functions, Objectives, Constraints, and boundary condition, Property limit and material index examples; Strategy for material selection on shape basis - Significance of Shape factors, Limits to shape efficiency, Material shape combinations, Material indices, Graphical co-selecting using indices, Architectured materials microscopic shape and examples.

**Case studies in materials selection**

Design basis- materials for large telescopes, Structural materials for buildings, Materials for flywheels, Springs, Elastic hinges and couplings, Seals, Safe pressure vessels, Shaker tables, Solar heating, Heat exchangers, Heat sinks for hot microchips, Radome, Shape basis - forks for racing bicycle, Floor joists, Bending stiffness and strength of steel sheets, Flexible shapes, and Ultra-efficient springs.

**Designing hybrid materials**

Introduction, Holes in materials, Concepts of hybrid design, Composites, Cellular structures-foams and lattices, Sandwich structures and multi-layer's, Segmented structures and examples.

**Designing for sustainable materials**

Material life-cycle, Material and energy consuming systems, Eco-attributes of materials, Designing for recycling- disassembly, Reusability and safety; Reducing carbon footprint; Material selection for circular economy; Choice of material on product lifecycle, and Case studies.

**Textbook**


1. Ashby, Michael F. (2011).Materials Selection in Mechanical Design (4th Edition). Butterworth-Heinemann.


**Reference Books**


1. Budinski, Kenneth G.(1996). Engineering Materials: Properties and Selection. Prentice Hall.
2. Callister,William D.& Wiley Jr. John. Materials Science and Engineering – An Introduction.
3. George E. Dieter (1991).Engineering Design: A Materials and Processing Approach. McGrawHill.
4. ASM Handbook – Materials Selection and Design (1997)
5. NPTEL course: https://archive.nptel.ac.in/courses/112/104/112104122/#


## MECHANICAL VIBRATION AND NOISE CONTROL

**Course Code:** **ME30024**
**Credit:** **3**
**L-T-P:** **3-0-0**
**Prerequisite:** **Kinematics and Dynamics of Machines (ME20002)**

**COURSE OBJECTIVE**

The objective of this subject is to introduce techniques to model and analyze vibrations in the systems especially in the field of mechanical engineering. This course also covers the basics of sound, noise as well as their control strategies.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Describe the role of damping, stiffness and inertia in mechanical systems undergoing longitudinal, transverse and torsional vibrations,
CO 2: Comprehend the basics of sound/noise propagation, sound measurement and the human response to noise,
CO 3: Apply the concepts for reducing the vibration of a primary system by adding an absorber to the system,
CO 4: Analyse the natural frequencies and mode shapes of lumped mass models and continuous systems,
CO 5: Evaluate noise reduction techniques for different industries and day to day life of human beings, and
CO 6: Develop schematic models and formulate governing equations of motion for single-/multi- degree of freedom systems..

**COURSE DETAILS**

**Introduction: One Degree of Freedom Systems**
Free and Forced vibration of single degree system with damping, Equilibrium Method, Energy method, stiffness of spring elements, Viscous damping, Logarithmic decrement, Transmissibility, Dynamic Vibration Absorber, and Vibration Isolation

**Two Degree of Freedom Systems**
Generalized Derivation of Equation of motion, Static and dynamic coupling, Langrange's equations, and Undamped dynamic vibration observers

**Multi-Degree of freedom system**
Derivation of Equations, Influence coefficients, Eigen values and Eigen vectors, and Calculation of Natural Frequencies by Rayleigh and Matrix iteration methods

**Torsional Vibration**
Multi-rotor systems, and Geared system and branched system

**Vibration of continuous system**
Vibration of strings, and Free longitudinal vibration of prismatic bars

**Introduction to acoustics**
Propagation of acoustic disturbances, The decibel scale for the measurement of sound pressure, Acoustic energy density and intensity, The wave equations, and Acoustic impedance.

**Human Response to sound**
Noise effects, Auditory response, and Ratings and Regulations.

**Noise control**

Principles of passive noise control, Acoustic enclosures, Acoustic barriers, Sound-absorbing materials, and Vibration isolations materials and Damping materials.

**Textbook**

1. Ambekar A. G. (2013). Mechanical Vibrations and Noise Engineering (7th edition). PHI.

**Reference Books**

1. Thomson, W.T. Theory of Vibration and Application, CBS.
2. Singh, V.P. Mechanical Vibrations, Dhanpat Rai & Co.(P) LTD.
3. Dukkipati, R.V. Textbook of Mechanical Vibrations, PHI.
4. Beranek, L. Noise and vibration control, McGraw-Hill.

## ROBOTICS AND AUTOMATION

**Course Code: ME30026**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Kinematics and Dynamics of Machines (ME20002)**

### COURSE OBJECTIVE

Nowadays, robotics is playing a vital role in industry 4.0, and robots are being applied to minimize human efforts and to improve the production rate. This course gives fundamental knowledge about robotics and its different hardware and software components. Moreover, the subject discusses kinematics and dynamic equations, which will be implemented to control the motion of the robot through the actuators. Further, the present course also describes the integration of various sensors and their programming, which will be used to make an autonomous control system for a robot.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Describe the fundamentals of robotics and its different components,
CO 2: Explain the robot’s forward and inverse kinematics,
CO 3: Apply the various kinematic and dynamic equations to control the motion of the robot through actuators,
CO 4: Analyze different articulated and wheeled robots with controlling mechanism,
CO 5: Measure physical quantities by using different sensors, and
CO 6: Create the codes to realize an autonomous sensor-actuator control in robots..

## COURSE DETAILS

**Robotics: Historical Background**
Robotic system: robotic manipulator and coordinate system, Description of position and orientation, Transformation of coordinate frames, and Euler's angle.

**Kinematics of Manipulators**
Joint variable and link connection, Direct manipulator kinematics, D-H algorithm, Inverse kinematics, Velocity and static forces, Jacobian, and Dynamics of manipulator.

**Robot Drives, Actuators and Control**
Drive systems in manipulator, Hydraulic systems: fluid properties and pump classification, Pneumatic systems: Introduction and elements of pneumatic system, Electrical drives: D.C., A.C. and servo motors, Piezoelectric actuators, and Drive mechanism.

**Robot End-Effectors**
Introduction, Classification of end-effectors, Types of grippers-mechanical grippers (two and three fingers grippers), Magnetic grippers, Pneumatic and hydraulic grippers, Vacuum and adhesive grippers, Drive systems for grippers, Analysis of gripper force, and Active and passive grippers.

**Sensor and Robot Vision**
Need of a sensor, Sensory devices, Types of sensors - displacement and position sensors (Optical encoders, Potentiometers, LVDT, Piezoelectric, Hall sensors) - Range and proximity sensors, Force and torque sensors, Robot vision systems - vision cameras, Lightening devices, Vision sensors, Signal conversion, Image storage, Segmentation, and Edge detection.

**Robot Languages and Programming**
Robot programming language features, Classification, Computer control and robot software (monitor mode, run mode and editor mode), and VAL system and language.

**Textbook**

1. Mittal, R.K. & Nagrath, I.J. (2003). Robotics and Control, Tata McGraw-Hill.

**Reference Books**

1. Craig, J.J. (2009). Introduction to Robotics Mechanics and Control (3rd Edition). Pearson Education.
2. Fu, K.S., Gonzalez, R.S. & Lee, C.S.G. (2014). Robotics; control, sensing, vision, and intelligence. Tata McGraw-Hill.
3. Schilling, R. J. (1990). Fundamentals of Robotics Analysis & Control. Tata McGraw-Hill.
4. Deb, S.R. & Deb, S. (2009). Robotics Technology and Flexible automation. Tata McGraw-Hill.
5. Groover, M.P. (2018). Automation, Production Systems, and Computer Integrated Manufacturing. Pearson.
6. Hegde, G.S. (2006). A Texbook of Industrial Robotics. Laxmi Publications.

## COMPUTATIONAL FLUID DYNAMICS

**Course Code:** **ME30028**
**Credit:** **3**
**L-T-P:** **3-0-0**
**Prerequisite:** **Heat Transfer (ME30003)**

## COURSE OBJECTIVE

- To know the various numerical techniques to solve a physical problem
- To understand the fluid mechanics of various research problems across different multidisciplinary areas
- To develop a CFD model of industrial process
- To understand the commercial CFD software and codes
- To be able to solve the real world engineering problem with CFD tool
- To be able to develop an optimized design for an industrial process

## COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Identify the various numerical techniques to solve a physical problem,
CO 2: Recognize the appropriate governing equations and boundary conditions of a physical problem,
CO 3: Apply suitable discretization techniques to develop a mathematical model,
CO 4: Distinguish different solution algorithms to find the solution to the physical problem,
CO 5: Evaluate the mathematical model before attempting experimental solutions, and
CO 6: Develope the solution procedure to predict the field variables.

## COURSE DETAILS

### Introduction
Definition of CFD, Solution procedure of a CFD problem, Classification of partial differential equations: Elliptic equations, Parabolic equations, Hyperbolic equations, Accuracy, Consistency, and Stability and Convergence.

### Mathematical Formulation
Governing Equations: Mass Conservation Equation, Energy Equation, Momentum Equation, The general scalar transport equation, Boundary conditions, and Initial condition.

### Discretization Methods
Finite Difference Formulation:
Steady one dimensional conduction problem, Unsteady one dimensional conduction problem (simple explicit method, simple implicit method, Crank-Nicolson method), Two dimensional heat conduction problem, and Convection diffusion problem.
Finite Volume Formulation:
Steady one dimensional conduction problem, Unsteady one dimensional conduction problem, Two dimensional conduction problem, Steady one dimensional convection diffusion problem (upwind scheme), and Two dimensional convection diffusion problem.

### Flow Field Calculation
Discretization of the momentum equation, Staggered grid, SIMPLE algorithm, and SIMPLER algorithm.

**Solution Methods**
Direct vs Iterative methods, Gauss-Seidel Method, SOR method, and Tri-Diagonal Matrix (TDMA) algorithm.

**Textbooks**

1. Patankar, S.V. Numerical Heat Transfer and Fluid Flow. Hemisphere Publishing.
2. Ozisik, M.N. Finite Difference Method. CRC.

**Reference Books**

1. Anderson, J.D. Computational Fluid Dynamics. McGraw Hill Book Company.
2. Versteeg, H. & Malalasekera, W. An Introduction to Computational Fluid Dynamics: The Finite Volume Method. Prentice Hall.
3. Ghoshdasdidar, P.S. Computer Simulation of flow and heat transfer. Tata McGraw-Hill Publishing Company Ltd.
4. Muralidhar & Sundararajan, T. Computational Fluid Flow and Heat Transfer. Narosa
5. Niyogi, P., Chakrabartty, S.K. & Laha, M.K. (2005). Introduction to Computational Fluid Dynamics. Pearson Edu.

## ANALYSIS OF METAL FORMING PROCESSES

**Course Code: ME30030**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Materials Science and Engineering (ME20005), Manufacturing Technology-I (ME21003), Advanced Mechanics of Solids (ME30011)**

**COURSE OBJECTIVE**

Metal Forming is an interdisciplinary course encompassing the study of some topics such as elastic plastic behaviour and the related properties of metals, applied mechanics, metallurgy, and heat transfer etc.; however, gaining its knowledge is essential to a Mechanical Engineer as the Metal Forming is the second most used manufacturing process in industries. In one of its prerequisite courses (namely, Manufacturing Technology-I) the students have already studied various techniques of bulk and sheet metal forming relating to the theoretical discussion of processes and equipment involved. However, in industries it is also expected from a Mechanical Engineer to analyse the process for the necessary load and/or power estimation for further modification and developments in the processes, technology, equipment and tooling to keep on fulfilling the customers' requirements. Therefore, considering these as the objectives, the present course is designed to teach basic elements of the metal forming analysis along with the numerical demonstration on the majorly used analysing methods, e.g., slab analysis, slip-line field method, load bounding method, and finite element method.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Recognize the basic elements needed for metal forming analysis and outline important methods of analysing a metal forming process,

CO 2: Understand the contrast among various analysing methods of metal forming and interpret their applications for industrial use,
CO 3: Classify the different friction conditions involved in a metal forming process and simplify the method of analysis with suitable assumptions,
CO 4: Choose appropriate methods of analysing metal forming problems by comparing the results obtained from the two or more analysing methods,
CO 5: Solve an industrial metal forming problem and calculate the necessary load and power requirements, and
CO 6: Predict the desired outputs by adapting finite element method and validate these outputs with that of the experimental findings.

**COURSE DETAILS**

**Basic Elements of Metal Forming Analysis**
Concept of Stress, Stress State at a Point, Three-dimensional Mohr's Representation of Stress and Strain, Stress Invariants, Hydrostatic and Deviatoric Stresses, Differential Equations of Equilibrium in Cartesian and Polar Coordinates, Strain State at a Point, Physical Interpretation of Strain Components, Compatibility of Strain, Strain Invariants, and Strain Deviator Tensor
**Preview of Plasticity Fundamentals**
Macroscopic Plastic Behaviour of Metals, Flow Curves for Engineering Stress-Strain and True Stress-Strain, Stress-Strain Relationships for Elastic, Plastic, and Elasto-Plastic Materials, Temperature and Strain Rate Effects, Microscopic Plastic Behaviour of Metals, Mechanisms of Plastic Deformation – Slip Planes and Slip Directions in BCC, FCC, and HCP Crystal Structures of Metals, Twinning, Dislocation Glide, Bauschinger Effect, Plastic Anisotropy, Lankford Parameter, Plane Anisotropic Exponent, Yield-to-Tensile Ratio, Plastic Instability, Condition of Yielding, Yield Criteria for Isotropic Ductile Materials – Tresca and von Mises Hypotheses, Generalised Stress-Strain Increment, Yield Surface for Three-dimensional Stress, Effective Stress, Effective Strain, Hill's 1948 Yield Criterion for Anisotropic Ductile Materials, Determination of its Constants, Strain-Hardening, Factors Affecting the Strain Hardening, Strain Hardening Exponent, Various Hardening Laws, Isotropic Hardening, Kinematic Hardening, Mixed Isotropic/Kinematic Hardening, Springback and the Techniques for its Compensation, and Residual Stresses

**Methods of Analysing Metal Forming Processes: Slab Method**
Introduction to the Method, Applications – Strip Rolling, Calculation of Rolling Load, Roll Separating Force, Driving Torque and Power etc., Open Die Forging (Slipping, Sticking, and Mixed Friction Conditions) Load Calculation, Determination of Work Load, Frictional Power Loss, and Stress Analysis in Direct Extrusion of Round Bar, Determination of Force and Power in Drawing of Wire, Rod and Tube, Determination of Drawing Force, Blank-holding Force and Limiting Drawing Ratio (LDR) in a Cylindrical Cup Drawing, and Estimation of Work Load and Elastic Recovery in a Sheet V-Bending

**Slip-Line Field Method**
Theory of Slip-Lines, Geiringer Velocity Relations, Stress and Velocity Discontinuities along Slip Lines, Hencky's First and Second Theorems, Construction of Slip-Lines, Direction of Slip-Lines (Stress Free Surface, Frictionless Interface, Interfaces with Coulomb and Sticking Frictions), Numerical Example of Slip-Line Solution for Direct Extrusion with 50% Reduction in Frictionless Cylindrical Walls and Die, and Some Typical Numerical Exercises

**Load Bounding Method**
Introduction, Principle of Maximum Plastic Work, Upper Bound Theorem, Application in Compression of a Strip in Plane Strain, Concept of Lower Bound Theorem, and Some Typical Numerical Examples

**Finite Element Method (FEM)**
Fundamentals of FEM Analysis, Preview of FEM used in Forming Processes, Simple Elastic Plane-Stress and Plane-Strain Examples, Applications of FEM to Plasticity, Eulerian Rigid-Plastic and Updated Lagrangian Elasto-Plastic FEM Formulations, Static-Implicit and Dynamic-Explicit Analyses, and FEM Computer Programs

**Textbook**

1. Juneja, B.L. (2010). Fundamentals of Metal Forming Processes (02nd Edition). New Age International Publishers.

**Reference Books**

1. Kumar, S. (2008). Technology of Metal Forming Processes. PHI Learning Private Limited
2. Dieter G.E. (2017). Mechanical Metallurgy (03rd SI Metric Edition). McGraw-Hill
3. Chakrabarty J. (2007). Theory of Plasticity (03rd Edition). McGraw-Hill
4. Semiatin, S.L. (2005 and 2006). ASM Metals Handbooks (Volume: 14 A and B)
5. Shiro, K., Oh S. & Altan, T. (1989). Metal Forming and the Finite-Element Method. Oxford University Press

## THEORY OF ADVANCE MACHINES AND MECHANISMS

**Course Code: ME30032**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Kinematics and Dynamics of Machines (ME20002)**

**COURSE OBJECTIVE**

Theory of Advance Machines and Mechanism is specialized to address engineering theory, analysis, design, and practice that are typically referred to as mechanisms and the kinematics and dynamics of machines. The purpose of this course is to give students the fundamental skills needed to identify and classify four-bar mechanisms according to their potential motion. The synthesis and analysis of many sorts of mechanisms will be covered in this course. Analytically and graphically place each link in a mechanism and group them into groups based on how they might move. The fundamental principles used in developing and constructing a robot will be covered in this course.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Describe the concepts for the synthesis and analysis of mechanisms,
CO 2: Understand the components, mechanisms, control systems and application of robots,
CO 3: Apply graphical synthesis procedure for linkage design,
CO 4: Implement various analytical methods for the synthesis of four bar mechanism,
CO 5: Evaluate different techniques in spatial mechanisms, and
CO 6: Develop and apply vector loop equations for the position analysis of four bar linkages..

**COURSE DETAILS**

**Introduction**

Machines and Mechanisms; Kinematics, Mechanism Terminology; Kinematic Diagrams, Inversion, Conditions of Mobility, The Four-Bar Mechanism; Grashof's Criterion; linkages of more than four bars; Geared five bar linkages, and Six bar linkages.

**Graphical Linkage Synthesis**

Synthesis, Function, Path and Motion Generation, Limiting Conditions, Dimensional Synthesis, Two-Position Synthesis, Three-Position Synthesis with Specified Moving Pivots, three-Position Synthesis with Alternate Moving Pivots, Three-Position Synthesis with Specified Fixed Pivots, Quick-Return Mechanisms, and Coupler Curves.

**Position Analysis**

Coordinate Systems, Position and Displacement, Position, Displacement, Translation, Rotation, and Complex Motion, Translation, Rotation, Complex Motion, Vector Loop Representation of Linkages, The Vector Loop Equation for a Four bar Linkage, The Four bar Slider Crank Position Solution, An Inverted Slider-Crank Position Solution, Transmission Angles, and Extreme Values of the Transmission Angle Toggle Positions.

**Analytical Linkage Synthesis**

Types of Kinematic Synthesis; Precision Points, Two-Position Motion Generation by Analytical Synthesis, Comparison of Analytical and Graphical Two-Position Synthesis Three-Position Motion Generation by Analytical Synthesis, Analytical Synthesis of a Path Generator with Prescribed Timing. Analytical Synthesis of a Four bar Function Generator, and Optimization Method: Newton-Raphson solution Method for four bar linkage.

**Synthesis of spatial mechanisms**

Displacement analysis, matrix method of analysis, Synthesis of 4 – revolute spherical mechanisms, and Synthesis of 2- revolute 2 spheric- pair mechanisms.

**Introduction to robotics**

Robot applications- Manufacturing industry, Defence, Rehabilitation, medical etc., Laws of Robotics, Robot mechanisms; Kinematics- coordinate transformations, Forward and Inverse Kinematics for 2D systems, Trajectory Planning, Actuators (electrical)- DC motors, BLDC servo motors, Sensors, and Sensor integration Control.

**Textbook**

1. Norton, R.L. (1999). Design of Machinery: An Introduction to the Synthesis and Analysis of Mechanisms and machines (2nd Ed.). WCB McGraw-Hill.

**Reference Books**

1. Hartenberg, R.S. & Denavit, J. (1964). Kinaematic Synthesis of Linkages. McGraw-Hill, New York.
2. Sandor, G.N. & Erdman, A.G. (1984). Advanced Mechanism Design Analysis and Synthesis. Vol. - 1, Prentice- Hall, New Jersey.
3. Myszka, D.H. (2012). Machines and Mechanisms: Applied Kinematic Analysis.
Pearson Prentice Hall.

## PRODUCT DESIGN AND DEVELOPMENT

**Course Code: ME30034**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Principles of Machine Tools (MH 2002); Solid Mechanics and Machine Design (MH 2018)**

### COURSE OBJECTIVE

Product design and development (PDD) is an interdisciplinary activity that requires significant cross-disciplinary participation. The course is governed by design thinking and facilitates manpower development for greater coordination of design, manufacturing, and marketing decisions. The course aims to strike a balance between theory and practice by focusing on design-for-X methods. Thus, students get exposure to concurrent engineering practices right from the conceptual stages of product development. The students will be exposed to the use of technology to create concept drawings and designs. They will be urged to give shape to their imagination within the bounds set by the product development software. They will be able to appreciate the use of technology that prevents downstream failures

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Identify and analyze the product design and development processes in the manufacturing industry,
CO 2: Use the concepts of process planning and its activities,
CO 3: Implement a methodical approach to the management of product development to satisfy customer needs,
CO 4: Analyze, evaluate, and apply the methodologies for product design, development, and management,
CO 5: Evaluate product using cost and benefit analysis through various cost models, and
CO 6: Design using computer-aided technology to develop new product..

### COURSE DETAILS

**Introduction: Fundamentals of Product Development**
Trend analysis, Competitive landscape, PESTLE Analysis, Overview of Products and services, Types of Product development, Overview of Product development methodologies, and Product development Planning and Management.

**Generic Product Development Process**
Identifying customer needs –voice of customer –customer populations- hierarchy of human needs-need gathering methods – affinity diagrams – needs importance- establishing engineering characteristics-competitive benchmarking- quality function deployment- house of quality- product design specification-case studies, Concept development stages, System level design, Detail design, Testing and refinement, and Production ramp up.

**Concept Generation and Selection**

Task, Structured, Approaches clarification, Search, Externally and internally, Explore systematically, Reflect on the solutions and processes, Concept selection, Methodology, and Benefits.

**Product Architecture**
Implications, Product change, Variety, Component standardization, Product performance, Manufacturability, Product development management, Establishing the architecture, Creation, Clustering, Geometric layout development, Fundamental and incidental interactions, Related system level design issues, Secondary systems, Architecture of the chunks, and Creating detailed interface specifications.

**Industrial Design**
Integrate process design, Managing costs, Robust design, Integrating CAE, CAD, CAM tools, Simulating product performance and manufacturing processes electronically, Need for industrial design, Impact, Design process, Investigation of for industrial design, Impact, Design process, Investigation of customer needs, Conceptualization, Refinement, Management of the industrial design process, Technology driven products, User, Driven products, and Assessing the quality of industrial design.

**Design for Manufacturing and Product Development**
Definition, Estimation of Manufacturing cost, Reducing the component costs and assembly costs, Minimize system complexity, Prototype basics, Principles of prototyping, Planning for prototypes, Economic Analysis, Understanding and representing tasks, Baseline project planning, Accelerating the project, and Project execution.

**Textbook**

1. Ulrich K.T. & Eppinger S.D. (1999). Product Design and Development. McGraw-Hill International Edns.

**Reference Books**

1. Crow, K. Concurrent Engg./Integrated Product Development, DRM Associates, 26/3, Via Olivera, Palos Verdes, CA 90274(310) 377-569, Workshop Book.
2. Rosenthal, S. (1992). Effective Product Design and Development. Business One Orwin, Homewood, ISBN 1-55623-603-4.
3. Pugh, S. Tool Design –Integrated Methods for Successful Product Engineering. Addison Wesley Publishing, New York, NY.

## APPLIED THERMAL ENGINEERING

**Course Code: ME31002**
**Credit: 4**
**L-T-P: 3-1-0**
**Prerequisite: Engineering Thermodynamics (ME21002), Heat Transfer (ME30003)**

**COURSE OBJECTIVE**

1. To design the thermal devices and related components from basic principles of thermodynamics.
2. To analyse the existing system for better working and to optimize the system parameters and components for better efficiency.

3. To identify the losses and take action to minimize them for efficient energy utilization or energy production.
4. To apply creativity for design thermal systems which lead to higher carbon credit and less pollution.
5. To investigate ways to modify the basic cycles, working principles, system components and system as a whole to improve the efficiency or coefficient of performance.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Describe different thermodynamic processes in thermal systems,
CO 2: Explain working principles of different components and sub-systems in power plants, engines refrigerators and air conditioners,
CO 3: Apply the thermal science principles for system operation,
CO 4: Analyse the thermal system to calculate different system parameters like efficiency, COP and loss etc,
CO 5: Evaluate the thermal performance of different thermal systems, and
CO 6: Propose different systems or sub systems to improve the system performance.

**COURSE DETAILS**

**IC Engine and Gas Turbine**
Air standard power cycles, Otto cycle, Diesel cycle, Dual combustion cycle, SI and CI engines, Four stroke engines, Carburetor, Petrol injection, Diesel injection system, Knocking, Detonation, Supercharging, Testing and performance, Air cooling and water cooling systems, Lubricating systems. Open and closed air gas turbine, Air standard Brayton Cycle, Net work output and thermal Efficiency, Condition for maximum efficiency, Maximum net wok, Inter cooling, Reheat, and Regeneration.

**Steam Generators and Steam Condensers**
Introduction to vapor power cycle, Fire tube, Water tube, High pressure and critical pressure boilers, Boiler mounting and accessories, Equivalent evaporation, Boiler efficiency and energy balance, Types of condensers, Surface and jet condenser, Vacuum and condenser efficiencies.

**Steam Nozzles and Steam Turbine**
Introduction to compressible fluids, Flow through variable area duct, Velocity and mass flow rate through nozzle, Condition for maximum discharge, Effect of friction, Impulse and reaction turbines, Compounding, Velocity diagram, Efficiencies and losses, Condition for maximum efficiencies in impulse and reaction turbines, Degree of reaction, Stage efficiency and reheat factor, Blade thickness, Height and number of blade calculations.

**Refrigeration**
Introduction, Reversed Carnot cycle and vapor compression refrigeration systems, Effects of COP on various operating parameters, Bell-Coleman cycle, Air refrigeration systems, Open and closed air refrigeration cycles, Simple air refrigeration system.

**Air-Conditioning**
Properties of air-vapour mixtures, Psychometric chart, Law of air-water vapour mixture, Enthalpy of mixture, Simple heating and cooling, Humidification, Dehumidification, Mixing of air streams, Adiabatic mixing, By-pass Factor, Apparatus Dew Point Temperature.

**Reciprocating Compressors**

Single stage compressor, PV diagram and work done, Volumetric Efficiency, Isothermal and adiabatic efficiencies, Multi-staging, Inter cooling, and minimum work done.

**Textbooks**

1. Rathore M. M., (2018) Thermal Engineering-I, McGraw Hill Education
2. Ballaney P.L., (1994) Thermal Engineering (Engineering Thermodynamics & Energy Conversion Techniques), Khanna Publisher

**Reference Books**

1. Cengel Y.A., Boles M.A., Thermodynamics An Engineering Approach, (2011) McGraw Hill Education, 7th Edition
2. C. P. Arora, (2017) Refrigeration and Air Conditioning, McGraw Hill Education, 3rd Edition
3. M.L. Mathur, Sharma R.P., (2010) Internal Combustion Engine, Dhanpat Rai Publications
4. V. Ganesan, (2017) Gas Turbines, McGraw Hill Education, 3rd Edition

## HEAT TRANSFER LAB

**Course Code: ME39001**
**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Heat Transfer (ME30003)**

**COURSE OBJECTIVE**

This laboratory is intended to describe the fundamental concepts to students in the area of heat transfer and its applications. This provides knowledge about different modes of heat transfer, like conduction, convection and radiation. The practical significance of various parameters those are involved in different modes of heat transfer can be recognized. The knowledge of heat transfer can be applied for different applications in an effective manner. The students can be trained practically to utilize this knowledge in industry.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Identify the thermal conductivity of given metal bars of different material and a solid disc,
CO 2: Explain the conduction heat transfer through fluids and assess their thermal conductivity,
CO 3: Apply the principle of the heat transfer and calculate the heat transfer coefficient for a pin fin,
CO 4: Analyze and compare the heat transfer from flat, finned and pinned surfaces in forced convection and natural convection,
CO 5: Estimate the overall heat transfer coefficient and efficiency of parallel and counter flow heat exchangers, and

CO 6: Develop standard test the emissivity of different surfaces and examine the Stefan Boltzmann Constant.

**COURSE DETAILS**

Linear heat conduction experiment

Radial heat conduction experiment

Extended surface heat transfer

Thermal conductivity of liquid

Concentric tube heat exchanger

Investigations of heat transfer in natural convection

Investigations of heat transfer in forced convection

Determination of Stefan-Boltzmann constant

Determination of emissivity

## METROLOGY AND INSTRUMENTATION LAB

**Course Code: ME39002**
**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Engineering Metrology and Control (ME30002)**

**COURSE OBJECTIVE**

This laboratory is intended to describe the fundamental concepts of measuring instruments. It provides in-depth knowledge about different inspection gauges, measuring instruments, and their fields of application. The students can know the suitability and applicability of the instruments effectively and efficiently. It is a kind of training that helps them utilize it in industrial applications.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Identify the different inspection gauges and their applications,
CO 2: Understand the working principle of different measuring instruments and their applications,
CO 3: Articulate the results from different measuring instruments,
CO 4: Inspect the bore diameter by using four ball and two ball methods,
CO 5: Evaluate the dimensions of a specimen using Sine bar and slip gauges, and
CO 6: Justify the use of profile projector for specimen inspection..

**COURSE DETAILS**

Study of different types of inpection gauges and their methods of application

Determination of diameter and length of stepped shaft using Micrometer, Vernier Calliper and Vernier height gauge

Determination of angle of an angle gauge plate by using sine bar method

Determination of bore diameter by bore diameter by four ball and two ball method

Determination of the included taper angle, large end, smaller end diameter (DL and Ds) and check the outer roundness and uniformity of an externally tapered specimen

Determination of the included taper angle, large end, smaller end diameter (DL and Ds) and check the uniformity of an internally tapered specimen

Determination of the chordal thickness of gear tooth using gear tooth vernier calliper

Determination of external radius of specimen

## THERMAL ENGINEERING LAB

**Course Code: ME39004**
**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Applied Thermal Engineering (ME31002)**

**COURSE OBJECTIVE**

This laboratory helps the student learn about the energy conversion systems related to thermal engineering. The course is aimed at demonstrating the thermal science theory by carrying out a series of experiments. The course is designed to fulfill these requirements by including experiments related to Thermodynamics, IC Engines, Refrigeration and Air-conditioning. There are 12 experimental setups, out of which 8 to 10 experiments are conducted in this course.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Recall the working principles of various processes related to IC Engines, Air-Conditioning and Refrigeration,
CO 2: Recognize the different components related to IC Engines, refrigeration and air conditioning,
CO 3: Apply the effects of various important parameters such as load, speed and fuel consumption in case of IC Engine and super heating, under cooling, DBT and WBT,
CO 4: Anlyze the experimental result / heat balance sheet for better performance and improved accuracy,
CO 5: Evaluate performance of refrigeration and air conditioning systems under standard laboratory condition, and
CO 6: Write the sources of difference between experimental and theoretical results.

**COURSE DETAILS**

Load test on a 2-stroke, single-cylinder petrol engine and study of its performance characteristics

Constant speed performance test on a 4-stroke single-cylinder diesel engine and study of its performance characteristics

Constant speed performance test on a Four-Stroke Single-Cylinder Petrol Engine

Determination of the indicated power (IP) of multi-cylinder petrol engine by Morse test

Study of the vapor compression test rig and determination of the theoretical and actual COP of the refrigerator in batch and continuous mode

Determination of the ice making capacity of an ice plant per day and COP of the ice plant

Study of the Mechanical Heat Pump (Air to Air Type) test rig and determination of the COP of the unit when working as Air to Air heat pump and cooling capacity of the refrigeration cycle

Determination of the actual COP and theoretical COP of a vapour absorption refrigeration system

Determination of cooling load in automotive air conditioner test rig

Trial on cascade refrigeration systems for low temperature applications and determination of individual COPs and overall COP in two stage cascade systems
Trial on air-conditioning test
Study of cooling and dehumidification of air in air washer test rig and calculation of the change in specific humidity and temperature of air

## LASER MATERIALS PROCESSING

**Course Code:** **ME40011**
**Credit:** **3**
**L-T-P:** **3-0-0**
**Prerequisite:** **Manufacturing Technology-I (ME21003), Manufacturing Technology-II (ME21004)**

**COURSE OBJECTIVE**

Laser Materials Processing is an extension of Material Science and Manufacturing Technology. The objective of this course is to build the fundamental knowledge regarding the Laser, it's application and it's uses for processing of different materials. In particular, the course will cover different types of laser, different types of laser processing and the mechanism of different laser processing.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Describe the fundamental of laser and safety standards and procedure in Laser Use,
CO 2: Explain the different types of laser and their applications, economics, advantages and disadvantages,
CO 3: Apply the laser beam characteristics and heat flow mechanism during laser processing of different materials,
CO 4: Analyze different laser surface modifications techniques and their mechanisms,
CO 5: Evaluate the effect of process parameters on mechanical and microstructural aspect during laser metal forming and laser peening, and
CO 6: Design the process parameters for practical performances in evaluating laser cutting and laser welding..

**COURSE DETAILS**

**Laser Fundamentals**
Spontaneous & stimulated emission/absorption, population inversion & pumping, cavity design, coherence and interference

**Laser Safety**
Laser safety standards, and safety procedures

**Common industrial lasers, and their output characteristics**
CO2, Ruby, Nd-YAG, Nd-glass, excimer, & Diode laser

**Overview of laser Applications**
Laser application in various fields, advantages, & disadvantages, economics

**Laser processing fundamentals**
Beam characteristics, optical components and design of beam delivery systems, absorption characteristics of materials, heat flow theory, and metallurgical considerations

**Laser cutting and drilling**
Process characteristics, material removal modes, practical performances

**Laser welding**
Process mechanisms like keyhole and plasma effect, operating characteristics, and process variation

**Laser surface modifications**
Heat treatment, surface remelting, surface alloying and cladding, surface texturing, LCVD and LPVD

**Laser metal forming and Laser peening**
Mechanisms involved including thermal temperature gradient, buckling, upsetting,
Fundamentals of Laser Shock Processing, Effects of various laser and process parameters, Mechanical effects and microstructure modification during laser shock processing

**Textbooks**

1. W. M. Steen, Laser Material Processing, Springer
2. Elijah Kannatey-Asibu, Principles of Laser Materials Processing, Wiley

**Reference Books**


1. N B Dahotre, S Harimkar, Laser Fabrication and Machining of Materials, Springer
2. John Ion, Laser Processing of Engineering Materials: Principles, Procedure and Industrial Application, Butterworth- Heinemann


# TRIBOLOGY

**Course Code: ME40012**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Kinematics and Dynamics of Machines (ME20002)**

## COURSE OBJECTIVE

This course, an off-shoot of Mechanical Engineering, has been designed to impart the pragmatic knowledge in context to the science of interacting surfaces and to offer a deeper insight in regard to the application as well as principles of friction, wear and lubrication. The domain of tribology happens to be interdisciplinary in nature and so accommodates the ingredients of plural disciplines like mechanical engineering, chemistry, material science, etc. Under the applicative scope of tribology, students are expected to get cognitive exposure pertaining to various tribological aspects of machine elements and a wide range of composite materials. The knowledge of tribology can be deployed meaningfully in checking the wasteful dispersal of energy on account of some uncalled for friction, and thereby contributes towards maintaining a green environment.

## COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Comprehend and identify tribological issues in the design of machine components, such as rolling element bearings, journal bearings and thrust bearings,
CO 2: Understand the fundamentals of friction, wear and lubrication in context of relative motion between two surfaces in contact,
CO 3: Apply different theories of hydrodynamic lubrication to bearings,
CO 4: Analyze the surface topography and properties of lubricants by using related instruments,
CO 5: Evaluate the dynamic load carrying capacity, power losses and other attributes of various tribological elements based on design considerations, and
CO 6: Design the hydrodynamic/hydrostatic bearings..

## COURSE DETAILS

**Properties of Lubricants**
Viscosity, flow of fluids, viscosity and its variation-absolute and kinematic viscosity, temperature variation, determination of viscosity index, different viscometers used

**Hydrostatic Lubrication**
Hydrostatic step bearing, application to pivoted pad thrust bearing and other applications, hydrostatic lifts, hydrostatic squeeze films and its application to journal bearing

**Hydrodynamic Theory of Lubrication**
Various theories of lubrication, petroffs equation, Reynold's equation in two dimensions, Friction in sliding bearing, hydro dynamic theory applied to journal bearing, minimum oil film thickness, oil whip and whirl anti -friction bearing

**Friction and Power Losses in Journal Bearings**
Calibration of friction loss friction in concentric bearings, bearing moduIus, Sommerfield number, heat balance, practical consideration of journal bearing design considerations

**Air Lubricated Bearing**
Advantages, disadvantages and application to hydrodynamic journal bearings, hydrodynamic thrust bearings. Hydrostatic thrust bearings. Hydrostatic bearing Analysis including compressibility effect. Study of current concepts of boundary friction and dry friction

**Bearing Materials**
General requirements of bearing materials, types of bearing materials

**Friction and Wear**
Friction theories, stick-slip, rolling friction, sliding contact, single/multi-point contact, types of wear and its mechanisms , wear of metals, wear test

**Textbook**

1. Fundamentals of Tribology, Basu, Sen Gupta and Ahuja, PHI

**Reference Books**

1. Engineering Tribology, Gwidon W. Stachowiak and Andrew W. Batchelor, 4th Edition, 2014
2. Tribilogy, Friction and Wear of Engineering Materials, I.M. Hutchings, Elsevier Limited
3. Introduction to Tribology of Bearing, B.C. Majumdar, S.Chand
4. Theory and Practice of lubrication of Engineers, D.D. Fuller, John Wiley Sons 1998

## TOTAL QUALITY MANAGEMENT

**Course Code:** **ME40013**
**Credit:** **3**
**L-T-P:** **3-0-0**
**Prerequisite:** **Nil**

**COURSE OBJECTIVE**

Over the years Total Quality Management has become very important for improving firm's processing capabilities in order to sustain competitive advantages. This course provides a fundamental yet comprehensive coverage of TQM. The course contents focuses on evolution of TQM concept, Quality tools, SPC, Sampling plan and the implementation of TQM in industry.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Explain the evaluation, contributions of quality Gurus,
CO 2: Understand the quality engineering methods and tools,
CO 3: Apply techniques for improving qualities in organisations and supplier end,
CO 4: Analyse different concepts of acceptance sampling plan,
CO 5: Evaluate the concept of QFD, Kaizen in achieving the organization's key target, and
CO 6: Design and interpretation of control charts and process capability..

**COURSE DETAILS**

**Introduction**
Defining Quality, 4 stages of Quality, Some important philosophies and their impact on quality, Quality as a management Frame work, Quality Cost, Quality Losses and its competitive advantage, Relation between Quality and Productivity. Basic Tools of Quality, Total Quality Management & its evolution, TPM. Leadership concepts, Role of Senior Management. Components of TQM, Mission and Vision, ISO 9000/TS 16949, Malcolm Baldridge award, Concepts of Six Sigma

**Statistical Methods for Quality Control**
Statistical Methods for Quality Control and improvement, Statistical Process Control, Specification & Limits, Charts for variables and Attributes (X, R and P chart), Designing Control charts. Calculation of Process capability (Cp/Cpk studies).and its interpretation and analysis. New 7 management Tools. FMEA and Control Plan. Zero Defect

**Planning**
Long Term Understanding with Supplier (LOTUS), Supplier as Partner, Supplier selection and Rating, supplier Mentoring and continuous Improvement, Design of single sampling plan. Double, multiple and sequential sampling plans, O.C. Curve, AOQ and AOQL

**Quality Auditing**
5s, Kaizen, Benchmarking, QFD process and House of Quality, Implementation of Quality system, Documentation, Quality Auditing, Customer perception of Quality, Customer Loyalty, Service Quality and Retention of Customer. Employee motivation and Reward, Employee Involvement and Performance measures

**Textbooks**

1. Fundamental of Quality Control and Improvement, Mitra A, PHI
2. Quality Planning and Analysis, Juran J M and Gryna F M, Tata McGraw Hill

**Reference Books**

1. Total Quality Management, Dale H Besterfield, Pearson Education, 2003

2. The Management and Control of Quality, James R Evans and William M Lidsay
3. Total Quality Management, L Suganthi, PHI, 2004

## VIRTUAL REALITY AND HAPTICS

**Course Code: ME40014**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

This course introduces the fundamental concepts and techniques behind Virtual Reality (VR) and Haptics, the science of touch. Topics covered include the basics of VR, 3D modelling, rendering, display, and interaction, as well as the physics, perception, and algorithms of haptic feedback. Students will also have hands-on experience with the development of VR and haptic applications.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Know various types of haptic devices used in industry,
CO 2: Understand the basic concept of virtual reality and haptics in engineering application,
CO 3: Apply the concepts of geometric modelling and virtual reality programming,
CO 4: Illustrate the haptic architecture,
CO 5: Evaluate the efficacy of hand tracking and body tracking, and
CO 6: Design current generation systems for creating 3D VR environments.

**COURSE DETAILS**

**Introduction to Virtual Reality and Haptics**
Definition of VR and haptics, brief history, and applications of VR and Haptics, The VR pipeline: modelling, rendering, display, interaction; The haptic pipeline: physics, perception, feedback

**3D Modelling and Simulation**
3D modelling techniques: polygonal meshes, texture mapping, lighting; 3D modelling tools: Blender, Unity, Unreal Engine; Physics simulation: rigid body dynamics, collision detection

**VR Display and Interaction**
VR display technologies: head-mounted displays, cave systems, projection-based displays, VR interaction techniques: hand and body tracking, gesture recognition; VR locomotion: teleportation, smooth locomotion

**Haptic Feedback**
Principles of haptic feedback: force, texture, vibration; Haptic devices: force feedback joysticks, haptic gloves, exoskeletons; Haptic rendering algorithms: position-based dynamics, impedance control

**Applications of VR and Haptics**

Medical VR: surgery simulation, rehabilitation, pain management; Entertainment VR: gaming, cinema, theme parks; Industrial VR: training, design, prototyping

**Textbooks**

1. Philippe Fuchs and Gérard Moreau "Virtual Reality: Concepts and Technologies", CRC Press, 2011
2. Kelly S. Hale (Editor), Kay M. Stanney (Editor). 2014. Handbook of Virtual Environments: Design, Implementation, and Applications, Second Edition (Human Factors and Ergonomics) ISBN-13: 978-1466511842
3. M. LaValle, "Virtual Reality, Steven", Cambridge University Press, 2016
4. William R Sherman and Alan B Craig, "Understanding Virtual Reality", Interface, Application and Design, (The Morgan Kaufmann Series in Computer Graphics)". Morgan Kaufmann Publishers, San Francisco, CA, 2002

**Reference Books**

1. Gerard Jounghyun Kim, "Designing Virtual Systems: The Structured Approach", 2005
2. Doug A Bowman, Ernest Kuijff, Joseph J LaViola, Jr and Ivan Poupyrev, "3D User Interfaces, Theory and Practice", Addison Wesley, USA, 2005
3. Oliver Bimber and Ramesh Raskar, "Spatial Augmented Reality: Merging Real and Virtual Worlds", 2005
4. Burdea, Grigore C and Philippe Coiffet, "Virtual Reality Technology", Wiley Inter science, India, 2003

## RENEWABLE ENERGY SYSTEMS

**Course Code: ME40015**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

- To understand about renewable energy sources such as solar, wind, biomass and geothermal
- To understand different advantages and limitations of renewable energy sources over conventional sources of energy like fossil fuels, wood etc.
- To decide the best possible renewable power generation method for a given location and budget
- Storage and distribution of energy extracted from renewable sources
- Comparison of merits and demerits of different renewable energy sources
- Future scope of energy extraction from different renewable sources

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Recall different power generation methods,
CO 2: Demonstrate the understandings of working principles of different renewable energy production methods,
CO 3: Solve problems based on wind and solar power generation,
CO 4: Decide the best choice of renewable power generation for any given location and budget,
CO 5: Examine the difficulties and challenges associated with any renewable energy source, and

CO 6: Design the layout of renewable energy generation for any given location, budget etc.

**COURSE DETAILS**

**Introduction to Renewable Energy**
Forms of energy, Fossil fuels and climate change, Renewable energy sources, Importance of energy storage and distribution, Biological storage, Chemical storage, Heat storage, Electrical and mechanical storage, and Distribution of energy.

**Solar power generation**
The nature and availability of solar radiation, Low temperature solar energy application, Active and passive solar heating, Solar thermal energies and electricity generation, and Economics and environmental impact.

**Bio power generation**
Bio energy past and present, Bio mass as a storage of solar energy, Bio mass as a fuel, Primary bio mass energy sources, Plant materials, Secondary bio mass sources: wastes, residues, Physical processing of bio mass, Thermo-chemical processing, Bio-chemical processing, Vegetable oils and bio diesels, Environmental impacts, and Future prospects.

**Tidal and wave power generation**
Nature of tidal source, Physics of tidal energy, Power generation from barrages, Environmental consideration for tidal barrages, Integration of electrical power from tidal barrages, Economics of tidal barrages, Tidal lagoons, Tidal current projects, Physical principles of wave energy, Wave energy sources, and Wave energy technology.

**Wind power generation**
Energy and power in the wind, Characteristics of the wind, Wind turbines (types, horizontal and vertical axis), Linear momentum and basic theory, Dynamic matching, Blade element theory, Aero dynamics of wind turbines, Power extraction, Electricity generation, Environmental impact, Commercial development, and Offshore energy.

**Geothermal power generation**
The mining of geothermal heat, Sources of heat, Physics of deep geothermal resources, Technologies for exploiting high enthalpy steam fields, Technologies for direct use, Harnessing geothermal resources, Environmental impact, and World potential.

**Textbook**

1. Boyle, G. (2013). Renewable Energy: Power for a sustainable future (3rd Edition). Oxford University Press.

**Reference Book**

1. Twidell, J. & Weir, T. (2010). Renewable energy resources (3rd Edition). Taylor and Francis Group. Vikas Publication.

## MICRO ELECTRO MECHANICAL SYSTEMS

**Course Code:** **ME40016**
**Credit:** **3**
**L-T-P:** **3-0-0**
**Prerequisite:** **Nil**

## COURSE OBJECTIVE

The objective of this course is to make students to gain basic knowledge on overview of MEMS (Micro electro Mechanical System) and various fabrication techniques. This enables them to design, analysis, fabrication and testing the MEMS based components. And to introduce the student's various opportunities in the emerging field of MEMS.

## COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Identify the basic concepts of micro electromechanical systems,
CO 2: Understand the tools and processes used in micromachining of MEMS,
CO 3: Apply the concepts of working of micro-sensors and actuators, to enable selection, design and configuration of Micro-sensors and actuators,
CO 4: Illustrate various nanomaterials and various nano measurements techniques,
CO 5: Evaluate microsystems technology for technical feasibility as well as practicality, and
CO 6: Develop appropriate material for any microsystem and packaging method for any microsystem..

## COURSE DETAILS

**Introduction to Microsystems**
Overview of microelectronics manufacture and Microsystems technology, Definition- MEMS materials, Laws of scaling, The multi-disciplinary nature of MEMS, Survey of materials central to micro engineering, and Applications of MEMS in various industries.

**Micro Sensors & Actuators**
Working principle of Microsystems, Micro actuation techniques, Micro sensors types, and Micro actuators types: micro pump, micro motors, micro valves, micro grippers, and micro accelerometers.

**Basic characteristics of feedback control systems**
Stability, Steady-state accuracy, Transient accuracy, Disturbance rejection, Insensitivity and robustness, Basic modes of feedback control: proportional, integral and derivative. Feed-forward and multi-loop control configurations, Stability concept, Relative stability, Routh stability criterion, Time response of second-order systems, Steady-state errors and error constants, Performance specifications in time-domain, Root locus method of design, and Lead and lag compensation.

**Fabrication Process**
Substrates-single crystal silicon wafer formation, Photolithography, Ion Implantation, Diffusion Oxidation, CVD-Physical Vapor Deposition, and Deposition by epitaxy-etching process.

**Microfabrication techniques**
LIGA and other moulding techniques, Soft lithography and polymer processing, Thick-film processing, Low temperature co-fired ceramic processing, and Smart material processing.

**Microsystems Design and Packaging**

Design considerations, Mechanical Design, Process design, Realization of MEMS components using intellisuite, Micro system packaging, Packing Technologies, Assembly of Microsystems, Reliability in MEMS, What's next MEMS, Micro factories and Nanotechnology.

**Textbooks**

1. Hak, M. G. El (2002). MEMS Handbook. CRC Press.
2. Choudhury, P. R. (2009). MEMS and MOEMS Technology and Applications. PHI Learning Private Limited.
3. Solomon, S. (1998). Sensors Handbook.McGraw Hill.
4. Madou, M.F. (2002). Fundamentals of Micro Fabrication (2nd Edition). CRC Press.

**Reference Books**

1. Tay, E. H. F. & Choong, W. O. (1997). Micro fluidics and Bio mems application. IEEE Press. New York.
2. Trimmer W. S. (1997). Micromechanics and MEMS. IEEE Press New York.

## SOFT COMPUTING TECHNIQUES

**Course Code: ME40017**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

This course will provide students the basic concepts of different methods and tools for processing of uncertainty in intelligent systems, such as, fuzzy models, neural networks, probabilistic models, and foundations of it's using in real systems. This course covers main concepts of philosophy of artificial intelligence, hybrid intelligent systems, classification and architecture of hybrid intelligent systems.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Describe the soft computing techniques and their roles in building intelligent machines,
CO 2: Recognize the feasibility of applying a soft computing methodology for a particular problem,
CO 3: Apply fuzzy logic and reasoning to handle uncertainty and solve engineering problems,
CO 4: Illustrate the structure of an Artificial Neural Network (ANN) and its role in machine learning,
CO 5: Solve using Genetic Algorithms to combinatorial optimization problems and neural networks to pattern classification and regression problems, and
CO 6: Create hybrid neuro-fuzzy models blending fuzzy logic and ANN..

**COURSE DETAILS**

**Introduction to Soft Computing**

Evolution of computing, Soft computing constituents, Conventional AI to computational intelligence, and Machine learning basics.

**Fuzzy Logic**
Fuzzy sets, Operations on Fuzzy sets, Fuzzy relations, membership functions, Fuzzy rules and Fuzzy reasoning, and Fuzzy inference systems.

**Artificial Neural Networks**
Basic concepts, Single layer perception, Multi layer perception, Supervised and unsupervised learning, Back propagation networks application, and Machine Learning using Neural Network.

**Neuro-Fuzzy Modeling**
Adaptive Neuro-Fuzzy inference systems, Coactive Neuro-Fuzzy modelling, Neuro-Fuzzy control, and Case studies.

**Genetic Algorithms**
Survival of the fittest, Pictures computations, Cross over mutation, Reproduction, Rank method, Rank space method, and Application.

**Artificial Intelligence**
AI search algorithm, Predicate calculus rules of interface, Semantic networks, Frames, Objects, Hybrid models, and Applications.

**Textbooks**

1.Pratihar, D.K. Soft Computing. Narosa Publications.
2.Ross T. J. (1997). Fuzzy Logic Engineering Applications. McGraw Hill. NewYork.
3.Fauseett, L. (1994). Fundamentals of Neural Networks. Prentice Hall India. New Delhi.

**Reference Books**

1.Charniak, E. & McDermott, D. Introduction to Artificial Intelligence. Pearson Education.
2.Patterson, D. W. Artificial Intelligence and Expert Systems. Prentice Hall of India.
3.Kumar, K. V. Soft computing. S.K. Kataria and Sons.
4.Kumar, S. Neural Network- A class room approach. McGraw Hill.

## PRODUCT LIFE CYCLE MANAGEMENT

**Course Code:** **ME40018**
**Credit:** **3**
**L-T-P:** **3-0-0**
**Prerequisite:** **IEOR (ME30005)**

**COURSE OBJECTIVE**

PLM stands for Product Lifecycle Management. The primary goal of PLM is to coordinate the information, processes and people associated with the lifecycle of a product. It provides students some basic knowledge of production errors, reduced cycle iterations and, increased speed to market. As PLM focuses itself primarily generate an innovative idea for product design in a systematic approach and apply the check the quality of the new design by using product design tools.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Describe the fundamentals of Product life cycle management processes,
CO 2: Understand the different types of product development process,
CO 3: Apply analytical methods, numerical tools to design product and service design requirement,
CO 4: Analyse the components of product life cycle management and its effect on human resources,
CO 5: Evaluate the strategies in product life cycle management, and
CO 6: Design the product outflow in industrial point of view..

**COURSE DETAILS**

**Introduction**
Overview, Need, Benefits, Concept of Product Life Cycle, Components / Elements of PLM, Emergence and significance of PLM, PLM implementation cases in various industry verticals. Trend analysis, Competitive landscape, PESTLE analysis, Overview of products and services, Types of product development, and Overview of product development methodologies.

**Generic Product Development Process**
Identifying customer needs, Voice of customer, Customer populations, Hierarchy of human needs, Need gathering methods, Affinity diagrams, Needs importance, Establishing engineering characteristics, Competitive bench marking, Quality function deployment, House of quality, Product design specification, Case studies, Concept development stages, System level design, Detail design, Testing, and refinement production ramp.

**Product design tools and technology**
Theory of inventive problem solving, General theory of innovation and TRIZ, Value engineering applications in product development and design, Model-based technology for generating innovative ideas, Quality aspects in product design, and Failure mode effect analysis.

**Product Life Cycle Management**
System architecture, Information models and product structure, Functioning of the system. Significance of PLM, and Customer involvement.

**Product life cycle environment**
Product data and product workflow, The link between product data and Product Workflow, Key management issues around product data and product workflow, Company's PLM vision, The PLM strategy, Principles for PLM strategy, and Preparing for the PLM strategy.

**Components of Product Life Cycle Management**
Different phases of product life cycle and corresponding technologies, Foundation technologies and standards (e.g. Visualization, Collaboration and Enterprise application integration), Core functions (e.g., Data vaults, Document and Content management, Workflow and program management), Functional applications (e.g., Configuration management) Product organizational structure, Human resources in product life cycle, Methods, Techniques, Practices, Methodologies, Processes, System, Components in life cycle, Slicing and dicing the systems , Interfaces, Information, Standards, and Examples of PLM in use.

**Textbooks**

1.Ulrich, K. T. & Eppinger, S. D. (1995). Product design and development. McGraw Hill Pub. Company.
2.Michael, G. (2006). Product Lifecycle Management. McGraw-Hill, ISBN 0071452303

**Reference Books**

1.Otto, K. & Wood, K. (2004). Product Design. Pearson Education. ISBN 9788177588217
2.Michael, G. (2006). Product Lifecycle Management - Driving the Next Generation of Lean Thinking. McGraw-Hill.
3.Terninko, J. & Zusman, A. Systematic innovation: an introduction to TRIZ; (theory of inventive Problem Solving). CRC Press.
Saaksvuori, A. & Immonen, A. (2003). Product Life Cycle Managemen (1st Edition). Springer.

## PLANT LAYOUT AND MATERIAL HANDLING

**Course Code: ME40019**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

The main objective of this course is to enable the students to be trained with planning/production and plant layouts, studying about strategies of material handling and equipment's, and selection of site locations. It also aims to explore the layout planning by computer applications following different algorithms.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Identify equipment requirements for a specific process,
CO 2: Understand what effect process layout has on the material handling system,
CO 3: Apply the techniques to evaluate and design material handling and storage systems,
CO 4: Analyze the benefit of an efficient material handling system,
CO 5: Plan, analyze and design to improve manufacturing and services facilities, and
CO 6: Explore integrate concepts and techniques learned through this course in order to design and efficient plant layout in a team environment..

**COURSE DETAILS**

**Introduction**
Classification of layout, Advantages and limitations of different layouts, Layout design procedures, Overview of the plant layout, Process layout & product layout: Selection, Specification, Implementation and Follow up, and Comparison of product and process layout.

**Plant layout**
Heuristics for plant layout — ALDEP, CORELAP, CRAFT, Group Layout, Fixed position layout, Quadratic assignment model, and Branch and bound method.

**Material Handling**
Introduction, Material handling systems, Material handling principles, Classification of material handling equipment, and Relationship of material handling to plant layout.

**Material handling systems**
Basic material handling systems: Selection, Material handling method - Path, Equipment, and Function oriented systems.

**Improved Material Handling**
Methods to minimize cost of material handling, Maintenance of material handling equipment's, Safety in handling ergonomics of material handling equipment, Design, and Miscellaneous equipment's.

**Textbooks**

1. Mahapatra, P.B. Operations Management. PHI.
2. Arora, K.C. Aspects of Material handling. Lakshmi Publications.

**Reference Books**

1. Panneerselvam, R. Production and Operations Management. PHI.
2. Ray, S. Introduction to Material handling. New Age.
3. Chowdary, R.B. & Tagore, G.R.N. Plant Layout and Material Handling. Khanna Publishers. 4. Raju, N.V.S. Plant Maintenance and Reliability Engineering. Cengage Learning.
5. Francis, R. L. & White, J. A. (1974). Facility Layout and Location: An Analytical Approach. Prentice-Hall Inc.

## COMBUSTION ENGINEERING

**Course Code: ME40020**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Engineering Thermodynamics (ME21002)**

**COURSE OBJECTIVE**

Combustion engineering harnesses the energy from reaction of a fuel and an oxidizer, in which the chemical energy stored in the fuel is released. The applications of combustion engineering are used in everything, from home heating systems to car engines, and in all areas of manufacturing. The objective of this course is to understand combustion fundamentals and their application to engineered combustion systems. The course will make the students familiar with the fundamental physical and chemical principles regarding formation and control of air pollutants in industrial and technological processes.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Recall the basics of combustion and thermo chemistry relations,
CO 2: Explain the fundamentals of chemical kinetics,
CO 3: Articulate the needs and the technical detail of laminar diffusion flame,
CO 4: Illustrate the mechanism and explain technicality of laminar premixed flame,
CO 5: Formulate the physical process through mathematical relation of droplet evaporation, and
CO 6: Develop strategy to mitigate causes of pollution.

**COURSE DETAILS**

**Combustion and Thermo-chemistry**
Review of property relations, Equation of state, Calorific equations of state, Ideal gas mixtures, Thermodynamics (1st & 2nd law for pure, non-reacting (mixture) and reacting systems); Stoichiometry, Absolute enthalpy and enthalpy of formation, Enthalpy of combustion and heating values, and Adiabatic flame temperatures.

**Chemical Kinetics**
Global versus elementary reactions, Elementary reaction rates, Unimolecular, Bimolecular and Termolecular reactions, Collision theory; Reaction rate and its functional dependence; Arrhenius equation; Order of reaction, Steric factor, Collision frequency, Activation energy etc. Rates of reaction for multistep mechanisms: Relation between rate coefficients and equilibrium constants, Chain and chain branching reactions, and Chemical time scales.

**Laminar premixed flame**
Definition, Principal characteristics; Simplified Analysis: Assumptions, Conservation (mass, species & energy) equations with boundary conditions and their solutions to find out temperature & mass-fraction distribution; Factors affecting flame velocity and thickness, Correlations of flame velocity & thickness; Quenching; Flammability & ignition, and Flame stabilization.

**Laminar diffusion flame**
Laminar Jet, Jet flame physical description, Simplified theoretical descriptions, Burke-Schumann solution: Assumptions, Simplification and solution of mass, Species, Momentum & energy equation with the boundary conditions; Determination of temperature & mass-fraction distribution as well as flame height, and Soot formation and destruction.

**Droplet evaporation & combustion**
Applications, Simple model of droplet evaporation, Assumptions, Solution of mass, Species & energy equation with the boundary conditions; Determination of temperature & mass-fraction distribution, Mass evaporation rate, Flame stand-off ratio, Flame temperature, Expression for transfer numbers, Evaporation/burning rate constant, and Droplet life-time etc.

**Pollutant emissions**
Effects of pollutants, Quantification of emissions, Emission indices, Various specific emission measures, Emissions from premixed combustion, and Emissions from non-premixed combustion.

**Textbook**

1.Turns, S. R. (2000). Introduction to Combustion: Concepts and Applications. McGraw Hill.

**Reference Books**

1. Datta, A. (2017). Combustion: Fundamentals and Application. Alpha Science International Ltd.
2. Kuo, K. Combustion Engineering. New Age Pvt. Ltd.

## CRYOGENICS

**Course Code: ME40021**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: (ME30003)**

**COURSE OBJECTIVE**

1. To choose suitable materials for low temperature applications.
2. To investigate different gas liquefaction systems.
3. To make the cryogenic systems more cost effective.
4. To explore various low temperature applications.
5. To exploit the material properties at cryogenic temperature.
6. To evaluate different low temperature measurement systems.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Identify and describe historical developments in cryogenic systems.,
CO 2: Explain material behaviour at very low temperature.,
CO 3: Demonstrate the important applications of cryogenics.,
CO 4: Choose appropriate measurement systems at very low temperature.,
CO 5: Evaluate and compare gas liquefaction and purification systems/methods., and
CO 6: Develop important system parameters and performance parameters..

**COURSE DETAILS**

**Introduction**
Chronology of cryogenic technology, Present areas of cryogenic engineering, Low temperature properties of engineering material, Mechanical, thermal and magnetic properties.

**Gas Liquefaction Systems**
System performance parameters, Ideal systems, Joule-Thomson Effect, Linde-Hanpson System, Pre- cooled Linde-Hampson System, Linde Dual Pressure System, Claude and Kaptiza System, liquefaction systems for Neon, Hydrogen and Helium, Critical components for liquefaction systems.

**Gas Separation and Purification Systems**
Physical adsorption, Refrigeration purification: Gibbs phase rule, Dalton and Raults law, Rectification Column, Design of rectification column ( Mccabe-Thiele Method).

**Cryogenic Refrigeration**

Ideal refrigeration systems, Refrigerator above 2 K, J-T refrigerator, Expansion engine refrigerator, Philips refrigerator, G-M refrigerator Refrigerator below 2 K, Magnetic cooling, Magnetic refrigerator System.

**Measurement Systems for Low Temperatures**
Introduction, Metallic resistance thermometer, Semiconductor resistance thermometer, Thermocouples, Constant volume gas thermometer, Vapor pressure thermometers, Liquid level measurement, Hydrostatic gauges, Electric resistance gauges, Thermodynamic liquid level gauges.

**Application of Cryogenics**
Cryogenic fluid storage systems, Insulation, Important of vacuum technology in cryogenics, Super conductive devices and its application, Space technology, Cryogenics in Biology and Medicine.

**Textbooks**

1. Barron, R. F., & Nellis, G. F. (2017). Cryogenic heat transfer. CRC press.
2. Bose A. and Sengupta, P. Cryogenics: Applications and Progress, TMH.

**Reference Books**

1. Flynn, T. M. (2005). Cryogenic engineering.(rev. and expanded.).
2. Walker, G. Cryo-Cooler Fundamentals, Plenum Press New York.

## NON TRADITIONAL MANUFACTURING

**Course Code:** **ME40022**
**Credit:** **3**
**L-T-P:** **3-0-0**
**Prerequisite:** **Manufacturing Technology-I (ME20005), Manufacturing Technology-II (ME21004)**

### COURSE OBJECTIVE

- To understand foundational knowledge about the Non-traditional machining processes.
- To know application-based extension of the conventional manufacturing process.
- To know about various advanced manufacturing processes adopted in the industry.
- To discusses the principle and working mechanisms of various advanced manufacturing processes.
- To know various advanced welding processes
- To know various advanced forming processes

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Know the working principle, mechanism and applications of various advanced machining processes,
CO 2: Understand the need and importance of non-traditional manufacturing processes and process selection,
CO 3: Apply various process parameters on the material removal rate of advanced machining processes,
CO 4: Analyze the principles of advanced welding techniques,,
CO 5: Evaluate efficacy of advanced metal forming processes, and
CO 6: Develop strategy of implementing various non-conventional manufacturing processes.

**COURSE DETAILS**

**Introduction**
Limitations of traditional manufacturing processes Need of non-traditional manufacturing process and its classification, and Process Selection.

**Non- Traditional Machining Process**
Working Principle, Mechanics of material removal, Effect of process parameters on material removal rate, advantages, disadvantages and applications of thermal metal removal processes (Electro discharge machining, Wire-Electro Discharge Machining, Plasma Arc Machining, Laser Beam Machining, Ion beam machining, Electron Beam Machining, Hot machining, Neutral Particle Etching), Mechanical processes (Ultrasonic machining, Abrasive jet machining, Water jet machining, Abrasive Water Jet Machining), Electro-chemical and Chemical metal removal process (Electro-chemical machining, Electro-chemical Grinding, Electrochemical de-burring, Electrochemical Honing, and Chemical Machining).

**Introduction to Micro/ Nano machining**
Abrasive Micromachining, Diamond Micro- grinding/turning, Ultrasonic Micromachining, Electro-discharge Micro-machining, Laser Micro-machining, Electrochemical Micro-machining, Chemical Micro-machining, Ion Beam Machining, Electron Beam Machining, Abrasive flow finishing, Magnetic Abrasive finishing, Magneto rheological abrasive flow finishing, and Magnetic float polishing.

**Non- Traditional Welding Processes**
Friction and Intertia Welding, Friction stir welding, Ultrasonic welding, Roll Bonding, Diffusion Welding, Electron beam welding, Laser welding, Explosive welding, Plasma arc welding, Underwater welding, and Laser cladding. Principle, applications, advantages and limitations.

**Non- Traditional Forming Processes**
Hydro forming, Hydro-mechanical Forming, Electro-hydraulic forming, Electromagnetic forming, Explosive forming, Incremental Forming, Flexible Die Forming, Explosive compaction, Petro-forging, Contour roll forming, working , applications, advantages and limitations.

**Textbooks**

1. Pandey, P.C.& Shan, H.S. Modern Machining Processes. Tata McGraw Hill.
2. Sharma, P. C. A Textbook of Production Technology. S. Chand Publications.

**Reference Books**

1. Benedict, G.F. Non Traditional Manufacturing Processes, Marcel Dekker Inc., New York.
2. Garmo, P. D., Black & Ronald & Kohser, A. Material & Processes in Manufacturing.

3. Brown, J. A., Modern Manufacturing Processes, Industrial Press.

## THEORY OF MICROFLUIDICS

**Course Code: ME40031**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Fluid Mechanics and Hydraulic Machines (ME20001)**

### COURSE OBJECTIVE

1. Understand the fundamentals of micro-fluidics their applications.
2. Co-relate the concept of micro-fluidics in the domain of fluid mechanics.
3. Implement the knowledge of electro-kinematics in practical applications.
4. Analyze the micro-fluids components and sensors.
5. Evaluate the performance and efficiencies of micromixers and microreactors.
6. Apply the concept of micro-fluids in bio medical field.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Describe the fundamentals of microfluidics and its applications to interdisciplinary fields.,
CO 2: Understand the physics of fluids through micro-channels.,
CO 3: Apply the concept of electrodynamics in micro-scale dimensions.,
CO 4: Analyse the use and working principle of microfluidics devices and its integration in Lab-on-Chip devices.,
CO 5: Evaluate the concept of the microfluidics in realistic problems., and
CO 6: Design different microfluidic devices for bio-medical applications..

### COURSE DETAILS

**Introduction**
Origin, Definition, Benefits, Challenges, Commercial activities, Physics of miniaturization, Scaling laws.

**Micro-scale fluid mechanics**
Intermolecular forces, States of matter, Continuum assumption, Governing equations, Constitutive relations, Gas and liquid flows, Boundary conditions, Slip theory, Transition to turbulence, Low Re flows, Entrance effects, Exact solutions, Couette flow, Poiseuille flow, Stokes drag on a sphere, Time-dependent flows, Two-phase flows, Thermal transfer in micro-channels, Surface tension and interfacial energy, Young-Laplace equation, Contact angle, Capillary length and capillary rise, Interfacial boundary conditions, Marangoni effect.

**Electrokinetics**
Electro-hydrodynamics fundamentals, Electro-osmosis, Debye layer, Thin EDL limit, Ideal electroosmotic flow, Ideal EOF with back pressure, Cascade electroosmotic micro-pump, EOF of power-law fluids, Electro-capillary effects, Continuous electro-wetting, Direct electro-wetting, Electro-wetting on dielectric.

**Microfluidics components and sensors**
Micropumps, Check-valve pumps, Valve-less pumps, Peristaltic pumps, Rotary pumps, Centrifugal pumps, Ultrasonic pump, EHD pump, MHD pumps. Microvalves, Pneumatic valves, Thermo-pneumatic valves, Thermomechanical valves, Piezoelectric valves, Electrostatic valves, Electromagnetic valves, Capillary force valves, Microflow sensors, Differential pressure flow sensors, Drag force flow sensors, Lift force flow sensors, Coriolis flow sensors, Thermal flow sensors.

**Micromixer and micro reactor**
Micromixers, Physics of mixing, Pe-Re diagram of micromixers, Parallel lamination, Sequential lamination, Taylor-Aris dispersion, Droplet generators, Kinetics of a droplet, Dynamics of a droplet, In-channel dispensers, T-junction and Cross-junction, Droplet formation, breakup and transport, Microparticle separator, Principles of separation and sorting of microparticles, Design and applications, Microreactors, Design considerations, Liquid-phase reactors, PCR, Design consideration for PCR reactors.

**Bio-microfluidics**
Introduction to Bio-microfluidics, Selected applications, Drug delivery, Diagnostics, Bio-sensing.

**Textbook**

1. Tabeling, P. (2005). Introduction to microfluidics. Oxford University Press on Demand.

**Reference Books**

1. Nguyen, N. T., Wereley, S. T., & Shaegh, S. A. M. (2002). Fundamentals and Applications of Microfluidics (Norwood, MA: Artech House).
2. Colin, S. (Ed.). (2013). Microfluidics. John Wiley & Sons.

## THEORY OF ADVANCED HEAT AND MASS TRANSFER

**Course Code: ME40032**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: ME30003**

**COURSE OBJECTIVE**

1. To understand the basic principles of heat transfer
2. To explain the transport phenomena of a real engineering problem
3. To be able to design the heat transfer equipment used for engineering process
4. To be able to identify the different parameters effecting the physical process
5. To be able to develop experimental techniques and correlations to understand the real life engineering applications

6. To be able to know the heat transfer calculations relating to industry problems

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Identify the type of heat transfer associated with physical problems.,
CO 2: Distinguish between different types of heat transfer mechanisms.,
CO 3: Apply the theoretical and experimental correlations to different physical problems.,
CO 4: Analyze the solutions to the different heat transfer applications.,
CO 5: Evaluate the performance of different heat transfer applications., and
CO 6: Combine different governing equations of heat and mass transfer to solve the engineering application problems..

**COURSE DETAILS**

**Conduction**
Review of heat transfer modes, Heat conduction in anisotropic media, Heat conduction in porous media, Phase change problems, Moving heat source problems, Non- Fourier conduction problems.

**Convection**
Differential equation of heat convection, Laminar flow heat transfer in a circular pipe, Derivation of boundary layer equations by order of magnitude analysis, Solution of boundary layer equations by similarity variable and integral methods, Natural convection in boundary layers, Integral method, Rayleigh-Benard convection, Turbulent heat transfer.

**Radiation**
Equation of radiative transfer in participating media, Exact solution for one dimensional grey media, Approximate solution methods, Pn and Sn approximate methods, Zonal method, Monte Carlo method for thermal radiation, Experimental techniques on radiation heat transfer.

**Boiling and Condensation**
Types of boiling, Boiling curve, correlations, Flow boiling, condensation on a vertical plate, correlations of condensation.

**Mass Transfer**
Basic definitions, Fick‘s law of diffusion, Species conservation equation, Solution of one dimensional mass transfer problem, Diffusion in a moving medium, simultaneous heat and mass transfer.

**Textbooks**


1. Incropera, F. P., DeWitt (1998). Fundamentals of heat and mass transfer, New York: John Wiley & Sons.
2. Kreith, F., & Manglik, R. M. (2016). Principles of heat transfer. Cengage learning.


**Reference Books**

1. Cengel, Y.A. (2003). Heat and Mass Transfer, Tata McGraw Hill.
2. Ozisik, M. N. (1993). Heat Conduction, John Wiley and Sons.
3. Burmister, L.C. (1983). Convective Heat Transfer, John Willey and Sons.
4. Balaji, C. (2014). Essential of Radiation Heat Transfer, Wiley.
5. Eckert, E. R., & Drake Jr, R. M. (1987). Analysis of heat and mass transfer.
6. Convective Heat and Mass Transfer, W.M. Kays and W. Crawford, McGraw Hill Inc., 1993
7. Kays, W. M., & Crawford, M. E. (1993). Convective Heat and Mass Transfer, 3rd ed.; McGraw-Hill Inc.: New York, NY, USA.

## MECHANICS OF COMPOSITE MATERIALS

**Course Code: ME40033**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: ME21001**

### COURSE OBJECTIVE

1. To provide the students the analyzing tools.
2. To find the effective properties of a lamina.
3. To find its strength and to develop the stress strain relation.
4. To develop the analyzing skills for the orthotropic laminates.
5. To find the failure modes and environmental effect in designing the laminates.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Describe the basics of fibers, matrices and composites and their manufacturing processes.,
CO 2: Understand the general stress-strain relation for different materials.,
CO 3: Articulate different types of laminates, their failure modes.,
CO 4: Analyze macro-mechanical behaviour of laminates.,
CO 5: Evaluate the ultimate strengths of unidirectional lamina using micromechanics., and
CO 6: Predict the elastic modulii and various strengths of orthotropic lamina..

### COURSE DETAILS

**Introduction**
An overview of composites, Classification and characteristics of composite materials, Fibers, Matrices, Application and advantages of composites, Fabrication of composites.

**Macro-mechanical behavior of a lamina**
Stress-strain relation for anisotropic materials, Stiffness, Compliances and engineering constants for orthotropic materials, Stress-strain relation for plane stress in an orthotropic material, Strength of an orthotropic lamina, Expansion coefficients.

**Micro-mechanical behavior of a lamina**
Determination of elastic constants (E1, E2, μ12, G12), Longitudinal behavior of unidirectional composites, transverse stiffness and strength, Prediction of shear modulus,
Prediction of Poisson's ratio, Failure modes, Expansion coefficients.

**Analysis of laminated composites**
Laminate description system, Classical lamination theory, Lamina stress-strain behaviour,
Stress and strain variation in laminate, Resultant laminate forces and moments, Determination of laminate stresses and strains, Analysis of laminates after initial failure.

**Test Methods**
Measurement of physical properties, Measurement of mechanical properties, Flexural properties, Fracture toughness, Impact properties.

**Textbook**

1. Kaw, A. K. (2005). Mechanics of composite materials. CRC press.

**Reference Books**

1. Jones, R. M. (2018). Mechanics of composite materials. CRC press.
2. Daniel, I. M., Ishai, O., Daniel, I. M., & Daniel, I. (2006). Engineering mechanics of composite materials (Vol. 1994). New York: Oxford university press.

## NANO MATERIALS

**Course Code:** **ME40034**
**Credit:** **3**
**L-T-P:** **3-0-0**
**Prerequisite:** **PH10001 and ME20005**

**COURSE OBJECTIVE**

1. To Understand the influence of dimensionality of the object at nanoscale on their properties.
2. To Understand size and shape-controlled synthesis of nanomaterials and their future applications in industry.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Describe the terminology and basic concepts of nanomaterials and nanomanufacturing.,
CO 2: Understand the fundamental mechanism of unique properties of nanomaterials using structure-properties approach.,
CO 3: Apply the appropriate techniques for various nanomaterials synthesis and processing methods.,

CO 4: Correlate properties of nanostructures with their size, shape and surface characteristics,
CO 5: Frame the appropriate methods of nano materials fabrications, and
CO 6: Collaborate between the societal and technological issues that impede the adoption of nanotechnology..

**COURSE DETAILS**

**Introduction and Overview**
Introduction to nanomaterials, Bulk (metallic and non-Metallic) materials, Nanostructured materials, Thin film nanomaterials and nano-composites etc., Features of nano-systems, Characteristic length scales of materials and their Properties, Density of states in 1-D, 2-D and 3-D bands, Variation of density of states and band gap with size of crystal

**Theoretical Fundamentals**
Size and shape dependence of optical, electronic, photonic, mechanical, magnetic and catalytic properties, Deformation mechanism, Constitutive modelling of strength and strain hardening, Finite-element simulation of severe plastic-deformation (SPD) method, MD simulation of deformation mechanisms in nano crystalline materials,

**Fabrication and Processing**
Fabrication and Synthesis of Thin Film Nanomaterials
Chemical routes, Electrochemical methods, Vapor growth, Thin films methods, Chemical vapor deposition, Physical vapor deposition (sputtering, laser ablation), Langmuir-Blodgett Growth.

**Fabrication of Bulk Nanostructured Metals**
Equal channel angular pressing (ECAP), High-pressure torsion, Accumulative roll bonding (ARB), Friction stir processing (FSP), Ball milling and consolidation, Fabrication from amorphous Solids, Continuous severe plastic deformation (SPD) technique and post-SPD Processing.

**Fabrication of Nano-Composites**
Nanocomposite fabrication via melt-mixing techniques, Electrospinning and selective laser sintering, Nanolithography etc.

**Properties and Performances**
Mechanical and structural properties of nanomaterials, Performances of nanomaterials, Super-plasticity, Fatigue, Fracture, Crack growth and creep behaviours, Diffusion etc.

**Testing and Characterization**
Transmission Electron Microscopy (TEM) Analysis
Lattice defects, Structural morphology, Boundary spacing, Boundary disorientation, Interior dislocation density, Local texture analysis.
Scanning Electron Microscopy (SEM) Analysis
Electron back-scattered diffraction (EBSD) test for texture evaluation and grain refinement.
X-Ray Line-profile Analysis
Interpretation of crystallite size, Dislocation structure, Strain anisotropy, Determination of vacancies, Stacking faults and twinning etc.

**Applications and Commercialization**

Applications in Nano-electronics, Nano optics, Biological/bio-medical applications, Solar cells, Photovoltaic, fuel cells, batteries and energy-related applications, Various usages in current scenario, Commercialization, Impact on metal industries, Competition from other materials, Appropriability to capture profit and market drivers, Maturity for process design paradigm, The need for complementary assets.

**Textbooks**

1. Zehetbauer, M. J. and Zhu, Y. T. (2009). Bulk Nanostructured Materials. John Wiley & Sons.
2. Owens, F. J. and Poole, C. P. (2008). The Physics and Chemistry of Nano Solids by Wiley-Interscience.

**Reference Books**

1. Edelstein, A. S., & Cammaratra, R. C. (Eds.). (1998). Nanomaterials: synthesis, properties and applications. CRC press.
2. Ozin, G. A., & Arsenault, A. (2015). Nanochemistry: a chemical approach to nanomaterials. Royal Society of Chemistry.
3. Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience, Edward L. Wolf, Wiley-VCH, 2 nd Reprint (2005).
4. Somer Jr, F. L. (2005). Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience (Wolf, Edward L.).

## MATERIAL CHARACTERIZATION AND METHODS

**Course Code: ME40035**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Materials Science and Engineering (ME20005)**

**COURSE OBJECTIVE**

Material Characterization and Methods course provides a detailed understanding of important techniques used for characterization of materials for industrial application as well as research and development environment. The established and new techniques of material characterization and analysis are discussed. Emphasis is given on applications and working principles, operating procedure of each technique in order to develop better understanding of the characterization method.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Identify various material characterization methods and instruments.,
CO 2: Understand different characterization techniques and basic principles of various characterization instruments.,
CO 3: Apply material characterization techniques to understand the structure and properties of materials.,

CO 4: Analyze the properties of materials through different characterization methods.,
CO 5: Evaluate various characterization techniques used for data collection and property evaluation., and
CO 6: Design the thermo-mechanical processing route to modify the properties of the materials..

**COURSE DETAILS**

**Mechanical Characterization**
Destructive Testing: Tensile Test, Compressive test, Bending test, Hardness test, Impact test, and other Mechanical testing methods.

**Non-destructive testing**
Ultrasonic testing, Dye penetration testing, Magnetic testing, Acoustic testing, X-ray testing, and Radiographic testing.

**X-Ray methods**
X-ray diffraction (XRD) analysis, Introduction to x-rays, Filters, Atomic scattering factors and structure factor, Intensity calculations, Reciprocal lattice, Ewald sphere construction, X-ray diffraction, Experimental techniques and analysis of materials through x-ray scattering techniques: Powder method, Laue method, Crystal structure determination, Phase identification, Residual stress measurement, and other applications, X-ray spectroscopy, Energy dispersive X-ray spectrometry(EDS), and Wavelength dispersive X-ray spectrometry(WDS).

**Electron Microscopy**
Optical microscopy, Microscope components, Types of microscope, Bright field, Dark field, Electron microscopy, Electron-specimen interactions, Principles of scanning electron microscopy(SEM), Depth of field, Depth of focus, Crystallographic information in a SEM, Electron back scattered diffraction, Transmission Kikuchi diffraction, Transmission electron Microscopy (TEM): Construction and operation of a TEM, Electron diffraction, Image interpretation, and Atomic Force Microscope(AFM).

**Spectroscopic characterization**
Theoretical back ground, Interpretation of vibrational spectra, UV-Visible spectroscopy, Raman spectroscopy, and Fourier Transform Infrared Spectroscopy (FTIR).

**Thermo-Mechanical Characterization**
Differential Thermal Analyzer(DTA), DSC (Differential Scanning Calorimetry), Thermo gravimetric analyser (TGA), dilatometry, Thermo-mechanical Analysis (TMA), Dynamic light scattering (DLS) and Zeta potential analyzer, Porosimetry, Creep, Fatigue, Gleeble, and Case studies.

**Reference Books**

1. Mitra, P.K. (2014). Characterization of Materials. PHI.
2. Leng, Y. (2009). Materials characterization: introduction to microscopic and spectroscopic methods. John Wiley & Sons.
3. Goodhew, P. J., & Humphreys, J. (2000). Electron microscopy and analysis. CRC press.
4. Cullity, B. D. (2014). Elements of X-ray Diffraction. Pearson Education India.
5. Jenkins, R., & Snyder, R. L. (1996). Introduction to X-ray Powder Diffractometry (Volume 138). NY, John Wiley & Sons.
6. Wendlandt, W. W. (1986). Thermal Analysis. 3rd edition, Wiley NY.
7. Prakash, R. (2021). Non-Destructive Testing Techniques. New Age International Private Limited.

8. Callister Jr, W. D., & Rethwisch, D. G. (2020). Callister's materials science and engineering. John Wiley & Sons.

## THEORY OF ELASTICITY AND PLASTICITY

**Course Code: ME40036**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Mechanics of Solids (ME21001)**

### COURSE OBJECTIVE

Theory of elasticity and plasticity is a specialized need-based extension of mechanics of solids. The objective of this course is to build a strong knowledge of the students which is required for understanding and predicting the behaviour of materials in elastic and plastic region of their stress strain curve. In particular, the course will cover the Airy's stress function approach to 2-D problems of elasticity, solution of axi-symmetric problems, stress concentration due to the presence of a circular hole in planes and elementary problems of elasticity in three dimensions. Further it will cover the hardening of materials, flow and hardening rule followed by the plastic stress strain relations for both isotropic and anisotropic ductile materials.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Describe the elastic and plastic behavior of material in different loading conditions,
CO 2: Understand Airy's stress function and its application in 2-D problems of elasticity,
CO 3: Apply the compatibility equations and boundary conditions for 2-D and 3-D cases,
CO 4: Analyze the plastic behaviour of materials using various analysis methods,
CO 5: Evaluate stress and strain state at a point and its components in Cartesian and Polar co-ordinates, and
CO 6: Develop different methods for hardening of the materials using flow rule and hardening rule..

### COURSE DETAILS

**Elasticity-I**
Introduction, Definition of stress and strain at a point, Components of stress and strain at a point in Cartesian and polar co-ordinates, Constitutive relations, Equilibrium equations, Compatibility equations and boundary conditions in 2-D and 3-D cases. Plain stress and plain strain: Airy's stress function approach to 2-D problems of elasticity, Solution of axi-symmetric problems, and Stress concentration due to the presence of a circular hole in planes.
**Elasticity-II**
Elementary problems of elasticity in three dimensions, Stretching of a prismatical bar by its own weight, Twist of circular shafts, and Torsion of non-circular sections.

**Plasticity-I**

Introduction to plasticity: One-dimensional elastic-plastic relations, Isotropic and kinematic hardening, Yield function, Flow rule, and Hardening rule.

**Plasticity-II**

Incremental stress-strain relationship, Governing equations of elasto-plasticity. Plastic stress-strain relations, Slab method, Slip line methods, and Load bonding methods.

**Textbooks**

1. Timoshenko and Goodier (1983), Theory of Elasticity (3rd Edition), McGraw Hill Book Company.
2. Lal G. K., Reddy N. Venkata (2009), Introduction to Engineering Plasticity, Narosa Publishing House.

**Reference Books**

1. Johnson W. and Mellor P. B. (1962), Plasticity for Mechanical Engineers, D.Van Nostrand Co. Ltd.
2. Chakrabarty J. (2007), Theory of Plasticity (3rd Edition), McGraw-Hill.
3. Haffman Oscar and Sachs George, Introduction to the Theory of Plasticity for Engineers, McGraw Hill Co.
4. Kachanov M., Theory of Plasticity, Mir publishers, Moscow.

## MANUFACTURING PROCESSES

**Course Code: MH20003**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite(s): NIL**

**COURSE OBJECTIVE**

The main objective of this course is to emphasize the importance of manufacturing sciences in the day-to-day life. To understand the concepts of basic mechanics of metal cutting and the factors affecting the machinability. To study and learn the basics of machine tools, concepts of CNC and Constructional features of CNC, CNC programming concepts to develop the part programme for Machine centre and turning centre

**COURSE OUTCOMES**

Upon completion of the course, the students will be able to:

CO 1: State the importance of the geometry of cutting tools in machining.
CO 2: Recognize the distinctions between orthogonal and oblique cutting. Also, understand the mechanics of chip formation for ductile and brittle materials.
CO 3: Analyse the mechanism of metal removal and identify the factors involved in improving machinability.
CO 4: Describe the construction and operation of centre lathes and other specialized machines

CO 5: Understand and apply CNC machine tool construction and working principles.

CO 6: Demonstrate CNC programming by planning, writing codes, and setting up machines to manufacture for a given component.

**COURSE DETAILS**

**Geometry of cutting tools**

Introduction: Machining in manufacturing, Orthogonal and oblique cutting, Types of cutting tools, Tool materials, General configuration of cutting edges of tools, concept of rake and clearance angles, Description of tool geometry: Tool-in-hand system, ASA, ORS, NRS Systems, Geometry of multiple-point cutting tools, and Conversion of tool angles.

**Mechanics of metal cutting**

Mechanics of chip formation in machining ductile and brittle materials, Forces in machining, Types of chips, Thermal aspects, Cutting tool materials, Tool wear, Tool life, Surface finish, Cutting fluids and Machinability, Definitions, Factors affecting machinability, Cutting Force: Purposes of determination of cutting forces, and Force system during turning and their significances**.**

**Turning machines**

Centre lathe, Constructional features, Specification, Operations: Taper turning methods, Thread cutting methods, Special attachments, Surface roughness in turning, Machining time and power estimation, Tool layout, Special lathes: Capstan and turret lathes, Automatic lathes, Semi-automatic, Single spindle: Swiss type, and Automatic screw type and multi spindle.

**CNC machines**

Computer Numerical Control (CNC) machine tools, Constructional details, Special features: Drives, Recirculating ball screws and tool changers, CNC Control systems: Open/closed, Point-to-point/Continuous, Turning and machining centres: Work holding methods in turning and machining centres, Coolant systems, Safety features.

**Programming of CNC machine tools**

Coordinates, Axis and motion, Absolute Vs Incremental, Interpolators, Polar coordinates, Program planning, G and M codes, Manual part programming for CNC machining centers and Turning centers: Fixed cycles and Macros, Loops and subroutines, Setting up a CNC machine for machining.

**Textbooks**


1. Chattopadhyay, A. B. Machining and Machine Tools, Wiley-India Pub (2nd edition).
2. Fitzpatrick, M. (2013). Machining and CNC Technology, McGraw-Hill Education, 3rd edition.


**Reference books**


1. Bhattacharyya, A., & Sen J. K. (1984). Metal Cutting Theory and Practice of Central Book Pub.
2. Juneja, B.L., Sekhon, G.S., & Seth, Nitin. (2005). Fundamentals of Metal Cutting and Machine Tools. New Age International Pub.
3. Shaw, M. C. (2002). Metal Cutting Principles, Oxford Pub.
4. Smid, Peter. (2007). CNC Programming Handbook, Industrial Press Inc, 3rd edition.

## THERMOFLUIDS

**Course Code: MH21001**
**Credit: 4**
**L-T-P: 4-0-0**
**Prerequisite(s): Nil**

### COURSE OBJECTIVE

This course covers the basic understanding of the streams in thermal and fluid science. After completion of this course, the students will be able to decide the feasibility of any process from thermodynamic points of view. Basis of power production in different ways like steam power cycle and internal combustion engine and fluid power systems are covered. Fluids are used in all types of engineering equipment, and understanding of fluid properties, fluid machines and head loss in flow, will help the students to maximize the efficiency of these equipment.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Recall different parameters related to thermo-physical properties like temperature, pressure, flow, velocity etc.
CO 2: Explain working principle of different thermo-fluid engineering equipment such as heat engine, refrigerator, turbine and pump etc.
CO 3: Illustrate the ways of improving performance of different engineering systems.
CO 4: Analyze the effect of different properties variation on the performance of fluid machines like turbines and pumps.
CO 5: Assemble different components related to refrigeration systems and work producing engines/turbines.
CO 6: Evaluate the performance of engineering equipment under varied temperature, pressure and fluids.

### COURSE DETAILS

**Introduction**
Introductory Concepts of Thermodynamics, Fluid Mechanics, Importance and Applications of Thermodynamics and Fluid Mechanics in Electronic Product Design, Thermal/Fluid Sciences and the Environment.

**Basics thermodynamics**
Temperature and the Zeroth Law of Thermodynamics, The First Law of Thermodynamics, second law of thermodynamics: Entropy, Work done, Heat added and entropy changes in simple processes, Relationship between CP, CV, R and J, Constant Pressure, Constant Volume, Isothermal and adiabatic process.

**Gas power systems**

The Internal Combustion Engine, The Air Standard Otto Cycle, Design Example, The Air Standard Diesel Cycle, Air standard efficiency of Dual combustion cycle, The Gas Turbine, Simple open and closed cycles.

**Vapor power systems**

Constant pressure formation of steam, Enthalpy and specific volume of dry, Wet and super-heated steam. Use of Mollier chart, The Ideal Rankine Cycle, The Effect of irreversibility, The Rankine Cycle with Superheat and Reheat, The Ideal Rankine Cycle with Regeneration, The Ideal Vapor Compression Refrigeration Cycle and its representation in TS and PH Chart

**Fluid statics**

Physical properties of fluids, Types of fluid, Hydrostatic Law, Measurement of pressure by manometers. Total pressure and center of pressure on horizontal, Vertical and inclined surfaces submerged in liquid, Centre of buoyancy, Meta center & meta-centric height and its determination, Stability of floating and submerged bodies, Oscillation of a floating body.

**Fluid power systems**

Frictional loss in Pipes, Fully developed flow, Friction factors for fully developed flow, Friction factor and head loss determination for pipe flow, The principles of centrifugal pump, The net positive suction head, Combining pump and system performance, Axial and mixed flow pumps, Turbines.

**Textbook**

1. Kraus, Allan D., Welty, James R., Aziz, Abdul. (2019). Introduction to Thermal and Fluid Engineering, CRC Press.

**Reference books**

1. Kaminski, D. A., Jensen, M. K. (2017). Introduction to Thermal and Fluids Engineering, Wiley.
2. Chattopadhyay, Parthasarthi. Engineering Thermodynamics, 1st Ed., Oxford Univ. Press.
3. Khurmi, R.S., Gupta, J.K. A Textbook of Thermal Engineering (SI Units), 15th Ed., S. Chand.
4. Bansal, R.K. A Textbook of Fluid Mechanics and Hydraulic Machines, 9th Ed., Laxmi Publ.
5. Cengel, Y.A., Cimbala, J.N. Fluid mechanics Fundamentals and Applications, 3rd Ed., Tata McGraw Hill Education P. Ltd.

## DESIGN OF MECHATRONIC SYSTEMS

**Course Code: MH30002**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite(s): EC21001, EE29007**

**COURSE OBJECTIVE**

The course emphasizes on the advanced mechatronics deign approaches, system modelling, General Purpose I/O Card and Its Installation, Data Conversion Process, components and design of mechatronics system such as Fuzzy Based Washing Machine, Engine Management System etc. At the end of this course, students will be able to learn and understand the mechatronic system, use of system models in mechatronics, application and design of micro- mechatronics devices and aspects of data acquisition system. Students will get the practical knowledge of Application Software- Lab View Environment and Its Applications, Vim-Sim Environment & Its Applications -Man Machine Interface.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to:

CO 1: Describe the mechatronic systems design and their structure, ergonomic and safety,
CO 2: Understand the use of system models in mechatronic system,
CO 3: Apply the knowledge to design mechatronics products,
CO 4: Analyse theoretical and practical aspects of computer interfacing and real time data acquisition and control,
CO 5: Evaluate the real time interfacing, and
CO 6: Design and implement the micro mechatronic system.

**COURSE CONTENTS**

**Introduction to Mechatronics System**
Key elements, Mechatronics design Process, Design parameters, Traditional and mechatronics Designs, Advanced approaches in mechatronics, Industrial design and ergonomics, and Safety.

**System Modelling**
Introduction, Model categories, Fields of application, Model development, Model verification, Model validation-Model, Simulation & design of mixed systems, Electro mechanics, Design-model Transformation, Domain-independent description forms, and Simulator coupling.

**Real Time Interfacing**
Introduction, Selection of Interfacing Standards, Elements of Data Acquisition & Control Systems, Over View of I/O Process, General Purpose I/O Card and Its Installation, Data Conversion Process, Application Software-Lab View, Environment and Its Applications, Vim-Sim Environment & Its Applications, and Man Machine Interface.

**Case Studies on Mechatronic System**
Introduction –Fuzzy Based Washing Machine – pH Control System – Autofocus Camera, Exposure Control– Motion Control Using D.C. Motor & Solenoids – Engine Management Systems. – Controlling Temperature of a Hot/Cold Reservoir Using PID- Control of Pick and Place Robot – Part Identification and Tracking Using RFID, and Online Surface Measurement Using Image Processing.

**Micro Mechatronic System**
Introduction, System Principle , Component Design , System Design , Scaling Laws , Micro Actuation, Micro Robot , Micro Pump, and Applications of Micro Mechatronic Components.

## Textbooks


1. Shetty, Devdas., Richard A. Kolk. (2011). Mechatronics System Design, (2nd Edition), Cengage Learning.
2. Pelz, Georg. (2003). Mechatronic Systems Modeling and simulation with HDL's, John Wiley and sons Ltd.


## Reference books


1. Bishop, Robert H. (2002). Mechatronics Hand book, CRC Press.
2. Bradley, D. Dawson., Burd, N.C., Loader, A.J. (2010). Mechatronics Electronics in Products and Processes, CRC Press 1991, First Indian print.
3. Silva, DE. (2013). Mechatronics a Foundation Course, Taylor & Francis, Indian Reprint.


# INDUSTRIAL AUTOMATION AND ROBOTICS

**Course Code: MH30004**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite(s): ME21002**

## COURSE OBJECTIVE

This course aims to provide students with a comprehensive understanding of industrial automation and control, understand the role of automation in improving productivity, quality, and safety in industrial processes, covering topics such as sensors, measurement systems, hydraulics, pneumatics, industrial control systems, industrial robots and their applications, automation system design, advanced automation technologies, and practical project experience.

## COURSE OUTCOMES

After successfully completing the course, the students will be able to:

CO 1: Understand the industrial automation with computer controlled machines, measurement systems and industrial robots.
CO 2: Design and apply pneumatics and hydraulic circuit using computer for automated factory.
CO 3: Identify and Design PLC programs, implement PID using electronic, digital, pneumatic and hydraulic methods to solve industrial control problems.
CO 4: Select the best robotics applications and be able to justify the overall advantages to industry
CO 5: Understand the principles of application of AGV, ASRS in automated industries.

CO 6: Apply modern computational, analytical, simulation tools and techniques in manufacturing

**COURSE CONTENTS**

**Introduction**

Introduction to industrial automation and control, Automations, Basic laws and principles, Level of automation Introductions to sensors and measurement systems, Pressure measurement, Temperature measurement, Velocity measurement, Force and torque measurements, and Response of measuring systems.

**Laws and principles of hydraulics and pneumatics**

Components of basic pneumatic and hydraulic systems, Characteristics and properties pumps and compressors used in industry, Pneumatic and hydraulic accessories like filters, lubricators, air dryers, pipelines, connectors, Pneumatic and Hydraulic actuators and their classifications, Proportional and servo Valves, Construction and working of various pneumatics and hydraulics valves, and Pneumatic and hydraulic circuits.

**Industrial Control systems**

Continuous and discrete control, Control requirements, Programmable Logic Controllers (PLCs), Sensors and Actuators. Introduction to process control, PID control, Implementation of PID controllers, Logic circuits: Pneumatic logic circuits, and Electric and electronic controls used in automation.

**Industrial Robotics**

Industrial robot applications, Robotic grippers, Sensors in robotics. Robot programming, Robot application in machining, Welding and assembly, and Hostile and remote environment.

**Automation in material handling and storage system**

Automated guided vehicle systems (AGV), Monorails and other rail guided vehicles, Conveyor systems, Automated storage systems, and Engineering analysis of storage system.

**Textbooks**

1. Gupta, A. K., Arora, S. K. (2009). Industrial Automation and Robotics, Lakshmi Publication, New Delhi, ISBN 8131805921.
2. Mahalik, N.P. (2003), Mechatronics Principles, Concepts and Application, TMH, ISBN-0-07-048374-4.

**Reference books**

1. Groover, Mikell P. (2007). Automation, Production Systems, and Computer-Integrated Manufacturing, Pearson Education, (3rd Edition) ISBN 81-7808-511-9..
2. Sharma, K. L. S. Overview of Industrial Process Automation (1st Edition), Elsevier, ISBN-978-012-415779-8.

3. Groover, Mikell P. (2001). Industrial Robotics-Technology, Programming and Applications, McGraw Hill.

## IoT AND SMART MANUFACTURING

**Course code:** **MH30011**
**Credit:** **3**
**L-T-P:** **3-0-0**
**Prerequisite:** **Nil**

### COURSE OBJECTIVE

Internet of Things (IoT) and Smart Manufacturing encompassing practically all branch of fundamental Engineering-Mechanical, Electronics, Middleware, Analytics, Cloud, Mobile and Firmware. This course is presented to cover all of these critical aspects of IoT Engineering and manufacturing, which includes predictive and preventative maintenance, condition-based monitoring of the machines, production optimization, energy optimization, supply-chain optimization and uptime of manufacturing utilities etc. Through the course, students will be able to integrate internet of things (IOT) and manufacturing through extensive and systematic research.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to:

CO 1: Describe the requirements of IOT and apply on the relevant domain.
CO 2: Understand the concepts and contribute on digital transformation.
CO 3: Apply various IoT enabled techniques for manufacturing processes.
CO 4: Articulate the technology behind industry 4.0 manufacturing.
CO 5: Evaluate the concept of adopting and implementing a smart factory solution.
CO 6: Develop the opportunities for automating operations and use of data analytics.

### COURSE DETAILS

**Introduction**
Concept of Internet of Things (IoT), common definitions, IoT applications, and functional view. Internet of Things and Internet Technology

**Design Principles for Connected Devices**
Calm and Ambient Technology, Magic as Metaphor, Privacy, Web Thinking for Connected Devices, and Affordances.

**Internet Principles**
Internet Communications: An Overview (IP, TCP, The IP Protocol Suite (TCP/IP), UDP), IP Addresses (DNS, Static IP Address Assignment, Dynamic IP Address Assignment, IPv6), MAC Addresses, TCP and UDP Ports, and Application Layer Protocols

**IoT Enabled Manufacturing System**

Architecture of IoT- Manufacturing System, Integration framework of Real-time manufacturing information, Work logic of IoT- Manufacturing System, Cloud based Manufacturing Resource configuration, Concept of cloud manufacturing, Real-time production information perception and capturing, Cloud service selection, Cloud Machine model.

**Smart Factory and Smart Manufacturing**

Concepts of Industry 4.0 standard, Real-time information-based scheduling, capacity planning, material planning, Real-time production monitoring techniques with smart sensors, Configuration of smart shop floor, traceability and call back of defective products

**Textbook**

1. Zhang, Yingfeng., Tao, Fei. (2016). Optimization of Manufacturing Systems using the Internet of Things, Academic Press- Technology & Engineering.

**Reference books**

1. Wan, Jiafu., Humar, Iztok., Zhang, Daqiang. (2016). Industrial IoT Technologies and Applications, Springer.
2. Wang, Y, K., Wang, J.O., Strandhagen, T. Yu. (2016). Advanced Manufacturing and Automation V, WIT Press.
3. Vermesan, Ovidiu., Friess, peter. (2014). Internet of Things – From Research and Innovation to Market Deployment, River Publishers.

## PRODUCT DESIGN AND DEVELOPMENT

**Course code: MH30013**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

Product design and development (PDD) is an interdisciplinary activity that requires significant cross-disciplinary participation. The course is governed by design thinking and facilitates manpower development for greater coordination of design, manufacturing, and marketing decisions. The course aims to strike a balance between theory and practice by focusing on design-for-X methods. Thus, students get exposure to concurrent engineering practices right from the conceptual stages of product development. The students will be exposed to the use of technology to create concept drawings and designs. They will be urged to give shape to their imagination within the bounds set by the product development software. They will be able to appreciate the use of technology that prevents downstream failures.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to:

CO 1: Identify the product design and development processes in the manufacturing industry.
CO 2: Use the concepts of process planning and its activities,
CO 3: Apply a methodical approach towards management of product development to satisfy customer needs,
CO 4: Analyze, evaluate, and apply the methodologies for product design, development, and management,
CO 5: Evaluate the cost and benefit analysis through various cost models, and
CO 5: Implement the use of computer-aided technology to develop superior product.

**COURSE DETAILS**

**Introduction**
**Fundamentals of Product Development**
Trend analysis, competitive landscape, PESTLE Analysis, Overview of Products and services, Types of Product development, Overview of Product development methodologies, Product development Planning and Management.

**Generic Product Development Process**
Identifying customer needs –voice of customer –customer populations- hierarchy of human needs-need gathering methods – affinity diagrams – needs importance- establishing engineering characteristics-competitive benchmarking- quality function deployment- house of quality- product design specification-case studies, concept development stages, system level design, Detail design, Testing and refinement Production ramp up.

**Concept Generation and Selection**
Task, Structured, approaches clarification, search, externally and internally, explore systematically, reflect on the solutions and processes, concept selection, methodology, and benefits.

**Product Architecture**
Implications, Product change, variety, component standardization, product performance, manufacturability, product development management, establishing the architecture, creation, clustering, geometric layout development, fundamental and incidental interactions, related system level design issues, secondary systems, architecture of the chunks, and creating detailed interface specifications.

**Industrial Design**
Integrate process design, managing costs, Robust design, Integrating CAE, CAD, CAM tools, simulating product performance and manufacturing processes electronically, need for industrial design, impact,

design process, investigation of for industrial design, impact, design process, investigation of customer needs, conceptualization, refinement, management of the industrial design process, technology driven products, user, driven products, and assessing the quality of industrial design.

**Design for Manufacturing and Product Development**
Definition, Estimation of Manufacturing cost, reducing the component costs and assembly costs, minimize system complexity, Prototype basics, principles of prototyping, planning for prototypes, Economic Analysis, Understanding and representing tasks, baseline project planning, accelerating the project, and project execution.

**Textbook**


1. Ulrich, Kari. T., Eppinger, Steven. D. (1999). Product Design and Development, McGraw-Hill International Edn.


**Reference books**


1. Crow, Kemnneth. Concurrent Engg. /Integrated Product Development”, DRM Associates, 26/3, Via Olivera, Palos Verdes, CA 90274(310) 377-569, Workshop Book.
2. Rosenthal, Stephen. (1992). Effective Product Design and Development, Business One Orwin, Homewood, ISBN 1-55623-603-4.
3. Pugh, Staurt. Tool Design – Integrated Methods for Successful Product Engineering, Addison Wesley Publishing, New York, NY.


## MICRO AND NANO MANUFACTURING SYSTEMS

**Course Code: MH30014**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite(s): Nil**

### COURSE OBJECTIVE

Micro and Nano Manufacturing Systems course encompassing various methods used in micro and nano manufacturing. This course is presented to cover all of these critical aspects including in-depth idea of the conventional and non-conventional micro-nano manufacturing techniques basics. Through the course, students will be able to find best methods to fabricate and design, test, and implement various micro and Nano system through extensive and systematic research.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Describe the manufacturing considerations at the micro and nano scale,
CO 2: Understand the definition of nanotechnology and increase in nanotechnology awareness,
CO 3: Apply design-and-analysis methods and tools used for micro and nano manufacturing,
CO 4: Analyze the processing and applications of nanoparticles and nanomaterials,

CO 5: Evaluate select industrially-viable processes, equipment and manufacturing tools for specific industrial products, and

CO 6: Develop the application of computers in the area of nano design.

**COURSE DETAILS**

**Introduction**

Working principles and process parameters, Machine tools, Applications of the micro manufacturing processes, Challenges in meso, Micro, and nano manufacturing, Industrial applications, and Future scope of micro-manufacturing processes.

**Microfabrication**

Mechanical micromachining, Physical fabrication methods, Lithography, Processing setup, Nano Lithography & manipulation, Precision micro and Nano grinding, Use of spectrometers & microscopes Laser based micro and nanofabrication pulsed water drop micromachining, Nano materials, Synthesis of Nano materials, Bio materials, Nano composites, and Development of Nano particles.

**Nano Technology**

Nano technology concepts and applications micro and nanofabrication, Nano technology in India scope for microfabrication, and Rise Nano technology fields commercialization issues of Micro-Nano technology.

**Innovative Applications on Present Devices**

Nanochips, Nanotubes and Nanowires, Integration of chips and microprocessors, Technology Support, and Meeting Social Needs.

**Nano Design & CAD**

Computer Aided Nano Design, VLSI product detailing Finite Element Analysis of Microstructures,and 3-D Molecular Modelling.

**Acceptability of Nano Workmanship**

Nano to millimeter Integration Atomic Scale Precision & Control, and Promising Nano-centered Future.

**Textbooks**


1. Hsu, T. R. (2002). *MEMS and Microsystems Design and Manufacture*. New Delhi: Tata-McGraw Hill.
2. Franssila, S. (2004). *Introduction to Micro fabrication.* John Wiley & sons Ltd. ISBN: 470-85106-6.
3. Fahrner, W.R. (2011). *Nanotechnology and Nano electronics*. Springer (India) Private Ltd.
4. Taniguchi, N. (2003). *Nano Technology*. New York: Oxford University Press.


**Reference books**


1. Jackson, M. J. Microfabrication & Nonmanufacturing ASM handbook on machining.
2. Mohamed, G. (2006). MEMS Handbook. CRC press. ISBN: 8493-9138-5.
3. Madou, Mark. (1997). Fundamentals of Microfabrication. New York: CRC Press, New York.

## MICRO-ELECTRO-MECHANICAL SYSTEMS

**Course Code: MH30015**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

### COURSE OBJECTIVE

The objective of this course is to make students to gain basic knowledge on overview of MEMS (Micro electro Mechanical System) and various fabrication techniques. This enables them to design, analysis, fabrication and testing the MEMS based components. And to introduce the student's various opportunities in the emerging field of MEMS.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Describe the basic concepts of micro electromechanical systems,
CO 2: Understand the tools and processes used in micromachining of MEMS.
CO 3: Apply the concepts of working of micro-sensors and actuators, to enable selection, design and configuration of Micro-sensors and actuators,
CO 4: Analyze the knowledge about nanomaterials and various nano measurements techniques,
CO 5: Evaluate microsystems technology for technical feasibility as well as practicality, and
CO 6: Choose appropriate material for any microsystem and packaging method for any microsystem.

### COURSE DETAILS

**Introduction to Microsystems**
Overview of microelectronics manufacture and Microsystems technology. Definition- MEMS materials. Laws of scaling. The multi-disciplinary nature of MEMS. Survey of materials central to micro engineering, and applications of MEMS in various industries.

**Micro Sensors & Actuators**
Working principle of Microsystems, Micro actuation techniques, Micro sensors types, Micro actuators types: Micro pump, Micro motors, Micro valves, Micro grippers, and Micro accelerometers.

**Basic characteristics of feedback control systems**
Stability, Steady-state accuracy, Transient accuracy, Disturbance rejection, Insensitivity and robustness. Basic modes of feedback control: Proportional, Integral and derivative. Feed-forward and multi-loop control configurations, Stability concept, Relative stability, Routh stability criterion. Time response of

second-order systems, Steady-state errors and error constants. Performance specifications in time-domain. Root locus method of design. Lead and lag compensation.

**Fabrication Process**

Substrates-single crystal silicon wafer Formation-Photolithography-Ion Implantation-Diffusion Oxidation, CVD-Physical Vapor Deposition-Deposition by epitaxy-etching process.

**Microfabrication techniques**

LIGA and other moulding techniques- soft lithography and polymer processing- Thick-film processing, Low temperature co-fired ceramic processing- Smart material processing.

**Microsystems Design and Packaging**

Design considerations, Mechanical Design, Process design, Realization of MEMS components using intellisuite. Micro system packaging, Packing Technologies, Assembly of Microsystems, Reliability in MEMS. What ‘s next- MEMS, Micro factories and nanotechnology.

**Textbooks**


1. Mohamed Gad el Hak. (2002). MEMS Handbook, CRC Press.
2. Choudhury, P. Rai. (2009). MEMS and MOEMS Technology and Applications, PHI Learning Private Limited.
3. Solomon, Sabrie. (1998). Sensors Handbook, McGraw Hill.
4. Madou, Marc F. (2002). Fundamentals of Micro Fabrication, CRC Press, 2nd Edition.


**Reference books**


1. Francis, E.H., Tay and Choong, W.O. (1997). Micro fluidics and Bio mems application, IEEE Press. New York.
2. Trimmer William, S. (1997). Micromechanics and MEMS, IEEE Press New York.


## SMART MANUFACTURING WITH DIGITAL TWIN

**Course Code: MH30016**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

The course aims to equip students with a comprehensive understanding of smart manufacturing principles and digital twin technology, along with the skills and knowledge to implement and leverage these concepts in real-world manufacturing scenarios.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to:

CO 1: Describe the fundamentals of digital twin technology,
CO 2: Understand the digital twin technology in shop floor environments creating virtual models that mirror the physical systems,
CO 3: Analyze the application of digital twin in process industries to simulate, monitor and optimize complex processes,
CO 4: Analyze the integration of digital twin with cyber-physical systems,
CO 5: Assess the role of the Internet of Things (IoT) in digital twin applications, and
CO 6: Design and develop digital twin solutions for real-world scenarios

**COURSE DETAILS**

**Introduction**
Digital twin – Theoretical definition of digital twin, Types of Industry and its key requirements, Importance, Application of digital twin in process, product, Service industries, History of digital twin, DTT role in industry innovation, Technologies/tools enabling digital twin

**Application of Digital Twin**
Digital twin in product lifecycle, Digital twin in industrial applications, Future market for digital twin, Challenges of digital twin applications

**Digital Twin Shop Floor**
Evolution path of shop-floor, Related works, Concept of digital twin shop-floor, Implementation of digital twin shop-floor, Characteristics of digital twin shop-floor, Key technologies for digital twin shop-floor, Challenges for digital twin shop-floor

**Digital Twin in a Process Industry**
Basics of Process Industry, Trends in the process industry, Control system requirements in a process industry, Digital Twin of a plant, Digital Thread in process Industry, Data collection and analysis for process improvements, process safety, Automation simulation, Digital Enterprise

**Digital Twin, Cyber–Physical System, and Internet of Things**
Introduction, CPS in Manufacturing, IoT in Manufacturing, Digital Twin and CPS, IoT in Digital Twin-Based CPS, IoT in Manufacturing, Brief History and Concept of IoT, Applications of IoT Toward Smart Manufacturing, IoT in Digital Twin-Based CPS.

**Advantages of Digital Twin**
Improvement in product quality, Production process, Process Safety, Identify bottlenecks and improve efficiency, Achieve flexibility in production, Continuous prediction and tuning of production process through Simulation, Reducing the time to market.

**Textbooks**

1. Yeh Chris Nee, Andrew., Tao, Fei., and Zhang, Meng. (2019). Digital Twin Driven Smart Manufacturing, Elsevier Science., United States.
2. Ustundag, Alp., and Cevikcan, Emre. (2018). Industry 4.0: Managing The Digital Transformation, Springer Series in Advanced Manufacturing., Switzerland.

**Reference books**

1. Elangovan, Uthayan. (2022). Industry 5.0: The Future of the Industrial Economy, CRC Press.
2. Gilchrist, Alasdair, (2015). Industry 4.0: The Industrial Internet of Things, United States.
3. Bartodziej, Christoph Jan. (2017). The Concept Industry 4.0 an Empirical Analysis of Technologies and Applications in Production Logistics, Springer Gambler., Germany.
4. Garbie, Ibrahim. (2016). Sustainability in Manufacturing Enterprises, Concepts, analyses and assessments for Industry 4.0, Springer, Switzerland.
5. Yager, Ronald R. and Espada, Jordan Pascual. (2018). New Advances in the Internet of Things, Springer, Switzerland

## MODELING AND SIMULATION OF MECHATRONIC SYSTEMS

**Course Code: MH30018**
**Credit: 3**
**Prerequisite(s): Nil**

### COURSE OBJECTIVE

Modeling and Simulation of Mechatronic Systems course encompassing design of problems within time domain simulation. This course is presented to cover all of these critical aspects including state variables, initialization, time integration, and setting up linear and non-linear algebraic equations in combination with differential equations. Through the course, students will be able to solve linear and non-linear sets of equations, optimization, and parameter identification.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to:

CO 1: Describe the basic concept and principles of modeling and simulation of systems,
CO 2: Understand and apply various modeling techniques to physical systems,
CO 3: Apply various simulation techniques to solve practical problems related to mechatronic systems,
CO 4: Analyze the design, model and simulate the Mechatronic Systems using commercial software,
CO 5: Evaluate practical problems using fundamental concepts of kinematics and kinetics of particles, and
CO 6: Integrate systems across different physical domains with respect to the control aspects and desired system behavior.

### COURSE DETAILS

**Introduction**

Principles of modeling and simulation, Modeling and simulation of mixed systems, Transfer function, state space representation of SISO, MIMO, Modeling of dynamic systems, Construction, Analysis, Practical applications.

**Physical Modelling**

Mechanical and electrical systems, Physical laws, Continuity equations, Compatibility equations, System engineering concept, System modelling with structured analysis, Modelling paradigms for mechatronic system, Block diagrams, Mathematical models, Systems of differential-algebraic equations, Response analysis of electrical systems, Thermal systems, Fluid systems, Mechanical rotational system, Electrical-mechanical coupling**.**

**Simulation Techniques**

Solution of model equations and their interpretation, Zeroth, first and second order system, Solution of 2nd order electro-mechanical equation by finite element method, Transfer function and frequency response, Non-parametric methods, Transient, Correlation, Frequency, Fourier and spectra analysis, Design of identification experiments, Choice of model structure, Scaling, Numeric methods, Validation, Methods of lumped element simulation, Modelling of sensors and actuators, Hardware in the loop simulation (HIL), Rapid controller prototyping, Coupling of simulation tools, Simulation of systems in software (MATLAB, LabVIEW) environment.

**Modelling and Simulation of Practical Problems:**

Pure mechanical models, Models for electromagnetic actuators including the electrical drivers, Models for DC-engines with different closed loop controllers using operational amplifiers, Models for transistor amplifiers, Models for vehicle system.

**Textbooks**


1. Ljung, L., Glad, T. (1994). Modeling of dynamical systems, Prentice Hall Inc.
2. Karnopp, D.C., Margolis, D.L. and Rosenberg, R.C. (1990). system dynamics a unified approach, 2nd Edition, Wiley- Inderscience.
3. Gordon, G. (2009). System Simulation‖, 2nd Edition, PHI Learning.


**Reference books**


1. Giurgiutiu, V., and Lyshevski, S. E. (2009). Micro-mechatronics, Modeling, Analysis, and Design with MATLAB, 2nd Edition, CRC Press.


## MODELLING AND SIMULATION OF AUTOMOTIVE SYSTEMS

**Course Code: MH30020**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: AE20001**

## COURSE OBJECTIVE

Design of components is a core competency expected of the graduates. Advanced level machine component design is taught in this course when the students have already known about mechanics of solids and kinematics of machine. IC engine components like piston, connecting rod are demonstrated and the students are exposed to the concept of factor of safety. Students fine tune their skill by designing components and arrive at important dimensions.

## COURSE OUTCOMES

After successfully completing the course, the students will be able to:

CO 1: Describe the basic design requirement and suitable material selection for machine components,

CO 2: Compare and determine geometrical dimensions of a component subjected to complex stress system,

CO 3: Sketch the engine component as per standards,

CO 4: Analyze the stresses and strain imparted on automotive component subjected to static and variable loads,

CO 5: Evaluate the life of component subjected to complex loading, and

CO 6: Develop a new design strategy putting the knowledge into practice.

## COURSE DETAILS

### Design of Shaft

Materials used for shaft, types of shaft, Standard size of transmission shafts, Stresses in shafts, Maximum permissible working stresses for transmission for transmission shafts, Design of shaft- shaft subjected to twisting moment only, Shaft subjected to bending moment, Shaft subjected to combined twisting moment and bending moment, Design of shaft subjected to fluctuating load, Axial load in addition to combined torsion and bending loads, Design of shaft on the basis of rigidity.

### Design of Cylinder and Piston

I.C engines and components design requirement, Materials selection based on engine components and its function, Design of cylinder block and cylinder. Functions of piston in an I.C Engines-Design of piston, Description on piston rings-compression ring-oil rings, piston failure, Case study on piston for car with Modelling and simulation.

### Design of Connecting Rod

Introduction - material selection for connecting rod, Design of connecting rod small end, Design of connecting rod big end and shank design, Design of connecting rod-cap bolt design, Design of connecting rod-cap bolt design.

### Design of Crankshaft

Introduction about crank shaft and its function in an I.C Engine, Materials selection for crankshaft, Balancing of I.C. engines, MI of Crankshaft, significance of firing order, Design of crankshaft under bending and twisting, balancing weight calculations, Development of short and long crank arms, modeling of cylinder and piston for combustion analysis.

**Design of Vehicle Frame and Suspension**

Study of loads-moments and stresses on frame members. Design of frame for passenger and commercial vehicle - Design of leaf Springs-Coil springs and torsion bar springs.

Case study on development of frame for ATV, Modelling and simulation of suspension system.

**Design of Front and Rear Axle**

Design of propeller shaft, Design details of final drive gearing, Design details of full floating, semi-floating and three quarter floating rear shafts and rear axle housings, Analysis of loads moments and stresses at different sections of front axle, Determination of optimum dimensions and proportions for steering linkages, Design of front axle beam, Modelling and simulation of steering system, Transmission system.

**Textbooks**


1. Bhandari, V.B. Design of Machine Elements McGraw-Hill Education Pvt. Ltd., 4th Ed.
2. Jallaludeen, S. Md. Design Data Hand Book, Anuradha Pub.


**Reference books**


1. Sharma, P.C., Agarwal, S. K. (2010). Machine Design, Kataria and Sons.
2. Machines Design Data Book - P.S.G. College of Technology, Coimbatore.
3. Shigley J E, Mischiee C. R. Mechanical Engineering Design, TMH
4. Maleev and Hartman's. (2011). Machine Design, CBS, 5th edition.


## PLC AND MOTION CONTROL LAB

**Course Code: MH39001**
**Credit: 1**
**L-T-P: 0-0-1**
**Prerequisite: Nil**

**COURSE DESCRIPTION**

PLC Laboratory is to aware the students about the Industrial Automation Techniques. The students will be familiar with different switches, sensors, actuators and measuring instruments which are most frequently used in process control industries. The students will be enabling with the upgraded relevant advanced software based controller utilized in modern industry. PLC laboratory gives the effort for making them efficient to design and construct the hardware part related to desired process control. Students can be able to know the technique and logical programme behind the Industrial process control.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to:

CO 1: Describe typical components of a Programmable Logic Controller,
CO 2: Understand the concept of electrical ladder logic and its relationship to programmed PLC instruction,
CO 3: Apply the concept of basic digital electronics and data manipulation,
CO 4: Illustrate the use timer, counter, and other intermediate programming functions,
CO 5: Evaluate the programming capability of basic PLC circuits for entry-level PLC applications, and
CO 6: Design and program automated industrial production line.

**COURSE CONTENTS**

- Introduction to PLC programmable logic controller.
- Details of programming language as LAD.
- LADDER Programming using NO, NC.
- Programming on SPST and SPDT Logic.
- Introduction to TIMER and COMPARATOR BLOCK.
- Introduction to COUNTER BLOCK.

## CIM AND ROBOTICS LAB

**Course Code: MH39002**
**Credit: 1**
**L-T-P: 0-0-1**
**Prerequisite: Nil**

**COURSE DESCRIPTION**

This laboratory imparts skill and the basic knowledge on manufacturing, industrial automation, installation, modification, maintenance, and repair. This provides and helps them to integrate and transform the ideas into a high quality and precised products in minimum time and cost. Integration of data in CIM with CAD system to link NC, CAM, Part Programs, Manufacturing process planning and Robotics, with programming. The students can be trained practically to utilize this knowledge in industry.

**COURSE OUTCOMES**
After successfully completing the course, the students will be able to:

CO 1: Describe the latest developments and the main elements in computer integrated manufacturing systems.
CO 2: Understand and interpret different controllers used in in industries, machines NC, CNC and DNC systems, ASRS, AGV, VIS, Industrial robots and entire CIM System.
CO 3: Identify and demonstrate manual and APT part programs for 2D complex profiles, automated tool paths and G-s for machining components and test the programs through simulation.

CO 4: Illustrate modern computational, analytical, simulation tools and techniques to face the challenges in manufacturing,
CO 5: Evaluate the programming scope for Flexible Manufacturing Systems & Robotics, and
CO 6: Design a program for automated industrial production line.

**COURSE CONTENTS**

- Introduction to Computer Integrated Manufacturing (CIM) Lab.
- Introduction to OPEN CIM Software.
- Operating Aristo Robo.
- Operating ASRS.
- Introduction to CNC and Part Programming.
- Operating CNC mill.
- Introduction to CNC Simulator CNC Train.
- Programming using Linear and Circular Interpolation, contouring with Left Cutter Diameter Compensation, contouring with Right Cutter Diameter Compensation, Contouring Through Subprogram, MIRRORING, Drilling and Pocketing.
- Operating CNC Turn.
- Introduction to CNC Simulator CNC Train.
- Contouring (Rough Turning), Box Facing, Taper Facing, Multiple Facing,Step, Taper Turning, External box Turning.
- Demonstration on entire CIM.

## MECHATRONICS SYSTEM DESIGN LAB

**Course Code: MH39004**
**Credit: 1**
**L-T-P: 0-0-1**
**Prerequisite: Nil**

**COURSE DESCRIPTION**

This laboratory imparts skill and knowledge on, how to approach a system by understanding the module, application of components in the system, characteristic and design function in the system. This provides knowledge about synergistic integration of Mechanical engineering, Electronics, Control & Computer through the design process. The practical significance of various parameters those are involved in different modes of mechatronics can be recognized. The knowledge of mechatronics can be applied for different applications in an effective manner. The students can be trained practically to utilize this knowledge in industry.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to:

CO 1: Select and apply the knowledge, techniques, skills and modern tools in mechatronics engineering technology.

CO 2: Apply concepts of circuit analysis, analog and digital electronics, and troubleshooting of mechatronics systems.

CO 3: Apply the different drive systems for actuation of various parts and components of a system.

CO 4: Illustrate different controllers used in industries, machines and industrial robots.

CO 5: Evaluate the performance of position control systems using a microcontroller and MATLAB/SIMULINK.

CO 6: Design a cost effective and accurate system using these sensors.

**COURSE DEAILS**

- Study the working of IR range finder using LabVIEW.
- Study the working of Accelerometer using LabVIEW.
- Study the working of an ultrasonic sensor using LabVIEW.
- Myoelectric signal acquisition using LabVIEW.
- Controlling of stepper motor using LabVIEW.
- Controlling of stepper motor with microcontroller using MATLAB.
- Study of DC Servomotor Position Controller for P and PI Control with microcontroller using MATLAB/SIMULINK.
- Detection of smaller objects with one-way light barrier and background suppression.
- Development of wireless sensors provide useful information at a distance from the data acquisition system.

## PNEUMATICS AND HYDRAULICS LAB

**Course Code: MH39006**
**Credit: 1**
**L-T-P: 0-0-1**
**Prerequisite: Nil**

**COURSE DESCRIPTION**

This laboratory provides hands-on learning opportunities for students to gain practical skills and knowledge in working with pneumatic and hydraulic systems, reinforce theoretical concepts, and develop problem-solving and critical thinking abilities in the field of fluid power.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to:

CO 1: Describe the principles of direction control in pneumatic systems,

CO 2: Understand the circuits using logical conditions to control pneumatic systems,

CO 3: Demonstrate and actuate different types of cylinders using a solenoid-operated valve,

CO 4: Illustrate the use of simulation software’s like Automation Studio, P-sim, H-sim by simulating different circuits,
CO 5: Comprehend the properties of hydraulic components and circuits apply them in the laboratory, and
CO 6: Design and simulate various circuits in pneumatic and hydraulic systems.

**COURSE CONTENTS**

**Pneumatics**
Exercises on Direction control, Actuation of single acting cylinder by 3/2 D.C. valve
Actuation of double acting cylinder by 5/2 D.C. valve, Direct control of DAC by 5/2 D.C. valve, Indirect control of DAC by 5/2 D.C. valve, Exercises on Flow control, Speed control of SAC by throttle valve, Speed control of DAC by Flow control valve, and Speed control of DAC by quick exhaust valve

**Logic Conditions**
Use of OR logic to actuate DAC, Use of AND logic to actuate DAC, Circuits using logical conditions, Advanced Circuit Design, Retraction of DAC after preset pressure is reached, Memory circuit and speed control of DAC, Examples for using Time delay valve, and Actuation of DAC’s with A+B=A-B- logic.

**Electro-Pneumatics**
Actuation of SAC by solenoid operated valve, Actuation of DAC by solenoid operated valve, Actuation of SAC using OR Logic by solenoid operated valve, and Actuation of SAC using AND Logic by solenoid operated valve

**Hydraulics**
Pressure Control, Use of pressure relief valve in DAC, Use of pressure regulating valve in DAC, Flow Control, Use of 1 -way flow control valve, Use of 2- way flow control valve, Direction control, Actuation by 2/2 or 3/2 DC valve, Actuation by check valve, Actuation by solenoid operated valve, Driving of Pneumatic circuit with PLC, and Design assignments and simulation Exercises on various circuit design & simulation

## MOBILE AND AUTONOMOUS ROBOTS

**Course Code: MH40011**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite(s): Nil**

**COURSE OBJECTIVE**

Mobile and Autonomous Robots course encompassing basic concepts and algorithms required to develop mobile robots that act autonomously in complex environments. This course is presented to cover all of these critical aspects including mobile robot locomotion and kinematics, environment perception, probabilistic map-based localization and mapping, and motion planning. Through the course, students will be able to develop several types of robots such as wheeled robots, legged robots and drones.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to:

CO 1: Define key issues and constraints of locomotion.
CO 2: Interpret different sensor technologies for tracking.
CO 3: Identify robotic platforms and their limitations.
CO 4: Analyze the kinematics of robot.
CO 5: Determination of different parameters of mobile robot by programming.
CO 6: Design of automation solutions using mobile robots.

## COURSE DETAILS

**Locomotion**
Introduction: Key issues for locomotion, Legged Mobile Robots, Leg configurations and stability, Consideration of dynamics, Examples of legged robot locomotion, Wheeled Mobile Robots, Wheeled locomotion: The design space.

**Mobile Robot Kinematics**
Introduction, Kinematic Models and Constraints, Representing robot position, Forward kinematic models, Wheel kinematic constraints, Robot kinematic constraints, Mobile Robot Manoeuvrability**,** Degree of mobility, Degree of steer-ability, Robot manoeuvrability**,** Mobile Robot Workspace, Degrees of freedom, Holonomic robots, Path and trajectory considerations, Beyond Basic Kinematics, Motion Control (Kinematic Control), Open loop control (trajectory-following), Feedback control

**Perception**
Sensors for Mobile Robots, Sensor classification, Characterizing sensor performance, representing uncertainty, Wheel/motor sensors, heading sensors, Accelerometers, Inertial measurement unit (IMU), Ground beacons, Active ranging, Motion/speed sensors, Vision sensors, Fundamentals of Computer Vision, Digital camera, Image formation, Omnidirectional cameras, Structure from stereo, Structure from motion, Motion and optical flow, Colour tracking, Fundamentals of Image Processing, Image filtering, Edge detection, Computing image similarity, Image Feature Extraction: Interest Point Detectors, Place Recognition, Line fitting, Six line-extraction algorithms

**Mobile Robot Localization: Introduction**
The Challenge of Localization: Noise and Aliasing, Sensor noise, Sensor aliasing, Effector noise an error model for odometric position estimation, To Localize or Not to Localize: Localization-Based Navigation Versus, Single-hypothesis belief, Multiple-hypothesis belief, The ingredients of probabilistic map-based

localization, Classification of localization problems, Markov localization, Kalman filter localization. SLAM: The simultaneous localization and mapping problem, Mathematical definition of SLAM

**Planning and Navigation**

Introduction, Competences for Navigation: Planning and Reacting, Path Planning, Graph search, Potential field path planning, Obstacle avoidance, Bug algorithm, Navigation Architectures, Control localization, Techniques for decomposition Case studies: tiered robot architectures.

**Textbook**


1. Choset, Howard, et. al. (2005). Principles of Robot Motion: Theory, Algorithms, and Implementations, The MIT Press, ISBN-10: 0262033275.


**Reference book**


1. Hexmoor. (2013). Essential Principles for Autonomous Robotics, Morgan and Claypool publishers.


## INTELLIGENT MANUFACTURING SYSTEMS

**Course Code: MH40013**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite(s): Nil**

**COURSE OBJECTIVE**

Intelligent Manufacturing Systems course encompassing advanced information technology tools for manufacturing industries. This course is presented to cover all of these critical aspects of smart manufacturing including basics of advanced (machine learning, data science and information analytics) and digital technologies. Through the course, students will be able to contribute effectively to operate in the industries of the future through extensive and systematic research.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to:

CO 1: Demonstrate the concepts of machine learning techniques,
CO 2: Understand the concepts of AI and its various applications,
CO 3: Apply fuzzy logic and reasoning to handle uncertainty and solve engineering problems,
CO 4: Identify various components of knowledge-based systems,
CO 5: Evaluate various Intelligent techniques for manufacturing process optimization, and
CO 6: Develop various methods to solve group technology problems and demonstrate the structure for knowledge-based system for group technology.

**COURSE DETAILS**

**Introduction to Machine Learning**

Goals of AI in manufacturing, tools for AI such as Search algorithm, Mathematical optimization, Evolutionary computation, fuzzy logic, Probabilistic methods for uncertain reasoning such as Bayesian network, Hidden Markov model, Kalman filter, Decision theory and Utility theory, statistical learning methods, support vector machines, neural networks, expert systems.

**Industrial planning and decision making using intelligent systems**

Production planning using fuzzy cognitive maps, Computer aided process planning, Methods for inventory space allocation and storage processes analysis, Optimization of production costs and methods finding of the best process plan, Methods for production equipment selection and layout, Heuristic scheduling of multiple resources, Fuzzy multiple attribute decision making methods.

**Intelligent techniques for manufacturing process optimization**

Application of neural networks and fuzzy sets to machining and metal forming, Artificial neural network modeling of surface quality characteristics in machining processes, Parametric optimization of machining processes using evolutionary optimization methods.

**Knowledge Based Group Technology**

Group Technology: Models and Algorithms, Visual method, Coding method, Cluster analysis method, Knowledge based group technology, Group technology in automated manufacturing system, Structure of knowledge based system for group technology (KBSGT), Database, Knowledge base, Clustering algorithms. Knowledge Based System for Equipment Selection (KBSES), Manufacturing system design, Equipment selection problem, Modelling the manufacturing equipment selection problem, problem solving approach in KBSES, Structure of the KBSES

**Textbooks**

1. Narayana, Yagna. (2009). Artificial Neural Networks, PHI.
2. Kussiak, Andrew. (1990). Intelligent Manufacturing Systems, Prentice Hall.
3. Badiru, A.B. (1992). Expert Systems Applications in Engineering and Manufacturing, Prentice-Hall, New Jersey.

**Reference books**

1. Rao, R.V. Advanced Modeling and Optimization of Manufacturing Processes, Springer-verlag, London. ISBN 978-0-85729-014-4.
2. Parsaei, Hamid R., and Jamshidi, Mohammad. (2009). Design and Implementation of Intelligent Manufacturing Systems, PHI.
3. Maluf, Nadim. (2000). An introduction to Micro electro mechanical Systems Engineering, AR Tech house, Boston.
4. Gardner, Julian W., Vijay, K., Osama, Varadan O., Karim, Awadel. (2001). Micro sensors MEMS and Smart Devices, John Wiby & sons Ltd.

## SMART MOBILITY AND INTELLIGENT VEHICLES

**Course Code: MH40015**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

This course provides a framework for students to develop a strong foundation in automotive electronics, sensor technology, connected and autonomous vehicle technology, wireless technology, and connected car technology. Gain a comprehensive understanding of smart mobility and intelligent vehicles, including their components, technologies, and applications.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to:

CO 1: Describe the significance of automotive electronics in modern vehicles,
CO 2: Understand the principles of sensor data fusion and its integration with on-board control systems,
CO 3: Articulate the role of wireless data networks in connected and autonomous vehicles,
CO 4: Comprehend the wireless system block diagram and the components involved,
CO 5: Evaluate the efficacy of vehicle connectivity, and
CO 6: Develkop the technologies and applications of vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication.

**COURSE DETAILS**

**Introduction to the Concept of Automotive Electronics:**
Overview of automotive electronics and its significance in modern vehicles, Evolution of automotive electronics and its impact on vehicle functionality, Automotive Electronics Overview, History & Evolution, Infotainment, Body, Chassis, and Powertrain Electronics, overview of electronics used in vehicle body, chassis, and powertrain systems.

**Sensor Technology for Smart Mobilty:**
Basics of radar, ultrasonic sonar, lidar, camera technology, and night vision technologies, Sensor data fusion and integration with on-board control systems.

**Connected and Autonomous Vehicle Technology**
Basic Control System Theory applied to Automobiles, Overview of the Operation of ECUs, Basic Cyber-Physical Systems, Theory and Autonomous Vehicles, Role of Surroundings Sensing Systems and Autonomy, Role of Wireless Data Networks and Autonomy
**Overview of Wireless Technology**
Wireless System Block Diagram and Overview of Component, Transmission Systems -Modulation /Encoding., receiver System Concepts - Demodulation/Decoding, basics of Computer Networking - the Internet of Things, Wireless Networking Fundamentals, Integration of Wireless Networking and On-

Board Vehicle Network

**Connected Car Technology**
Fundamentals of vehicle connectivity, Navigation and other applications in connected cars, Vehicle -to-vehicle (V2V) and vehicle-to-infrastructure (V2I) technologies and their applications, Overview of wireless security in connected cars

**Textbooks**

1. (2016). Intelligent Transportation Systems and Connected and Automated Vehicles, Transportation Research Board.
2. Miucic, Radovan. (2019). Connected Vehicles: Intelligent Transportation Systems, Springer.

**Reference book**

1. Denton, Tom. (2018). Automobile Electrical and Electronic systems, Roult edge, Taylor & Francis Group, 5th Edition.

## SMART HEATING, VENTILATION, AIR CONDITIONING AND REFRIGERATION

**Course Code: MH40017**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite:**

**COURSE OBJECTIVE**
The primary objective of this Heating, Ventilation and Air Conditioning (HVAC) Systems course is to empower students with fundamental information and knowledge of refrigeration and air-conditioning systems and their operation, Knowledge of basic working principles and requirement of different components of the refrigeration and air-conditioning systems and the ability to determine necessary sizing and capacity of the refrigeration systems. Will experience with adequate knowledge and to work with HVAC systems to ensure optimal levels of operation, maintenance, reduced wear and tear, in turn increasing life or longevity.

**COURSE OUTCOMES:**

CO 1 : Describe the fundamentals of refrigeration processes in engineering problems,
CO 2 : Explain the different refrigeration and air-conditioning methodologies and the equipment needed,
CO 3 : Apply the vapour compression thermodynamic cycle concept to inmprove performance,
CO 4 : Analyze the different conditions of the air in air-conditioning systems through psychometric properties,
CO 5 : Evaluate the performance of various refrigeration and air-conditioning systems, and
CO 6 : Design the air-conditioning systems based on psychometric properties and processes.

**COURSE DETAILS**

**Vapour Refrigeration System**
Overview of refrigeration and air-conditioning applications, Introduction to Vapour compression refrigeration cycle, p-h chart, Theoretical vapour compression cycle with different combination at the inlet of the condenser (dry-saturated, superheated and wet mixture), Actual vapour compression cycle, Effect of suction and discharge pressure. Vapour absorption refrigeration system (simple and practical), Advantages of absorption system over compression system.

**Air Refrigeration System**
Air refrigerator working on a Bell-Colemn cycle (Reversed Brayton Cycle), Air-refrigeration System, Merits and Demerits of Air-refrigeration Systems, Simple Air-cooling system

**Psychometrics**
Properties of air-vapour mixtures, Psychometric chart, Law of air-water vapour mixture, Enthalpy of mixture, Psychometric processes: simple heating and cooling, Humidification, Dehumidification mixture of air streams, Sensible Heat factor, Cooling and Humidification through water injection (evaporative coolng)

**Air conditioning system**
Introduction, factors affecting comfort air-conditioning, Air-conditioning systems, Equipment used in an air-conditioning system, Classification of Air-conditioning system (comfort air-conditioning system, industrial Air-conditioning system, winter air-conditioning system, summer air-conditioning system, Year round Air-conditioning system, central air-conditioning system).

**Cooling Load Estimation**
Introduction, components of cooling load, Sensible heat gain through building structure by conduction, Heat gain from solar radiation, Solar heat gain (sensible) through outside walls and roofs, Sol air temperature, heat gain due to Sun, infiltration, ventilation, occupants, appliances, products, lighting equipment, power equipment, ducts.

**Components in refrigeration and Air-conditioning Systems**
Evaporative condensers, Cooling Towers and Spray Ponds, Natural draft and mechanical draft cooling towers, bare tube coil evaporators, finned tube evaporator, Frosting and defrosting evaporator, Capillary tube, Hand operated expansion valve, Automatic expansion valve, Thermostatic expansion valve, Ducts (classification, duct material, Construction, Shape), duct design, centrifugal and axial fans, Application of air-conditioning in industry, Cold storages.

**Smart Technologies in HVAC**

**Textbook**

1. Khurmi, R. S., and Gupta. Refrigeration and Air-conditioning, S Chand Publication

**Reference books**


1. Arora, R. C. (2013). Refrigeration and Air Conditioning, PHI Learning Pvt. Ltd.
2. Arora, R.C., and Domkundwar, S. (2013). A course in Refrigeration and Air Conditioning, Dhanpat Rai & Co (P) Ltd.
3. Prasad, Manohar. (2003). Refrigeration and Air Conditioning, New Age International.
4. Refrigeration and air conditioning - Stocker and Jones.
5. Basic refrigeration and Air-conditioning, Anantanarayana, TMH Publication


## PRODUCT LIFE CYCLE MANAGEMENT

**Course Code: MH40018**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

PLM stands for **Product Lifecycle Management**. The primary goal of PLM is to coordinate the information, processes and people associated with the lifecycle of a product. It provides students some basic knowledge of production errors, reduced cycle iterations and, increased speed to market. As PLM focuses itself primarily generate an innovative idea for product design in a systematic approach and apply the check to the quality of the new design by using product design tools,

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Describe the fundamentals of Product life cycle management processes,
CO 2: Explain the different types of product development process,
CO 3: Apply analytical methods, numerical tools to design product and service design requirement,
CO 4: Illustrate the components of product life cycle management and its effect on human resources,
CO 5: Evaluate the strategies in product life cycle management, and
CO 6: Design the product outflow in automated industrial point of view.

**COURSE DETAILS**

**Introduction**
Overview, Need, Benefits, Concept of Product Life Cycle, Components / Elements of PLM, Emergence and Significance of PLM, PLM implementation cases in various industry verticals. Trend analysis, competitive landscape, PESTLE Analysis, Overview of Products and services, Types of Product development, Overview of Product development methodologies.

**Generic Product Development Process**

Identifying customer needs –voice of customer –customer populations- hierarchy of human needs-need gathering methods – affinity diagrams – needs importance- establishing engineering characteristics-competitive bench marking- quality function deployment- house of quality- product design specification- case studies, Concept development stages, System level design, Detail design, Testing and refinement, Production ramp up.

**Product design tools and technology**

Theory of inventive problem solving, General Theory of Innovation and **TRIZ**, Value engineering Applications in Product development and design, Model-based technology for generating innovative ideas, Quality aspects in product design, Failure mode effect analysis.

**Product Life Cycle Management**

System architecture, Information models and product structure, Functioning of the system. Significance of PLM, Customer Involvement.

**Product life cycle environment**

Product Data and Product Workflow, The Link between Product data and Product Workflow, Key Management Issues around Product Data and Product Workflow, Company's PLM vision, The PLM Strategy, Principles for PLM strategy, Preparing for the PLM strategy.

**Components of Product Life Cycle Management**

Different phases of product life cycle and corresponding technologies, Foundation technologies and standards (e.g. visualization, collaboration and enterprise application integration), Core functions (e.g., data vaults, Document and content management, Workflow and program management), Functional applications (e.g., configuration management) Product organizational structure, Human resources in product lifecycle, Methods, Techniques, Practices, Methodologies, Processes, System, Components in life cycle, Slicing and dicing the systems, Interfaces, Information, Standards, Examples of PLM in use.

**Textbooks**


1. Ulrich, Kari. T., Eppinger, Steven. D. (1999). Product Design and Development, McGraw-Hill International Edn.
2. Grieves, Michael. (2006). Product Lifecycle Management, McGraw-Hill, ISBN 0071452303.


**Reference books**


1. Otto, Kevin., Wood, Kristin. (2004). Product Design, Indian Reprint, Pearson Education, ISBN 9788177588217.
2. Michael, Grieves. (2006). Product Lifecycle Management - Driving the Next Generation of Lean Thinking, McGraw-Hill.
3. Terninko, John., Zusman, Alla. Systematic innovation: an introduction to TRIZ, (theory of inventive Problem Solving), CRC Press.
4. Saaksvuori, Antti., AnselmiImmonen. (2003). Product Life Cycle Management, Springer,1st Edition.

## ADVANCED MANUFACTURING SYSTEMS

**Course Code: MH40020**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

### COURSE OBJECTIVE

The objective of this course is to make student understand the concepts and principles of advanced manufacturing systems. To Develop lean implementation strategies, Agile manufacturing in various industries based on case studies and best practices. Able to assess the challenges and opportunities in implementing intelligent manufacturing systems, analysing industrial automation and control systems in the context of smart manufacturing etc.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to
CO 1: Describe the principles and foundations of lean manufacturing and its importance in improving operational efficiency and eliminating waste,
CO 2: Understand the principles and characteristics of agile manufacturing and its ability to respond quickly to changing customer demands,
CO 3: Articulate application of Artificial Intelligence (AI) and machine learning techniques in optimizing manufacturing operations,
CO 4: Illustrate the concepts and technologies of smart manufacturing and their potential to transform traditional manufacturing processes,
CO 5: E€evaluate implementation strategies and challenges in adopting advanced manufacturing systems in different organizational contexts, and
CO 6: Write on industry trends and emerging technologies in advanced manufacturing.

### COURSE DETAILS

**Lean Manufacturing**
Principles and foundations of lean manufacturing, Value stream mapping and analysis, Just-in-Time (JIT) production and Kanban systems, Kaizen and continuous improvement methodologies, Lean tools and techniques (5S, TPM, SMED, etc.), Lean implementation strategies and case studies

**Agile Manufacturing**
Principles and characteristics of agile manufacturing, Flexibility and responsiveness in manufacturing operations, Agile supply chain management, Quick response manufacturing (QRM), Agile project management methodologies, Case studies and applications of agile manufacturing

**Intelligent Manufacturing**

Introduction to intelligent manufacturing systems, Automation and robotics in manufacturing, Artificial Intelligence (AI) and machine learning in manufacturing, Cyber-physical systems and Industrial Internet of Things (IIoT), Data analytics and predictive maintenance, Intelligent manufacturing implementation challenges and opportunities

**Smart Manufacturing**

Overview of smart manufacturing concepts and technologies, Integration of digital technologies in manufacturing processes, Industrial automation and control systems, Cloud computing and edge computing in smart manufacturing, Cybersecurity in smart manufacturing environments, Case studies and applications of smart manufacturing

**Advanced Manufacturing Systems Integration**

Integration of lean, agile, intelligent, and smart manufacturing principles, Designing and optimizing advanced manufacturing systems, Performance measurement and evaluation of advanced manufacturing systems, Implementation strategies and challenges in adopting advanced manufacturing systems, Industry 4.0 and future trends in advanced manufacturing

**Textbooks**

1. Wilson, Lonnie. (2015). How to Implement Lean manufacturing, McGraw-Hill Professional, 2nd edition.
2. Garbie, Ibrahim. (2016). Sustainability in Manufacturing Enterprises Concepts, Analyses and Assessments for Industry 4.0, Springer International Publishing., United States, ISBN-13: 978-3319293042.
3. Andrew, Kusiak. (1990). Intelligent Manufacturing Systems, Prentice Hall, 1st edition.

**Reference books**

1. Seliger G. (2012). Sustainable Manufacturing: Shaping Global Value Creation, Springer, United States, ISBN 978-3-642-27289-9.
2. Rao R. V. (2006). Advanced Modeling and Optimization of Manufacturing Processes, 2nd edition.
3. Ronald, G. Askin., and Goldberg, Jeffrey B. (2003). Design and Analysis of Lean Production Systems, John Wiley and Sons.

## ARTIFICIAL INTELLIGENCE FOR MECHATRONICS SYSTEMS

**Course Code: MH40022**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite(s): Nil**

## COURSE OBJECTIVE

Artificial Intelligence for Mechatronics Systems would encompass a complete study of a variety of topics in computational intelligence. This course is presented to cover all aspects of neural networks, learning methods including unsupervised learning, reinforcement learning and semi-supervised learning, fuzzy systems, evolutionary algorithms and mechatronic applications in broader terms. Through the course, students will be able to apply the capability of artificial intelligence in engineering applications.

## COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Describe the concepts of artificial intelligence approaches,
CO 2: Understand awareness of the major challenges facing AI and the complex of typical problems within the field,
CO 3: Exhibit strong familiarity with a number of important AI techniques, including in particular search,
CO 4: Illustarte the concepts of Neural Networks and various types of learning algorithms,
CO 5: Solve using neural networks to pattern classification problems, and
CO 6: Design and compare solutions by various soft computing approaches for a given problem.

## COURSE DETAILS

**Introduction**
Overview, Foundation, History, The State of Art.

**Intelligent Agents**
Agents and environment, Rationality, The nature of environment, The structure of agents.

**Solving Problems by Searching**
Problem-solving agents, well defined problems & solutions, Formulating problems, Searching for solution, Informed/Uninformed search strategies: (BFS, DFS, DLS, IDDFS, Bidirectional Search)

**Knowledge Representation and Reasoning**
Ontologies, foundations of knowledge representation and reasoning, representing and reasoning about objects, relations, events, actions, time, and space, predicate logic, situation calculus, description logics, reasoning with defaults, reasoning about knowledge, sample applications.

**Neural Networks**
Supervised Learning Neural Networks, Perceptrons, Adaline, Back propagation Mutilayer Perceptrons, Radial Basis Function Networks, Unsupervised Learning Neural Networks, Competitive Learning Networks, Kohonen Self-Organizing Networks, Learning Vector Quantization, Hebbian Learning, Hop-field networks.

**Recent Advances**

Neural network structures for pattern recognition - Neural network based pattern associators – Unsupervised learning in neural pattern recognition - Self organizing networks - Fuzzy logic - Fuzzy pattern classifiers -Pattern classification using Genetic Algorithms.

**Textbook**

1. Russel, Stuart., Norvig, Peter. (2009). Artificial Intelligence: A Modern Approach, 3rd Edition, Pearson Education.

**Reference books**

1. Rich, Elaine., Knight, Kevin., and Shivashankar, B. Nair. (2008). Artificial Intelligence, 3rd Edition, Tata McGraw Hill.
2. Nilsson, Nils J. (1997). Artificial Intelligence: A new Synthesis, 1st Edition, Elsevier.
3. Patterson, Dan W. (2009). Introduction to Artificial Intelligence and Expert Systems, 2nd Edition, PHI.
4. Christopher, M. Bishop. Pattern Recognition and Machine Learning, Springer.

## ADVANCED DRIVER ASSISTANCE SYSTEMS

**Course Code: MH40024**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

The course aims to provide students with a comprehensive understanding of advanced driver assistance technologies. They will learn about the principles, concepts, and components involved in these technologies, including sensors, control systems, and actuation methodologies. Develop Knowledge on Vehicle Automation, acquire skills to analyze and predict the condition of vehicle components through vehicle prognostics. They will develop an understanding of impaired driver technology and its significance in ensuring safe driving.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Describe the operation and characteristics of various automotive sensors,
CO 2: Understand the principles and components of power systems in vehicles,
CO 3: Articulate the basics of the theory of operation for driver assistance systems,
CO 4: Illustrate the applications of driver assistance technology in vehicles,
CO 5: Evaluate the alignment and calibration of ADAS sensors, and
CO 6: Recognize and apply possible evolution of vehicle prognostics and impaired driver technology.

## COURSE DETAILS

**Automotive Fundamentals**

Power System: Overview of engine components and their functions, drive train and its components, suspension system and its role in vehicle handling, Overview of the ABS (Anti-lock Braking System) and its operation, Introduction to the steering system and its components.

**Automotive Sensors**

Introduction to Automotive Sensors: Overview of automotive sensors and their role in vehicle operation, Introduction to various types of automotive sensors, Sensor Types and Applications: Study of specific automotive sensors such as knock sensors, oxygen sensors, crankshaft angular position sensors, temperature sensors, speed sensors, pressure sensors, mass air flow sensors, manifold absolute pressure sensors, crash sensors, coolant level sensors, and brake fluid level sensors, operation, characteristics, advantages, and applications.

**Overview of Driver Assistance Technology**

Theory of Operation and Applications: Basics of theory of operation for driver assistance systems, exploration of different applications of driver assistance technology, integration of advanced driver assistance systems (ADAS) into vehicle electronics, case studies and examples of ADAS systems, Role of Sensor Data Fusion

**Advanced Driver Assistance Systems (ADAS)**

Overview of ADAS: Introduction to various ADAS technologies, Detailed study of specific ADAS systems, such as lane departure warning (LDW), active cruise control (ACC), blind spot detection, parking assist, autonomous emergency braking (AEB), night vision, traffic sign recognition (TSR), intelligent high beam assistant (IHC), tire pressure monitoring (TPMS), front collision warning system (FCWS), front vehicle departure warning (FVDW), adaptive lighting, driver drowsiness detection, hill descent control, and rear cross-traffic.

**ADAS Display and Impaired Driver Technology**

ADAS Display Technologies: Overview of center console technology, gauge cluster technology, and heads-up display technology, warning technologies and driver notification systems, Impaired Driver Technology: Introduction to driver impairment sensor technology, study of sensor technology used for driver impairment detection, transfer of control technology and its application in impaired driver situations.

**Textbooks**

1. Denton, Tom. (2018). Automobile Electrical and Electronic systems, Roultedge, Taylor & Francis Group, 5th Edition.
2. William, B. Ribbens. (2017). Understanding Automotive Electronic: An Engineering Perspective, Elsevier Science, 8th Edition.

**Reference books**

1. (2016). Intelligent Transportation Systems and Connected and Automated Vehicles, Transportation Research Board.
2. Miucic, Radovan. (2019). Connected Vehicles: Intelligent Transportation Systems, Springer.

## MECHATRONIC SENSORS AND ACTUATORS

**Course Code: MH40031**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

### COURSE OBJECTIVE

The course aims to provide students with a comprehensive understanding of sensor and transducer technology, measurement techniques for displacement, force, weight, pressure, temperature, level, flow, and micro sensors/actuators. They will be able to apply this knowledge to select appropriate sensors and transducers for specific applications and design systems involving measurement and actuation.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Identify and describe various displacement sensors for linear and rotary motion,
CO 2: Understand the basic concepts and definitions of sensors and transducers,
CO 3: Comprehend the principles and methods of force, weight, and pressure measurement,
CO 4: Illustrate about temperature measurement, level measurement techniques,
CO 5: Apprise the basic principles of flow measurement, including differential pressure devices, and
CO 6: Write on micro sensors, working principles and examples, Micro actuators and their types.

### COURSE DETAILS

**Introduction**
Definition of sensor and transducer, Classification, Characteristics. Selection criteria of transducers. Smart sensor: Block diagram, and features.

**Displacement and velocity Measurement**
Linear and rotary displacement sensors: Potentiometer, Capacitive, Inductive. Position measurement: Optical Encoder, Proximity sensors. Velocity measurement: Tachometer types, Stroboscope, and Encoder.

**Measurement of Force, Weight and Pressure**
Force and weight measurement: Strain gauge, Types, load cell. Pressure measurement: Manometer types, Strain gauge, Diaphragm gauge, Capsule, Bellows, Bourdon tube, and Piezoelectric sensor.

**Temperature measurement**
Temperature scales. Mechanical thermometers: Filled in systems, Metallic expansion. Electrical thermometers: RTD, Thermocouple, Semiconductor temperature sensors, and Radiation pyrometers.

**Level measurement**

Mechanical methods: float and displacer. Electrical methods: Resistance, inductive, capacitance type, Gamma radiation method and Ultrasonic level gauging.

**Flow measurement**

Basic principles of flow measurement, Differential pressure devices: Orifice, Venturi, Flow nozzle, Pitot tube, Annular. Area flow meter: Rotameter. Mass flow meter: Coriolis, Thermal & impeller types. Electromagnetic type, Ultrasonic type, Vortex type, Turbomagnetic type, Target type, and Positive displacement type.

**Micro sensors and actuators**

Micro sensors: Principles and examples, Force and pressure micro sensors, Position and speed micro sensors, Acceleration micro sensors, Chemical sensors, Bio sensors, Temperature micro sensors and flow micro sensors. Micro actuators: Actuation principle, Shape memory effects-one way, Two way and pseudo elasticity. Types of micro actuators: Electrostatic, magnetic, Fluidic, and inverse piezo effect.

**Textbook**

1. Singh, S. K. Industrial instrumentation and control, TMH, 3rd Edition.

**Reference books**

1. Murthy, D.V.S. (2001). Transducers and Instrumentation, Prentice Hall of India.
2. Patranabis, D. (2003). Sensors and transducers, PHI.
3. Sergej, Fatikow., Rembold, Ulrich. Microsystem Technology and Microrobotics, Springer-Verlag Berlin Heidelberg, 1st Edition.
4. Kohl, Manfred. Shape memory actuators, Springer, 1st Edition.

## MEMS AND MICROSYSTEMS

**Course Code: MH40032**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

Through this course, students will be able to understand the fundamentals of MEMS and Microsystems. They will be equipped with the knowledge and skills to analyze, design, and fabricate components and systems for microsystems, considering engineering science, mechanics, scaling laws, and micromanufacturing techniques.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to:

CO 1: Describe the field of MEMS (Micro-Electro-Mechanical Systems) and Microsystems, including typical products and the evolution of microfabrication,
CO 2: Understand the working principles of microsystems, including microsensors, microactuation, MEMS with microactuators, microaccelerometers, and microfluidics,
CO 3: Articulate the design process and fabrication process of Microsystems,
CO 4: Illustrate the engineering mechanics concepts as applied to microsystems design,
CO 5: Evaluate the scaling laws in miniaturization and their impact on microsystems design, and
CO 6: Write an overview of micromanufacturing techniques used in the fabrication of microsystems.

**COURSE DETAILS**

**Overview of MEMS and Microsystems**
MEMS and Microsystem, Typical MEMS and Microsystems Products, Evolution of Microfabrication, Microsystems and Microelectronics, Multidisciplinary Nature of Microsystems and manufacture, Miniaturization. Applications of Microsystems and Markets.

**Working Principles of Microsystems**
Introduction, Microsensors, Microactuation, MEMS with Microactuators, Microaccelerometers, and Microfluidics.

**Engineering Science for Microsystems Design and Fabrication**
Introduction, Atomic structure of matter, ions and ionization, Molecular Theory of Matter and Inter-Molecular Forces, Diffusion process, Plasma Physics, and Electrochemistry.

**Engineering Mechanics for Microsystems Design**
Introduction, Static Bending of Thin Plates, Mechanical Vibration, Thermomechanics, Fracture Mechanics, Thin Film Mechanics and Overview on Finite Element Stress Analysis.

**Scaling Laws in Miniaturization**
Introduction, Scaling in Geometry, Scaling in Rigid-Body Dynamics, Scaling in Electrostatic Forces, and in electromagnetic forces, Scaling in electricity, Fluid Mechanics, and in Heat Transfer.

**Overview of Micromanufacturing and design**
Introduction, Bulk Micromanufacturing, Surface Micromachining, The LIGA Process, and Summary on Micromanufacturing. Design consideration, Process design, Mechanical design, Mechanical design using finite element method, Design of a silicon die for a micropressure sensor and for microfluidic network systems,

**Textbook**
**1.** Hsu, Tai. Ran. (2002). MEMS and Microsystems Design and Manufacture, Tata McGraw Hill.

**Reference books**

1. Madou, Marc. (1997). Fundamentals of Microfabrication, CRC press.
2. Stephen D. Senturia. (2001). Micro system Design, Kluwer Academic Publishers. 3
3. Chang, Liu. (2006). Foundations of MEMS, Pearson education India limited.

## CIM AND ROBOTICS

**Course Code: MH40033**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

### COURSE OBJECTIVE

This Course provides students to have a comprehensive understanding of Computer Integrated Manufacturing (CIM), automation principles and strategies, CNC programming, Group Technology and CAPP, robotics concepts, kinematics, sensors, programming, and various applications of robots. They will be equipped with the knowledge and skills to analyze and design automated manufacturing systems, apply CNC techniques, implement Group Technology and CAPP approaches, and understand the principles and applications of robotics in various industries.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Describe the concepts and elements of Computer Integrated Manufacturing (CIM) systems, including its definition, scope, and benefits,
CO 2: Understand the Computer Numerical Control (CNC), including its components and programming,
CO 3: Articulate the concepts of Group Technology (GT) and Computer-Aided Process Planning (CAPP),
CO 4: Illustrate the fundamentals of robotics, including the definition of a robot, elements of a robotic system, and the need for using robots,
CO 5: Evaluate various kinematic and dynamic equations to control the motion of the robot through actuators, and
CO 6: Write on the wide range of industrial and non-industrial applications of robots.

### COURSE DETAILS

**Introduction to CIM and Automation**

CIM – definition, scope and elements of CIM system-benefits, Production system facilities, Low-Medium-High-Manufacturing support systems, Automation in production systems, Automated manufacturing systems, Computerized Manufacturing Support Systems, Reasons for Automating, Automation principles and strategies, USA Principle, Ten Strategies for Automation and Production Systems, Automation, Definition, Basic elements of an automated system, and Levels of automation.

**Computer Numerical Control**

Introduction, Components of CNC, CNC programming, Manual part programming, G Codes, M Codes, Programming of simple components in turning, Drilling and milling systems, Programming with canned cycles, and Cutter radius compensations.

**Group Technology and CAPP**

Group technology, Definition, Advantages and limitations of GT-Part family formation, Classification and coding, Opitz coding system, Applications & benefits of GT, Cellular manufacturing, Machining cell designs, Machining cell planning, Computer aided process planning, Approaches to CAPP, Implementation techniques, Essential elements in a retrieval type CAPP system, Essential elements in a generative CAPP system, Flexible manufacturing system, Scope of FMS, FMS compared to other types of manufacturing approaches, Types of FMS, and Benefits of FMS.

**Robotics**

**Introduction**

Definition of robot, Elements of a robotic system, Need for using robots, Types of robots, Classification of robots based on mechanical configuration, Gantry robot-SCARA robot and Freedom of motion. End effectors, Classification, Types of Mechanical actuation, Gripper design, Robot drive system Types, Position and velocity feedback devices, Robot joints and links, Types, and Motion interpolation.

**Robot Kinematics and Sensors**

Basics of direct and inverse kinematics, Robot trajectories, 2D and 3D Transformation-Scaling, Rotation, Translation Homogeneous transformation, Control of robot manipulators, Point to point, Continuous Path Control, Robot programming, Sensors in robot, Touch sensors, Tactile sensor, Proximity and range sensors. Force sensor, Light sensors, Pressure sensors, Introduction to Machine Vision and Artificial Intelligence.

**Robot Applications**

Industrial applications of robots, Medical, Household, Entertainment, Space, Underwater, Defense, Disaster management. Applications, Micro and Nanorobots, and Future Applications.

**Textbook**

1. Groover., Mikell. P. (2007). Automation, Production Systems, and Computer Integrated Manufacturing, John Wiley & sons, 2nd Edition.
1. Mittal, R.K. & Nagrath, I.J. (2003). Robotics and Control, Tata McGraw-Hill.

**Reference books**

1. Craig, J.J. (2009). Introduction to Robotics Mechanics and Control (3rd Edition). Pearson Education.
2. Fu, K.S., Gonzalez, R.S. & Lee, C.S.G. (2014). Robotics; control, sensing, vision, and intelligence. Tata McGraw-Hill.

## BIOMECHATRONIC SYSTEMS

**Course Code: MH40034**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

### COURSE OBJECTIVE

Through this course, Students will have a comprehensive understanding of biosensors, biomedical signal and image processing, sensory assist devices, prosthetic limbs, and wearable mechatronics devices used in healthcare and rehabilitation. They will be equipped with the knowledge and skills to analyze, design, and develop technologies that enhance healthcare, improve sensory capabilities, and assist individuals with impairments.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to:

CO 1: Describe the fundamentals of biosensors, including their working principles and various types of biosensors used in healthcare and biological applications.
CO 2: Comprehend the principles and techniques of biomedical signal and image processing.
CO 3: Explore sensory assist devices used to aid individuals with sensory impairments.
CO 4: Illustrate the concepts of active and passive prosthetic limbs.
CO 5: Evaluate efficacy of wearable mechatronic devices used in the medical field.
CO 6. Develop an understanding on the technologies that enhance healthcare, improve sensory capabilities, and assist individuals with impairments.

### COURSE DETAILS

#### Biosensors and Actuators

Fundamentals of biosensor, working principle and types of metabolism sensors, affinity sensors, applications, and Smart actuators for biological applications.

#### Biomedical Signal and Image Processing

Biomedical signals and images, neurological signal processing, cardiological signal processing, adaptive noise cancelling, and Bio-Image processing.

**Sensory Assist Devices**
Hearing aids – Implants, Optical Prosthetics, Visual Neuro-prostheses – Sonar based systems, Respiratory aids, Tactile devices for visually challenged.

**Active and Passive Prosthetic Limbs**
Introduction to prosthetics, Passive Prosthetics – walking dynamics, Knee and foot prosthesis. Active prosthesis - Control of Prosthetic Arms and Hands, Leg Mechanisms, Ankle–Foot Mechanisms, and Prosthesis Suspension.

**Wearable Mechatronics Devices Hours**

Wearable Artificial Kidney, Wireless capsule endoscope, Wearable Exoskeletal rehabilitation system, and Wearable hand rehabilitation.

**Textbook**

1. Brooker, Graham. M. (2012) Introduction to Bio-Mechatronics, Sci Tech Publishing.

**Reference books**

1. Reddy, D. C. (2005). Modern Biomedical Signal Processing: Principles and Techniques, TMH, New Delhi.
2. Cromwell, Leslie., Weibell, Fred. J., Pfeiffer, Erich. A. (2009). Bio-Medical Instrumentation and Measurements, 2nd Edition, Pearson Education.
3. Kaiyu, Raymond. Tong. (2011). Bio-mechatronics in Medicine and Healthcare‖ Pan Stanford Publishing, CRC Press.

## INDUSTRY 4.0 AND SMART MANUFACTURING

**Course Code: MH40035**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

The course aims to provide students with a comprehensive understanding of Industry 4.0 concepts, automation technologies, communication protocols, IoT platforms, and machine learning foundations. They will be able to apply this knowledge to analyze and design systems in the context of smart factories and connected business perspectives, leveraging the power of emerging technologies for improved efficiency and productivity.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to:

CO 1: Learn about automation technologies, with a focus on Programmable Logic Controllers (PLCs) and their programming software,

CO 2: Understand the concept of Industry 4.0 and its significance in the context of globalization and emerging issues,

CO 3: Articulate the concept of IoT platforms and data modeling,

CO 4: Illustrate communication protocols used in the context of Industry 4.0,

CO 5: Evaluate case studies that demonstrate the practical application of the concepts covered in the course, and

CO 6: Develop a foundation in machine learning, including various learning algorithms such as supervised, unsupervised, self-learning, and feature learning.

**COURSE DETAILS**

**Industry 4.0**

Concept, Globalization and emerging issues, The Fourth Revolution, LEAN manufacturing, Smart and connected business perspectives, and Smart factories.

**Automation**

Programmable Logic Controller (PLC) and its Programming software, Communication of different devices with PLC, Sensor, Smart Sensor, HMI design, Cyber Physical System – key components, ISA-95 architecture, CPS-5C architecture, and Concept of Digit Twin.

**Communication**

Protocols – MQTT, OPC UA, EtherNet/IP, Profinet, EtherCAT, etc, MQTT – History, MQTT broker, Message types, Quality of Service (QoS), Application; OPC UA – History, Specification, Client, Server, Programming with – Free and open-source software, Propriety software, and Augmented Reality.

**IoT Platform**

Data Modelling, IoT platforms – Thing, basic functionalities, Abstract definition of Thing, Networks, etc; IoT Gateway, Machine interfaces – Cloud-based Mosquitto brokers, Programming with – Free and open-source software and Propriety software.

**Machine Learning Foundation**

Learning algorithms – Supervised, Unsupervised, Self-learning, Feature learning, etc. Models – Artificial Neural Networks, Decision trees, Regression analysis, Genetic algorithms, etc.; Programming with – Free and open-source software, and Propriety software.

**Case Studies**

**Textbook**

1. Raj, Pethuru., Raman, Anupama. C. The Internet of Things: Enabling Technologies, Platforms, and Use Cases, CRC Press.
2. Zhang, Yingfeng., Tao, Fei. (2016). Optimization of Manufacturing Systems using the Internet of Things, Academic Press- Technology & Engineering.

**Reference books**

1. Kamal, Raj. Internet of Things: Architecture and Design, McGraw Hill.
2. Pfister, Cuno., Reilly, O. Media Getting Started with the Internet of Things.
3. Wang, K., Wang, Y., Strandhagen, J.O., Yu. T. (2016). Advanced Manufacturing and Automation V, WIT Press.

## INDUSTRIAL INTERNET OF THINGS

**Course Code: MH40036**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

In this course, students will explore the latest advancements in hardware, software, and data within the context of the Industrial Internet of Things (IIoT), they will gain valuable knowledge and insights on navigating these challenges and flourishing in this dynamic and promising field. The course provides a roadmap to the connected world of Industrial IoT, equipping students with the necessary tools and understanding to overcome obstacles and capitalize on the exciting possibilities that lie ahead.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to:

CO 1: Describe the concept and scope of the Internet of Things (IoT) and its global context, including Machine-to-Machine (M2M) communication.
CO 2: Compare popular IoT hardware platforms such as Arduino Uno, Arduino Yun, Raspberry Pi, etc.,
CO 3: Articulate communication protocols relevant to Industrial Internet of Things (IIoT),
CO 4: Illustrate Industrial IoT (IIoT) concepts, including smart factory, automation to digitalization, platforms for smart industry, and study case examples of smart industries,
CO 5: Evaluate a web development technology like HTML and JavaScript, including the Document Object Model (DOM) integration, and
CO 6. Develop practical projects in IoT.

**COURSE DETAILS**

**Introduction to IoT**
Introduction to Internet of Things, M2M towards IoT -the global context, Scope of IoT - Smart home, Smart Grid Applications, Skills required to switch career to IoT, Industries working on IoT, IoT Products

by Indian Companies, IoT Hardware Requirements, Analysis of Arduino Uno, Arduino Yun, Raspberry Pi, Beaglebone Black, Intel Edision and Galileo.

**IIOT Components**

Fundamentals of Control System, introductions, components, closed loop & open loop system.

Introduction to Sensors (Description and Working principle), Types of sensors, working principle of basic Sensors -Ultrasonic Sensor, IR sensor, MQ2, Temperature and Humidity Sensors (DHT-11), Digital switch, Electro Mechanical switches. Measurement of temperature & pressure values of the process, Modules and Sensors Interfacing (IR sensor, Ultrasonic sensors, Soil moisture sensor) using Arduino/ Raspberry pi/node mcu. Modules and Actuators Interfacing (Relay, Motor, Buzzer) using Raspberry pi/node mcu.

**Communication Technologies of IIoT**

Communication Protocols: IEEE 802.15.4, ZigBee, Z Wave, Bluetooth, BLE, NFC, RFID Industry standards communication technology (LoRAWAN, OPC UA, MQTT), connecting into existing Modbus and Profibus technology, wireless network communication, Connecting HC05 with Arduino, Sensor Data Analytics using readily available Bluetooth Terminal Android Apps, Android Controlled Device Automation with Arduino , Working with Relay & Interfacing with Arduino and Controlling AC Appliances with from PC – SMART Home Applications

**Using ESP8266 as a HTTP Client**

Uploading live sensor data on thingspeak cloud using ESP8266 & GET Request, Making a Local Webserver, Using Arduino Using Arduino as a TCP data server, Accessing UI in a local network, Analyzing HTTP callbacks in webserver, Projects and Tasks and Introduction to Transport Layer Protocols

**Industrial IoT**

Smart Factory Concept, Automation to Digitalization, Platforms for Smart Industry, Case Studies on Smart Industries, IoT based smart energy meter, Smart Agriculture system, Automation using controller via Bluetooth, Temperature Controlled Fan /Cooler Using Controller, Automatic street light, Smart Baggage Tracker and Home Appliances Control Using Blynk Application

**API Building & Integration**

Introduction to HTML, Introduction to JavaScript, Document object model integration, Making fetch calls, Introduction to Firebase Database, Making an API for Firebase and Sending data to firebase database CRUD operation with Firebase

**Textbook**

1. Zaigham, Mahmood. The Internet of Things in the Industrial Sector (Springer Publication)
2. Jeschke, Sabina. Brecher., Christian. Song. Houbing., B, Rawat, Danda. Industrial Internet of Things: Cyber-manufacturing System, (Springer Publication)

**Reference book**

1. Butun, Ismail. Industrial IoT Challenges, Design Principles, Applications, and Security.

## SCIENCE OF PUBLIC HEALTH

**Course Code: PE10002**
**Credit: 2**
**L-T-P: 2-0-0**
**Prerequisite: Nil**

### COURSE OBJECTIVE

The objective of this course is to orient the students to core scientific disciplines in public health practice.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Understand and enlist the scientific approaches in public health,
CO 2: Understand and apply the epidemiologic and biostatistical science in evidence synthesis,
CO 3: Understand and apply the environmental health science in public health practice,
CO 4: Understand and apply the social and behavioral science in public health practice,
CO 5: Understand and apply the health economic and health management principles in setting priority for resource allocation, and
CO 6: Understand and apply the health economic and health management principles in health system optimization.

### COURSE DETAILS

**Scientific Approaches to Public Health**
Health and public health concepts, Science and practice of applied public health: Scientific disciplines as part of interdisciplinary public health, Examples of use of behavioral model in changing the community perception of public health interventions.

**Social and Behavioral Sciences in Public Health**
Social and behavioral determinants of health and disease, WHO and CDC models of social determinants of health, Disease and social status, Disease and poverty, Social interventions for good health.
Health behavior change models for public health interventions, Health Belief Model, Transtheoretical Model. The theory of planned behavior, Health communication to improve the outcome of public health interventions.

**Environment Health Sciences in Public Health**
**E**nvironment & climate change, Ecosystem, Lifestyle and dietary effects on health, food safety and sanitation, Environmental pollution, waste disposal and treatment.

**Epidemiology and Data Science in Public Health**

Epidemiology and achievements in public health, Measurements in Epidemiology—Incidence and prevalence, Causation and association, and Measures of association.
Outline of study designs (including cross-sectional study design, case-control study design, cohort study design and randomized control trials); Introduction to confounding and bias; Screening tests- validity and reliability methods.

**Management and Economic Sciences in Public Health**
Systems approach (input, process and outcome) in public health. Health management information system, Horizontal and vertical integration of public health interventions, Public-Private mix.
Understanding community, Community health related needs assessment, Community orientation and Community mobilization, Introduction to digital health.

**Textbooks**


1. R Detal, Oxford Textbook of Global Public Health, Oxford, 7th Edition, 2021.
2. K Parks, Textbook of Preventive and Social Medicine, M/S Banarsidas Bhanot Publishers, . 26th Edition, 2021.


**Reference Books**


1. Robert H. Friis, Essentials of Environmental Health, Jones & Bartlett Publishers, 2018
2. Warrier S., Information and Communication Technologies in Public Health A Sociological Study, CBS Publishers, 2020.
3. Baker JJ. Baker RW, Dworkin NR, Health Care Finance: Basic Tools for Non-financial Managers, Jones and Bartlett Publishers, Inc, 5th Edition, 2017.
4. Ross TK, Practical Budgeting for Health Care: A Concise Guide, Jones and Bartlett Publishers, Inc, 2020.


## PHYSICS

**Course Code: PH10001**
**Credit: 3**
**L-T-P: 3-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

This course is designed to enrich the basic knowledge of engineering students in the field of physics and to support the engineering and research programs. The course will also help the students to develop mathematical models to understand the behavior of physical systems and phenomena.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Learn the basic concepts of oscillation, waves, wave function and fields,
CO 2: Understand the principles of wave phenomena in light and matter, and the quantum mechanics,

CO 3: Apply the principles of oscillation, superposition of waves, electromagnetic theory, and quantum mechanics in different fields,
CO 4: Analyze different types of particle motion in different media,
CO 5: Evaluate the problem-solving skills for the topics learnt, and
CO 6: Develop critical thinking ability supported by the learned concepts of Physics.

**COURSE DETAILS**

**Oscillation**
Damped Harmonic Oscillation (underdamped, overdamped and critically damped), Energy decay, Relaxation time, Quality factor, Forced oscillation, Resonance, Coupled oscillations, Applications.

**Waves and Interference**
Wave equation, Superposition of waves, Interference of light, Types of interference: Division of wavefront and division of amplitude.

**Interference in thin films**
Wedge shaped thin film, Newton's rings and their applications, Michelson interferometer, Applications.

**Diffraction**
Diffraction and its applications, Types of diffraction, Fraunhofer diffraction by a single slit, Plane diffraction grating (condition of maxima, minima), Maximum order of observable spectra, Absent spectra, and Dispersive power, Applications.

**Quantum Mechanics**
Dual nature of radiation and matter, de Broglie hypothesis for matter waves, Phase velocity and Group velocity, Heisenberg's uncertainty principle and applications, Wave function and its interpretation, Concepts of operators, Schrodinger's time-dependent and time-independent equations, Postulates of Quantum mechanics, Particle in one-dimensional box and applications, Quantum tunnelling and applications.

**Electromagnetic Theory**
Vector calculus: scalar and vector field, Gradient, divergence and curl, Line, surface and volume integrals, Gauss divergence and Stoke's theorem, Maxwell's equations in differential and integral form with necessary derivations. Electromagnetic wave equations, Transverse nature of electromagnetic waves.

**Laser and Fiber Optics**
LASER: Properties and applications, Spontaneous and stimulated emission, Meta-stable state, Population inversion, Pumping, Three and four-level Laser, Ruby Laser.

**Optical fiber**
Principle, Construction, Types of optical fiber, Acceptance angle, Numerical aperture, Applications.

**Textbook**

1. B.K. Pandey and S. Chaturvedi, Engineering Physics, Cengage Publication, New Delhi, 2$^{nd}$ Edition 2022, ISBN-13: 978-81-953536-7-5.

**Reference Books**
1. D. J. Griffiths, Introduction to Electrodynamics, Pearson Education, 4$^{th}$ Edition, 2015.

2. L.I. Schiff and J. Bandhyopadhyay, Quantum Mechanics, Tata McGraw-Hill Publications, 4th Edition, 2014, ISBN- 9781259062865.
3. A.K. Ghatak, Optics, Tata McGraw-Hill Publications, 4th Edition, 2008, ISBN: 9780070262157.
4. A. Beiser, Concepts of Modern Physics, Tata McGraw-Hill Publications, 6th Edition, 2002, ISBN 10: 0071234608.
5. R K Gaur and S. L. Gupta, Engineering Physics, Dhanpat Rai Publications, New Delhi, 2nd Edition, 2012, ISBN-10: 8189928228.

## SMART MATERIALS

**Course Code: PH10003**
**Credit: 2**
**L-T-P: 2-0-0**
**Prerequisite: Nil**

### COURSE OBJECTIVE

This course is designed with the objective of enabling engineering students to get a flavour of advances in materials science. The knowledge of smart materials learnt by the students in the course will let them to realize the usefulness of various new-age materials for technological advances and allow them to explore further in their higher semesters. This course will help them bridge the gap between traditional Textbook science put into physics, chemistry, etc. and the state-of-the-art science of materials.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Learn about smart materials, their properties and applications,
CO 2: Understand types of smart material based on their electrical and magnetic properties,
CO 3: Characterize piezoelectric, ferroelectric and multiferroic materials,
CO 4: Identify novel functions of smart materials,
CO 5: Apply the acquired knowledge of smart materials in different applications, and
CO 6: Evaluate the importance of smart materials in day-to-day life.

### COURSE DETAILS

**Introduction to Smart Materials**
common smart materials and associated stimulus-response, Classification: active and passive, Piezoelectric, Shape-memory alloys, Photo-responsive polymers, Electroactive polymers, Magnetostriction and Electro-striction, Thermo-responsive polymers, Dielectric elastomers, Halochromic, Thermoelectric materials; Application areas of smart materials: Space, health care and biomedical sectors.

**Piezoelectric Materials: Piezoelectric Effect**
Direct and Converse, Piezoelectric coefficients, Piezoceramics, Piezopolymers, Piezoelectric Materials as Sensors, Actuators etc.

**Shape-memory Alloys**

Shape memory alloys (SMAs) and properties, Phase change in SMAs, Shape memory effect: One-way and two-way, binary, and ternary alloy systems, Applications.

**Chromic Materials**

Photochromic, Thermochromic, Electrochromic, Magneto-chromic and Piezo-chromic Materials.

**Multiferroic Materials**

Multiferroics definitions, Ferroic phases, Magnetoelectric coupling; Type-I and Type-II multiferroics, Mechanism: Charge ordering, lone pair, geometric effect, and spin driven mechanism; Multiferroic materials, Applications.

**Textbook**


1. B. K. Pandey and S. Chaturvedi, Engineering Physics, Cengage Publication, New Delhi, 2$^{nd}$ Edition 2022, ISBN-13: 978-81-953536-7-5.


**Reference Books**


1. Mohsen Shahinpoor, Fundamentals of Smart Materials, 2020, Royal Society of Chemistry, ISBN: 9781782626459.
2. M. Schwartz, Smart Materials, 1$^{st}$ Edition, 2008, CRC Press, ISBN 9781420043723.


## PHYSICS LAB

**Course Code: PH19001**
**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

This lab course covers different measurement techniques of various parameters using the instruments i.e., interferometer, spectrometer, spherometer, screw gauge, vernier calliper, microscope, and telescope. It includes the application of photoelectric effect and photovoltaic effect in photo cell and solar cell respectively. Evaluation of the mechanical strength of materials by calculating elastic constants such as Young's modulus, rigidity modulus and Poisson's ratio are also included. This course provides hands on training for the usage of electrical, optical and mechanical systems for various measurements with precision and analysis of the experimental data by graphical interpretation and error calculation.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Understand the wave nature of light through experiments based on interference and diffraction phenomena,
CO 2: Apply the laws of quantum physics to understand the photoelectric emission using the particle nature of light,
CO 3: Characterize photovoltaic cells to find out efficiency in terms of power output,
CO 4: Evaluate mechanical properties of materials using their elastic properties,

CO 5: Apply the principles of optics such as refraction, total internal reflection to calculate refractive index and related parameters, and

CO 6: Use the principles of oscillation to understand phenomena such as damping, resonance and to determine the factors (such as gravity, elasticity etc) affecting the time period of various oscillators.

**COURSE DETAILS**

- Measurement by vernier callipers, screw gauge, spherometer: A review.
- Determination of wavelength (λ) of a monochromatic light by Newton's ring experiment.
- Determination of wavelength (λ) and difference (dλ) between wavelengths of sodium D-lines by Michelson's interferometer.
- Determination of grating element (e+d) of a plane diffraction grating.
- Determination of Planck's constant using photocell.
- Study of the characteristics of a photo cell.
- Study of the characteristics of a solar cell.
- Determination of Young's modulus (Y) of a material by bending of beam method.
- Determination of Poisson's ratio (σ) of rubber.
- Determination of rigidity modulus (η) of a material by dynamic method.
- Determination of refractive index (μ) of a transparent liquid by Boy's method.
- Determination of numerical aperture of optical fibre.
- Determination of acceleration due to gravity (g) by bar pendulum.
- Determination of damping coefficient, relaxation time and quality factor of damped harmonic oscillation by simple pendulum.
- Measurement of velocity of sound in air using resonance column method.
- Studies on dielectric/multi-ferroic materials (Open ended).
- Diffraction studies using Laser sources (Open ended).

**Reference Books**

1. Physics laboratory instruction manual, School of Applied Sciences, Department of Physics, KIIT Deemed to be University, Bhubaneswar.
2. S.L. Gupta and V. Kumar, 2018, Practical Physics, Pragati Prakashan, 33rd Edition, ISBN: 978-93-87151-58-1.

## THINKING PERSPECTIVES

**Course Code: PS10043**
**Credit: 2**
**L-T-P: 2-0-0**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

Cognition plays a significant role in accumulation and processing of information. This course provides an in-depth understanding of some of the cognitive processes in terms of current theories, models and applications. It helps learners to understand the importance of these cognitive processes and the rationale behind cognition, problem solving, critical thinking, and scientific thinking. It facilitates students to identify and analyze the key conceptual and theoretical frameworks underpinning cognitive process.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Understand the definition and scope of cognition, problem solving, and creativity,
CO 2: Understand the theories related to cognition, decision making, and critical thinking,
CO 3: Understand the classic and current experimental research in cognitive processes,
CO 4: Develop skills essential in designing and conducting experiments in cognition, reasoning, and problem solving,
CO 5: Understand various aspects of critical thinking, scientific thinking, and design thinking process, and
CO 6: Apply the knowledge of cognitive processes to one's own personal life and to real life issues.

**COURSE DETAILS**

**Basics of Cognition**
A Brief History, Emergence of Modern Cognitive Approach, Thinking, Basic Elements of Thought: Forming Concepts, Propositions, Images.
Reasoning, some Basics sources of error, Information-processing approach, connectionist approach, evolutionary approach, ecological approach.

**Memory Processes and Critical Thinking**
Organization of Long Term Memory, Forgetting, Retrieval and Metamemory; Proactive and Retroactive inference; Amnesia and Retrieval, Flashbulb Memory, Eyewitness Memory, Traumatic Memory, False Memories.
Phases of Critical Thinking: Intellectualization, Suggestion, Hypothesis, Reasoning, and Testing, Critical Thinking Abilities: Thinking, Observational, and Questioning and Dispositions, Critical Thinking Skills: Analysis, Communication, Creativity, Problem-solving Skills, and Open-mindedness.

**Systems Thinking and Scientific Thinking**
System Definition and Characteristics, Approaches to System Modelling, Causal-Loop Diagramming, System Archetypes, Micro world and Learning Laboratory, The Learning Organization and the Fifth Discipline, Systems Thinking Study, Examples.
Characteristics of Science: Systematic observation and experimentation, Inductive and deductive reasoning, Lessons from Scientific Thinking: Empirical Evidence, Logical Reasoning.

**Creativity and Designing Thinking**
Creative Thinking, Stages in Creative Thinking, Nature of Creative Thinking, Features of Creativity—Novelty, Originality and Usefulness, Guilford's Measure of Creativity—Fluency, Flexibility, and Originality, Barriers to Creativity, Enhancing Individual and Organizational Creativity.
Designing Thinking as a Process of Problem Solving: Defining Problems, Challenging Assumptions, Developing Concepts, identifying Alternative Strategies and Solutions, Prototyping, and Experimenting Problem Solving through Innovative Solutions, Stages of Design Thinking—Empathize, Define, Ideate, Prototype and Test.
.
**Textbooks**


1. Solso, R.L., Cognitive Psychology, Pearson Education, $6^{th}$ Edition. 2004.
2. Baron, R.A., Psychology,Pearson Education, $5^{th}$ Edition, 2002.

3. Rathus, S.A. Introductory Psychology Wadsworth Cengage, 5th Edition, 2016.
4. Ciccarelli, S. & White, N.J, Psychology 5th Edition, Pearson Education., 2017.
5. The Fifth Discipline: The Art & Practice of the Learning Organization, Cengage Publication, 2nd Edition, 2006.
6. Cross, N., Design Thinking: Understanding How Designers Think and Work, Berg Publishers.

**Reference Books**


1. Baddley, A., Human memory: Theory and practice. New York Psychology Press, 1997.
2. Treror, A., The psychology of language: From data to theory. Taylor Francis, 2002
3. Smith, E.E. & Kosslyn, Cognitive psychology: Mind and brain. Prentice Hall, 2007.
4. Tripathi, A.N. &Babu, Nandita (2008). Cognitive processes. In Misra, G. Psychology in India: Advances in Research, Vol. 1, Pearson Education.
5. Vaid, J., & Gupta, Ashum, Exploring word recognition in a semi-alphabetic script: the case of Devanagari. Brain and Language, 81, 679-690.


## CREATIVITY, INNOVATION AND ENTREPRENEURSHIP

**Course Code: PS10045**
**Credit: 2**
**L-T-P: 2-0-0**
**Prerequisite: Nil**

### COURSE OBJECTIVE

The course is designed for students who want to enhance their creative and innovative skills and apply them to prepare business plans to form entrepreneurial enterprises. More specifically, the course is designed to help students to stimulate creativity in themselves and learn the impact of innovation on growth creation and design thinking in real-world business situations. In this course, the concepts of entrepreneurship and the environment in which the entrepreneurs act will be developed along with business plans and business models for start-ups.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Describe key elements of creativity and innovation,
CO 2: understand the impact of innovation on growth creation,
CO 3: Apply creative and design thinking to real-world business situations,
CO 4: Illustrate the foundation of entrepreneurship development and its theories,
CO 5: Analyze the business plan and implement it in real field, and
CO 6: Develop business plans and business models to start entrepreneurial enterprises.

### COURSE DETAILS

**Introduction**
Definitions, Importance, and Relationships among Creativity, Innovation, and Entrepreneurship; Examples.

**Creativity**

Definitions, Importance, and Relationships among Creativity, Innovation, and Entrepreneurship; Examples, Creative Thinking and Stages of Creative Thinking, Barriers to Creativity, Enhancing Individual Creativity, Guilford's Usual Unusual Test, Psychometric Approaches to Tests of Creativity, Structured tools of Creativity (Developing Creative Focus, Exercising Mind, Setting Directions, Suspending Rules, Thinking Differently, Establishing Formatted Work Space, Stimulating Mechanisms, Utilizing Experiences.

**Innovation**

Innovation, Benefits, Keys to Successful Innovations, Types of Innovation, Barriers to Innovation, Methods of Generating Ideas, Design Thinking. Creative Problem Solving, and Measures of Innovation.

**Entrepreneurship**

Entrepreneur, Functions of an Entrepreneur, Types of Entrepreneur, Intrapreneur, Social Entrepreneur, Case Study on the Entrepreneurial Excellence of N. R. Narayan Murthy, Introduction to Agricultural, Rural, Tourism, Social and Digital Entrepreneurship, Entrepreneurial Motivational Behavior (Creativity, Self-Efficacy, Locus of Control, Risk Taking, Leadership, Communication),

Converting Ideas into Products/Services with Differentiating Features, Niche Market, Design of the Products/Services, Bootstrap Marketing, Formulation of Business Plan, Business Model, Financial Planning, and Sources of Finance.

Practical classes will be devoted to organizing practicing sessions on creativity, case study discussion sessions and market analysis sessions on generating novel ideas, and developing and presenting business plans. Students, in groups, will design a new product/service, do a bootstrap market study, develop a business plan, and make an elevator pitch.

**Textbooks**


1. Khanka, S.S., Creativity, Innovation, and Entrepreneurship, S. Chand.
2. Praveen Gupta, Business Innovation, S. Chand, 2007.


**Reference Books**


1. Barringer B.R. and R. Duane, Entrepreneurship: Successfully Launching New Ventures: Pearson Prentice Hall, Ireland, 3rd Edition 2009.
2. Duening, T.N., R.D. Hisrich, and M.A. Lechter, Technology Entrepreneurship: Taking Innovation to the Marketplace, Elsevier, Amsterdam, 2nd Edition 2015.
3. Harrington, H.J., Creativity, Innovation, and Entrepreneurship: The Only Way to Renew Your Organization, Routledge, 2019.


## K-XPLORE

### (Practice Oriented Open Elective – I)

The B. Tech. curriculum provides for a 1-Credit practice-oriented Open Elective K-Xplore in Semester V to make our undergraduate engineering programme holistic, multidisciplinary, skill-based, and balanced. This course allows the students to explore the opportunity that the KIIT University offers to them to sharpen their skills in areas which excite them the most.

Offered in a self-learning mode, this course allows the students to hone their skills in areas they are passionate about which they select from a wide spectrum of courses in art, literature, technology, community engagement and service, health, and environment and sustainability. In addition, the students develop soft skills that are important for them in their professional life. This course, thus, allows students to explore and grow in areas outside of core academics and provides a channel for complementing the lessons learned in the classroom, offering them the opportunity to apply academic skills in a real-world context and providing a truly well-rounded education.

This course is designed on the basis of the guiding philosophy of student-centered learning where the students define problems, evaluate alternatives, design solutions, and self-learn by performing certain assigned activities with limited guidance from faculty facilitators.

Each student selects an area of his (or her) choice from a specified list of areas. All the students with choice in a particular area are assigned to one or more faculty facilitators. Faculty facilitators assign the activities and tasks necessary for the course to the students and decide the desired mode of skills training. They may decide to make small groups of students of varying group sizes to carry out the assigned activities and tasks. They also make the required facilities available to the students to enable them to carry out the assigned activities and tasks.

The timetable will earmark specific hours for the course. But the students are expected to use their spare time (including holidays and after-lecture hours on working days) to learn the required skills and use these skills to accomplish the assigned activities and tasks. The students, however, have to meet the faculty supervisors on the specified hours every week to appraise them of their progress, clear their doubts, if any, and chart their future plan.

The Head of KIIT Student Activity Centre (KSAC) will coordinate offering of the course.

### COURSE OUTCOMES

After successfully completing the course, the students will be able to

CO 1: Develop the needed technical skills in their chosen fields of interest,
CO 2: Develop higher levels of self-confidence and soft skills such as communication, writing, discussion and debate, time-management, and leadership skills,
CO 3: Apply the learned skills to give shape to their passionate ideas,
CO 4: Develop Innovation and entrepreneurial mindset,
CO 5: Analyze and judge a problem situation for deploying the learnt knowledge and skills and develop problem solving strategies, and
CO 6: Build new products and services using the learned knowledge and skills.

## ROBOTICS

**Course Code: SA38001**
**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Nil**

### COURSE OBJECTIVE

To assist students, develop the knowledge of robotics and circuitry, build circuits, bots and robots, and participate in different Robotics events such as Robo Wars.

## WEB DESIGNING

**Course Code: SA38003**
**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

To help a student learn and develop front-end and back-end web development skills and create websites.

## CIVIL-TECH

**Course Code: SA38005**
**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

To make a student ready to plan and design selected aspects of real-life construction projects with relation to environment, transport & connectivity, water resource engineering & soil exploration and gain pre-, present-, and post- construction experience.

## CIRCUIT DESIGN & CONTROL

**Course Code: SA38007**

**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

To let the students, learn the required skills to design and develop electrical circuits and implement controllers for use in robotics, automation, voice recognition, gesture recognition, etc.

## INDIAN CLASSICAL, FOLK & BOLLYWOOD DANCE

**Course Code: SA38009**

**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Nil**

### COURSE OBJECTIVE

To encourage and boost the confidence of the students to choreograph and perform in classical, semi classical / folk and bollywood dance forms.

## INDIAN CLASSICAL & WESTERN MUSIC

**Course Code: SA38011**

**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Nil**

### COURSE OBJECTIVE

To give confidence to the students to participate and perform as a vocalist and/or instrumentalist in different forms of Indian classical and western music.

## GRAPHIC DESIGNING & EDITING

**Course Code: SA38013**
**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Nil**

### COURSE OBJECTIVE

To nurture the students' skills in creative designing, photo and video editing activities, and digital sketching and painting, using Designing & Editing software such as Photoshop, Illustrator and video editing software.

## ART & CRAFT

**Course Code:** **SA38015**
**Credit:** **1**
**L-T-P:** **0-0-2**
**Prerequisite:** **Nil**

**COURSE OBJECTIVE**

To endow the students with the skills to do various types of painting such as portrait painting, landscape painting, abstract painting, pencil sketching, and doodling and craft, using various Painting and Sketching tools.

## THEATRE & STREET PLAY

**Course Code:** **SA38017**
**Credit:** **1**
**L-T-P:** **0-0-2**
**Prerequisite:** **Nil**

**COURSE OBJECTIVE**

To give students the confidence to perform in Theatres, Nukkad, Mono Acts and skits based on written scripts.

## FILM MAKING

**Course Code:** **SA38019**
**Credit:** **1**
**L-T-P:** **0-0-2**
**Prerequisite:** **Nil**

**COURSE OBJECTIVE**

To impart skills for film making in areas such as cinematography, script writing, audio recording, and editing.

## DEBATING, PUBLIC SPEAKING & ANCHORING

**Course Code:** **SA38021**
**Credit:** **1**
**L-T-P:** **0-0-2**
**Prerequisite:** **Nil**

## COURSE OBJECTIVE

To develop the students' skills for performing oratory activities such as extempore speech, debate, poetry reading, open topic speech, public speaking, interviewing, open dialogue, anchoring, and presentation.

## CREATIVE WRITING

**Course Code: SA38023**
**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Nil**

## COURSE OBJECTIVE

To develop the students' skills in creative writing, content writing, article writing, and poem composition.

## PHOTOGRAPHY & VIDEOGRAPHY

**Course Code: SA38025**
**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Nil**

## COURSE OBJECTIVE

To provide the technical knowledge required to create photos and videos that tell a story or capture a real-world occurrence.

## FASHION STYLING

**Course Code: SA38027**
**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Nil**

## COURSE OBJECTIVE

To impart the basic skills of costume design, styling, grooming, and presentation relevant to a specified theme.

## CULINARY ARTS

**Course Code: SA38029**
**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

To help the students learn the skills of cooking, knowing ingredients, and preparing cuisines of Pan India and 65 countries.

## QUIZ ACTIVITY

**Course Code: SA38031**
**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

To give the students the confidence to participate in, and conduct, various forms of quiz, such as Technical Quiz and Business Quiz.

## SOCIAL OUTREACH

**Course Code: SA38033**
**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

To sensitize the students on the social issues and giving them an opportunity to connect with the community and the environment through outreach activities, community projects, and volunteering.

## HEALTH & EMERGENCY CARE

**Course Code: SA38035**
**Credit: 1**
**L-T-P: 0-0-2**
**Prerequisite: Nil**

**COURSE OBJECTIVE**

To let the students, learn about health issues, basic Life-saving skills and participate in health awareness and sensitization programs.

## SOCIO-POLITICAL ENVIRONMENT

**Course Code: SO10043**
**Credit: 2**
**L-T-P: 2-0-0**

**Prerequisite:** **Nil**

**COURSE OBJECTIVE**

The objective of this paper includes providing basic knowledge on socio-political environment of India and to equip the students with an understanding of their roles, duties, and responsibilities in a democratic set up.

**COURSE OUTCOMES**

After successfully completing the course, the students will be able to

CO 1: Understand contemporary Indian social problems,
CO 2: Understand the roles and functions of the three political institutions in our democratic setup,
CO 3: Familiarize the students with the Rights and Duties enlisted in the Indian Constitution,
CO 4: Grasp the interrelationships among political, social and economic issue,
CO 5: Visualize contemporary changes in Political Institutions, and
CO 6: Realize the importance of equity, equality, and dignity in a democratic system.

**COURSE DETAILS**

**Social Problem in India**
Meaning and Definition of Social Problems, Characteristics, Causes and Consequences, Problems of Poverty, Unemployment, Population growth, Problems ofWomen and Aged, Corruption and Nepotism, Illiteracy, Substance Abuse, and Terrorism.

**Social Stratification**

Equity and Equality, Caste, Religion, Class, Gender Discrimination, UrbanSlums.

**Political Institutions**
Meaning and Basic Concepts of PoliticalInstitutions: Legislative, Executive and Judiciary Systems of the Indian Constitution.

**Fundamental Rights and Duties**
Fundamental Rights and Duties in Indian Constitution, Directive Principles of State Policy.

**Contemporary Changes in Political Institutions**
Changing Role of the Government in Contemporary India, Role of Government in the Formation of National and International Policies and Their Impact on Business and Trade.

**Textbooks**


1. C. N. Shankar Rao, S. Chand., Indian Social Problems, S.Chand Publication, 2017.
2. M. Laxmikanth., Constitution of India, Cengage Learning, 2020.
3. Himanshu Roy & M.P Singh Indian Political System, Pearson publisher, 4th Edition, 2018.
4. Ram Ahuja, Social Problems in India, Rawat publisher, 4th Edition, 2014.

**Reference Books**


1. Our Parliament, Subhash C Kashyap, NBT, 2021.
2. Social Stratification, Dipankar Gupta (Ed), Oxford India Publication, 1997.
3. Modernisation of Indian Tradition, Yogendra Singh, Rawat Publication, 1986.

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