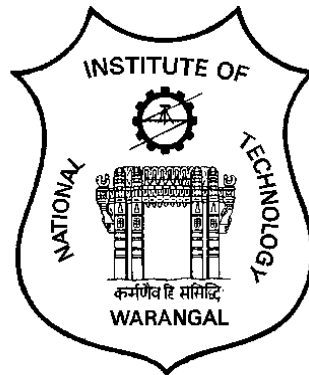


**NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL**



**RULES AND REGULATIONS  
SCHEME OF INSTRUCTION AND SYLLABI  
FOR B.TECH PROGRAM**

**Effective from 2017-18**

**DEPARTMENT OF MECHANICAL ENGINEERING**



# **NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL**

## **VISION**

Towards a global knowledge hub, striving continuously in pursuit of excellence in education, research, entrepreneurship and technological services to the society.

## **MISSION**

- Imparting total quality education to develop innovative, entrepreneurial and ethical future professionals fit for globally competitive environment.
- Allowing stake holders to share our reservoir of experience in education and knowledge for mutual enrichment in the field of technical education.
- Fostering product oriented research for establishing a self-sustaining and wealth creating centre to serve the societal needs.

## **DEPARTMENT OF MECHANICAL ENGINEERING**

### **VISION**

To be a global knowledge hub in mechanical engineering education, research, entrepreneurship and industry outreach services.

### **MISSION**

- Impart quality education and training to nurture globally competitive mechanical engineers.
- Provide vital state of the art research facilities to create, interpret, apply and disseminate knowledge.
- Develop linkages with world class educational institutions and R&D organizations for excellence in teaching, research and consultancy services.

**DEPARTMENT OF MECHANICAL ENGINEERING**  
**B.TECH IN MECHANICAL ENGINEERING**

**PROGRAM EDUCATIONAL OBJECTIVES**

<b>PEO1.</b>	Plan, design, construct, maintain and improve mechanical engineering systems that are technically sound, economically feasible and socially acceptable to enhance quality of life.
<b>PEO2.</b>	Apply analytical, computational and simulation tools & techniques to address the challenges faced in mechanical and allied engineering streams.
<b>PEO3.</b>	Communicate effectively using innovative tools and demonstrate leadership & entrepreneurial skills.
<b>PEO4.</b>	Exhibit professionalism, ethical attitude, team spirit and pursue lifelong learning to achieve career and organizational goals.

**PROGRAM ARTICULATION MATRIX**

PEO Mission Statement	PEO1	PEO2	PEO3	PEO4
Impart quality education and training to nurture globally competitive mechanical engineers	3	3	2	2
Provide vital state of the art research facilities to create, interpret, apply and disseminate knowledge	3	2	2	2
Develop linkages with world class educational institutions and R&D organizations for excellence in teaching, research and consultancy services	1	1	3	2

## PROGRAM OUTCOMES (POs):

At the end of the program, the student will be able to:

<b>PO1</b>	<b>Engineering knowledge:</b> Apply the knowledge of mathematics, science, engineering fundamentals, and mechanical engineering to the solution of complex engineering problems.
<b>PO2</b>	<b>Problem analysis:</b> Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
<b>PO3</b>	<b>Design/Development of solutions:</b> Design solutions for complex mechanical 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.
<b>PO4</b>	<b>Conduct investigations of complex problems:</b> 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.
<b>PO5</b>	<b>Modern tool usage:</b> Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex mechanical engineering activities with an understanding of the limitations.
<b>PO6</b>	<b>The engineer and society:</b> 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.
<b>PO7</b>	<b>Environment and sustainability:</b> Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
<b>PO8</b>	<b>Ethics:</b> Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
<b>PO9</b>	<b>Individual and team work:</b> Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
<b>PO10</b>	<b>Communication:</b> 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.
<b>PO11</b>	<b>Project management and Finance:</b> 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.
<b>PO12</b>	<b>Life-long learning:</b> 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 OBJECTIVES (PSOs):

<b>PSO1</b>	Apply mechanical and interdisciplinary knowledge to analyze, design and manufacture products to address the needs of the society.
<b>PSO2</b>	Apply state of the art tools and techniques to conceptualize, design and introduce new products, processes, systems and services.

## Rules and Regulations of B.Tech. Programs effective from 2017-18

**1. Introduction:** Provision of these regulations shall come into force with effect from the academic year 2017 - 2018 and shall be applicable to all B. Tech. courses (unless otherwise stated) offered by the Institute.

1.1 B.Tech. Degree Programs are offered in the following specializations by the respective engineering departments.

S No	Department	B. Tech. Program Name
1	Civil Engineering	Civil Engineering
2	Electrical Engineering	Electrical and Electronics Engineering
3	Mechanical Engineering	Mechanical Engineering
4	Electronics and Communication Engineering	Electronics and Communication Engineering
5	Metallurgical and Materials Engineering	Metallurgical and Materials Engineering
6	Chemical Engineering	Chemical Engineering
7	Computer Science and Engineering	Computer Science and Engineering
8	Biotechnology	Biotechnology

1.2 The provisions of these regulations shall be applicable to any new discipline that may be introduced from time to time.

1.3 The sanction of stipend will be as per the guidelines prescribed AICTE/MHRD from time to time.

1.4 Prescribed service courses for all the programs listed in 1.1 are supported by a) Mathematics b) Humanities and Social Sciences c) Physics d) Chemistry and e) School of Management

1.5 The provisions of these regulations shall be applicable to any new discipline that may be introduced from time to time.

## **2. Admission:**

2.1 Admission to National Institute of Technology Warangal will be made in accordance with the instructions received from the Ministry of Human Resource Development (MHRD), Government of India from time to time. Seats are reserved for candidates belonging to Scheduled Castes (SC), Schedules Tribes (ST), Other Backward Classes (OBC), Persons with Disability (PH/PWD) and other categories as per the guidelines issued by MHRD from time to time.

- 2.2 Admission to all courses will be made in the odd semester of each academic year at the first year level based on the relative performance in the Joint Entrance Examination (JEE - Mains) as per the guidelines issued by the MHRD, New Delhi from time to time. The candidates should have successfully passed the 12<sup>th</sup> class examination or equivalent with the combination of subjects prescribed by the Competent Authority.
- 2.3 A limited number of admissions are offered to Foreign Nationals and Indians living abroad in accordance with the rules applicable for such admission, from time to time, issued by MHRD.
- 2.4 If, any time after admission, it is found that a candidate had not in fact fulfilled all the requirements stipulated in the offer of admission, in any form whatsoever, including possible misinformation etc., the Dean-Academic shall report the matter to the Senate recommending for cancelling the admission of the candidate.
- 2.5 The institute reserves the right to cancel the admission of any student and ask him/her to discontinue his/her studies at any stage of his/her career on the grounds of indiscipline or any misconduct.
- 2.6 The decision of the Senate, regarding sections 2.4 and 2.5 above, is final and binding.
- 2.7 Candidates must fulfil the medical standards required for admission as prescribed in the Institute Information Brochure or the Prospectus.
- 2.8 Every Under Graduate student of the Institute shall be associated with the parent department offering the degree program that the student undergoes, throughout his/her study period.

### **3. Course Structure:**

- 3.1 The total course package for B.Tech. Degree Program typically consists of the following components.
- a) Basic Science Core (BSC)
  - b) Engineering Science Core (ESC)
  - c) Humanities and Social Science Core (HSC)
  - d) Program Core Courses (PCC)
  - e) Departmental Elective Courses (DEC)
  - f) Open Elective Courses (OPC)
  - g) Program Major Project (PRC)
  - h) EAA: Games and Sports (MDC)

Note: Open *Elective Courses* can be any of the following areas: *Basic Sciences, Engineering Science Courses, Humanities, Social Sciences and Management.*

- 3.2 Each student should have cleared, with P or better grade, at least 173 credits to be eligible for the award of the B. Tech. Degree.
- 3.3 The DAC - UG along with external members will discuss and finalize the exact credits offered for the program for the components (a) to (h) of 3.1, the semester-wise distribution among them, as well as the syllabi of all courses offered by the Department along with course outcomes of each course from time to time and recommend the same to the Senate for consideration and approval.
- 3.4 Curriculum in the first two semesters:
- 3.4.1 In the first two semesters, students of all the B.Tech. programmes will have the same curriculum.
- 3.4.2 Every student admitted in the first year is required to register and complete satisfactorily in Extra-Academic Activity (E.A.A. = Games & Sports) in the first two semesters, which is mandatory. However, the EAA does not carry any credits. Interested students can also enroll in NCC / NSS.
- 3.5 Major Project: The Major Project is a 6-credit course and is offered in the IV Year First and Second semesters. The method of evaluation may be as per the guidelines given under B.Tech.project evaluation. (See Section 10.6)
- 3.6 Minimum number of credits that a student can register in any given semester is 16. Maximum number of credits that can be registered in a semester is 30 inclusive of backlog subjects registered.

#### **4. Degree Requirements:**

The requirements for a student of B.Tech. degree program are as follows:

- (a) Credit Requirements: Minimum Earned Credit Requirements for the award of Degree is 173 with a CGPA of not less than 4.0.
- (b) The minimum duration for a student for complying with the Degree requirement is FOUR academic years from the date of first registration for his/her first semester.
- (c) The maximum duration for a student for complying with the Degree requirement is EIGHT academic years from the date of first registration for his/her first semester.

#### **5. Academic Calendar:**

The *academic year* is divided into two semesters.

The Senate shall approve the schedule of academic activities for an academic year including the dates of registration, Mid-semester and End-semester examinations. Each semester will normally be of 19

weeks, which includes End-semester examinations. It may *be* ensured that the number of ***effective teaching days in a semester is 80.***

Academic calendar declared by the Senate in the beginning of each academic year shall also fix *Festival* dates during which the co-curricular and extra-curricular programs like Technical seminars /*Spring Spree/Institute Fest* etc., are to be organized.

#### **6. Residential Requirement:**

The Institute is essentially residential and unless otherwise exempted/permitted, every student shall be required to reside in and be a boarder of one of the Halls of Residence and mess to which he/she is assigned. The rules relating to the residential requirements are given in Appendix I.

#### **7. Attendance:**

Following are the rules relating to attendance requirements:

- 7.1 Every student is expected to have 100% attendance in each subject in which he/she has registered at the beginning of the semester. However, condonation for shortage of attendance up to 20% (i.e., not lower than 80% aggregate attendance in any course) may be granted by the Head of the concerned Department.
- 7.2 Students not having the mandatory requirement of minimum 80% attendance in any course, shall not be permitted to appear for the end semester examination in that subject and is awarded "R" Grade in that course. Such student has to register for the course in which he/she has shortage of attendance, as and when the course is offered next.
- 7.3 If the period of absence is for a short duration (of not more than two weeks), application for leave shall have to be submitted to the Head of the Department concerned stating fully the reasons for the leave requested for along with supporting document(s). The Head of the Department will grant such leave. During such leave period, the student will be marked as absent. Even with this leave applied, the student must satisfy at least 80% attendance requirement to appear for end semester examination.
- 7.4 If the period of absence exceeds two weeks, a prior application for grant of leave will have to be submitted through the Head of the Department to the Dean-Academic with supporting documents. The decision to grant such leave shall be taken by the Dean-Academic, after considering the recommendation of the Head of the Department, if the aggregate attendance is at least 80%.



- 7.5 A resident student must take prior permission from the corresponding warden before proceeding on leave. Failing to do so will be construed as breach of discipline and will be dealt with as per provisions.
- 7.6 A student representing the Institute in approved extracurricular activities such as Sports, Games, Cultural meets, Seminar, Workshop, Conference and Interview arranged through Training & Placement Department, NCC/ NSS Camps shall be considered as on-duty subject to a maximum of five working days in a semester. Prior permission from competent authority is required for availing on-duty permission. The period of absence can be counted as present for the computation of percentage of attendance at the end of semester.
- 7.7 Attendance for both theory and laboratory courses shall be entered before the end of each working week by the concerned faculty through faculty portal of the Institute website. Students are advised to monitor the status of their attendance through student portal of the Institute website.

## **8. Registration:**

- 8.1 Every student is required to be present and register at the commencement of each semester on the day(s) fixed for and notified in the Academic Calendar.
- 8.2 Percentage attendance for all students will be counted from the date of commencement of the semester, irrespective of his/her date of registration. However, in case of I Year I Semester, attendance will be counted from date of admission into the Institute or date of commencement of class work, whichever is later.
- 8.3 Registration for all courses in the first two semesters is organized centrally.
- 8.4 From the third semester onwards, the registration will be organized at the respective Department under the supervision of the Head of the Department.
- 8.5 A student who does not register on the day announced for the purpose may be permitted, in consideration of any compelling reason, late registration within the next week on payment of additional late fee as prescribed by the Institute from time to time. Normally no late registration shall be permitted after one week from the scheduled date.
- 8.6 After registration in each semester, each student should collect a registration sheet, which indicates the courses registered by him/her in that semester, signed by the faculty advisor. The student should carry this registration sheet for all the examinations in that semester. This sheet serves the purpose of hall ticket for appearing for the examinations in that semester.
- 8.7 If a student finds his/her load heavy in any semester, or for any other valid reason, he/she can drop some courses within three weeks from the commencement of the class work in the semester with

the written approval of his/her Faculty Advisor and Head of the Department, with an intimation to Dean-Academic.

- 8.8 Only those students will be permitted to register who have
- Cleared all the Institute and Hostel dues of the previous semesters,
  - Paid all required fees for the current semester, and
  - Not been debarred from registering for a specified period on disciplinary or any other ground.
- 8.9 A Student can register for a backlog subject whenever it is offered. His/her previous marks/grades are cancelled and will have to attend all classes and examinations as and when they are conducted. Major changes in the time table shall not be entertained to accommodate backlog students. Alternatively, a student can appear for make-up examination in the backlog subject as and when it is conducted. In such a case, the student shall be awarded only P grade, if he/she gets 35% or more marks in the makeup examination.
- 8.10 A student must register the backlog courses first giving priority to the oldest backlogs. The students will register by default for backlog courses being offered in a particular semester. The maximum credits (including backlog students) that a student can register in a semester is 30.

## 9. Evaluation - Grading System:

- 9.1 As a measure of student's performance an 8-scale grading system using the following letter grades and corresponding grade points per credit shall be followed. Grading will be done based on the total marks obtained by the student in that subject.

<b>Letter Grade</b>	<b>S</b>	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>	<b>E</b>	<b>P</b>	<b>F</b>
<b>Grade Point</b>	<b>10</b>	<b>9</b>	<b>8</b>	<b>7</b>	<b>6</b>	<b>5</b>	<b>4</b>	<b>0</b>

*Relative grading scheme shall be followed for all the UG Programs.*

### The norms for the award of the letter grade are as follows:

- No student can be awarded *P* or better grade without securing at least **35%** aggregate marks in any course.
- It is also mandatory that the student should secure at least 35% marks in the End Semester examination in the course for award of "*P*" or better Grade.
- The class average is calculated by excluding the marks obtained by "*F*" grade students.

- Further, there shall be four transitional grading symbols, which can be used by the examiners to indicate the special position of a student in the subject.
  - **I**: for "Incomplete assessment", when the student misses the End-semester examination on Medical grounds (see rule 11.6).
  - **R**: for 'Insufficient attendance' in the course (see Rule 7.2).
  - **W**: for "Temporary withdrawal" from the Institute (see rule 14).
  - **X**: for "Debarred" on grounds of indiscipline/ malpractices in examinations (See rule 16).

9.2 A semester Grade Point Average (SGPA) will be computed for each semester. The SGPA will be calculated as follows:

$$SGPA = \frac{\sum_1^n C_i GP_i}{\sum_1^n C_i}$$

where  $C_i$  is Credits for the course,  $GP_i$  is the grade point obtained for the course and  $n$  is Number of subjects registered in the Semester.

9.3 Starting from I Year II Semester a Cumulative Grade Point Average (CGPA) will be computed for every student at the end of every semester. The CGPA would give the Cumulative performance of the student from the first semester up to the end of the semester to which it refers and calculated as follows.

$$CGPA = \frac{\sum_1^n S_i C_i}{\sum_1^n C_i}$$

where  $n$  is the total number of Semesters under consideration,  $C_i$  is the total number of Credits Registered during a particular Semester and  $S_i$  is the SGPA of the Semester.

9.4 The CGPA, SGPA and the grades obtained in all the subjects in a semester will be communicated to every student at the end of every semester excepting IV year II semester. In its place a consolidated grade sheet (with 173 credits) is issued. This consolidated grade sheet supersedes all the earlier grade sheets.

9.5 Both SGPA and CGPA will be rounded off to the second place of decimal and recorded as such. Whenever these grade point averages are to be used for the purpose of determining the inter-semester merit ranking of a group of students, only the rounded off values will be used.

9.6 Transitional Grades:

**(a) About Grade I:** When a student gets "I" Grade for any subject(s) during a semester, the SGPA of that semester and the CGPA at the end of that semester will be tentatively calculated ignoring this (these) subjects. After these transitional grades have been converted to appropriate grades,

the SGPA for the semester and CGPA at the end of the semester will be recalculated after taking into account the new grades.

**(b) About grades R, W and X:** When a student gets any of these transitional grades in any subject(s) during a semester, the SGPA of that semester and the CGPA at the end of that semester will be tentatively calculated by taking 'zero point' for these subject(s). After these transitional grades have been converted to appropriate grades, the SGPA for the semester and CGPA at the end of the semester will be recalculated after taking into account the new grades.

**(c) About Grade F:** When a student gets the "F" grade in any subject during a semester, the SGPA and the CGPA from that semester onwards will be tentatively calculated, taking only 'zero point' for each such "F" grade. After the "F" grade has been substituted by better grades during a subsequent semester, the SGPA and CGPA of all these semesters starting from the earliest semester in which the "F" grade has been updated, will be recomputed and recorded to take this change of grade into account.

9.7 Students registering for makeup examination shall be awarded only "P" grade, if they get 35% or more marks in the makeup examination.

#### **10. Assessment of Academic Performance:**

10.1 There will be continuous assessment of a student's performance through class tests/ quizzes/ Assignments etc. throughout the semester and grades will be awarded by the subject teacher/co-ordination committee formed for this purpose (see Academic Committees)

10.2 Each theory subject in a semester is evaluated for 100 marks, with the following weightages.

<b>Sub-component</b>	<b>Weightage</b>
Class tests/ Quizzes/ Assignment etc.	20 marks
Mid-semester Examination	30 marks
End-semester Examination	50 marks

10.3 The mid-semester examination will be conducted after 7 or 8 weeks of instruction.

10.4 The mode and nature of the evaluation and the corresponding weightages, for the subcomponent (a) shall be intimated to the students at the beginning of the semester along with the lecture schedule.

10.5 Each laboratory course in a semester is evaluated for 100 marks, with the following weightages:

<b>Sub-component</b>	<b>Weightage</b>
Continuous evaluation	60 marks
End Semester examination	40 marks

The marks for continuous evaluation may be distributed among various components like class work performance, Lab records, Quizzes, skill tests/ assignments/ mini projects. This is to be informed to students and supervisor before commencement of the dissertation work by the Faculty Advisor.

10.6 The B.Tech. project work will be evaluated for 100 marks, with the following weightages:

<b>Sub-component</b>	<b>Weightage</b>
Periodic evaluation by Guide	40 marks
Midterm review	20 marks
End Semester viva-voce examination	40 marks

The midterm review and the end semester viva-voce examination will be conducted by a committee constituted by the Head of the Department. If the performance of a student is not satisfactory, he/ she can be awarded “F” grade. Such a student will be given a maximum time of three months to improve his/her performance. If the performance of such a student is not satisfactory even after the extended time period, he/ she will have to repeat the project work in the next academic year.

The Departments have to evolve rubrics for evaluation of Project work. The marks may be distributed among various components like selection of topic, problem statement, literature review, methodology, oral and written presentation of the work done and performance in viva-voce examination.

The project work will commence in IV year I semester and will be for a duration of two semesters. The final evaluation of the project work will be done at the end of second semester and the grade for project will be given at the end of second semester.

## **11 Mid-Semester and end-Semester Exams:**

11.1 The Mid-Semester and the End-semester examinations in respect of theory courses will be conducted centrally by the examination section as per the schedule.

11.2 Head of the Department sends the list of courses registered by each student for the semester along with percentage of attendance.

11.3 Class tests, surprise tests, assignments, quizzes, viva-voce, laboratory assignments etc. are the constituent components of continuous assessment process, and a student must undergo the continuous assessment process as prescribed by the teacher/coordination committee of the subject. If due to any compelling reason (such as his/her illness, calamity in the family etc.) a student fails to meet any of the requirements within/on the scheduled date and time, the

teacher/coordination committee in consultation with the concerned Head of the Department may take such steps (including the conduct of compensatory tests/examinations) as are deemed fit.

- 11.4 If a student fails to appear for the mid semester examination in any subject(s) due to compelling reason like serious illness of himself/herself which necessitates hospitalization (with intimation to the medical officer) or a calamity in the family, he/she shall apply immediately to Dean-Academic, along with relevant certificates and duly recommended by the respective Head of the Department, within one week after completion of the examinations. All such cases will be scrutinized by a committee and approved list of candidates shall be permitted for a re-examination and the period of re-examination and syllabus shall be notified by the Dean- Academic.
- 11.5 Appearing in the end-semester examination in the theory and laboratory subjects is mandatory for a student. Unless exempted as stated below, if a student fails to appear for the end-semester examination, he/she shall be awarded “F” grade in the subject. He/She can be permitted to appear for the makeup examinations to be conducted later, as announced in the academic calendar.
- 11.6 However, if a student misses the end-semester examinations due to a compelling reason like **serious illness of himself/herself which necessitates hospitalization or a calamity in the family**, he/she may appeal to the Dean-Academic before commencement of examination through his/her Head of the Department and Institute Medical Officer for permitting himself/herself to appear in the subsequent examination(s), when conducted next. A committee consisting of the following members may, after examining the documents and being convinced about the merit of the case, recommend permitting him/her to appear in the subsequent re-examination(s), when conducted next, condoning his / her absence. In such cases, transitory grade “I” is temporarily awarded to the student in the subject.

**Sub-committee:**

Dean-Academic, Chairman.

Dean, Students Welfare

Concerned Head of the Department

The Institute Medical officer

Associate Dean, Examinations (Convener)

- 11.7 Students will be permitted to appear in the examinations in only those subjects for which they have registered at the beginning of the semester.
- 11.8 The final grades awarded to the students in a subject must be submitted by the teacher/Chairman, Coordination committee, within five working days from the date of the last examination to the concerned Head of the Department. The Head of the Department shall place

the grades of students in all subjects before the DAC-UG for its consideration and recommendation. The grades recommended by the DAC-UG shall be sent to the Examination section.

- 11.9 Any change of grade of a student in a subject consequent upon detection of any genuine error of omission and/or commission on part of the concerned teacher must be recommended by the DAC-UG and shall be forwarded by the teacher/Chairman, Coordination Committee, through the Head of the concerned Department within 20 (twenty) days from the commencement of the next semester.
- 11.10 As a process of learning by students and also to ensure transparency, the answer scripts after correction of class tests, mid-semester examinations, assignments etc., will be shown to the students within two weeks from the date of test/examination. The teacher/ Chairman, Coordination Committee must submit the marks obtained in mid-semester examinations to the Head of the Department two weeks after the end of mid-semester examinations. The marks obtained in class tests/ minor tests held till that date also need to be submitted to the Head of the Department. The performance of the students in these examinations will be discussed in the Class Review Committee.
- 11.11 In order to ensure transparency in the evaluation of scripts of end-semester examination, those answer scripts also shall be shown to the students up to one day before the finalization of grades in the DAC-UG. Once the Grades are finalized by DAC-UG, the student will no longer have any right to verify his/her answer scripts.
- 11.12 The student can appeal to DAAC for any arbitration within 20 days from the date of official publication of results in the Institute Website.
- 11.13 A student of the B.Tech. degree program must complete the prescribed course work with a minimum requirement of 173 credits within a maximum period of eight years starting from registration of I year I Sem.
- 11.14 A student who has passed all the courses without securing *R*, *X*, or *F* Grades during the period of study and with a **CGPA of 8.5 and above** is considered eligible for the award of First Division with Distinction.
- 11.15 A student failing to satisfy Rule 11.14, even if he/she gets a **CGPA of 8.5** or more will be eligible for the award of First Division only.
- 11.16 A student with a CGPA of 6.5 and above but less than 8.5 is considered eligible for the award of First Division.

- 11.17 A student with a CGPA of 5.0 and above but less than 6.5 is considered eligible for the award of Second Division.
- 11.18 A student with a CGPA of 4.0 and above but less than 5.0 is considered eligible for the award of Pass Division.
- 11.19 The valued answer scripts shall be preserved for a maximum period of 6 months after publication of results. The teachers are required to send the valued answer scripts of both mid semester and end semester examinations to the examination section to preserve them.
- 11.20 Examination record of all students shall be maintained in both soft and hard copy form in the academic section.

## **12 Makeup Examination:**

Students appearing in Makeup examination shall be governed by the following rules:

- 12.1 Students with “R”Grade in any subject are not eligible for writing the makeup examination for that subject.
- 12.2 Students with “F”or “I”Grade only are eligible to write makeup examination. In the case of a student who has got “I”grade, the marks obtained by the student in continuous evaluation and mid-semester examination will be added to the marks obtained in makeup examination and will be graded as per the grading used for his/ her class. In the case of a student who has obtained “F”grade in regular examination, he/ she will be awarded only “P” grade if he or she get 35% or more in the makeup examination. A student will be given only one chance to write the makeup examination. If he/she gets “F” grade in the makeup examination, he/she has to repeat the course whenever it is offered.
- 12.3 Makeup examination is offered only once in an academic year.
- 12.4 A student who has obtained “F”grade in makeup examination has to register for the course whenever it is offered.
- 12.5 The schedule for makeup examination is given in the Academic calendar.
- 12.6 A student can register for makeup examinations in any number of courses.

## **13 Summer Quarter:**

- 13.1 Students who have obtained “F”grade in first year courses can register for summer quarter up to a maximum of 3 courses on payment of registration fees at prescribed rates. Students with “R” grade are not eligible to register for Summer Quarter. A course will run during summer provided a



faculty member is available for running the course and a minimum of 5 students are registered for the course. The Summer Quarter typically runs for 8 weeks, during May-July.

**13.2** The total number of contact hours for the courses remains the same as that during the regular semesters, and therefore the courses run at accelerated pace. The evaluation and grading patterns also remain the same as during the regular semesters.

#### **14 Temporary Withdrawal from The Institute:**

14.1 A student who has been admitted to an undergraduate degree course of the institute may be permitted to withdraw temporarily for a period of one semester or more from the Institute on grounds of prolonged illness or acute problem in the family, which compelled him/her to stay at home, provided that

- He/she applies to the Institute within 15 days of the commencement of the Semester or from the date he/she last attended his/her classes whichever is later, stating fully the reasons for such withdrawal together with supporting documents and endorsement of the parent/guardian.
- The Institute is satisfied that, including the period of withdrawal, the student is likely to complete his/her requirements for the degree within the time limits specified in clause 11.13.
- There are no outstanding dues against him/her or demands from him/her in the Institute/Hostel/Department/Library/NCC etc.

14.2 A student, who has been granted temporary withdrawal from the Institute under the above provisions will be awarded “W” grade. He will be required to pay the tuition fees and other essential fees/charges for the intervening period till such time as his/her name is borne on the Roll list.

14.3 A student will be granted only one such temporary withdrawal during his/her tenure as a student of the Institute.

#### **15. Conduct and Discipline:**

Students shall conduct themselves within and outside the precincts of the institute in a manner befitting the students of an Institute of National importance. Detailed rules regarding conduct and discipline are given in Appendix-II.

#### **16. Malpractices:**

Students are not allowed to leave the Examination Hall without submitting the answer script. They will not be permitted to enter the examination hall after 30 minutes of commencement of the examination and to leave the examination hall before 30 minutes of the closure of examination.

The nature of malpractice and the minimum punishment are indicated in the following table:

Sl. No	Nature of the Malpractice	Punishment
1	Taking out, used or unused answer booklets outside the examination room.	Fine of Rs. 1000/- per paper. In case of used answer booklets, in addition to the above, the candidate shall be awarded an "F" Grade in that subject.
2	Verbal or oral communication with neighboring students after one warning.	Taking away the answer script and asking the student to leave the hall.
3	<p>Possession of any incriminating material inside the examination hall (whether used or not) For Example: written or printed materials, bits, writings on scale, calculator, hand kerchief, dress, part of the body and hall ticket etc.,</p> <p>Possession of cell phones, programmable calculator, recording apparatus or any unauthorized electronic equipment.</p> <p>Copying from neighbor.</p> <p>Exchange of question papers and other materials with some answers.</p>	<p>In case of Mid/Sessional examination, award zero marks.</p> <p>In case of End semester examinations, award "F" Grade. The candidate may be allowed to write make-up examination.</p>
4	<p>Possession of answer book of another candidate.</p> <p>Giving answer book to another candidate.</p>	The candidate shall be awarded zero marks in that examination and he/she shall be awarded "F" Grade in that particular subject.
5	<p>Misbehavior in the examination hall (unruly conduct, threatening the invigilator, or any other examination officials).</p> <p>Repeated involvement in malpractices 2 to 4 above.</p>	Cancellation of all theory examinations registered in that semester and further debaring from continuing his/her studies for one year (two subsequent semesters). However such student may be permitted to appear for makeup examinations of the previous semesters.
6	Cases of impersonation	<p>Handing over the impersonator (outsider) to the police with a complaint to take appropriate action.</p> <p>Cancelation of all examinations (all papers registered) for the bonafide student for whom the impersonation was done and further the bonafide student will be debarred from continuing his/her studies and writing all examinations for two years.</p> <p>If a student of this institute is found to impersonate a bonafide student, the impersonating student will be debarred from</p>

		continuing his/her studies and writing all examinations for two years.
7	Physical assault causing injury to the invigilator or any examination officials.	Rustication from the Institute.

For any other type of malpractices reported, The Malpractice and Disciplinary Action Committee (Academic) may recommend appropriate punishment.

#### **17. Certificate Retention Fee:**

Students will be charged with Certificate retention fees as per the details shown below:

All students -

- Who have passed in current and previous academic year - No charge
- Who have passed in the last 2 to 10 academic years - Rs. 1,000
- Who have passed in the last 11 to 20 academic years - Rs. 5,000
- Who have passed more than 20 academic years back - Rs. 10,000

#### **18. Student Appraisal:**

It is mandatory for every student to submit the feedback on each and every course, he/she has undergone, at the end of every semester. Results will be withheld for those students who have not submitted the feedback. All such students have to a) pay a fine of Rs. 500/-, b) obtain permission from Dean - Academic and c) fill the feedback for viewing the withheld result.

#### **19. Change of Regulations:**

Notwithstanding all that has been stated above, the Senate, has the right to modify any of the above rules and regulations from time to time. All such modifications shall be documented and numbered sequentially and shall be made available in the Institute website.

## APPENDIX-I

### RULES RELATING TO RESIDENTIAL REQUIREMENT

1. All the students are normally expected to stay in the hostels and be a boarder of one of the messes.
2. Under special circumstances, the Director/Dean-Academic may permit a student to reside with his parent(s) within a reasonable distance from the institute. However, this permission may be withdrawn at the discretion of the Institute at any time considered appropriate without assigning any reason.
3. Married accommodation shall not be provided to any student of the undergraduate courses.
4. No student shall come into or give up the assigned accommodation in any Hall of residence without prior permission of the Chief Warden.
5. A student shall reside in a room allotted to him/her and may shift to any other only under the direction/permission of the Chief Warden.
6. Students shall be required to make their rooms available whenever required for inspection, repairs, maintenance or disinfecting and shall vacate the rooms when leaving for the vacation/holidays.
7. Students shall be responsible for the proper care of the furniture; fan and other fittings in the rooms allotted to them and shall generally assist the Warden in ensuring proper use, care and security of those provided in the Halls for common use of all students.
8. Students will be responsible for the safe keeping of their own property. In the event of loss of any personal property of a student due to theft, fire or any other cause the Institute shall accept no responsibility and shall not be liable for payment of any compensation.
9. Engaging personal attendants, keeping pets and use of appliances like electric heater, refrigerator, etc. by a student in Halls of Residence are prohibited.
10. All students must abide by the rules and regulations of the Halls of Residence as may be framed from time to time.
11. **It is mandatory for all ICCR students to stay in the Hostels.**

## APPENDIX-II

### STUDENTS' CONDUCT AND DISCIPLINARY CODE

It is the responsibility and duty of each and every student of the Institute to become acquainted with "Students Conduct and Disciplinary Code". It is presumed that every student from the date of his/her admission to the Institute has knowledge of this code. All students are required to strictly adhere to this code as a condition of their admission to the Institute and these rules would be binding on and enforceable against them or any one among them.

#### **Section 1: Responsibilities of the Students**

It shall be the responsibility of the students

- i) To behave and conduct themselves in the Institute campus, hostels and premises in a dignified and courteous manner and show due respect to the authorities, employees and elders.
- ii) To follow decent and formal dressing manners. Students should avoid clothing depicting illegal drugs, alcohol, profane language, racial, sexual and vulgar captions etc.
- iii) To access all educational opportunities and benefits available at the Institute and make good use of them to prosper academically and develop scientific temper.
- iv) To respect the laws of the country, human rights and to conduct in a responsible and dignified manner at all times.
- v) To report any violation of this Code to the functionaries under this Code.

#### **Section 2: Behavior of the Students**

- i) Groupism of any kind that would distort the harmony is not permitted.
- ii) Students are expected to spend their free time in the Library. They shall not loiter along the verandas or crowd in front of the offices or the campus roads. Students should refrain from sitting on places such as parapets, stairs, footpaths etc.
- iii) Possession or consumption of narcotic drugs and other intoxicating substances are strictly prohibited in the campus and hostels.
- iv) Silence shall be maintained in the premises of the Institute.
- v) Students are not permitted to use mobile phones in the class room, library, computer center, examination halls, etc.
- vi) **Students shall refrain from all activities considered as ragging which is a criminal offence.**

- vii) Students are prohibited from indulging in anti-institutional, anti-national, antisocial, communal, immoral or political expressions and activities within the campus and hostels.
- viii) Politically based students' and other organizations or outfits are not allowed in the campus. Students are strictly prohibited from organizing, attending or participating in any activity or agitation sponsored by politically based organizations.
- ix) Students shall not deface, disfigure, damage or destroy or cause any loss in any manner to all the public, private or Institute properties.
- x) Without specific permission of the authorities, students shall not bring outsiders to the Institute or hostels.
- xi) No one shall bring, distribute or circulate unauthorized notices, pamphlets, leaflets etc within the campus or hostels. The possession, distribution or exhibition of any item by any means which is *per se* obscene is prohibited within the campus or on any property owned/ managed by the Institute.
- xii) No student shall collect money either by request or by coercion from others within the campus or hostels.
- xiii) The Institute being a place of learning and an exclusive academic zone, nobody shall respond to any call for any form of strike, procession or agitation including slogan shouting, *dharna*, *gherao*, burning of effigy or indulge in anything which may harm the peaceful atmosphere of the Institution and shall eschew from violence in the campus and hostels and even outside.
- xiv) Possession or usage of weapons, explosives or anything that causes injury/ damage to the life and limb or body of any human being or property is prohibited.
- xv) **Use of motorized vehicles within the Institute premises is strictly prohibited.**
- xvi) Students shall only use the waste bins for dispensing waste materials within the campus including classrooms, hostels, offices, canteen and messes.
- xvii) Any conduct which leads to lowering of the esteem of the Institute is prohibited.
- xviii) **Any unauthorized tour/visit by individual or group of students shall be treated as a serious conduct violation and all such students will be imposed disciplinary penalties.**

### **Section 3: Disciplinary Sanctions**

Any student exhibiting prohibited behavior mentioned in this Code shall, depending upon the gravity of the misconduct or depending on its recurrence, be subjected to any of the following disciplinary sanctions. Any student who is persistently insubordinate, who is repeatedly or wilfully mischievous, who

is guilty of fraud, in the opinion of the competent authority, is likely to have an unwholesome influence on his/ her fellow students, will be removed from the rolls.

### **I. Minor Sanctions**

- i. *Warning or Reprimand:* This is the least sanction envisaged in this Code. The student engaged in any prohibited behavior will be issued a warning letter.
- ii. *Tendering Apology:* The student engaged in any prohibited behavior may be asked to tender an apology for his/her act and undertaking that he/she shall not indulge in such or any of the prohibited behavior in future.

### **II. Major Sanctions**

- i. *Debarring from Examinations:* A student/group of students may be debarred from writing all/any/some of the examinations, which forms part of the academic program for which he/she/they has/ have joined.
- ii. *Suspension:* A student may be suspended from the Institute for violation of any of the provisions of this Code. The period of suspension and conditions, if any, shall be clearly indicated in the communication addressed to the student. The student shall lose his/her attendance for the suspended period.
- iii. *Restitution:* Restitution implies reimbursement in terms of money and/or services to compensate for personal injury or loss, damage/disfiguration to property of the Institute or any property kept in the premises of the Institute in any manner. The students/group of students may be asked to compensate for the loss that has been caused to any person or property of the Institute or any property kept in the premises of the Institute due to the act of vandalism perpetrated by the students. The students/group of students shall also be liable to put in their service to restore any loss or damage caused to any property and thereby bringing it to its original form if it is possible.
- iv. *Forfeiture:* Caution deposit of any student engaged in any prohibited behavior shall be forfeited.
- v. *Expulsion:* This is the extreme form of disciplinary action and shall be resorted to only in cases where stringent action is warranted. Expulsion is the permanent dismissal of a student from the Institute. Such a student will not be eligible for readmission to any of the courses of this Institute.

### **Section 4: Functionaries under the Code**

- i. **Heads of the Departments/ Faculty Advisors/Chief Warden/ Wardens of Hostels:** As the persons in charge of the Departments/Hostels, the respective functionaries of all Teaching Departments and Hostels shall have the power and duty to take immediate action to curb any

prohibited behavior as envisaged under this code. As these functionaries cannot single handedly manage all the issues, they can assign part of the work to the teachers and the teachers of all the departments/wardens have the responsibility to inform any incident of prohibited behavior to the Heads of the Departments/ Chief Warden so that any serious issue can be settled before the same goes out of control. The Head of the Departments/ Chief Warden shall have the power to impose minor sanctions as envisaged under section 3(I) of this Code.

They can also recommend imposition of major sanctions as envisaged under Section 3(II) of this Code to the Director. The Head of the Departments/ Faculty Advisors/Chief Warden/ Wardens of Hostels while taking any action as envisaged in the code shall do so in an impartial manner and see to it that the sanction imposed/proposed is commensurate with the gravity of the prohibited behavior. Any lapse on the part of a teacher/ Warden to report any instance of violence and misconduct on the part of the students shall be reported to the Director by the respective Head of the Departments/Chief Warden. The Wardens of Hostels shall be responsible for maintaining strict discipline and decorum in the hostel. He/she shall specifically see to it that the inmates of the hostel do not involve themselves in violation of any clause under Section 2 of this Code.

- ii. **Deans:** Any authority of the Institute with delegated powers shall have the power to visit/inspect any premises, buildings or any property of the Institute when there is a genuine doubt that any act of prohibited behavior is taking place and can take any lawful actions to curb such behavior. The HODs/ Faculty Advisors/Chief Warden/ Wardens of Hostels shall report to the Dean (Students) any instances of prohibited behavior, who in turn shall bring it to the notice of the Director. The Dean (Students) shall forward the recommendations from the HODs/ Chief Warden to impose a major sanction under Section 3(II) of this Code to the Director after noting his observations. The Dean (Student Welfare) can also *suo moto* recommend action against any student/students indulging in prohibited behavior which is brought to his/ her notice.
- iii. **Director:** The Director shall be the ultimate authority in imposing major sanctions as envisaged under Section 3(II) against the students for acts of prohibited behavior. The Director can also entertain any appeal from any student/students aggrieved by the action of any authority of the Institute under or subordinate to the Director and decide the case on merit.

### **Section 5: Right to Appeal**

The student/students aggrieved by the action of any authority of the Institute under or subordinate to the Director can appeal to the Director and any student aggrieved by the action of the Director can appeal to the Senate. The decision of the Senate shall be final and binding on the students.



**Section 6: Assistance from Law Enforcement Agencies**

The Deans/ HoDs/ Chief Warden shall have the power and duty to call the Police immediately with the concurrence of the Director when there is a threat of Law and Order situation in the Campus and also when there is a genuine apprehension that any incident of rioting, vandalism or any other act prohibited by law is likely to take place. The Deans/ HoDs/ Chief Warden shall in such a case give a detailed report to the Director. The Director/ Deans/ HoDs/ Chief Warden can also arrange for video recording of the entire situation and take requisite actions through police and other concerned authorities.

**Section 7: Grievance Redressal Committee**

The Institute will also set up "Grievance Redressal Committee" where the students can air their grievances. The Committee shall consist of the Deans/ HoDs/ Chief Warden and also members of the Parent-Teacher Association. Till these committees are constituted, *ad-hoc* committees shall be formed by the Director.

**Section 8: Undertaking by the Students**

The students joining any academic program of the Institute will have to give an undertaking to the effect that he/she will comply with the provisions envisaged in this Code in letter and spirit and even if it is not given them as well, will be bound by the provisions of this Code.

**Section 9: Opportunity for Hearing**

No order other than the order suspending or warning a student shall be passed without giving an opportunity of hearing to the Student/ Students.

**Section 10: Ultimate Authority**

For all disciplinary matters related to students, the Director shall be the ultimate authority as provided herein.

**Section 11: Amendments to the Code**

The Senate of the Institute shall have the power to amend any of the provisions in this Code. The amendments shall be brought to the notice of the students and faculty of the Institute through notice put on the Institute web site, notice boards of the Institute or through emails.

## ACADEMIC COMMITTEES: FUNCTIONS AND RESPONSIBILITIES

### 1. DEPARTMENTAL ACADEMIC COMMITTEE -UG (DAC-UG)

- a) The Head of the Department will nominate one of the members as secretary.
- b) There shall be one DAC-UG for every department that is involved in the teaching for the B.Tech. programme.
- c) There shall be one DAC-UG for each of the basic science and Humanities and Social Science Departments.
- d) The Chairman may co-opt and/or invite more members including external experts while framing the curriculum/or revising the curriculum

Constitution guidelines	Functions
<p><i>Chairman:</i> Head of the Department</p> <p><i>Members:</i> All professors and Associate Professors having Ph.D., and Two Assistant professors having Ph.D on rotation basis for two years.</p>	<ol style="list-style-type: none"> <li>a) To monitor the conduct of all undergraduate courses offered by the Department and course work of undergraduate program.</li> <li>b) To ensure academic standards and excellence of the courses offered by the department.</li> <li>c) Review and Recommend the grades to senate for approval.</li> <li>d) To consolidate the registration of the students and communicate to the course instructor and Dean-Academic.</li> <li>e) To consider any matter related to the undergraduate program(s) of the Department.</li> <li>f) To take up any responsibility or function assigned by the Senate or the Chairman of the Senate or Chairman of DAC-UG.</li> <li>g) To report the cases of malpractices to the Malpractices and Disciplinary Action Committee.</li> </ol>

### 2. CLASS REVIEW COMMITTEE (CRC)

- a) Every Class (group of students registered for a course and taking the course together in a section/class) of the UG Program shall have a Class Review Committee, consisting of Faculty and Students.
- b) Tenure: One Semester

Constitution guidelines	Functions
<p><i>Chairman:</i> Head of the Department / One Senior Faculty of the Department concerned, preferably not associated with teaching of the</p>	<ol style="list-style-type: none"> <li>a) The Class Committees shall meet at least twice in a semester, once after four to six weeks after the commencement of class work and once after two weeks after the mid semester examinations.</li> </ol>

<p>class, to be nominated by the Head of the Department concerned.  <i>Members:</i> All teachers of the class, Six students, to be chosen by the students of the class from amongst themselves  <i>Convener/Secretary:</i> Faculty advisor of the class.</p>	<p>b) The basic responsibilities of the Class Review Committee are to review periodically the progress of the classes, to discuss problems concerning curriculum and syllabi and the conduct of the classes.</p> <p>c) The class review committee will do a mid-semester review of the performance of the class work two weeks after the mid-semester examinations. The committee will review the performance of the class in mid semester and other exams conducted till that date.</p> <p>d) Each Class Review Committee will communicate its recommendations to the Head of the Department / DAC-UG of the parent teaching department.</p> <p>e) The minutes of each Class Review. Committee meeting shall be recorded in a separate minutes register maintained in the parent/teaching department.</p> <p>f) Any appropriate responsibility or function assigned by the DAC-UG or the chairman of the DAC-UG.</p>
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### 3. DEPARTMENTAL ACADEMIC APPEALS COMMITTEE (DAAC)

- a) There shall be one DAAC for every department.
- b) The Chairman may co-opt and / or invite more members.
- c) If the concerned instructor is a member of DAAC then he/she shall keep himself out of the Committee during deliberations.
- d) The quorum for each meeting shall be a minimum of THREE (Professor from outside department is mandatory)

<b>Constitution guidelines</b>	<b>Functions</b>
<p><i>Chairman:</i> Head of the Department  <i>Members:</i> Three faculty members of the Department Consisting of 1 Professor, 1 Associate Professor and 1 Asst. Professor.  <i>Nominee:</i> One Professor from outside the Department nominated by Dean-Academic</p>	<p>a) To receive grievance /complaints in writing from the students regarding anomaly in award of grades due to bias, victimization, erratic evaluation, etc. and redress the complaints.</p> <p>b) To interact with the concerned course instructor and the student separately before taking the decision.</p> <p>c) The decision of the DAAC will be based on simple majority</p> <p>d) The recommendations of the DAAC shall be communicated to the Dean-Academic for further appropriate action as required.</p>

#### 4. COURSE COORDINATION COMMITTEE (CCC)

5.

- a) CCC would be constituted for each subject taught by more than one teacher of one or more Departments/Centers.
- b) Validity : One semester
- c) Frequency of meetings: At least 4 times in semester
- d)

Constitution guidelines	Functions
<p><i>Chairman:</i> Nominated by the Head of the department from the constituted list of members</p> <p><i>Members:</i> All the teachers who are involved with the teaching of the Subject during the semester.</p>	<ul style="list-style-type: none"> <li>a) To plan the lecture schedule for the subject</li> <li>b) To coordinate instruction and progress of teaching in the subject and to ensure that the full syllabus is covered.</li> <li>c) To set the question papers jointly.</li> <li>d) To review periodically the performance of students who have registered in the subject.</li> <li>e) To forward the results of the examinations and the final grades obtained by each student.</li> </ul>

#### 6. DEPARTMENTAL BOARD OF STUDIES (UG)

- a) All the members must possess Ph. D.
- b) The Chairman will nominate one of the members as secretary.
- c) The Chairman may co-opt and / or invite more members including external experts while framing / revising the curriculum
- d)

Constitution guidelines	Functions
<p><i>Chairman:</i> Head of the department</p> <p><i>Members:</i> All professors and Associate Professors having Ph.D., One professor from allied department, one external expert each from Industry and Academia</p>	<ul style="list-style-type: none"> <li>a) To develop the curriculum for the postgraduate courses offered by the department and recommend the same to the Senate.</li> <li>b) The Board of studies is required to meet at least once in two years.</li> </ul>

## 7. ACADEMIC AUDIT COMMITTEE - DEPARTMENT (AACD)

The duration of the members of the committee will be two years

Constitution guidelines	Functions
<i>Chairman:</i> Professor nominated by Director <i>Members:</i> One Department Nominee <i>Convener:</i> Head of the Department	a) To review the internal audit reports submitted by faculty b) To recommend corrective measures, if any. c) To send a consolidated report to Academic Audit Committee - Institute

## 8. ACADEMIC AUDIT COMMITTEE - INSTITUTE (AACI)

The members of the duration of the committee is TWO years

Constitution guidelines	Functions
<i>Chairman:</i> Director <i>Members:</i> Dean (Academic), Two professors nominated by Director	a) To review the recommendations of AACD of each department b) To initiate appropriate measures (counseling/ training etc.).

## 9. MENTOR (FACULTY ADVISOR)

- a) Specific number of students will be assigned of the concerned department
- b) The students will have the same faculty advisor throughout their duration of study

Constitution guidelines	Functions
Faculty Advisors will be appointed by the Head of the Department and.	a) To help the Students in planning their courses and activities during study. b) To guide, advice and counsel the students on academic program.

## 10. MALPRACTICE AND DISCIPLINARY ACTION COMMITTEE

Constitution guidelines	Functions
<i>Chairman:</i> Dean(Academic) <i>Members:</i> Dean(Student Welfare), Concerned Head of the Department, Invigilator(s), Associate Dean(Exams) <i>Convener:</i> Associate Dean (Exams)	a) To recommend appropriate punishment.

## CURRICULAR COMPONENTS

### Degree Requirements for B. Tech in Mechanical Engineering

<b>Category of Courses</b>	<b>Credits Offered</b>	<b>Min. credits to be earned</b>
Basic Science Core (BSC)	<b>22</b>	<b>22</b>
Engineering Science Core (ESC)	<b>27</b>	<b>27</b>
Humanities and Social Science Core (HSC)	<b>06</b>	<b>06</b>
Program Core Courses (PCC)	<b>91</b>	<b>91</b>
Departmental Elective Courses (DEC)	<b>15+6</b>	<b>15</b>
Open Elective Courses (OPC)	<b>06</b>	<b>06</b>
Program Major Project (PRC)	<b>06</b>	<b>06</b>
Mandatory Audit Course	<b>00</b>	<b>00</b>
EAA: Games and Sports (MDC)	<b>00</b>	<b>00</b>
<b>Total</b>	<b>173+6</b>	<b>173</b>

## SCHEME OF INSTRUCTION

### B.Tech. (Mechanical Engineering) Course Structure

#### I - Year

<b>Physics Cycle</b>				
<b>Code No.</b>	<b>Subject</b>	<b>No. of Credits</b>	<b>L -T-P</b>	<b>Cat. Code</b>
MA101	Mathematics - I	03	3-0-0	<i>BSC</i>
HS101	English for Technical Communication	03	2-0-2	<i>HSC</i>
PH101	Physics	03	3-0-0	<i>BSC</i>
EC101	Basic Electronic Engineering	03	3-0-0	<i>ESC</i>
CE102	Environmental Science and Engineering	02	2-0-0	<i>ESC</i>
BT101	Engineering biology	02	2-0-0	<i>ESC</i>
CS101	Problem Solving & Computer Programming	05	3-1-2	<i>ESC</i>
PH102	Physics Laboratory	02	0-1-2	<i>BSC</i>
EA101	EAA: Games and Sports	00	0-0-3	<i>MDC</i>
	<b>Total</b>	<b>23</b>	<b>29</b>	

<b>Chemistry Cycle</b>				
<b>Code No.</b>	<b>Subject</b>	<b>No. of Credits</b>	<b>L -T- P</b>	<b>Cat. Code</b>
MA151	Mathematics - II	03	3-0-0	<i>BSC</i>
ME101	Basic Mechanical Engineering	03	3-0-0	<i>ESC</i>
CY101	Chemistry	03	3-0-0	<i>BSC</i>
EE101	Basic Electrical Engineering	03	3-0-0	<i>ESC</i>
CE101	Engineering Mechanics	03	3-0-0	<i>ESC</i>
ME102	Engineering Graphics	04	1-1-4	<i>ESC</i>
ME103	Workshop Practice	02	0-1-2	<i>ESC</i>
CY102	Chemistry Laboratory	02	0-1-2	<i>BSC</i>
EA151	EAA: Games and Sports	00	0-0-3	<i>MDC</i>
	<b>Total</b>	<b>23</b>	<b>30</b>	

**II - Year: I - Semester**

<b>S. No.</b>	<b>Course Code</b>	<b>Course Title</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>Credits</b>	<b>Cat. Code</b>
1	MA236	Transformation Techniques	3	0	0	3	BSC
2	MM235	Materials Engineering	3	0	0	3	PCC
3	CE235	Fluid Mechanics and Hydraulic Machines	3	1	0	4	PCC
4	CE236	Mechanics of Solids	3	1	0	4	PCC
5	ME201	Thermodynamics	3	1	0	4	PCC
6	ME202	Kinematics of Machinery	3	1	0	4	PCC
7	CE237	Fluid Mechanics and Hydraulics Machines Laboratory	0	1	2	2	PCC
8	CE238	Materials Testing Laboratory	0	1	2	2	PCC
		<b>TOTAL</b>	<b>18</b>	<b>6</b>	<b>4</b>	<b>26</b>	

**II - Year: II - Semester**

<b>S. No.</b>	<b>Course Code</b>	<b>Course Title</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>Credits</b>	<b>Cat. Code</b>
1	MA261	Numerical and Statistical Methods	3	0	0	3	BSC
2	ME251	Dynamics of Machinery	3	1	0	4	PCC
3	ME252	Turbomachines	3	0	0	3	PCC
4	ME253	Manufacturing Science	3	1	0	4	PCC
5	ME254	Geometric Modeling for CAD	3	0	0	3	PCC
6	ME255	Computer Aided Machine Drawing	1	0	4	3	PCC
7	ME256	Manufacturing Processes Laboratory	0	1	2	2	PCC
8	ME257	Kinematics and Dynamics Laboratory	0	1	2	2	PCC
		<b>TOTAL</b>	<b>16</b>	<b>4</b>	<b>8</b>	<b>24</b>	



**III - Year: I - Semester**

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	ME301	Design of Machine Elements	3	0	0	3	PCC
2	ME302	Prime movers for Automobiles	3	0	0	3	PCC
3	ME303	Machine tools and Metrology	3	1	0	4	PCC
4	ME304	Mechanical Measurements	3	0	0	3	PCC
5	ME305	Management Science and Productivity	4	0	0	4	PCC
6		Department Elective I	3	0	0	3	DEC
7	ME306	Thermal Engineering Laboratory	0	1	2	2	PCC
8	ME307	Machining and Metrology laboratory	0	1	2	2	PCC
9	EP349	EPICS	0	0	0	2*	
		<b>TOTAL</b>	<b>19</b>	<b>3</b>	<b>4</b>	<b>24</b>	

\*Credits are not considered for computation of SGPA and CGPA

**III - Year: II - Semester**

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	ME351	Design of Transmission Elements	3	1	0	4	PCC
2	ME352	Heat and Mass Transfer	3	1	0	4	PCC
3	ME353	Machining Science	3	0	0	3	PCC
4	ME354	Mechatronics	3	0	0	3	PCC
5		Department Elective II	3	0	0	3	DEC
6		Open Elective I	3	0	0	3	OPC
7	ME355	Heat Transfer and Fuels Laboratory	0	1	2	2	PCC
8	ME356	Measurements Lab	0	0	2	1	PCC
9	EP399	EPICS	0	0	0	2*	
		<b>TOTAL</b>	<b>18</b>	<b>3</b>	<b>4</b>	<b>23</b>	

\*Credits are not considered for computation of SGPA and CGPA



**IV - Year: I - Semester**

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	SM413	Engineering Economics and Accountancy	3	0	0	3	HSC
2	ME401	Refrigeration and Air-conditioning	3	0	0	3	PCC
3	ME402	Computer Aided Manufacturing	3	0	0	3	PCC
4		Open Elective II	3	0	0	3	OPC
5		Department Elective III	3	0	0	3	DEC
6	ME403	CAE Lab	0	0	2	1	PCC
7	ME404	CAM Lab	0	0	2	1	PCC
8	ME405	Mechatronics Lab	0	0	2	1	PCC
9	ME449	Project Work - Part A	0	0	4	2	PCC
		<b>TOTAL</b>	<b>15</b>	<b>0</b>	<b>10</b>	<b>20</b>	

**IV - Year: II - Semester**

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1		Department Elective IV	3	0	0	3	DEC
2		Department Elective V	3	0	0	3	DEC
3		Department Elective VI	3	0	0	3	DEC
4		Department Elective VII	3	0	0	3	DEC
5	ME451	Mandatory Audit Course (Self Study)*	0	0	0	0	MDC
6	ME499	Project Work - Part B	0	0	8	4	PRC
		<b>TOTAL</b>	<b>12</b>	<b>0</b>	<b>8</b>	<b>16</b>	

*\* The result of the Mandatory Audit Course (Self Study) completed by the student either in 6<sup>th</sup> or 7<sup>th</sup> semester will be reported in this semester*

## List of Department Electives

### III Year I Semester

#### Elective-1

- ME311 Mechanical Vibrations
- ME312 Design Optimization Methods
- ME313 Advanced Thermodynamics
- ME314 Gas Dynamics
- ME315 Advanced Welding Technology
- ME316 Advanced Metal Casting

### III Year II Semester

#### Elective-2

- ME361 Finite Element Method
- ME362 Theory of Elasticity
- ME363 Computational Fluid Dynamics
- ME364 Automobile Engineering
- ME365 Non-Destructive Testing
- ME366 Operations Research
- ME367 Production Planning and Control
- ME368 Design and Analysis of Experiments

### IV Year I Semester

#### Elective-3

- ME411 Condition Monitoring
- ME412 Tribology
- ME413 Non-conventional Energy Sources
- ME414 Advanced IC Engines
- ME415 Tool design
- ME416 Theory of Plasticity
- ME417 Total Quality Management
- ME418 Entrepreneurship

## **IV Year II Semester**

### **Electives - 4, 5, 6 and 7**

- ME461 Robotics
- ME462 Rotor Dynamics
- ME463 Engineering Acoustics
- ME464 Mechanics of Composite Materials
- ME465 Innovative Design
- ME466 Convective Heat Transfer
- ME467 Alternate Fuels
- ME468 Jet Propulsion and Rocketry
- ME469 HVAC
- ME470 Cryogenics
- ME471 Micro-scale Heat Transfer
- ME472 Power Plant Engineering
- ME473 Combustion
- ME474 Advanced Metal forming
- ME475 Machine Tool Design
- ME476 Micro and Nano Manufacturing
- ME477 Design for Manufacturing and Assembly
- ME478 Design and Analysis of Engineering Materials
- ME479 Additive Manufacturing
- ME480 Industrial Automation
- ME481 Advanced Operations Research
- ME482 Supply Chain Management
- ME483 Project Management
- ME484 Reliability Engineering
- ME485 Theory of Constraints
- ME486 Advanced Materials Processing

**List of Open Electives**  
**(Offered to Other Department Students)**

**III Year: II Semester**

ME390 Automotive Mechanics

ME391 New Venture Creation

**IV Year: I Semester**

ME440 Alternate Sources of Energy

ME441 Robust Design

**Mandatory Audit Course (Self Study)**

*Student is required to complete at least one course offered by the following agencies. The student is required to take prior approval from the Department, before registering for any course. The student can register for such a course either in 6<sup>th</sup> Semester or 7<sup>th</sup> semester. Unless the student submits a pass certificate, he/she shall not be eligible for the award of degree.*

ASME: American Society of Mechanical Engineer Certification Program - [www.asme.org](http://www.asme.org)

SWAYAM: [www.swayam.gov.in](http://www.swayam.gov.in)

NPTEL: [www.onlinecourse.nptel.ac.in](http://www.onlinecourse.nptel.ac.in)

Course Era: [www.coursera.org](http://www.coursera.org)

Free Online Courses: [www.edx.org](http://www.edx.org)

MIT Open Course ware: [www.ocw.mit.edu](http://www.ocw.mit.edu)

**Points to be noted:**

1. Definition of Pre-requisite: The student should have studied that subject which is mentioned as Pre-requisite.
2. Course with same name but with different code number indicates that the subject pertains to different departments and also the syllabus is different.
3. EPICS (Engineering Project in Community Service) Project is offered in two parts as Part-A in III Year I Semester and Part-B in III Year II semester, with Two credits each. The credits earned are not counted for Computation of SGPA and CGPA. The course is not mandatory. It is Optional. Interested students can take it.
4. In first year syllabus, Engineering Biology is included in Physics cycle and Basic Mechanical Engineering is included in Chemistry cycle. This is with effect from 2018-2019 onwards.

## DETAILED SYLLABUS

<b>MA101</b>	<b>MATHEMATICS - I</b>	<b>BSC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the students will be able to

<b>CO1</b>	Solve the consistent system of linear equations
<b>CO2</b>	Apply orthogonal and congruent transformations to a quadratic form
<b>CO3</b>	Determine the power series expansion of a given function
<b>CO4</b>	Find the maxima and minima of multivariable functions
<b>CO5</b>	Solve arbitrary order linear differential equations with constant coefficients
<b>CO6</b>	Apply the concepts in solving physical problems arising in engineering

**Course Articulation Matrix:**

CO \ PO	PO												PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	3	3	1	2	1	-	-	-	-	-	-	-	2	-
<b>CO2</b>	3	3	1	2	1	-	-	-	-	-	-	-	2	-
<b>CO3</b>	3	3	1	2	1	-	-	-	-	-	-	-	2	-
<b>CO4</b>	3	3	1	2	1	-	-	-	-	-	-	-	2	-
<b>CO5</b>	3	3	1	2	1	-	-	-	-	-	-	-	2	-
<b>CO6</b>	3	3	1	3	1	-	-	-	-	-	-	-	3	-

**Detailed Syllabus:**

**Matrix Theory:** Linear dependence and independence of vectors; Rank of a matrix; Consistency of the system of linear equations; Eigen values and eigenvectors of a matrix; Caley-Hamilton theorem and its applications; Reduction to diagonal form; Reduction of a quadratic form to canonical form - orthogonal transformation and congruent transformation; Properties of complex matrices - Hermitian, skew-Hermitian and Unitary matrices.

**Differential Calculus:** Taylor's theorem with remainders; Taylor's and Maclaurin's expansions; Asymptotes; Curvature; Curve tracing; Functions of several variables - partial differentiation; total differentiation; Euler's theorem and generalization; Change of variables - Jacobians; maxima and minima of functions of several variables (2 and 3 variables) - Lagrange's method of multipliers.

**Ordinary Differential Equations:** Geometric interpretation of solutions of first order ODE  $y' = f(x, y)$ ; Exact differential equations; integrating factors; orthogonal trajectories; Higher order linear differential equations with constant coefficients - homogeneous and non-homogeneous; Euler and Cauchy's differential equations; Method of variation of parameters; System of linear differential equations; applications in physical problems - forced oscillations, electric circuits, etc.

**Reading:**

1. R. K. Jain and S. R. K. Iyengar, Advanced Engineering Mathematics, Narosa Publishing House, 5<sup>th</sup> Edition, 2016.
2. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons, 8<sup>th</sup> Edition, 2015.
3. B. S. Grewal, Higher Engineering Mathematics, Khanna Publications, 2015.



<b>HS101</b>	<b>ENGLISH FOR TECHNICAL COMMUNICATION</b>	<b>HSC</b>	<b>2-0-2</b>	<b>3 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the students will be able to:

<b>CO1</b>	Understand and learn the nuances of paragraph writing and sample different types of paragraphs that are commonly used; learn to write an effective paragraph using devices of coherence and cohesion; Understand the meaning of idioms and phrasal verbs and use them in context; learn to use sentences unambiguously.
<b>CO2</b>	Learn to construct an effective résumé and cover letter ; learn the finer points and dos and don'ts of résumé writing
<b>CO3</b>	Master the skills and sub skills of reading ; use strategies for reading effectively: skimming, scanning, mapping; Learn to analyze vocabulary through contextual clues, word parts, analogies; demonstrate the ability to employ a range of critical reading skills
<b>CO4</b>	Learn the importance and use of reported speech in a wide range of contexts; use active and passive voice in engineering and scientific contexts when compiling lab reports, project reports, writing technical papers, etc.
<b>CO5</b>	Learn the structure and format of technical reports; distinguish technical reports from other types of reports such as business reports, analytical reports, progress reports, etc. learn to write technical reports on a variety of topics
<b>CO6</b>	Learn to interpret graphs of various kinds and pie charts and diagrams; learn to use terms of comparison and contrast when interpreting charts, bar diagrams and graphs

**Course Articulation Matrix:**

CO \ PO	PO												PSO1	PSO2
	PO 1	PO2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12		
<b>CO1</b>	-	-	-	-	-	1	-	-	-	3	-	1	-	-
<b>CO2</b>	-	-	-	-	-	1	-	-	-	3	-	1	-	-
<b>CO3</b>	-	-	-	-	-	1	-	-	-	3	-	1	-	-
<b>CO4</b>	-	-	-	-	-	1	-	-	-	3	-	1	-	-
<b>CO5</b>	-	-	-	-	-	1	-	-	-	3	-	1	-	-
<b>CO6</b>	-	-	-	-	-	1	-	-	-	3	-	1	-	-

## Detailed Syllabus:

1. **Grammar Principles** (Correction of sentences, Concord) and Vocabulary Building (synonyms and antonyms): Idioms and Phrasal verbs--patterns of use and suggestions for effective employment in varied contexts
2. **Effective Sentence Construction** - strategies for bringing variety and clarity in sentences- removing ambiguity - editing long sentences for brevity and clarity
3. **Reported speech**- contexts for use of reported speech - its impact on audiences and readers- active and passive voice- reasons for preference for passive voice in scientific English
4. **Paragraph-writing**: Definition of paragraph and types- features of a good paragraph - unity of theme- coherence- linking devices- direction- patterns of development.
5. **Note-making** - definition- the need for note-making - its benefits - various note formats- like tree diagram, block or list notes, tables, etc.
6. **Letter-Writing**: Its importance in the context of other channels of communication- qualities of effective letters-types -personal, official, letters for various purposes- emphasis on letter of application for jobs - cover letter and resume types -examples and exercises
7. **Reading techniques**: Definition- Skills and sub-skills of reading- Skimming and Scanning - their uses and purposes- examples and exercises.
8. **Reading Comprehension** - reading silently and with understanding- process of comprehension- types of comprehension questions.
9. **Features of Technical English** - description of technical objects and process- Report-Writing- definition- purpose -types- structure- formal and informal reports- stages in developing report- proposal, progress and final reports-examples and exercises
10. **Book Reviews**- Oral and written review of a chosen novel/play/movie- focus on appropriate vocabulary and structure - language items like special vocabulary and idioms used

## Language laboratory

1. **English Sound System** -vowels, consonants, Diphthongs, phonetic symbols- using dictionary to decode phonetic transcription-- Received Pronunciation, its value and relevance- transcription of exercises
2. **Stress and Intonation** -word and sentence stress - their role and importance in spoken English- Intonation in spoken English -definition, patterns of intonation- -falling, rising, etc.-use of intonation in daily life-exercises
3. Introducing oneself in formal and social contexts- Role plays- their uses in developing fluency and communication in general.

4. **Oral presentation** - definition- occasions- structure- qualities of a good presentation with emphasis on body language and use of visual aids.
5. **Listening Comprehension** -Challenges in listening, good listening traits, some standard listening tests- practice and exercises.
6. **Debate/ Group Discussions**-concepts, types, Do's and don'ts- intensive practice.

**Reading:**

1. English for Engineers and Technologists (Combined Edition, Vol. 1 and 2), Orient Blackswan, 2006.
2. Ashraf, M Rizvi. Effective Technical Communication. Tata McGraw-Hill, 2006.
3. Meenakshi Raman and Sangeetha Sharma, Technical Communication: Principles and Practice 2nd Edition, Oxford University Press, 2011.

**Software:**

1. Clear Pronunciation - Part-1 *Learn to Speak English*.
2. Clear Pronunciation - Part-2 *Speak Clearly with Confidence*
3. Study Skills
4. English Pronunciation

<b>PH101</b>	<b>PHYSICS</b>	<b>BSC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the students will be able to:

<b>CO1</b>	Solve engineering problems using the concepts of wave and particle nature of radiant energy.
<b>CO2</b>	Understand the use of lasers as light sources for low and high energy applications
<b>CO3</b>	Understand the nature and characteristics of new Materials for engineering applications.
<b>CO4</b>	Apply the concepts of light propagation in optical fibers, light wave communication systems, holography and for sensing physical parameters.
<b>CO5</b>	Apply the knowledge of Solar PV cells for choice of materials in efficient alternate energy generation.

**Course Articulation Matrix:**

CO \ PO	PO													
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
<b>CO1</b>	3	3	1	1	-	-	-	-	-	-	-	-	3	1
<b>CO2</b>	3	3	1	1	-	-	-	-	-	-	-	-	2	-
<b>CO3</b>	3	3	1	1	-	-	-	-	-	-	-	-	2	-
<b>CO4</b>	3	3	1	1	-	-	-	-	-	-	-	-	3	1
<b>CO5</b>	3	3	1	1	-	-	-	-	-	-	-	-	3	1

**Detailed Syllabus:**

**Quantum Mechanics:** Concepts and Experiments that led to the discovery of Quantum Nature. Heisenberg uncertainty principle; Schrodinger time independent and time dependent wave equations, The free particle problem - Particle in an infinite and finite potential well, Quantum mechanical tunneling. MB, BE and FD distributions.

Wave and Quantum Optics:

**Interference and Diffraction:** Concept of interference and working of Fabry-perot Interferometer and its application as wavelength filter. Multiple beam diffraction and Working of diffraction Gratings, Application of Grating as wavelength splitter.

**Polarization Devices:** Principles, Working and applications of Wave Plates, Half Shade Polarimeter, Polaroscope, Isolators and Liquid Crystal Displays.

**Lasers:** Basic theory of Laser, Concept of population inversion and Construction and working of He-Ne, Nd-YAG, CO<sub>2</sub> Lasers, LED, White light LED, Semiconductor Laser, Holography and NDT.

**Optical Fibers:** Structure, Types, Features, Light guiding mechanism and applications in Communications and Sensing.

**Solar Cells:** Solar spectrum, photovoltaic effect, materials, structure and working principle, I-V characteristics, power conversion efficiency, quantum efficiency, emerging PV technologies, applications.

**Magnetic and Dielectric Materials:**

*Magnetic Materials and Superconductors:* Introduction - Weiss Theory of Ferromagnetism - Properties - Domains - Curie Transition - Hard and soft magnetic materials - Spinel Ferrites - Structure - Classification - Applications - Meissner effect - Type-I and Type-II Superconductors - Applications.

*Dielectric Materials:* Introduction to Dielectrics, Dielectric constant - Polarizability - Properties and types of insulating materials - Polarization mechanisms in dielectrics(Qualitative) - Frequency and temperature dependence of polarization - Dielectric loss Clausius-Mossotti Equation(Qualitative)- dielectric Breakdown - Applications.

**Functional and Nano Materials:**

*Functional Materials:* Fiber reinforced plastics, fiber reinforced metals, surface acoustic wave materials, Bio-materials, high temperature materials and smart materials - Properties and applications.

*Nano materials:* Introduction, classification, properties, different methods of preparation and applications.

**Reading:**

1. Halliday, Resnic and Walker, Fundamentals of Physics, John Wiley, 9<sup>th</sup> Edition, 2011.
2. Beiser A, Concepts of Modern Physics, McGraw Hill International, 5<sup>th</sup> Edition, 2003.
3. Ajoy Ghatak, Optics, Tata McGraw Hill, 5<sup>th</sup> Edition, 2012.
4. S.O. Pillai, Solid State Physics, New Age Publishers, 2015.

EC101	BASIC ELECTRONIC ENGINEERING	ESC	3-0-0	3 Credits
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the students will be able to

CO1	Comprehend the characteristics of semiconductor devices, and operational amplifiers
CO2	Understand the principles of working of amplifiers
CO3	Understand and design of simple combinational and basics of sequential logic circuits
CO4	Understand the principles of electronic measuring instruments and Transducers
CO5	Understand the basic principles of electronic communication

**Course Articulation Matrix:**

CO \ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	3	3	1	-	-	1	-	-	-	-	-	-	3	-
CO2	3	3	1	-	-	1	-	-	-	-	-	-	2	-
CO3	3	3	1	-	-	1	-	-	-	-	-	-	2	-
CO4	3	3	1	-	-	1	-	-	-	-	-	-	2	-
CO5	3	3	1	-	-	1	-	-	-	-	-	-	2	-

**Detailed Syllabus:**

**Electronics Systems:** Introduction to electronics, review of p-n junction operation, diode applications, Zener diode as regulator.

**Transistor and applications:** Introduction to transistors, BJT Characteristics, biasing and applications, simple RC coupled amplifier and frequency response. FET and MOSFET characteristics and applications.

**Feedback in Electronic Systems:** open loop and closed loop systems, Negative and positive Feedback, merits and demerits, Principles of LC and RC oscillators.

Integrated Circuits: Operational amplifiers - characteristics and linear applications

**Digital Circuits:** Number systems and logic gates, Combinational Logic circuits, Flip-Flops, counters and shift registers, data converters, Analog to Digital and Digital to Analog converters (ADC/DAC's), Introduction to microprocessors and microcontrollers.

Laboratory measuring instruments: principles of digital multi-meters, Cathode ray oscilloscopes (CRO's).

**Electronics Instrumentation:** Measurement, Sensors, principles of LVDT, strain gauge and thermocouples. Introduction to data acquisition system.

**Principles of Communication:** Need for Modulation, Definitions of various Modulation and Demodulation techniques, AM radio transmitter and receiver, brief understanding of FM and mobile communications.

**Reading:**

1. Bhargava N. N., D C Kulshreshtha and S C Gupta, Basic Electronics & Linear Circuits, Tata McGraw Hill, 2<sup>nd</sup> Edition, 2013.
2. Malvino and Brown, Digital Computer electronics, McGraw Hill, 3<sup>rd</sup> Edition, 1993.
3. Keneddy and Davis, Electronic Communication Systems, McGraw Hill, 4<sup>th</sup> Edition, 1999.
4. Helfrick and Cooper, Modern Electronic Instrumentation and Measurement Techniques, Prentice Hall India, 2011.
5. Salivahanan, N Suresh Kumar, Electronic Devices and circuits, McGraw Hill publications, 3<sup>rd</sup> Edition, 2012.
6. Neil Storey, Electronics A Systems Approach, Pearson Education Publishing Company Pvt. Ltd, 4<sup>th</sup> Edition, 2009.

<b>CE102</b>	<b>ENVIRONMENTAL SCIENCE AND ENGINEERING</b>	<b>ESC</b>	<b>2-0-0</b>	<b>2 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the students will be able to:

<b>CO1</b>	Identify environmental problems arising due to engineering and technological activities and the science behind those problems.
<b>CO2</b>	Estimate the population - economic growth, energy requirement and demand.
<b>CO3</b>	Analyze material balance for different environmental systems.
<b>CO4</b>	Realize the importance of ecosystem and biodiversity for maintaining ecological balance.
<b>CO5</b>	Identify the major pollutants and abatement devices for environmental management and sustainable development

**Course Articulation Matrix:**

CO \ PO	PO													
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS01	PS02
<b>CO1</b>	3	3	3	-	-	2	3	1	-	-	-	-	2	-
<b>CO2</b>	3	3	3	-	-	2	3	1	-	-	-	-	2	-
<b>CO3</b>	3	3	3	-	-	2	3	1	-	-	-	-	2	-
<b>CO4</b>	3	3	3	-	-	2	3	1	-	-	-	-	2	2
<b>CO5</b>	3	3	3	-	-	2	3	1	-	-	-	-	2	-

**Detailed Syllabus:**

**Introduction to Environmental Science:** Environment and society, major environmental issues: Ozone layer depletion, Acid rains, global climate change etc, sustainable development, Environmental impact assessment, environmental management

**Natural Resources Utilization and its Impacts:** Energy, minerals, water and land resources, Resource consumption, population dynamics, urbanization.



**Ecology and Biodiversity:** Energy flow in ecosystem, food chain, nutrient cycles, eutrofication, value of biodiversity, biodiversity at global, national and local levels, threats for biodiversity, conservation of biodiversity

**Water Pollution:** Sources, types of pollutants and their effects, water quality issues, contaminant transport, self-purification capacity of streams and water bodies, water quality standards, principles of water and wastewater treatment.

**Air Pollution:** Sources, classification and their effects, Air quality standards, dispersion of pollutants, control of air pollution, automobile pollution and its control.

**Solid Waste Management:** Sources and characteristics of solid waste, effects, Collection and transfer system, disposal methods

**Reading:**

1. G.B. Masters, Introduction to Environmental Engineering and Science, Pearson Education, 2013.
2. Gerard Kiely, Environmental Engineering, McGraw Hill Education Pvt Ltd, Special Indian Edition, 2007.
3. W P Cunningham, M A Cunningham, Principles of Environmental Science, Inquiry and Applications, Tata McGraw Hill, 8th Edition, 2016.
4. M. Chandrasekhar, Environmental science, Hi Tech Publishers, 2009.

<b>BT101</b>	<b>ENGINEERING BIOLOGY</b>	<b>ESC</b>	<b>2 - 0 - 0</b>	<b>2 Credits</b>
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**Pre-requisites:** Nil.

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Realize the significance of biomolecules for sustaining life
<b>CO2</b>	Identify the difference between unicellular to multi-cellular organisms
<b>CO3</b>	Understand heredity, variation and central dogma of life
<b>CO4</b>	Analyze and understand the concepts of biology for engineering the cell

**Course Articulation Matrix:**

CO \ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
	<b>CO1</b>	2	3	3	1	-	-	-	-	-	-	-	-	1
<b>CO2</b>	2	3	3	1	-	-	-	-	-	-	-	-	1	-
<b>CO3</b>	2	3	3	1	-	-	-	-	-	-	-	-	1	-
<b>CO4</b>	2	3	3	1	-	-	-	-	-	-	-	-	1	-

**Detailed Syllabus:**

**Molecules of life, water and carbon** - chemical basis of life, protein structure and function, nucleic acids and the RNA world, carbohydrates, lipids, membranes and first cells.

**Cell structure and function**, inside the cell, cell-cell Interactions, cellular respiration and fermentation, photosynthesis, cell cycle, biological signal transduction.

**Gene structure and expression**, Mitosis, Meiosis, Mendel and the gene, DNA and the gene: synthesis and repair, how genes work, transcription, RNA processing, and translation, control of gene expression, analyzing and engineering genes, genomics.

**Engineering concepts in biology** - genetic engineering, disease biology and biopharmaceuticals, stem cell engineering, metabolic engineering, synthetic biology, neuro transmission, bio safety and bioethics.

**Reading:**

1. Quillin, Allison Scott Freeman, Kim Quillin and Lizabeth Allison, Biological Science, Pearson Education India, 2016.
2. Reinhard Renneberg, Viola Berkling and Vanya Lorch, Biotechnology for Beginners, Academic Press, 2017.

CS101	PROBLEM SOLVING AND COMPUTER PROGRAMMING	ESC	3 - 1 - 2	5 Credits
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**Pre-requisites:** Nil.

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Design algorithms for solving simple mathematical problems including computing, searching and sorting
<b>CO2</b>	Compare and contrast algorithms in terms of space and time complexity to solve simple mathematical problems
<b>CO3</b>	Explore the internals of computing systems to suitably develop efficient algorithms
<b>CO4</b>	Examine the suitability of data types and structures to solve specific problems
<b>CO5</b>	Apply control structures to develop modular programs to solve mathematical problems
<b>CO6</b>	Apply object oriented features in developing programs to solve real world problems

**Course Articulation Matrix:**

CO \ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
<b>CO1</b>	3	2	3	2	3	-	-	-	-	-	-	-	2	2
<b>CO2</b>	3	2	3	2	3	-	-	-	-	-	-	-	2	2
<b>CO3</b>	3	2	3	2	3	-	-	-	-	-	-	-	2	2
<b>CO4</b>	3	2	3	2	3	-	-	-	-	-	-	-	2	2
<b>CO5</b>	3	2	3	2	3	-	-	-	-	-	-	-	2	2
<b>CO6</b>	3	2	3	2	3	-	-	-	-	-	-	-	2	2

**Detailed Syllabus:**

**Theory:**

**Fundamentals** of Computers, Historical perspective, Early computers, Components of a computers, Problems, Flowcharts, Memory, Variables, Values, Instructions, Programs.

**Problem solving techniques** - Algorithmic approach, characteristics of algorithm, Problem solving strategies: Top-down approach, Bottom-up approach, Time and space complexities of algorithms.

**Number systems** and data representation, Basics of C++, Basic data types, Numbers, Digit separation, Reverse order, Writing in words, Development of Elementary School Arithmetic Testing System, Problems on Date and factorials, Solutions using flow of control constructs, Conditional statements - If-else, Switch-case constructs, Loops - while, do-while, for.

**Functions**-Modular approach for solving real time problems, user defined functions, library functions, parameter passing - call by value, call by reference, return values, Recursion, Introduction to pointers.

**Sorting and searching algorithms**, large integer arithmetic, Single and Multi-Dimensional Arrays, passing arrays as parameters to functions

**Magic square and matrix operations** using Pointers and Dynamic Arrays, Multidimensional Dynamic Arrays

String processing, File operations.

**Structures and Classes** - Declaration, member variables, member functions, access modifiers, function overloading, Problems on Complex numbers, Date, Time, Large Numbers.

**Laboratory:**

1. Programs on conditional control constructs.
2. Programs on loops (while, do-while, for).
3. Programs using user defined functions and library functions.
4. Programs on arrays, matrices (single and multi-dimensional arrays).
5. Programs using pointers (integer pointers, character pointers).
6. Programs on structures.
7. Programs on classes and objects.

**Reading:**

1. Walter Savitch, Problem Solving with C++, Pearson, 9<sup>th</sup> Edition, 2014.
2. Cay Horstmann, Timothy Budd, Big C++, Wiley, 2<sup>nd</sup> Edition, 2009.
3. R.G. Dromey, How to solve it by Computer, Pearson, 2008.

PH102	PHYSICS LABORATORY	BSC	0 - 1 - 2	2 Credits
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Use CRO, signal generator, spectrometer, polarimeter and GM counter for making measurements
<b>CO2</b>	Test optical components using principles of interference and diffraction of light
<b>CO3</b>	Determine the selectivity parameters in electrical circuits
<b>CO4</b>	Determine the width of narrow slits, spacing between close rulings using lasers and appreciate the accuracy in measurements

**Course Articulation Matrix:**

CO \ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
	<b>CO1</b>	3	2	-	3	-	-	-	-	3	2	-	-	2
<b>CO2</b>	3	2	-	3	-	-	-	-	3	2	-	-	2	2
<b>CO3</b>	3	2	-	3	-	-	-	-	3	2	-	-	2	2
<b>CO4</b>	3	2	-	3	-	-	-	-	3	2	-	-	2	2

**Detailed Syllabus:**

1. Determination of Wavelength of Sodium light using Newton's Rings.
2. Determination of Wavelength of He-Ne laser - Metal Scale.
3. Measurement of Width of a narrow slit using He- Ne Laser.
4. Determination of Specific rotation of Cane sugar by Laurent Half-shade Polarimeter.
5. Determination of capacitance by using R-C circuit.
6. Determination of resonating frequency and bandwidth by LCR circuit.
7. Measurement of half-life of radioactive source using GM Counter.
8. Diffraction grating by normal incidence method.

**Reading:**

1. Physics Laboratory Manual.

MA 151	MATHEMATICS - II	BSC	3-0-0	3 Credits
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**Pre-requisites:** MA101: Mathematics-I

**Course Outcomes:** At the end of the course, the students will be able to:

CO 1	Analyze improper integrals
CO 2	Evaluate multiple integrals in various coordinate systems
CO 3	Apply the concepts of gradient, divergence and curl to formulate engineering problems
CO 4	Convert line integrals into surface integrals and surface integrals into volume integrals
CO 5	Apply Laplace transforms to solve physical problems arising in engineering

**Course Articulation Matrix:**

CO \ PO	PO												PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1	2	1	-	-	-	-	-	-	-	2	-
CO2	3	3	1	2	1	-	-	-	-	-	-	-	2	-
CO3	3	3	1	2	1	-	-	-	-	-	-	-	3	-
CO4	3	3	1	2	1	-	-	-	-	-	-	-	2	-
CO5	3	3	1	2	1	-	-	-	-	-	-	-	3	-

**Detailed Syllabus:**

**Integral Calculus:** Convergence of improper integrals; Beta and Gamma integrals; Differentiation under integral sign; Double and Triple integrals - computation of surface areas and volumes; change of variables in double and triple integrals.

**Vector Calculus:** Scalar and vector fields; vector differentiation; level surfaces; directional derivative; gradient of a scalar field; divergence and curl of a vector field; Laplacian; Line and Surface integrals; Green's theorem in a plane; Stoke's theorem; Gauss Divergence theorem.

**Laplace Transforms:** Laplace transforms; inverse Laplace transforms; Properties of Laplace transforms; Laplace transforms of unit step function, impulse function, periodic function.

**Convolution theorem;** Applications of Laplace transforms - solving certain initial value problems, solving system of linear differential equations, finding responses of systems to various inputs viz. sinusoidal inputs acting over a time interval, rectangular waves, impulses etc.

**Reading:**

1. R. K. Jain and S. R. K. Iyengar, *Advanced Engineering Mathematics*, Narosa Publishing House, 5<sup>th</sup> Edition, 2016.
2. Erwin Kreyszig, *Advanced Engineering Mathematics*, John Wiley and Sons, 8<sup>th</sup> Edition, 2015.
3. B. S. Grewal, *Higher Engineering Mathematics*, Khanna Publications, 2015.

<b>ME102</b>	<b>ENGINEERING GRAPHICS</b>	<b>ESC</b>	<b>1 - 1- 4</b>	<b>4 Credits</b>
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**Pre-requisites:** Nil.

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Apply BIS standards and conventions while drawing Lines, printing Letters and showing Dimensions.
<b>CO2</b>	Classify the systems of projection with respect to the observer, object and the reference planes.
<b>CO3</b>	Construct orthographic views of an object when its position with respect to the reference planes is defined.
<b>CO4</b>	Analyse the internal details of an object through sectional views.
<b>CO5</b>	Develop 3D Isometric View in relation with 2D orthographic views
<b>CO6</b>	Construct 2D (orthographic) and 3D (isometric) views in CAD environment.

**Course Articulation Matrix:**

CO \ PO	PO												PS	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PS02
<b>CO1</b>	2	2	2	-	1	-	-	-	1	2	-	-	3	-
<b>CO2</b>	2	2	2	-	1	-	-	-	1	2	-	-	3	-
<b>CO3</b>	2	2	2	-	1	-	-	-	1	2	-	-	3	-
<b>CO4</b>	2	2	2	-	1	-	-	-	1	2	-	-	3	-
<b>CO5</b>	2	2	2	-	1	-	-	-	1	2	-	-	3	-
<b>CO6</b>	2	2	2	-	1	-	-	-	1	2	-	-	3	2

**Detailed Syllabus:**

**Introduction:** Overview of the course, Lines Lettering and Dimensioning: Types of lines, Lettering, Dimensioning, Geometrical Constructions, Polygons, Scales



**Orthographic Projection:** Principles of Orthographic projection, Four Systems of Orthographic Projection.

**Projection of Points:** Projections of points when they are situated in different quadrants.

**Projections of Lines:** Projections of a line parallel to one of the reference planes and inclined to the other, line inclined to both the reference planes, Traces.

**Projections of Planes:** Projections of a plane perpendicular to one of the reference planes and inclined to the other, Oblique planes.

**Projections of Solids:** Projections of solids whose axis is parallel to one of the reference planes and inclined to the other, axis inclined to both the planes.

**Section of Solids:** Sectional planes, Sectional views - Prism, pyramid, cylinder and cone, true shape of the section.

**Isometric Views:** Isometric axis, Isometric Planes, Isometric View, Isometric projection, Isometric views - simple objects.

**Auto-CAD Practice:** Introduction to Auto-CAD, DRAW tools, MODIFY tools, TEXT, DIMENSION, PROPERTIES

**Reading:**

1. N.D. Bhatt and V.M. Panchal, Engineering Graphics, Charotar Publishers, 2013.
2. Sham Tickoo, AutoCAD 2017 for Engineers & Designers, Dreamtech Press, 23<sup>rd</sup> Edition, 2016.

<b>CY101</b>	<b>CHEMISTRY</b>	<b>BSC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the students will be able to:

<b>CO1</b>	The basic knowledge of the organic reaction mechanism and intermediates.
<b>CO2</b>	The basic knowledge of methods of chemical structure analysis and the instrumentation involved.
<b>CO3</b>	The potential energy aspects of fuel cells, rechargeable batteries and new materials for their fabrication.
<b>CO4</b>	About optical fibres, liquid crystals, LCD, LED, OLED, conducting polymers and their applications.
<b>CO5</b>	The quantum and thermodynamic aspects of various types of bonding, coordination complexes and chemical and enzymatic reactions.
<b>CO6</b>	The synthetic methodologies, importance and applications of nanomaterials in different fields.

**Course Articulation Matrix:**

<b>CO \ PO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>	<b>PSO1</b>	<b>PSO2</b>
<b>CO1</b>	3	3	3	-	2	-	2	-	2	-	-	-	-	-
<b>CO2</b>	3	3	3	-	2	-	2	-	2	-	-	-	-	-
<b>CO3</b>	3	3	3	-	2	-	2	-	2	-	-	-	3	2
<b>CO4</b>	3	3	3	-	2	-	2	-	2	-	-	-	3	2
<b>CO5</b>	3	3	3	-	2	-	2	-	2	-	-	-	2	-
<b>CO6</b>	3	3	3	-	2	-	2	-	2	-	-	-	3	2

**Detailed syllabus:**

**Quantum Chemistry and Chemical Bonding:** Emergence of Quantum Theory; Postulates of Quantum Mechanics, Operators and Observables, Schrodinger Equation, Particle in a One-Dimensional Box and

Colour of Conjugate Molecules, Hetero-diatomic Molecule as Harmonic Oscillator and Rigid Rotor, Hydrogen Atom, LCAO-MO Theory (MO Diagram of CO and NO Molecules).

**Chemical Thermodynamics, Equilibrium and Kinetics:** Enthalpy and Free Energy Changes in Chemical Reactions; Relevance of  $C_p$  and  $C_v$  in Gas Phase Reactions, Chemical Potential; Heat Capacity of Solids, Absolute Entropy and Third Law of Thermodynamics, Rates of Enzyme-Catalyzed Homogeneous and Heterogeneous Surface-Catalyzed Chemical Reactions

**Electrochemistry and Chemistry of Energy Systems:** Electrodes and Electrochemical Cells; Potentiometric and Amperometric Sensors; Li-Ion and Ni-Cd Rechargeable Batteries; Fuel Cells (Methanol-Oxygen); Electrochemical Theory of Corrosion; Factors Affecting Rate of Corrosion; Sacrificial Anodic and Impressed Current Cathodic Protection of corrosion.

**Coordination Chemistry and Organometallics:** Shapes of Inorganic Compounds; Crystal Field and Molecular Orbital Theories; MO-Diagram for an Octahedral Complex; Metal Ions in Biology; Organometallic Chemistry (Metal Carbonyls).

**Basics of Organic Chemistry:** Classification of Organic reaction and their mechanisms. Reaction intermediates: formation, structure and properties. Named Reactions: Skraup's synthesis, Diels-Alder reaction, Click Reactions.

**Engineering Materials and Application:** Introduction to Optical fibres, types of optical fibres, applications of optical fibres. Liquid Crystals: LCD, LED, OLED, Conducting Polymers and applications.

**Instrumental Methods of Chemical Analysis:** Gas- and Liquid-Chromatographic Separation of Components of Mixtures; UV-Visible, FTIR, NMR and Mass Spectral Methods of Analysis of Structures of Organic Compounds.

#### **Reading:**

1. P. Atkins and Julio de Paula, Physical Chemistry, Freeman & Co. 8<sup>th</sup> Edition, 2017.
2. Atkins and Shriver, Inorganic Chemistry, Oxford University Press, 4<sup>th</sup> edition, 2008.
3. Clayden, Greaves, Warren and Wothers, Organic Chemistry, Oxford University Press, 2014.
4. Shashi Chawla, Engineering Chemistry, Dhanpat Rai & Co. 2017.
5. Paula Bruce, Organic Chemistry, Pearson, 8<sup>th</sup> Edition, 2013.

EE101	BASIC ELECTRICAL ENGINEERING	ESC	3-0-0	3 Credits
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the students will be able to:

CO1	Analyze and solve electric and magnetic circuits
CO2	Identify the type of electrical machines for a given application
CO3	Recognize the ratings of different electrical apparatus
CO4	Identify meters for measuring electrical quantities and requirements of illumination

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	-	-	-	1	-	-	-	-	-	3	2
CO2	3	3	2	-	-	-	1	-	-	-	-	-	3	-
CO3	3	3	2	-	-	-	1	-	-	-	-	-	2	-
CO4	3	3	2	-	-	-	1	-	-	-	-	-	2	-

**Detailed Syllabus:**

**DC Circuits:** Kirchoff's Voltage and Current Laws, Superposition Theorem, Star-Delta Transformations

**AC Circuits:** Complex representation of Impedance, Phasor diagrams, Power & Power Factor, Solution of 1- $\phi$  Series & Parallel Circuits, Solution of 3- $\phi$  circuits and Measurement of Power in 3- $\phi$  circuits

**Magnetic Circuits:** Fundamentals and solution of Magnetic Circuits, Concepts of Self and Mutual Inductances, Coefficient of Coupling

**Single Phase Transformers:** Principle of Operation of a Single Phase Transformer, EMF Equation, Phasor Diagram, Equivalent Circuit of a 1- $\phi$  Transformer, Determination of Equivalent circuit parameters, calculation of Regulation & Efficiency of a Transformer

**DC Machines:** Principle of Operation, Classification, EMF and Torque Equations, Characteristics of Generators and Motors, Speed Control Methods and Applications

**Three Phase Induction Motor:** Principle of Rotating Magnetic Field, Principle of Operation of 3- $\phi$  Induction Motor, Torque - Speed Characteristics of 3- $\phi$  Induction Motor, Applications

**Measuring Instruments:** Moving Coil and Moving Iron Ammeters and Voltmeters

**Illumination:** Laws of illumination and luminance.

**Reading:**

1. Edward Hughes, Electrical & Electronic Technology, Pearson, 12<sup>th</sup> Edition, 2016.
2. Vincent Del Toro, Electrical Engineering Fundamentals, Pearson, 2<sup>nd</sup> Edition, 2015.
3. V N Mittle and Arvind Mittal, Basic Electrical Engineering, Tata McGraw Hill, 2<sup>nd</sup> Edition, 2005.
4. E. Openshaw Taylor, Utilization of Electrical Energy, Orient Longman, 2010.

ME101	BASIC MECHANICAL ENGINEERING	ESC	3 - 0 - 0	3 Credits
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**Pre-requisites:** Nil.

**Course Outcomes:** At the end of the course, the student will be able to:

CO1	Identify Materials for Engineering Applications
CO2	Describe the functions and operations of Conventional, NC, CNC and 3D Printing methods of manufacturing.
CO3	Select a power transmission system for a given application.
CO4	Understand the concepts of thermodynamics and functions of components of a power plant.
CO5	Understand basics of heat transfer, refrigeration, internal combustion engines and automobile engineering.

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	1	-	1	1	-	-	-	-	-	3	-
CO2	3	3	3	1	3	1	1	-	-	-	-	-	3	2
CO3	3	3	3	1	-	1	1	-	-	-	-	-	3	-
CO4	3	3	3	1	-	1	1	-	-	-	-	-	3	-
CO5	3	3	3	1	-	1	1	-	-	-	-	-	3	-

**Detailed Syllabus:**

**Engineering Materials:** Introduction to Engineering Materials, Classification and Properties

**Manufacturing Processes:** Castings - Patterns & Moulding, Hot Working and Cold Working, **Metal**

**Forming processes:** Extrusion, Drawing, Rolling, Forging, Welding - Arc Welding & Gas Welding, Soldering, Brazing.

**Machine Tools:** Lathe - Types - Operations, Problems on Machining Time Calculations, Drilling M/c - Types - Operations, Milling M/c - Types - Operations - Up & Down Milling, Shaping M/c -Operations-

Quick Return Mechanism, Planer M/c.- Operations-Shaper Vs Planer, Grinding M/c-Operations.  
Introduction to NC/CNC Machines, 3D Printing

**Power Transmission:** Transmission of Power, Belt Drives, Gears and Gear Trains -Simple Problems

**Fasteners and Bearings:** Fasteners - Types and Applications, Bearings - Types and Selection,

**Thermodynamics:** Energy Sources - Conventional/Renewable, Thermodynamics - System, State, Properties, Thermodynamic Equilibrium, Process & Cycle, Zeroth law of Thermodynamics, Work & Heat, First law - Cyclic process, Change of State,  $C_p$ ,  $C_v$ , Limitations of First law, Thermal Reservoirs, Heat Engine, Heat Pump/Refrigerator, Efficiency/COP, Second law, PMM2, Carnot Cycle, Entropy - T-S and P-V diagrams.

**Thermal Power Plant:** Layout of Thermal Power Plant & Four circuits - Rankine cycle, T-S & P-V diagrams, Boilers - Babcock & Wilcox, Cochran Boilers, Comparison of Fire Tube & Water Tube Boilers, Steam Turbines - Impulse Vs. Reaction, Compounding - Pressure & Velocity Compounding, Condensers - Jet Condenser and Surface Condenser; Cooling Towers.

**I.C. Engines:** 2-Stroke & 4-Stroke Engines, P-v Diagram; S.I. Engine, C.I. Engine, Differences

Refrigeration: Vapor Compression Refrigeration Cycle - Refrigerants, Desirable Properties of Refrigerants

**Heat Transfer:** Modes of Heat Transfer, Thermal Resistance Concept, Composite Walls & Cylinders, and Overall Heat Transfer Coefficient - problems

**Automobile Engineering:** Layout of an Automobile, Transmission, Clutch, Differential, Internal Expanding Shoe Brake

### Reading:

1. M.L. Mathur, F.S. Mehta and R.P. Tiwari, R.S. Vaishwnar, Elements of Mechanical Engineering, Jain Brothers, New Delhi, 2008.
2. Praveen Kumar, Basic Mechanical Engineering, Pearson Education, India, 2013.
3. P.N. Gupta, M.P. Poonia, Elements of Mechanical Engineering, Standard Publishers, 2004.
4. C.P. Gupta, Rajendra Prakash, Engineering Heat Transfer, NemChand Brothers, New Delhi, 1994.
5. B.S. Raghuvanshi, Workshop Technology, Vol. 1&2, Dhanpath Rai & Sons, New Delhi, 1989.

CE101	ENGINEERING MECHANICS	ESC	3 - 0 - 0	3 Credits
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**Pre-requisites:** Nil.

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Determine the resultant force and moment for a given system of forces
<b>CO2</b>	Analyze planar and spatial systems to determine the forces in members of trusses, frames and problems related to friction
<b>CO3</b>	Calculate the motion characteristics of a body subjected to a given force system
<b>CO4</b>	Determine the deformation of a shaft and understand the relationship between different material constants
<b>CO5</b>	Determine the centroid and second moment of area

**Course Articulation Matrix:**

CO \ PO	PO												PS	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PS02
<b>CO1</b>	3	3	2	-	-	1	-	-	-	-	-	-	3	-
<b>CO2</b>	3	3	2	-	-	1	-	-	-	-	-	-	3	-
<b>CO3</b>	3	3	2	-	-	1	-	-	-	-	-	-	3	-
<b>CO4</b>	3	3	2	-	-	1	-	-	-	-	-	-	3	-
<b>CO5</b>	3	3	2	-	-	1	-	-	-	-	-	-	3	-

**Detailed syllabus:**

**Introduction:** Specification of force vector, Formation of Force Vectors, Moment of Force - Cross product - Problems, Resultant of a general force system in space, Degrees of freedom - Equilibrium Equations, Kinematics - Kinetics - De' Alemberts principle, Degree of Constraints - Freebody diagrams.

**Spatial Force systems:** Concurrent force systems - Equilibrium equations (Vector approach) - Tension Coefficient method (Tension Coefficient method), Parallel force systems - problems, Center of Parallel force system.



**Coplanar Force System:** Introduction - Equilibrium equations - All systems, Problems on Coplanar Concurrent force system, Coplanar Parallel force system, Coplanar General force system - Point of action, Method of joints, Method of sections, Method of sections, Method of members, Friction - Coulombs laws of dry friction - Limiting friction, Problems on Wedge friction, Belt Friction-problems.

**Mechanics of Deformable Bodies:** Stress & Strain at a point- Normal and shear stresses, Axial deformations - Problems on prismatic shaft, tapered shaft and deformation due to self-weight, Deformation of Stepped shaft due to axial loading, Poisson's Ratio - Bulk Modulus - Problems, change in dimensions and volume.

**Centroid & Moment of Inertia:** Centroid and M.I - Arial - Radius of Gyration, Parallel axis- Perpendicular axis theorem - Simple Problems.

**Dynamics of Particles:** Rectilinear Motion - Kinematics Problems, Kinetics - Problems, Work & Energy - Impulse Moment, Curvilinear Motion - Normal and tangential components.

**Reading:**

1. J.L. Meriam, L.G. Kraige, Engineering Mechanics, John Wiley & Sons, 7<sup>th</sup> Edition, 2012.
2. Timoshenko, Young, Engineering Mechanics, McGraw Hill Publishers, 3<sup>rd</sup> Edition, 2006.
3. Gere, Timoshenko, Mechanics of Materials, CBS Publishers, 2<sup>nd</sup> Edition, 2011.

<b>ME103</b>	<b>WORKSHOP PRACTICE</b>	<b>ESC</b>	<b>0 - 1 - 2</b>	<b>2 Credits</b>
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**Pre-requisites:** Nil.

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Study and practice on tools and their operations
<b>CO2</b>	Practice on manufacturing of components using workshop trades including fitting, carpentry, foundry and welding
<b>CO3</b>	Identify and apply suitable tools for machining processes including turning, facing, thread cutting and tapping
<b>CO4</b>	Apply basic electrical engineering knowledge for house wiring practice

**Course Articulation Matrix:**

CO \ PO	PO												PS	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PS02
<b>CO1</b>	3	3	1	-	-	1	-	-	2	2	-	-	2	-
<b>CO2</b>	3	3	1	-	-	1	-	-	2	2	-	-	2	-
<b>CO3</b>	3	3	1	-	-	1	-	-	2	2	-	-	2	-
<b>CO4</b>	3	3	1	-	-	1	-	-	2	2	-	-	2	-

**Detailed Syllabus:**

**Fitting Trade:** Preparation of T-Shape Work piece as per the given specifications, Preparation of U-Shape Work piece which contains: Filing, Sawing, Drilling, Grinding, and Practice marking operations.

**Plumbing:** Practice of Internal threading, external threading, pipe bending, and pipe fitting, Pipes with coupling for same diameter and with reducer for different diameters and Practice of T-fitting, Y-fitting, Gate valves fitting.

**Machine shop:** Study of machine tools in particular Lathe machine (different parts, different operations, study of cutting tools), Demonstration of different operations on Lathe machine, Practice of Facing, Plane Turning, step turning, taper turning, knurling and parting and Study of Quick return mechanism of Shaper. Demonstration of the working of CNC and 3D Printing Machines.

**Power Tools:** Study of different hand operated power tools, uses and their demonstration and Practice of all available Bosch Power tools.

**Carpentry:** Study of Carpentry Tools, Equipment and different joints, Practice of Cross Half lap joint, half lap Dovetail joint and Mortise Tenon Joint.

<b>CY102</b>	<b>CHEMISTRY LABORATORY</b>	<b>BSC</b>	<b>0- 1 - 2</b>	<b>2 Credits</b>
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**Pre-requisites:** Nil.

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Select a suitable methodology and compare the strategies involved in the estimation of metal content, iodine content, active chlorine or hardness of water for various applications.
<b>CO2</b>	Apply a selective instrumental method in the place of tedious and complex titration processes for repeated and regulated analysis of acids, bases, redox compounds, etc.
<b>CO3</b>	Test and validate optical activity, corrosion inhibitor efficiency and absorption isotherm of selective compounds and processes.

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	3	3	3	-	2	-	2	-	2	-	-	-	2	-
<b>CO2</b>	3	3	3	-	2	-	2	-	2	-	-	-	2	-
<b>CO3</b>	3	3	3	-	2	-	2	-	2	-	-	-	3	-

**Detailed Syllabus:**

**Cycle-I**

1. Standardization  $\text{KMnO}_4$  solution: Understanding the redox process, electron transfer, importance of qualitative and quantitative analysis.
2. Estimation of Hematite: Understanding the importance on purity of a ore, % of metal content (for Fe).
3. Hardness of Water: Understanding the metal complexes, multi dentate ligands, importance of purity of ground water, (EDTA method; complexometry).
4. Analysis of bleaching powder for available chlorine: Understanding the importance and purity of potable water, back titration (Iodometry).
5. Preparation of nano materials: Understanding the importance of nano materials, their preparation and characterization.

**Cycle-II**

1. pH metry: Concept of pH, Instrumentation, calibration, determination of the concentrations by instrumental methods
2. Conductometry: Concept of conductivity, importance of conductivity
3. Potentiometry: Determination of the redox potential of the reaction
4. Colorimetry: Importance of Beers and Lamberts law,
5. Photochemical experiment: Importance of visible light and its application for a redox process, importance of coloring agent
6. Preparation of bakelite / polypyrrole: Concepts of organic reactions and application for the organic material preparation.
7. Corrosion experiment: Concept of corrosion, importance of corrosion agents
8. Adsorption experiment: Understanding phenomena of adsorption and absorption
9. Analysis of a drug: Importance of the purity, concentrations of a drug molecule.
10. Preparation of bakelite / red azo dye / Aspirin / Fe(acac) / polypyrrole: Concepts of organic reactions and application for the organic material preparation

**Reading:**

1. Charles Corwin, Introductory Chemistry laboratory manual: Concepts and Critical Thinking, Pearson Education, 2012.
2. David Collins, Investigating Chemistry: Laboratory Manual, Freeman & Co., 1<sup>st</sup> Edition, 2006.

<b>MA236</b>	<b>TRANSFORMATION TECHNIQUES</b>	<b>BSC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Determine Fourier series expansion of functions
<b>CO2</b>	Determine solutions of PDE for vibrating string and heat conduction
<b>CO3</b>	Evaluate real integrals using residue theorem
<b>CO4</b>	Transform a region to another region using conformal mapping

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	3	3	-	3	-	-	-	-	-	-	-	1	2	-
<b>CO2</b>	3	3	-	3	-	-	-	-	-	-	-	1	2	-
<b>CO3</b>	3	3	-	3	-	-	-	-	-	-	-	1	2	-
<b>CO4</b>	3	2	-	3	-	-	-	-	-	-	-	1	2	-

**Detailed Syllabus:**

**Fourier series:** Expansion of a function in Fourier series for a given range - Half range sine and cosine expansions

**Fourier Transforms:** Complex form of Fourier series - Fourier transformation and inverse transforms - sine, cosine transformations and inverse transforms - simple illustrations.

**Partial Differential Equations:** Solutions of Wave equation, Heat equation and Laplace's equation by the method of separation of variables and their use in problems of vibrating string, one dimensional unsteady heat flow and two dimensional steady state heat flow including polar form.

**Complex Variables:** Analytic function - Cauchy Riemann equations - Harmonic functions - Conjugate functions - complex integration - line integrals in complex plane - Cauchy's theorem (simple proof only), Cauchy's integral formula - Taylor's and Laurent's series expansions - zeros and singularities - Residues - residue theorem, evaluation of real integrals using residue theorem, Bilinear transformations, conformal mapping.

**Reading:**

1. R.K. Jain and S.R.K.Iyengar, Advanced Engineering Mathematics, Narosa Pub. House, 2016.
2. Erwyn Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons, 8<sup>th</sup> Edition, 2008.
3. B.S.Grewal, Higher Engineering Mathematics, Khanna Publications, 2017.

MM235	MATERIALS ENGINEERING	PCC	3 - 0 - 0	3 Credits
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

CO1	Describe the crystal structure and constitution of alloys.
CO2	Describe methods of determining mechanical properties and their suitability for applications.
CO3	Classify steels and cast irons, and discuss their applications.
CO4	Describe the properties and applications of non-ferrous metals and alloys.
CO5	Differentiate the properties and applications of ceramics, polymers and composites.

**Course Articulation Matrix:**

PO \ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	2	1	2	-	1	-	-	-	-	1	2	1
CO2	2	3	2	1	2	-	1	-	-	-	-	1	2	1
CO3	2	3	1	1	1	-	3	-	-	-	-	1	2	1
CO4	2	3	1	1	2	-	1	-	-	-	-	1	2	1
CO5	2	3	2	1	2	-	3	-	-	-	-	1	2	1

**Detailed syllabus:**

Introduction to materials engineering, Classification of materials- Metals and alloys, Ceramics, Polymers and Composites

**Crystal geometry and Constitution of alloys:** Space lattices, Unit cells, Crystal structure, Crystal directions and planes, Crystal imperfections- Point defects, Line defects, Surface defects, Volume defects; Types of solid solutions- substitutional and interstitial; Hume-Rothery rules for solid solutions, Construction and interpretation of binary equilibrium diagrams-isomorphous, eutectic and peritectic-type diagrams, Intermediate phases and phase rule

**Mechanical properties:** Elasticity and plasticity in materials, Stress-strain curve, Resolved shear stress, Tensile properties, Hardness and hardness measurement, Impact properties, Fatigue, Creep.

**Steels and Cast Irons:** Iron-carbon phase diagram, Types of steels- low, medium and high carbon steels, stainless steels, alloy steels and their applications; Heat treatment-annealing, normalising,

hardening, tempering, surface hardening; Cast irons, types- white, grey, malleable and nodular, Properties and applications of cast irons

**Non-ferrous metals and alloys:** Properties and applications of - Cu and its alloys, Al and its alloys, Age hardening, Ti and its alloys, Ni-based alloys.

**Ceramics, Polymers and Composites:** Ceramics - Crystalline ceramics, Glasses, Properties and applications of ceramics; Polymers - Polymerization, Thermoplastics and thermosetting plastics, Properties and applications of polymers; Composites - Concept of composites, Matrix and reinforcement, Rule of mixtures, Classification of composites, Applications of composites

### Reading:

1. W.D. Callister (Adapted by R. Balasubramaniam), Materials Science and Engineering, 2<sup>nd</sup> ed. (2014), Wiley India, New Delhi (ISBN: 978-8126541607)
2. M.F. Ashby and D.R.H. Jones, Engineering Materials 1-An Introduction to Properties, Applications and Design, 4<sup>th</sup> ed. (2011), Butterworth-Heinemann Publishers, Massachusetts, USA (ISBN: 978-0080966656)
3. M.F. Ashby and D.R.H. Jones, Engineering Materials 2-An Introduction to Microstructures and Processing, 4<sup>th</sup> ed. (2012), Butterworth-Heinemann Publishers, Massachusetts, USA (ISBN: 978-0080966687)
4. S. H. Avner, Introduction to Physical Metallurgy, 2<sup>nd</sup> ed. (1997), McGraw-Hill Education Publishers, New York, USA (ISBN: 978-0074630068)
5. V. Raghavan, Physical Metallurgy: Principles and Practice, 2<sup>nd</sup> ed. (2012) Prentice Hall of India Learning Pvt. Ltd., Delhi (ISBN: 978-8120330122)
6. V. Raghavan, Materials Science and Engineering: A First Course, 6<sup>th</sup> ed. (2015), Prentice Hall of India Learning Pvt. Ltd., Delhi (ISBN: 978-8120350922)
7. D.S. Clark and W. Varney, Physical Metallurgy for Engineers, 2<sup>nd</sup> ed. (2004) CBS Publishers and Distributors, New Delhi (ISBN: 978-8123911786)

<b>CE235</b>	<b>FLUID MECHANICS &amp; HYDRAULIC MACHINES</b>	<b>PCC</b>	<b>3 - 1 - 0</b>	<b>4 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Apply conservation laws to fluid flow problems in engineering applications.
<b>CO2</b>	Design experimental procedure for physical model studies.
<b>CO3</b>	Design the working proportions of hydraulic machines.
<b>CO4</b>	Compute drag and lift coefficients using the theory of boundary layer flows.
<b>CO5</b>	Analyze and design free surface and pipe flows
<b>CO6</b>	Formulate and solve one dimensional compressible fluid flow problems

**Course Articulation Matrix:**

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	<b>CO1</b>	3	3	2	2	-	-	-	-	-	-	-	2	2
<b>CO2</b>	3	3	3	3	-	-	-	-	-	-	-	2	2	1
<b>CO3</b>	2	1	3	1	1	-	-	-	-	-	-	1	2	1
<b>CO4</b>	2	1	3	2	-	-	-	1	-	-	-	1	2	1
<b>CO5</b>	3	2	3	2	1	-	-	-	-	-	-	1	2	1
<b>CO6</b>	3	2	2	2	1	-	-	-	-	-	-	2	2	1

**Detailed Syllabus:**

**Introduction:** Purpose of study of fluid mechanics for design and operation of engineering systems in the fields of Mechanical Engineering, Aeronautical Engineering, Metallurgical Engineering, Civil Engineering, Biomedical Engineering, Chemical Engineering. Fundamental difference between a solid and fluid, constituent relationships for solids and fluids, conservation principles applied in fluid mechanics

Review of physical meaning of Mathematics necessary for understanding of fluid mechanics, review of analogies in mass transfer and heat transfer



**Description of fluid flow:** with reference to translation, rotation and deformation concept of continuum, control mass & control volume approach, Reynolds transport theorem. Steady flow and uniform flow.

Velocity field, one & two-dimensional flow analysis, circulation and vorticity, stream function and velocity potential function, potential flow, standard flow patterns, combination of flow patterns, flow net.

Continuity equation, Euler's equation of motion, Bernoulli's equation, Impulse momentum equation and applications.

**Dimensional Analysis** as a tool in design of experiments, identification of non-dimensional numbers and their significance, dimensional analysis methods.

**Equations of motion** for laminar flow of a Newtonian fluid - Viscous flow - Navier-Stoke's equations, simple exact solutions for Hydrodynamic lubrication.

**Boundary Layer Theory**-Formation, growth and separation of boundary layer-Integral momentum principles to compute drag and lift forces-Mathematical models for boundary layer flows.

Turbulence, universal velocity distribution laws of turbulence, smooth rough and transitional turbulent flow in pipes, pipe resistance equation for pipes design of pipe networks, free surface flow.

**Compressible flows**- Isentropic flows - Adiabatic flow with friction - Frictionless flow with heat addition - Shock waves.

**Principles of Hydraulic Turbines** - Impulse and Reaction Turbines - Pelton Turbine - Francis Turbine - Kaplan Turbine, working principles, design principles.

**Centrifugal pumps** - Axial flow pumps, working principles, design principles.

**Reading:**

1. Introduction to Fluid Mechanics, Robert W. Fox, Philip J. Pritchard, Alan T. McDonald. Wiley India Edition. (Wiley Student Edition Seventh 2011).
2. Fluid Mechanics Franck .M White Tata Mc GrawHill Publication 2011.
3. Shames, "*Mechanics of Fluids*", McGraw Hill Book Co., New Delhi, 1988
4. Streeter V.L., Benjamin Wylie, "*Fluid Mechanics*", Mc Graw Hill Book Co., New Delhi, 1999

CE236	MECHANICS OF SOLIDS	PCC	3 - 1 - 0	4 Credits
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**Pre-requisites:** CE101: Engineering Mechanics

**Course Outcomes:** At the end of the course, the student will be able to:

CO1	Understand statically determinate and indeterminate problems.
CO2	Determine the resistance and deformation in machine members subjected to axial, flexural and torsional loads.
CO3	Evaluate principal stresses, strains and apply the concept of failure theories for design.
CO4	Analyze and design thin, thick cylinders and springs.

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	1	-	-	2	-	-	-	-	1	2	1
CO2	3	3	2	2	-	-	2	-	-	-	-	1	2	1
CO3	3	3	2	1	-	-	2	-	-	-	-	1	2	1
CO4	3	3	3	1	-	-	2	-	-	-	-	1	2	1

**Detailed Syllabus:**

**Resistance and Deformation:** Concept of Resistance and deformation - Determinate and Indeterminate problems in Tension and Compression - Thermal Stresses - pure shear - Young's modulus of elasticity, Poisson's ratio, Modulus of rigidity and Bulk modulus - Relation between elastic constants - Stress-strain diagrams for brittle and ductile materials - working stress - Strain energy in tension and compression - Impact loading.

**Thin and Thick Cylinders:** Thin and Thick Cylinders - spherical shells subjected to internal fluid pressure - Wire wound thin cylinders - Compound cylinders - Shrink fit.

**Shear Force and Bending Moment:** Types of supports - Types of beams - Types of loads - articulated beams - Shear Force and Bending Moment diagrams.

**Theory of Simple Bending:** Assumptions - Bending stresses in beams - Efficiency of various cross sections - Composite beams.

**Shear Stress Distribution:** Flexural shear stress distribution in different cross sections of beams.

**Torsion of Circular cross sections:** Theory of pure torsion - transmission of Power in Solid and Hollow circular shafts - Combined bending and torsion.

**Principal Stresses and Strains:** Analysis of Biaxial state of stress with and without shear - Mohr's Circle

**Theories of failure:** Dilation - Distortion - Maximum Principal Stress Theory - Maximum Principal Strain Theory - Maximum Shear Stress Theory - Strain Energy Theory - Distortion energy theory.

**Deflection of Beams:** Slope and deflection of beams - Double Integration method - Macaulay's method - strain energy method.

**Springs:** Axial load and torque on helical springs - stresses and deformations - strain energy - compound springs - leaf springs.

**Reading:**

1. Timoshenko and Gere, Mechanics of Materials, CBS Publishers, 2011.
2. E.P.Popov, Engineering Mechanics of Solids, PHI, 2009.
3. S. B. Junarkar, Mechanics of Structures, Charotar Publishers, 2010.

ME201	THERMODYNAMICS	PCC	3 - 1 - 0	4 Credits
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**Pre-Requisites:** Nil

**Course Outcomes:** At the end of the course, student will be able to:

<b>CO1</b>	Understand the concepts of continuum, system, control volume, thermodynamic properties, thermodynamic equilibrium, work and heat.
<b>CO2</b>	Apply the laws of thermodynamics to analyze boilers, heat pumps, refrigerators, heat engines, compressors and nozzles.
<b>CO3</b>	Evaluate the performance of steam power cycles.
<b>CO4</b>	Evaluate the available energy and irreversibility.
<b>CO5</b>	Evaluate properties of pure substances and gas mixtures.
<b>CO6</b>	Analyze air standard cycles applied in prime movers.

**Course Articulation Matrix:**

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	3	3	3	3	2	1	2	1	2	-	-	2	1	1
<b>CO2</b>	3	3	2	3	3	1	2	-	2	-	-	2	2	2
<b>CO3</b>	3	2	1	2	1	1	1	-	2	-	-	2	2	2
<b>CO4</b>	3	3	3	-	1	1	1	-	2	-	-	2	2	2
<b>CO5</b>	3	3	1	3	1	1	2	-	2	-	-	2	2	2
<b>CO6</b>	3	3	1	3	2	1	2	-	1	-	-	2	2	2

**Detailed Syllabus:**

**Introduction:** Overview of the course. Examination and Evaluation patterns. Scope and applications of thermodynamics.

**Fundamental Concepts and Definitions:** Concept of continuum, microscopic and macroscopic approach, system, control volume, dimensions and units, force, weight, State, path, process, isolated system, adiabatic system, thermodynamic equilibrium, thermodynamic definition of work, different forms of work, path function, Heat, temperature and zeroth law of thermodynamics, thermometry.

**First Law of Thermodynamics:** First law applied to a system undergoing a cyclic process and a change of state, concept of energy, nature of energy, pure substance, two property rule. First law applied to a control volume, general energy equation, steady flow energy equation on unit mass and time basis, application of SFEE for devices such as boiler, turbine, heat exchangers, pumps, nozzles, etc.

**Second Law of Thermodynamics:** Limitations of the first law, definition of a heat engine, heat pump, refrigerator, thermal efficiency and the coefficient of performance. Kelvin-Planck and Clausius statements of the second law, their equivalence, reversible heat engine, Carnot theorems and corollaries. Reversible process, irreversible process, factors responsible for making a process irreversible. Carnot cycle, thermodynamic temperature scale. Entropy, Clausius theorem, Clausius inequality, Principle of increase of entropy, available and unavailable energy, irreversibility. Third law of thermodynamics, absolute entropy

**Ideal Gas and Real Gas:** Ideal gas, relation among the specific heats, internal energy, enthalpy. Analysis of isochoric, isobaric, isothermal, isentropic, isenthalpic processes, representation of the above processes on P-v, T-s planes. Determination of work, heat, entropy and enthalpy changes during the above processes, problems. Characteristic gas equations of a real gas, virial coefficients, law of corresponding states, compressibility factor, generalized compressibility chart, problems

**Ideal Gas Mixtures:** Gravimetric and volumetric analysis, Dalton's law, Amagat's law, mole fraction, volume fraction, evaluation of properties of gas mixtures, adiabatic mixing of gases at different temperatures and pressures, non-adiabatic mixing, mixing of gases in steady flow.

**Pure Substance:** Behavior of pure substance (steam) with reference to T-v, P-T, P-V, P-h & T-s diagrams, Triple and critical points, properties of steam, Quality of steam, its determination using throttling and separating-throttling calorimeters. Steam processes; expressions for the change in internal energy, enthalpy, work, heat, entropy in various processes, Mollier chart, Carnot cycle, Rankine cycle, modified Rankine cycle.

**Air Standard Cycles:** Assumptions for air standard cycles, Analysis of Otto, Diesel, Dual combustion, Joule/Brayton cycles.

**Reading:**

1. P.K.Nag, Engineering Thermodynamics, TMH, New Delhi, 2013
2. G.J.Vanwylen and R.E.Sonntag, Fundamentals of Classical Thermodynamics, Wiley Eastern, New Delhi, 2008
3. Yonus A Cengel and Michale A Boles, Thermodynamics: An Engineering Approach, McGraw Hill, 2002
4. A.Venkatash, Basic Engineering Thermodynamics, TMH, 2012

<b>ME202</b>	<b>KINEMATICS OF MACHINERY</b>	<b>PCC</b>	<b>3 - 1- 0</b>	<b>4 Credits</b>
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**Pre-requisites:** CE101: Engineering Mechanics

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Understand the principles of kinematic pairs, chains and their classification, DOF, inversions, equivalent chains and planar mechanisms.
<b>CO2</b>	Analyze the planar mechanisms for position, velocity and acceleration.
<b>CO3</b>	Synthesize planar four bar and slider crank mechanisms for specified design requirements.
<b>CO4</b>	Evaluate gear tooth geometry and select appropriate gears for the required applications.
<b>CO5</b>	Design cams and followers for specified motion profiles.

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	3	2	2	-	2	-	-	-	-	-	-	2	2	2
<b>CO2</b>	2	3	2	3	-	-	-	-	-	-	-	2	2	2
<b>CO3</b>	2	2	3	3	2	-	-	-	-	-	-	2	2	2
<b>CO4</b>	2	2	3	2	-	-	-	-	-	-	-	2	2	2
<b>CO5</b>	2	2	2	-	2	-	-	-	-	-	-	2	2	2

**Detailed Syllabus:**

**Mechanisms and Inversions:** Rigid body, Mechanism and Machine, Kinematic Link, Kinematic Pair, Degrees of Freedom, Classification, Kinematic Chain, Linkage, Mechanism and Structure, Gruebler's Criterion for degrees of freedom, Mobility, Four Bar mechanism, Slider- Crank mechanism, Kinematic inversions, Double slider-crank mechanism, Inversions

**Velocity and Acceleration Analysis:**

- Velocity analysis: Instantaneous center method, Kennedy's theorem, locating instantaneous centers, Relative velocity method for slider-crank mechanism, and crank and slotted lever mechanism.

b) Acceleration analysis: Klein's construction, slider crank mechanism, Coriolis acceleration component, Crank and slotted lever mechanism.

**Kinematic Synthesis:** Dimensional synthesis, function generation, path generation and motion generation, Synthesis of Four Bar linkage for specified Instantaneous conditions, Hirsch horn's method of components.

**Gears and Gear trains:** Classification, Terminology, Law of Gearing, Interferences, methods of avoiding interferences, path of contact, arc of contact. Simple gear train, compound gear train, reverted gear train, planetary/epicyclic gear train, Sun and planet gear.

**Cams:** Classification and application of cams. SVAJ diagrams. Analysis of Uniform velocity, Harmonic and cycloidal motion profiles. Graphical and analytical synthesis of planar cams with knife edge, roller and flat faced followers.

**Reading:**

1. Amitabha Ghosh and Ashok Kumar Mallik, Theory of Mechanisms and Machines, 3rd edition, East West Press Pvt. Ltd., New Delhi (Reprint 2017)
2. S.S.Rattan, Theory of Machines, 3rd edition, McGraw-Hill Publications, New Delhi (2011)
3. Shigley J. E. and John Joseph Uicker, Theory of Machines and Mechanisms, 2nd edition McGraw-Hill international edition (2003)
4. Norton, R.L., Design of Machinery - An introduction to Synthesis and Analysis of Mechanisms and Machines, McGraw Hill International Editions, New York, Edition II, 2000.

CE237	FLUID MECHANICS & HYDRAULIC MACHINES LABORATORY	PCC	0 - 1 - 2	2 Credits
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

CO1	Develop procedure for standardization of experiments.
CO2	Calibrate flow discharge measuring device used in pipes channels and tanks.
CO3	Determine fluid and flow properties.
CO4	Characterize laminar and turbulent flows.
CO5	Compute drag coefficients.
CO6	Test the performance of pumps and turbines.

**Course Articulation Matrix:**

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	-	3	-	-	-	-	1	-	-	1	2	1
CO2	2	2	2	3	-	-	-	-	1	-	-	1	2	1
CO3	-	-	1	3	-	-	-	-	-	-	-	-	2	1
CO4	2	2	2	3	1	-	-	-	1	-	-	1	2	1
CO5	2	2	2	3	2	-	-	-	1	-	-	1	2	1
CO6	2	2	2	3	2	-	-	-	1	-	1	1	2	1

**Detailed Syllabus:**

- Calibration of Venturi meter, Orifice meter (discharge measuring device in pipes)
- Calibration of Orifice and mouthpiece (discharge measuring device in Tanks).
- Calibration of Triangular - Notch and rectangular notch (discharge measuring device in Channels).
- Measurement of Viscosity of water, SAE - 10 Oil by Hazen Poiseuille method and that of gleserene by Stoke's method.
- Determination of Darcy Friction Factor, relative roughness for laminar and turbulent flows.



- f. Determination of Manning's and Chezy's coefficients for smooth and rough channels by gradually varied flow method.
- g. Application of momentum equation for determination of coefficient of impact of jets on flat and curved blades and Pelton bucket.
- h. Determination of Energy loss in Hydraulic jump.
- i. Computation of pressure drag coefficient for flow past a cylinder in a subsonic wind tunnel.
- j. Performance Characteristics of single stage centrifugal pump, multi stage centrifugal pump.
- k. Submersible pumps, and varying speed centrifugal pump.
- l. Performance Characteristics of Pelton turbine, Francis turbine, and Kaplan turbine.

**Reading:**

1. K.L.Kumar. "Engineering Fluid Mechanics" Experiments, Eurasia Publishing House, 1997
2. Jagdish Lal, Hydraulic Machines, Metropolitan Book Co, Delhi, 1995

<b>CE238</b>	<b>MATERIAL TESTING LAB</b>	<b>PCC</b>	<b>0 - 1 - 2</b>	<b>2 Credits</b>
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**Pre-requisites:** CY101: Chemistry

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Conduct tension test on steel, aluminium, copper and brass
<b>CO2</b>	Perform compression tests on spring and wood.
<b>CO3</b>	Determine elastic constants using flexural and torsion tests.
<b>CO4</b>	Determine hardness of metals

**Course articulation Matrix:**

<b>CO \ PO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>	<b>PSO1</b>	<b>PSO2</b>
<b>CO1</b>	3	3	2	2	2	-	-	-	1	1	-	1	1	1
<b>CO2</b>	3	3	2	2	2	-	-	-	1	1	-	1	1	1
<b>CO3</b>	3	3	2	2	2	-	-	-	1	1	-	1	1	1
<b>CO4</b>	3	3	2	2	2	-	-	-	1	1	-	1	1	1

**List of Experiments:**

1. To study the stress -strain characteristics of (a) Mild Steel and (b) Tor steel by conducting tension test on U.T.M
2. To study the stress - strain characteristics of (a) Copper and (b) Aluminium by conducting tension test on Hounsfield Tensometer
3. To find the Compressive strength of wood and punching shear strength of G.I. sheet by conducting relevant tests on Housfield Tensometer
4. To find the Brinnell's and Vicker's hardness numbers of (a) Steel (b) Brass (c) Aluminium (d) Copper by conducting hardness test.
5. To determine the Modulus of rigidity by conducting Torsion test on (a) Solid shaft (b) Hollow shaft
6. To find the Modulus of rigidity of the material of a spring by conducting Compression test.
7. To determine the Young's modulus of the material by conducting deflection test on a simply supported beam.
8. To determine the Modulus of elasticity of the material by conducting deflection test on a Propped Cantilever beam.
9. To determine the Modulus of elasticity of the material by conducting deflection test on a continuous beam
10. Ductility test for steel
11. Shear test on Mild Steel rods

MA261	NUMERICAL AND STATISTICAL METHODS	BSC	3 - 0 - 0	3 Credits
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

CO1	Interpret an experimental data using interpolation/curve fitting.
CO2	Solve numerically algebraic / transcendental and ordinary differential equations.
CO3	Understand the concepts of probability and statistics.
CO4	Test the hypothesis for large and small samples.

**Course Articulation Matrix:**

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	-	1	1	-	-	-	-	-	-	1	1	3
CO2	3	2	-	1	1	-	-	-	-	-	-	1	2	1
CO3	3	2	-	1	1	-	-	-	-	-	-	1	2	1
CO4	3	2	-	1	1	-	-	-	-	-	-	1	1	1

**Detailed Syllabus:**

**Numerical Analysis:** Curve fitting by the method of least squares. Fitting of (i) Straight line (ii) Second degree parabola (iii) Exponential curves. Calculation of dominant Eigen value by iteration, Gauss-Seidel iteration method to solve a system of equations and convergence (without proof). Numerical solution of algebraic and transcendental equations by Regula-Falsi method, Newton-Raphson method.

Lagrange interpolation, Newton's divided differences, Forward, backward and central differences, Newton's forward and backward interpolation formulae, Gauss's forward and backward interpolation formulae, Numerical differentiation at the tabulated points with forward backward and central differences. Numerical Integration with Trapezoidal rule, Simpson's 1/3 rule, Simpson's 3/8 rule and Romberg integration. Taylor series method, Euler's method, modified Euler's method, Runge-Kutta method of 2<sup>nd</sup> & 4<sup>th</sup> orders for solving first order ordinary differential equations.

**Statistics and Probability:** Review of fundamental concepts of probability, Moments and Moment generating function of Discrete and continuous distributions, Binomial, Poisson and Normal distributions, fitting these distributions to the given data, Testing of Hypothesis - Z-test for single mean and difference of means, single proportion and difference of proportions - t-test for single mean and difference of means, F-test for comparison of variances, Chi-square test for goodness of fit. - Correlation, regression.

**Reading:**

1. S.C.Gupta and V.K.Kapoor, *Fundamentals of Mathematical Statistics*, S.Chand & Co, 2006.
2. Jain, Iyengar and Jain, *Numerical methods for Scientific and Engineering Computation*, New Age International Publications, 2008.
3. Erwyn Kreyszig, *Advanced Engineering Mathematics*, John Wiley and Sons, 8<sup>th</sup> Edition, 2008.

<b>ME251</b>	<b>DYNAMICS OF MACHINERY</b>	<b>PCC</b>	<b>3 - 1- 0</b>	<b>4 Credits</b>
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**Pre-Requisites:** Nil

**Course Outcomes:** At the end of the course, the student shall be able to:

<b>CO1</b>	Understand free and forced vibrations of single degree freedom systems.
<b>CO2</b>	Analyze balancing problems in rotating and reciprocating machinery.
<b>CO3</b>	Characterize and design flywheels.
<b>CO4</b>	Understand the gyroscopic effects in ships, aero planes and road vehicles.
<b>CO5</b>	Analyze and design centrifugal governors.

**Course Articulation Matrix:**

<b>CO \ PO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>	<b>PSO1</b>	<b>PSO2</b>
<b>CO1</b>	3	3	3	3	2	-	3	-	-	-	-	2	2	2
<b>CO2</b>	3	3	3	3	3	3	2	-	-	-	-	2	3	2
<b>CO3</b>	3	3	3	3	1	-	2	-	-	-	-	2	2	2
<b>CO4</b>	3	3	3	3	1	-	2	-	-	-	-	2	2	2
<b>CO5</b>	3	3	3	3	3	3	2	-	-	-	-	2	3	2

**Detailed Syllabus:**

**Vibrations:**

Introduction, elements of a vibrating system, free vibrations of undamped system, natural frequency, phase, degree of freedom, applications of energy methods, namely, energy method and Rayleigh's method. Studying the effect of parameters on vibrations. Excitation sources, kinds of excitations. Vibration of undamped system under harmonic excitation. Effect of frequency of excitation on the amplitude of vibrations. Magnification Factor. Vibrations under resonance.

Free vibrations of spring mass damper system, concepts of critical damping coefficient and damping factor, under damping, critical damping and over damping. Vibrations of spring mass damper system under harmonic excitation. Magnification Factor. Phase difference between excitation and motion.

Rotating unbalance, whirling of shafts, critical speed and its practical importance in the design of shafts. Application of Dunkerley's method and Rayleigh's method for estimating the critical speed of shafts,

vibration isolation. Concepts of normal mode vibrations, natural frequencies, mode shapes, nodes.  
Practical problems

**Balancing:** Balancing and its types, Rotor balancing, Single plane and two plane balancing. Unbalanced forces and couples. Static and dynamic balancing, Balancing of rotors by analytical method and graphical method. Balancing machines. Balancing of reciprocating machines: primary, secondary and higher order unbalanced forces. Balancing of in line, V and radial engines.

**Flywheels:** Working principle of flywheel, Concept of dynamically equivalent link. Force analysis of single slider crank mechanism. Turning moment on the crank shaft. Turning moment diagrams. Maximum fluctuation of energy and its determination. Coefficient of fluctuation of speed. Design of flywheels. Rim type flywheel versus solid type flywheel.

**Gyroscope:** Principle of gyroscope, Roll, Yaw and pitch motions, Gyroscopic effect in a two wheeler, car, ship and aeroplane. Practical problems

**Governors:** Necessity of governor. Flywheels versus Governors. Different types of governors. Working principle of centrifugal governors. Concept of control force. Control force diagram. Definition of stability of governor. Condition for stability. Concept of isochronism. Sensitivity of governor. Energy of governor. Gravity controlled and spring controlled governors. Characteristics of Watt governor, Porter governor, Proell governor, Hartnell governor, Hartung governor. Hunting of governors.

**Reading:**

1. Shigley, J.E., and Uicker, J.J., Theory of Machines and Mechanisms, McGraw Hill Int. Edition, New York, Edition II, 2003.
2. Norton, R.L., Design of Machinery - An introduction to Synthesis and Analysis of Mechanisms and Machines, McGraw Hill International Editions, New York, Edition II, 2000.
3. Venkatachalam, R., Mechanical Vibrations, PHI, 2014.

<b>ME252</b>	<b>TURBOMACHINES</b>	<b>PCC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-Requisites:** ME201: Thermodynamics, CE235: Fluid Mechanics and Hydraulic Machines

**Course Outcomes:** At the end of the course, student will be able to:

<b>CO1</b>	Apply thermodynamic concepts to understand the working of turbo machines.
<b>CO2</b>	Differentiate ideal and practical gas turbine cycles.
<b>CO3</b>	Understand the working of gas turbine plant components and analyse their performance.
<b>CO4</b>	Analyse the steam power plant cycles
<b>CO5</b>	Design steam nozzles and steam turbines.

**Course Articulation Matrix:**

<b>PO</b> <b>CO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>	<b>PSO1</b>	<b>PSO2</b>
<b>CO1</b>	3	3	2	3	1	-	-	-	-	1		1	2	2
<b>CO2</b>	3	3	3	2	1	2	1	-	1	-	-	1	2	3
<b>CO3</b>	3	2	2	2	1	-	-	-	1	-	-	1	2	3
<b>CO4</b>	3	3	3	2	2	2	1	-	1	-	-	1	2	3
<b>CO5</b>	3	2	2	2	2	-	-	-	-	-	-	1	2	2

**Detailed Syllabus:**

**Review of Basics:** Introduction to Prime Movers, Gas Turbines, Review of Basic principles - Thermodynamics, Review of Basic principles - Fluid Dynamics and Heat Transfer, Fundamentals of Rotating Machines - Energy Equation, Dimensional Analysis, Airfoil Theory.

**Ideal Gas Turbine Cycles:** Analysis of Ideal Gas Turbine Cycles, Simple Cycle, Regeneration Cycle, Reheat Cycle, Inter cooling Cycle.

**Practical Gas Turbine Cycles:** Analysis of Practical Gas Turbine Cycles, Methods of accounting for component losses, Efficiencies, change in the composition of the working fluid.

**Centrifugal Compressors:** Centrifugal Compressors- Principle of Operation, T-s diagram, Energy equation, velocity triangles, types of blades. Analysis of Flow, Performance Characteristics.

**Axial Flow Compressors:** Axial Flow Compressors - Construction, Principle of Operation, T-s diagram, Energy equation, velocity triangles. Analysis of Flow. Work done factor, Stage efficiency, Degree of reaction, Performance characteristics.

**Combustion Chambers:** Gas turbine combustion systems - Introduction, Geometry, Factors affecting Design & Performance, Requirements of the Combustion Chamber, Gas Turbine Combustion Emissions.

**Rankine Cycle:** Properties of Pure Substances, Property diagrams, Steam Power plant Layout, Rankine Cycle- Analysis, Modified Rankine Cycle, and Combined Cycle.

**Steam Nozzles:** Steam Nozzles- Introduction, Area- velocity relationship, Mass flow rate, Choking of Nozzles, Performance characteristics of Nozzles.

**Steam Turbines:** Steam Turbines - Impulse and reaction Turbines, Compounding of steam turbines, multistage reaction Turbines, Reheat factor and Efficiency.

**Reading:**

1. Ganesan, V., Gas Turbines 3/e, Tata McGraw Hill Book Company, New Delhi, 2010.
2. Vasandani, V.P. and Kumar, D.S., Treatise on Heat Engineering, Chand and Co Publishers, New Delhi, 2011.
3. Saravanmuttoo, H.I.H., Rogers, G.F.C. and Cohen H., Gas Turbine Theory, 6/e. Pearson Prentice Education, 2008.

**Learning Resources/ Readings/ Video lectures:**

1. Lecture series on Turbomachinery Aerodynamics by Prof. Bhaskar Roy and Prof. A M Pradeep IIT, Bombay. For more details on NPTEL visit <http://nptel.ac.in>



ME253	MANUFACTURING SCIENCE	PCC	3 - 1 - 0	4 Credits
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**Pre-requisites:** ME101: Basic Mechanical Engineering, MM235: Materials Engineering

**Course Outcomes:** At the end of the course, the student will be able to:

CO1	Design core, core print and gating system in metal casting processes.
CO2	Develop process-maps for metal forming processes using plasticity principles
CO3	Design near net shaped components from metal and ceramic powders
CO4	Develop joints using solid state and fusion joining, brazing and soldering techniques

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	2	2	2	-	-	-	-	-	3	2
CO2	3	3	3	2	2	2	2	-	-	-	-	-	3	2
CO3	3	3	3	2	2	2	2	-	-	-	-	-	3	2
CO4	3	3	3	2	2	2	2	-	-	-	-	-	3	2

**Detailed Syllabus:**

Introduction to Manufacturing, Net and near-net shape manufacturing and their evolution

**Near-Net and Net Shaped Manufacturing:**

**Casting:** Solidification of Alloys and its mechanism, Gating System Design and Estimation of Solidification time, Riser Design and Riser Placement, Process Variations, Defects and Product Design, Shell Casting, Investment Casting, Centrifugal Casting.

**Powder Metallurgy:** (Metals and Ceramics) Techniques of near net shape manufacturing, techniques of powder manufacturing, characterization of powders, powder compaction methods, introduction to sintering, Sintering phenomenon, post sintering operations.

**Rapid Manufacturing:** Need for RP/RT/RM, Introduction to Processes for Prototyping, Tooling and Manufacturing.

**Deformation Processes:**

**Metal Forming:** Mechanism of plastic deformation, fundamentals of plasticity, Introduction to Force equilibrium method, State of Stress and boundary conditions in Upsetting/forging, Rolling, Wire and tube drawing, Extrusion and Deep Drawing, Defects, Load estimation for one plane strain and one axis-symmetric bulk deformation processes.

### **Joining Processes:**

Operating principle, basic equipment, merits and applications of Fusion and Solid state welding processes: V-I Characteristics, Solidification Phenomenon in Welding - Microstructural Evolution - Different Zones of Weld Region and their Microstructural Evolution - Brazing and Soldering, Mechanical and Adhesive Joining, Metal and nonmetal joining.

### **Reading:**

1. Amitabha Ghosh and Mallick A. K., Manufacturing Science. Affiliated East-West Press Pvt. Ltd. 2010.
2. M. P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, Third edition. Wiley India Private Limited, 2009.
3. S. Kalpakjian, Manufacturing Processes for Engineering Materials, Fifth edition. Pearson Education, 2009.
4. G. K. Lal and S. K. Choudhury, Fundamentals of Manufacturing Process, 2009. Boca Raton, FL: CRC Press, 2011.
5. J.P. Holman, Experimental Methods for Engineers, McGraw Hills Int. Edition.
6. P. C. Angelo and R. Subramanian, "Powder Metallurgy- Science, Technology and Applications", PHI, New Delhi, 2010.

### **References:**

1. Gowri P. Hariharan, A. Suresh Babu, "Manufacturing Technology I", Pearson Education, 2014
2. Roy. A. Lindberg, "Processes and Materials of Manufacture", PHI / Pearson education, 2006
3. Paul Degarmo E, Black J.T and Ronald A. Kosher, "Materials and Processes, in Manufacturing" Eight Edition, Prentice -Hall of India, 1997.
4. Sharma, P.C., "A Text book of production Technology", S. Chand and Co. Ltd., 2014.
5. P.L.JAIN. "Principles of Foundry Technology", TMH, 2014
6. Rao, P.N. "Manufacturing Technology Foundry, Forming and Welding", 2ndEdition, TMH; 2017

<b>ME 254</b>	<b>GEOMETRIC MODELLING FOR CAD</b>	<b>PCC</b>	<b>3 - 0- 0</b>	<b>3 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Apply geometric transformations and projection methods in CAD.
<b>CO2</b>	Develop geometric models to represent curves.
<b>CO3</b>	Design surface models for engineering design.
<b>CO4</b>	Model engineering components using solid modelling techniques for design.
<b>CO5</b>	Apply geometric modelling techniques in design and analysis.

**Course Articulation Matrix:**

<b>PO</b> <b>CO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>	<b>PSO1</b>	<b>PSO2</b>
<b>CO1</b>	3	2	2	2	1	-	2	-	-	-	-	2	2	3
<b>CO2</b>	3	2	2	2	1	-	2	-	-	-	-	2	2	3
<b>CO3</b>	3	2	3	2	1	-	2	-	-	-	-	2	2	3
<b>CO4</b>	3	2	2	2	1	-	2	-	-	-	-	2	2	3
<b>CO5</b>	3	2	3	3	2	-	2	-	-	-	-	2	2	2

**Detailed syllabus:**

**Introduction:** Introduction to CAE, CAD. Role of CAD in Mechanical Engineering, Design process, software tools for CAD, geometric modelling.

**Transformations in Geometric Modeling:** Introduction, Translation, Scaling, Reflection, Rotation in 2D and 3D. Homogeneous representation of transformation, Concatenation of transformations. Computer-Aided assembly of rigid bodies, applications of transformations in design and analysis of mechanisms, etc. Implementation of the transformations using computer codes.

**Projections:** Projective geometry, transformation matrices for Perspective, Axonometric projections, Orthographic and Oblique projections. Implementation of the projection formulations using computer codes.

**Introduction to Geometric Modeling for Design:** Introduction to CAGD, CAD input devices, CAD output devices, CAD Software, Display Visualization Aids, and Requirements of Modelling.

**Curves in Geometric Modeling for Design:** Differential geometry of curves, Analytic Curves, PC curve, Ferguson's Cubic Curve, Composite Ferguson, Curve Trimming and Blending. Bezier segments, de Casteljau's algorithm, Bernstein polynomials, Bezier- subdivision, Degree elevation, Composite Bezier. B-spline basis functions, Properties of basic functions, Knot Vector generation, NURBS. Conversion of one form of curve to other. Implementation of the all the curve models using computer codes in an interactive manner.

**Surfaces in Geometric Modeling for Design:** Differential geometry of surfaces, parametric representation, Curvatures, Developable surfaces. Surfaces entities (planar, surface of revolution, lofted etc). Free-form surface models (Hermite, Bezier, B-spline surface). Boundary interpolating surfaces (Coon's). Implementation of the all the surface models using computer codes.

**Solids in Geometric Modeling for Design:** Solid entities, Boolean operations, Topological aspects, Invariants. Wire-frame modeling, B-rep of Solid Modelling, CSG approach of solid modelling. Popular modeling methods in CAD software. Data Exchange Formats and CAD Applications:

**Reading:**

1. Michael E. Mortenson, Geometric Modeling, Tata McGraw Hill, 2013.
2. A. Saxena and B. Sahay, Computer-Aided Engineering Design, Anamaya Publishers, New Delhi, 2005.
3. Rogers, David F., An introduction to NURBS: with historical perspective, Morgan Kaufmann Publishers, USA, 2001.
4. David F. Rogers, J. A. Adams, Mathematical Elements for Computer Graphics, TMH, 2008.

<b>ME255</b>	<b>COMPUTER AIDED MACHINE DRAWING</b>	<b>PCC</b>	<b>1 - 0 - 4</b>	<b>3 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, student will be able to:

<b>CO1</b>	Develop the surfaces of different solids
<b>CO2</b>	Draw the machine elements including keys, couplings, and cotters, riveted, bolted and welded joints following the conventions for engineering materials.
<b>CO3</b>	Construct an assembly drawing using part drawings of machine components.
<b>CO4</b>	Create part drawing of machine components using machine assembly

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	2	2	1	-	3	-	-	-	2	2	-	2	2	2
<b>CO2</b>	2	3	2	-	3	-	-	-	2	3	-	2	2	2
<b>CO3</b>	2	2	2	-	3	-	-	-	2	3	-	2	2	3
<b>CO4</b>	2	2	2	-	3	-	-	-	2	3	-	2	2	3

**Detailed Syllabus:**

**Development of Surfaces:** Draw the development of surfaces for Prisms, Cylinders, Pyramids and Cones.

**Representation of elements of machine drawing:** Engineering Materials, Surface finishes, tolerances, sectional views, Screw threads.

**Component Drawings:** Bolts and Nuts, Locking devices, Keys and Cotter joints, Knuckle Joint, Riveted joints, Shaft Couplings, Bearings and Pipe joints.

**Assembly Drawing Practice:** Draw the assembly drawings of Stuffing Box, Eccentric, Swivel bearing, Drill jig, Tail stock, Toolpost, Tool head for shaping machine, machine vice, screw jack, using the component drawings, Draw the component drawings using the assembly drawings, Machine Drawing practice using AutoCAD and CREO

**Reading:**

1. Bhatt, N.D., Machine Drawing, Charotar Publishing House, 2003.
2. Sidheswar, N., Kannaiah, P. and Sastry, V.V.S., Machine Drawing, Tata McGraw Hill Book Company, New Delhi, 2000.

<b>ME256</b>	<b>MANUFACTURING PROCESSES LABORATORY</b>	<b>PCC</b>	<b>0 - 1 - 2</b>	<b>2 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Fabricate weldments using gas and arc welding.
<b>CO2</b>	Evaluate the quality of welded joints and cast components using non-destructive testing methods.
<b>CO3</b>	Test the properties of moulding sands.
<b>CO4</b>	Perform formability studies on sheet metals.

**Course Articulation Matrix:**

<b>PO</b> <b>CO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>	<b>PSO1</b>	<b>PSO2</b>
<b>CO1</b>	3	2	-	-	-	-	-	-	3	3	-	2	3	3
<b>CO2</b>	3	2	-	-	-	-	-	-	3	3	-	2	3	3
<b>CO3</b>	3	2	2	2	-	-	-	-	3	3	-	2	3	3
<b>CO4</b>	3	2	2	2	2	2	-	-	3	3	-	2	3	3

**List of Experiments:**

1. Fabricate the butt joint in the given samples by using shielded metal arc welding in the given samples
2. Fabricate the butt joint in the given samples by using shielded metal submerged arc welding
3. Fabrication of circumferential butt joint in the given samples by using shielded metal arc welding
4. Fabricate butt joint in the given samples by using gas welding, SAW, TIG and MIG welding.
5. Join metal plates in the given samples using resistance spot welding
6. Join rectangular cross section plates in the given samples by flash butt welding
7. Identify welding defects by liquid penetration test in the welded sample
8. Demonstration on sweep pattern and core making in mould preparation

9. Calculate the amount of the clay content in the given moulding sand
10. Find the grain fineness number of the given moulding sand
11. Find the green and dry shear strength, compression strength and permeability of the given moulding sand.
12. Find shatter index of the given moulding sand
13. Demonstration on sand casting of at least two products.
14. Perform formability studies on sheet metals.
15. Evaluate coefficient of friction using ring compression test.

**Reading:**

1. Manufacturing Technology Lab manual

<b>ME257</b>	<b>KINEMATICS AND DYNAMICS LABORATORY</b>	<b>PCC</b>	<b>0-1-2</b>	<b>2 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, student will be able to:

<b>CO 1</b>	Analyse the kinematics of different mechanisms.
<b>CO 2</b>	Identify the essential system properties and physically visualize the concepts of frequency and time period of vibrations under free vibration
<b>CO 3</b>	Explain the mechanism of forced vibration to analyse the damping properties.
<b>CO 4</b>	Evaluate the mechanism of forced vibration to analyse the different mode shapes and critical speed of shaft.

**Course Articulation Matrix:**

PO \ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	3	2	2	2	-	2	-	-	2	2	-	2	3	1
<b>CO2</b>	3	2	2	2	-	2	-	-	2	2	-	2	3	1
<b>CO3</b>	3	2	3	2	-	3	-	-	3	2	-	2	3	2
<b>CO4</b>	3	2	2	2	-	3	-	-	3	2	-	2	3	2

**Detailed Syllabus:**

**Cycle 1: KINEMATICS**

1. To determine the link lengths of four bar chain, Single slider crank chain, and Double slider crank chain mechanisms.
2. To study the belt, rope and chain drives
3. To identify the motion of cam and follower mechanism
4. Basic ideas concerning to clutch drive and gear and gear trains

**Cycle 2: DYNAMICS**

1. To estimate the acceleration due to gravity using bifilar pendulum.
2. To determine the mass moment of inertia of a given object using a Trifilar pendulum.
3. To verify the natural frequency of a bar resting on a Cylindrical surface



4. To verify the natural frequency of a semi cylindrical shell resting on a horizontal surface.
5. To find the location of the center of mass  $G$  and the moment of inertia about  $I_G$  of a given connecting rod (Compound pendulum).
6. To determine the viscous damping coefficient of a given viscous damper
7. To estimate the damping in given vibrating system through Logarithmic decrement.
8. To determine the viscous damping coefficient of a viscous damper by observing free vibrations of Spring-Mass-Damper system.
9. To determine the coefficient of friction between two surfaces.
10. To determine the natural frequencies of the Coupled pendulum (Two degree freedom) through (a) Normal mode vibrations (b) Beat phenomenon and then calculate the stiffness of the coupling spring
11. To determine the first and second natural frequencies of a Cantilever beam (Vibration of Continuous system)
12. To estimate the Critical speed of shafts

<b>ME301</b>	<b>DESIGN OF MACHINE ELEMENTS</b>	<b>PCC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-requisites:** CE101: Engineering Mechanics and CE236: Mechanics of Solids

**Course Outcomes:** At the end of the course, the student shall be able to:

<b>CO1</b>	Identify the preferred sizes and codes, and selection of proper material for design of machine element.
<b>CO2</b>	Design the machine element under static and dynamic loading conditions.
<b>CO3</b>	Design the temporary and permanent joints required to assemble the machine elements.
<b>CO4</b>	Design the required spring for the given application.

**Course Articulation Matrix:**

<b>PO</b> <b>CO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>	<b>PSO1</b>	<b>PSO2</b>
<b>CO1</b>	3	3	3	2	2	-	-	-	-	-	-	2	2	1
<b>CO2</b>	3	3	3	2	2	-	-	-	-	-	-	2	2	1
<b>CO3</b>	3	3	3	2	3	-	-	-	-	-	-	2	2	1
<b>CO4</b>	3	3	3	2	2	-	-	-	-	-	-	2	2	1

**Detailed Syllabus:**

**Introduction:** Engineering Design and classification, Basic design procedure, requirement of machine element, traditional design methods, standards and codes, selection of preferred sizes, Engineering material and its classification, Mechanical properties of engineering materials, Selection of materials, Manufacturing considerations and their selection.

**Static Loading:** Basics- Stresses in members subjected to different types of loads, Modes of failure, Principal stresses, Theories of failure- Rankine theory, Guests theory and Von Mises theory, Selection of failure theories to design simple machine parts.

**Dynamic Loading:** Stress concentration and its Importance in design, Methods to reduce stress concentration, Stress concentration factor-Theoretical and actual stress concentration factors, Notch sensitivity, Design of stress concentrated members subjected to various loads-Problems, Types of variable/Cyclic loads, Mean & amplitude Stresses, Fatigue Failure, Endurance Limit & Strength, S-N Diagram, Goodman and Soderberg criterion, Modifying factors: Size effect, surface effect, Reliability,

stress concentration effects etc., Problems on design of members for finite & infinite life in members subjected to individual & combined loading, Cumulative damage in fatigue.

**Design of Temporary Joints:** Types of temporary joints- cotter joints, knuckle joint and fasteners, Design of cotter and knuckle joint, Forms of screw threads, Nomenclature of screw thread, Thread series and its designation, Power screws and their advantages over v-threads, Stress in screwed threads, Design of bolts based on uniform strength, Empirical relation for initial tightening, Design of screw & Nut for power screw-Problems.

**Design of Permanent Joints:** Types of permanent joints-Riveted and Welded Joints, Rivet heads, Terminology, Caulking and fullering, Analysis of riveted joint, Efficiency of a riveted joint, Design of boiler joints and structural joints, Eccentrically loaded riveted joints, Welding process, merits and demerits of welded joint over riveted joints, weld symbols, Strength of parallel and fillet weld, Eccentrically loaded welded joints, Weld subject to bending moment and torsional moment, Problems.

**Design of Springs:** Types of Springs, Spring materials, terminology - Stresses in Helical coil springs of circular and non-circular cross sections, Compression-spring surge, Springs under eccentric loading and fluctuating loads, - Energy stored in springs, torsion, Belleville springs. Leaf Springs: Stresses in leaf springs, Nipping. Equalized stresses.

**Reading:**

1. Bhandari, V B., Design of Machine Elements, 3/e, Tata McGraw Hill Book Company, New Delhi, 2009.
2. Norton, R. L., Machine Design: An Integrated Approach, 3/e, Pearson, 2004.
3. Shigley, J.E and Mischke, C. R. Mechanical Engineering Design, 6/e, Tata McGraw Hill, 2005.
4. Paul H Black and O. E. Adams, P., Machine Design, 3/e, McGraw Hill Book Company, Inc., New York, USA., 2007.
5. Kannaiah, P., Machine Design, 2/e, Scitech Publication Pvt. Ltd., 2009.

<b>ME302</b>	<b>PRIME MOVERS FOR AUTOMOBILES</b>	<b>PCC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-Requisites:** ME201: Thermodynamics

**Course Outcomes:** At the end of the course, student will be able to:

<b>CO1</b>	Understand the importance of IC engine as a prime mover and compare its performance on the basis of thermodynamic cycles and combustion processes.
<b>CO2</b>	Estimate engine performance and emission parameters.
<b>CO3</b>	Identify harmful IC engine emissions and use viable alternate fuels in engines.
<b>CO4</b>	Classify electric vehicles based on batteries, electric motors and alternate power sources.
<b>CO5</b>	Analyze batteries and electric motors commonly used in electric/hybrid vehicles.

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	3	2	2	2	2	-	1	-	-	-	-	1	2	1
<b>CO2</b>	3	2	2	2	2	-	2	-	-	-	-	2	2	2
<b>CO3</b>	3	2	2	1	1	-	3	-	-	-	-	3	2	2
<b>CO4</b>	2	2	2	1	2	-	2	-	-	-	-	1	1	1
<b>CO5</b>	2	2	2	1	2	-	1	-	-	-	-	1	1	1

**Detailed Syllabus:**

**Introduction to IC engines:** Overview of the course, Examination and Evaluation patterns- Classification of Prime Movers; IC Engines as Prime Movers; Historical Perspective-Contribution of IC Engines for Global Warming. Concept of charge, Differences between EC Engines and IC Engines- Classification, Mechanical cycle and Thermodynamic cycle, Air standard cycles-Diesel, Otto, Dual and Miller cycles. Classification of 2-s cycle engines based on scavenging, Differences between 2-s and 4-s cycle engines, Differences between SI and CI engines.

**Two-stroke engines:** Definition of parameters-Scavenging Efficiency, Delivery ratio and trapping Efficiency, Theoretical Scavenging Processes-Practical Scavenging Systems- Kadenacy effect- Numerical problems on 2-stroke cycle engines

**Spark Ignition Engines:** Flame Propagation- Combustion phenomena (Normal and Abnormal), Factors affecting, Detonation, Ignition quality, HUCR-Carburetion and fuel injection systems for SI Engines

**Compression Ignition Engines:** Advantages of CI engines-Importance of air motion and Compression Ratio, Mixture Preparation inside the CC. Normal and abnormal combustion - Ignition Quality-Cetane number-Characteristics of a Good Combustion Chamber-Classification of Combustion Chambers (DI and IDI).Description of Fuel injection Systems -Individual, Unit and Common Rail (CRDI),Fuel Injectors-Nozzle types, Electronic Control Unit(ECU)-Numerical problems on fuel injection

**Supercharging of IC Engines:** Need of Supercharging and advantages, Configurations of Supercharging-Numerical problems on turbocharging.

**Pollutant emissions from IC Engines:**Introduction to clean air, Pollutants from SI and CI Engines: Carbon monoxide, UBHCs, Oxides of nitrogen(NO-NOX) and Particulate Matter.Mechanism of formation of pollutants, Factors affecting pollutant formation.Measurement of engine emissions-instrumentation, Pollution Control Strategies, Emission norms-EURO and Bharat stage norms.

**Performance of IC Engines:** Classification of engine performance parameters-Measurement of brake power, indicated power and friction power.Factors affecting performance, Heat loss, Air-fuel ratio, Pumping loss, Energy Balance: Pi and Sankey diagrams Numerical problems.

**Alternate Fuels:** Need for Alternate fuels, Desirable Characteristics of good Alternate Fuel-Liquid and Gaseous fuels for SI and CI Engines, Kerosene, LPG, Alcohols, Bio-fuels, Natural gas, Hydrogen and use of these fuels in engines.

**Electric vehicles:** Introduction: Limitations of IC Engines as prime mover, History of EVs, EV system, components of EV-DC and AC electric machines: Introduction and basic structure-Electric vehicle drive train-advantages and limitations, Permanent magnet and switched reluctance motors

**Hybrid vehicles:** Configurations of hybrids-Series and Parallel, advantages and limitations-Hybrid drive trains, sizing of components Initial acceleration, rated vehicle velocity, Maximum velocity and maximum gradeability-Hydrogen: Production-Hydrogen storage systems-reformers

**Batteries:** Battery: lead-acid battery, cell discharge and charge operation, construction, advantages of lead- acid battery- Battery parameters: battery capacity, discharge rate, state of charge, state of discharge, depth of discharge, Technical characteristics-Ragone plots.

**Fuel Cell vehicles:** Fuel cells: Introduction-Fuel cell characteristics, Thermodynamics of fuel cells-Fuel cell types: emphasis on PEM fuel cell

#### **Reading:**

1. J.B. Heywood Internal Combustion Engine Fundamentals, McGraw Hill Co.1988
2. W.W.Pulkrabek Engineering Fundamentals of IC Engine, PHI Pvt.Ltd 2002
3. Seth Leitman and Bob Brant Build your own electric vehicle McGraw Hill Co.2009.
4. F.Barbir PEM Fuel Cells-Theory and Practice Elsevier Academic Press-2005.

<b>ME303</b>	<b>MACHINE TOOLS AND METROLOGY</b>	<b>PCC</b>	<b>3 - 1 - 0</b>	<b>4 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Analyse the kinematic motions in a machine tool.
<b>CO2</b>	Estimate machining times for various machining operations
<b>CO3</b>	Design speed and feed gear boxes for a given configuration.
<b>CO4</b>	Select methods and devices for the measurement of machining and geometric features of components.
<b>CO5</b>	Design limit gauges for verifying the component tolerances.

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	2	2	-	-	-	-	-	-	-	-	-	-	3	2
<b>CO2</b>	2	2	-	-	-	-	-	-	-	-	-	-	3	2
<b>CO3</b>	3	2	-	2	-	-	-	-	-	-	-	-	2	-
<b>CO4</b>	3	2	2	2	-	-	-	-	-	-	-	-	3	-
<b>CO5</b>	2	2	3	-	-	-	-	-	-	2	-	2	2	2

**Detailed syllabus:**

**Machine Tools:** Working and Auxiliary Motions in Machine Tools, Kinematics of Machine Tools, Machining time calculations for various machining operations, Accessories and Attachments, Thread Cutting on Lathe, Methods of indexing - Dividing head.

**Regulation of Speed and Feed Rates:** Methods of Speed and Feed Regulation, Stepped Regulation of Speeds, Ray Diagrams and Design Considerations, Design of Speed Gear Boxes, Feed Drives, Feed Box Design.

**Finishing Processes:** Grinding, Lapping, Honing & Broaching Processes.

**Metrology:**

Linear and Angular Measurements: Linear Measuring Instruments, Angle measuring instruments, Comparators, Calibration of Instruments.

Limits, Fits, Tolerances and Gauging: Interchangeability, Types of fits, Basic-Hole System, Basic-Shaft System, Types of Assemblies, Design of limit gauges, Introduction to GD&T.

**Gear and Screw Thread Measurements:**

Gear measurement: Introduction and Classification of gears; Forms of gear teeth; Gear tooth terminology; Methods of measuring tooth thickness, tooth profile & pitch, Gear Errors;

Screw Thread Measurement: Terminology, Forms of thread, Errors in threads, Measurement of major, minor and effective diameters (2-wire and 3-wire methods).

**Surface Roughness Measurement:** Components of surface texture, Need for surface roughness measurement, Measurement of surface roughness, Roughness characterization, Roughness grades.

**Interferometry:** Principle of Interference, Optical Flat, Fringe Patterns, NPL Interferometer.

**Geometric Form Measurement:** Straightness, Flatness, Roundness, Coordinate Measuring Machine.

**Reading:**

1. Kalpakjian, S. and Steven R. Schmid, Manufacturing, Engineering & Technology, Pearson.
2. Rao, P.N., Manufacturing Technology-Metal Cutting and Machine Tools, Tata McGraw Hill, New Delhi, 2000.
3. N.K. Mehta, Machine Tool Design, Tata McGraw Hill, 2012
4. I.C. Gupta, Engineering Metrology, Dhanpat Rai & Sons, 2003
5. R. K. Jain, Engineering Metrology, Khanna Publishers, 19/e, 2005.

<b>ME304</b>	<b>MECHANICAL MEASUREMENTS</b>	<b>PCC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-Requisites:** Nil

**Course Outcomes:** At the end of the course, student will be able to:

<b>CO1</b>	Understand the measurement terminologies and the concept of generalized measurement system.
<b>CO2</b>	Estimate errors and uncertainty in measurements using statistical analysis.
<b>CO3</b>	Analyze zeroth, first and second order measurement systems.
<b>CO4</b>	Classify sensors for measurement of specific parameters with required accuracy.
<b>CO5</b>	Design experiments by combining measuring devices to acquire desired outputs.

**Course Articulation Matrix:**

CO \ PO	PO												PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	2	3	3	3	-	2	-	-	-	-	-	-	2	2
<b>CO2</b>	2	3	3	2	-	2	-	-	-	-	-	-	2	2
<b>CO3</b>	2	3	3	3	-	2	-	-	-	-	-	-	2	2
<b>CO4</b>	3	3	3	2	-	3	-	-	-	-	-	-	2	2
<b>CO5</b>	3	2	3	2	-	3	-	-	-	-	-	-	3	3

**Detailed Syllabus:**

**Basics of Measurements:** Introduction, Generalized measurement system, Signal flow diagram of measurement system, Inputs and their methods of correction

**Presentation of experimental data:** Errors in measurement, Propagation of errors, Uncertainty analysis, Regression analysis.

**Pressure measurement:** Different pressure measurement instruments and their comparison, Transient response of pressure transducers

**Thermometry:** Overview of thermometry, Thermo-electric temperature measurement, Resistance thermometry, Pyrometer, Other methods, issues in measurements.

**Flow Measurement:** Flow obstruction methods, Magnetic flow meters, Interferometer, LDA, Other methods.



**Thermal and transport property measurement:** Measurement of thermal conductivity, diffusivity, viscosity, humidity and gas composition.

**Nuclear, thermal radiation measurement:** Measurement of reflectivity, transmissivity, emissivity, nuclear radiation, neutron detection, etc.

**Other measurements:** Basics in measurement of torque, force, strain

**Advanced topics:** Issues in measuring thermos-physical properties of micro and Nano fluidics

**Design of Experiments:** Basic ideas of designing experiments, Experimental design protocols with some examples.

**Reading:**

1. Experimental Methods for Engineers, J P Holman, Tata McGraw Hill publications
2. Mechanical Measurements by Thomas G Beckwith, Pearson publications.
3. Measurement systems by Ernest O Doebelin, Tata McGraw Hill publications

<b>ME305</b>	<b>MANAGEMENT SCIENCE AND PRODUCTIVITY</b>	<b>PCC</b>	<b>4 - 0 - 0</b>	<b>4 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Understand the evolutionary development of management thought and general principles of management.
<b>CO2</b>	Apply marketing concepts and tools for successful launch of a product.
<b>CO3</b>	Understand the role of productivity in streamlining a production system.
<b>CO4</b>	Apply the inventory management tools in managing inventory.
<b>CO5</b>	Apply quality engineering tools to the design of products and process controls.
<b>CO6</b>	Apply project management tools to manage projects.

**Course Articulation Matrix:**

<b>CO \ PO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>	<b>PSO1</b>	<b>PSO2</b>
<b>CO1</b>	-	-	2	-	-	2	-	3	3	3	2	2	3	2
<b>CO2</b>	-	-	2	-	-	2	2	2	2	2	2	2	3	2
<b>CO3</b>	2	2	2	2	-	2	-	2	2	-	2	2	3	3
<b>CO4</b>	2	2	-	-	-	-	-	-	-	-	-	-	2	2
<b>CO5</b>	2	3	2	3	-	-	-	2	2	-	-	2	3	3
<b>CO6</b>	2	-	2	-	-	-	2	2	2	2	3	-	2	3

**Detailed Syllabus:**

**General Management:** Introduction of the course, Evolution of industry and professional management, Functions of Management, Organization Structures, Hawthorne Experiments, Motivational Theories and Leadership Styles, American and Japanese Style of Management.

**Marketing Management:** Marketing management process, Market segmentation, Targeting and Positioning, 4 P's of marketing mix, Product Life Cycle and marketing strategies.

**Production Management:** Production systems classification and characterization, Production strategies, Process management, Facility Design.

**Productivity and Work study:** Productivity and its role in the economy, Techniques for improving productivity, Method study, Principles of motion economy, Stopwatch time study, Work sampling.

**Quality Management:** Dimensions of quality, Process control charts, Acceptance sampling, Taguchi's total quality control, Quality function deployment, Introduction to TQM.

**Inventory Management:** Purpose of inventories, Inventory costs, ABC classification, Economic Order Quantity (EOQ), P and Q systems of inventory control.

**Project Management:** Project activities, Network diagrams, Critical path method, PERT, Project Feasibility studies.

**Reading:**

1. Koontz H. and Wehrich H., "Essentials of Management", 10<sup>th</sup> Edition, McGraw-Hill, New York, 2015.
2. Kotler P., "Marketing Management", 15<sup>th</sup> Edition, Prentice Hall of India/Pearson, New Delhi 2017.
3. Chase, Shankar and Jacobs, "Operations and Supply Chain Management", 14<sup>th</sup> Edition, Tata McGraw Hill, New Delhi, 2017.

<b>ME306</b>	<b>THERMAL ENGINEERING LABORATORY</b>	<b>PCC</b>	<b>0 - 1 - 2</b>	<b>2 Credits</b>
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**Pre-Requisites:** Nil

**Course Outcomes:** At the end of the course, student will be able to:

<b>CO1</b>	Conduct constant speed and emission tests on IC engines and interpret their performance.
<b>CO2</b>	Estimate energy distribution by conducting heat balance test on IC engines.
<b>CO3</b>	Determine the friction power of an IC engine by motoring, Morse and retardation tests.
<b>CO4</b>	Evaluate performance parameters of steam power plant.
<b>CO5</b>	Evaluate the performance of turbomachines.

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	3	3	1	3	2	1	1	-	3	2	1	1	2	1
<b>CO2</b>	2	1	1	3	2	1	1	-	3	2	-	1	2	1
<b>CO3</b>	3	3	1	1	2	-	2	-	3	1	-	1	2	1
<b>CO4</b>	3	3	1	3	3	2	2	-	3	2	1	1	2	1
<b>CO5</b>	1	1	2	2	3	1	-	1	3	2	3	3	2	1

**List of Experiments:**

1. Performance test on twin cylinder air cooled diesel engine
2. Valve timing diagram
3. Retardation test on Kirloskar diesel engine
4. Performance characteristics of an Axial flow fan
5. Morse Test on Hindustan Engine
6. Performance characteristics of a single stage centrifugal blower
7. Heat balance test on Kirloskar engine
8. Performance test on single cylinder SI engine
9. Load test on Steam turbine
10. Heat Balance Test on steam condenser
11. Demonstration of boiler

**Reading:**

1. Vasandhani V.P. and Kumar, D.S., Treatise on Heat Engineering, Chand & Co Publishers, New Delhi, 2015.
2. Ganesan, V., Gas Turbines 3rd Edition, Tata McGraw Hill Book Company, New Delhi, 2015.

<b>ME307</b>	<b>MACHINE TOOLS AND METROLOGY LABORATORY</b>	<b>PCC</b>	<b>0-1-2</b>	<b>2 Credits</b>
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**Pre-requisites:**

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Perform different operations on a lathe.
<b>CO2</b>	Evaluate the effect of process parameters on shear angle, cutting forces and surface finish in machining.
<b>CO3</b>	Evaluate the effect of process parameters on MRR and surface finish in EDM.
<b>CO4</b>	Perform indexing to machine spur and helical gears on milling machine.
<b>CO5</b>	Evaluate internal and external taper angles, straightness and flatness of a given surface.
<b>CO6</b>	Evaluate dimensional and form accuracies of thread and gear profiles.

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	2	-	-	3	-	-	-	-	2	2	-	2	3	-
<b>CO2</b>	2	-	-	3	-	-	-	-	2	2	-	2	3	-
<b>CO3</b>	2	-	-	3	-	-	-	-	2	2	-	2	3	-
<b>CO4</b>	2	-	-	3	-	-	-	-	2	2	-	2	3	-
<b>CO5</b>	2	-	-	3	-	-	-	-	2	2	-	2	3	-
<b>CO6</b>	2	-	-	3	-	-	-	-	2	2	-	2	3	-

**List of Experiments:****Machining Cycle:**

1. Turning, Taper turning, Facing, Thread cutting and chamfering on lathe (Demo: Split-half nut).

2. Eccentric turning (Demo: Different types of chucks, Belt, Chain and Geardrives).
3. Spur Gear and Helical milling (Demo: Indexing).
4. Chip reduction coefficient on shaper (Demo: 1. Quick-return mechanism, 2. Pawl and Ratchet mechanism, 3. Rack & Pinion mechanism).
5. Measurement of cutting forces and surface finish in turning (Demo: Dynamometer and its setup).

**Metrology Cycle:**

1. Internal and external taper measurement.
2. Thread measurement using floating carriage diameter measuring machine.
3. Straightness measurement using auto-collimator.
4. Measurement of Thread and Gear profiles for their form and geometrical accuracies.
5. Demonstration Coordinate Measuring Machine for the evaluation of form errors.

**Reading:**

1. Kalpakjian S. and Steven R. Schmid, "Manufacturing, Engineering & Technology", Pearson, 2007
2. I.C. Gupta, "Engineering Metrology", DhanpatRai and Sons, 2003.

ME311	MECHANICAL VIBRATIONS	DEC	3-0-0	3 Credits
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**Pre-requisites:** Nil.

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Develop schematic models for physical systems and formulate governing equations of motion.
<b>CO2</b>	Analyse rotating and reciprocating systems and compute critical speeds.
<b>CO3</b>	Analyse and design machine supporting structures, vibration isolators and absorbers.
<b>CO4</b>	Calculate free and forced vibration responses of multi degree freedom systems using modal analysis.

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	3	3	3	1	1	-	-	-	-	-	-	2	2	2
<b>CO2</b>	3	3	2	2	2	-	-	-	-	-	-	2	2	2
<b>CO3</b>	3	3	2	3	2	-	-	-	-	-	-	3	2	2
<b>CO4</b>	3	3	2	2	3	-	-	-	-	-	-	3	2	2

**Detailed Syllabus:**

**Introduction:** Causes and effects of vibration, Classification of vibrating system, Discrete and continuous systems, degrees of freedom, Identification of variables and Parameters, Linear and nonlinear systems, linearization of nonlinear systems, Physical models, Schematic models and Mathematical models.

**SDF systems:** Formulation of equation of motion: Newton -Euler method, De Alembert's method, Energy method, Undamped Free vibration response and Damped Free vibration response, Case studies on formulation and response calculation.

**Forced vibration response:** Response to harmonic excitations, solution of differential equation of motion, Vector approach, Complex frequency response, Magnification factor Resonance, Rotating/reciprocating unbalances, Force Transmissibility, Motion Transmissibility, Vehicular suspension, Vibration measuring instruments, Case studies on forced vibration,

**Two degree of freedom systems:** Introduction, Formulation of equation of motion: Equilibrium method, Lagrangian method, Case studies on formulation of equations of motion. Free vibration response, Eigen values and Eigen vectors, Normal modes and mode superposition, Coordinate coupling, decoupling of equations of motion, Natural coordinates, Response to initial conditions, free vibration response case studies, Forced vibration response, undamped vibration absorbers, Case studies on undamped vibration absorbers.

**Multi degree of freedom systems:** Introduction , Formulation of equations of motion, Free vibration response, Natural modes and mode shapes, Orthogonally of model vectors, normalization of model vectors, Decoupling of modes, model analysis, mode superposition technique, Free vibration response through model analysis, Forced vibration analysis through model analysis, Model damping, Rayleigh's damping, Introduction to experimental model analysis.

**Continuous systems:** Introduction to continuous systems, Exact and approximate solutions, free vibrations of strings, bars and beams.

**Reading:**

1. L. Meirovich, Elements of Vibration analysis, 2nd Ed. Tata Mc-Grawhill, 2007
2. Singiresu S Rao, Mechanical Vibrations. 4th Ed., Pearson education, 2011
3. W.T., Thompson, Theory of Vibration, CBS Publishers
4. Clarence W. de Silva , Vibration: Fundamentals and Practice, CRC Press LLC, 2000



ME 312	DESIGN OPTIMIZATION METHODS	DEC	3-0-0	3 Credits
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student shall be able to

CO1	Formulate a design task as an optimization problem
CO2	Solve unconstrained optimization problems
CO3	Formulate constrained optimization problem and solve using corresponding methods
CO4	Solution of discontinuous optimization problems using special methods
CO5	Solve the nonlinear optimization problems with evolutionary methods

**Course Articulation Matrix:**

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	3	3	3	3	3	-	-	1	-	2	-	1	3
CO2	3	3	3	3	3	-	-	1	-	2	-	1	3	3
CO3	3	3	3	3	3	-	-	1	-	2	-	1	3	3
CO4	3	3	3	3	3	-	-	1	-	2	-	1	3	3

**Detailed syllabus:**

**Introduction to optimization in design:** Problem formulation, Optimization problems in Mechanical Engineering, Classification of methods for optimization

**Single-variable Optimization:** Optimal criteria, Derivative-free methods (bracketing, region elimination), Derivative based methods, root-finding methods.

**Multiple-variable Optimization:** Optimal criteria, direct search methods (Box's, Simplex, Hooke-Jeeves, Conjugate methods), Gradient-based methods (Steepest Descent, Newton's, Marquardt's, DFP method). Formulation and Case studies.

**Constrained Optimization:** KKT conditions, Penalty method, and Sensitivity analysis, direct search methods for constrained optimization, quadratic programming, GRG method, Formulation and Case studies.

**Specialized algorithms:** Integer programming (Penalty function and branch-and-bound method), Geometric programming.

**Evolutionary Optimization algorithm:** Genetic algorithms, simulated annealing, Anti-colony optimization, Particle swarm optimization.

**Multi-objective Optimization:** Terminology and concepts, the concepts of Pareto optimality and Pareto optimal set, formulation of multi-objective optimization problem, NSGA.

**Case studies and Computer Implementation:** Representative case studies for important methods and development of computer code for the same to solve problems.

**Readings:**

1. Jasbir Arora, Introduction to Optimum Design, Academic Press, 2004
2. Kalyanmoy Deb, Optimization for Engineering Design: Algorithms and Examples, PHI, 2004.
3. Kalyanmoy Deb, Multi-Objective Optimization using Evolutionary Algorithms, Wiley, 2001.

ME313	ADVANCED THERMODYNAMICS	DEC	3 - 0 - 0	3 Credits
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**Pre-Requisites:** ME201: Thermodynamics

**Course Outcomes:** At the end of the course, student will be able to:

CO1	Understand Maxwell's and thermodynamic relations of gas mixtures.
CO2	Estimate thermodynamic properties of gas mixtures.
CO3	Identify the models to estimate the properties of real gases.
CO4	Analyze reactive and non-reactive gas mixtures using the concepts of statistical thermodynamics and kinetic theory of gases.
CO5	Analyze chemical reaction and combustion of gas-mixtures.

**Course Articulation Matrix:**

PO \ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	-	-	-	-	-	-	-	-	-	-	2	-
CO2	3	3	3	3	-	-	-	-	-	-	-	-	3	2
CO3	3	3	3	-	-	-	-	-	-	-	-	-	3	3
CO4	3	3	2	2	-	-	-	-	-	-	-	-	3	3
CO5	3	3	2	3	-	-	-	-	-	-	-	-	3	2

**Detailed Syllabus:**

**Revision of Thermodynamics:** I Law of Thermodynamics, II Law of Thermodynamics, Entropy, and Availability.

**Properties of Gases and Gas Mixtures:** Equations of State, changes in internal energy, enthalpy and entropy for an ideal gas, Equations of state for a real gas, Virial Expansions, Law of Corresponding States, Generalized Compressibility Chart, Reduced coordinates, Other Equations of state, Dalton's Law of Partial Pressures, Internal Energy, Enthalpy and Entropy and Specific Heats of Gas Mixtures, Gibbs Function of a Mixture.

**Thermodynamic Relations:** Some Mathematical Theorems, Maxwell's Relations, T-ds Equations, Difference in Heat Capacities, Ratio of Heat Capacities, Energy Equation, Clausius-Clapeyron Equation, Joule-Thomson Coefficient, Evaluation of Thermodynamic Properties from Equation of State,

Mixtures of Variable Composition, Conditions of Equilibrium for a Heterogeneous System, Gibbs Phase Rule, Types of Equilibrium, Conditions of Stability, Third Law of Thermodynamics.

**Reactive Mixtures:** Degree of Reaction, Reaction Equilibrium, Equilibrium Constant, Law of Mass Action, Thermal Ionization of Monatomic Gas, Gibbs Function Change, Fugacity and Activity, Enthalpy of Formation, Enthalpy of Combustion, Heating Values, Adiabatic Flame Temperature, Second Law Analysis of reactive Systems, Chemical Exergy, Second Law Efficiency.

**Statistical Thermodynamics:** Quantum Hypothesis, Quantum Principle Applied to a System of Particles, Wave-Particle Duality, De Broglie Equation, Heisenberg's Uncertainty Principle, Schrodinger's Wave Equation, Probability Function, Particle in a Box, Rigid Rotator, Harmonic Oscillator, Phase Space, Maxwell-Boltzmann Statistics, Stirling's Approximation, Bose-Einstein Statistics, Fermi-Dirac Statistics, Partition Function, Entropy and Probability, Monatomic Ideal Gas, Principle of Equi-partition of Energy, Statistics of a photon gas, Electron Gas, Thermodynamic Properties.

**Kinetic Theory of Gases:** Molecular Model, Distribution of Molecular Velocities, Molecular Collisions with a Stationary Wall, Maxwell-Boltzmann Velocity Distribution, Average, Root-Mean Square and Most Probable Speeds, Molecules in a Certain Speed Range, Energy Distribution Function, Specific Heat of a Gas, Specific Heat of a Solid.

**Transport Processes in Gases:** Mean Free Path and Collision Cross-section, Distribution of Free Paths, Transport Properties.

**Reading:**

1. Cengel, Y.A & Boles, M.A., Thermodynamics-An Engineering Approach, 8<sup>th</sup> Ed, TMH, 2017.
2. Borgnakke, C & Sonntag, R.E., Fundamentals of Thermodynamics, 7<sup>th</sup> Ed, Wiley, 2009.
3. Nag, P.K., Basic and Applied Thermodynamics, 2<sup>nd</sup> Ed, TMH, 2017.
4. Smith, J.M. et al, Introduction to Chemical Engineering Thermodynamics, 7<sup>th</sup> Ed, TMH, 2009.
5. Mcquarrie, D.A., and Simon, J.D., Molecular Thermodynamics, Viva Books, 2010.

<b>ME314</b>	<b>GAS DYNAMICS</b>	<b>DEC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-Requisites:** ME201: Thermodynamics

**Course Outcomes:** At the end of the course, student will be able to:

<b>CO1</b>	Solve flow equations for quasi one dimensional flow through variable area ducts.
<b>CO2</b>	Analyze the flow through constant area ducts with friction and heat transfer.
<b>CO3</b>	Analyze flows with normal and oblique shocks.
<b>CO4</b>	Solve flow problems with supersonic velocities using shock-expansion theory.
<b>CO5</b>	Solve linearized velocity potential equation for multi-dimensional flows.

**Course Articulation Matrix:**

<b>PO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>	<b>PSO1</b>	<b>PSO2</b>
<b>CO</b>														
<b>CO1</b>	3	3	2	1	-	-	-	-	-	-	-	-	2	2
<b>CO2</b>	3	3	3	1	-	-	-	-	-	-	-	-	2	2
<b>CO3</b>	3	3	2	3	-	-	-	-	-	-	-	-	2	2
<b>CO4</b>	3	1	2	3	-	-	-	-	-	-	-	-	2	2
<b>CO5</b>	3	3	3	2	-	-	-	-	-	-	-	-	2	2

**Detailed Syllabus:**

**Introduction:** Review of basic fluid dynamic and thermodynamic principles, Conservation equations for inviscidflows.

**One Dimensional flow:** One-dimensional wave motion, normal shock waves, Oblique shock waves, Prandtl-Meyer expansions and applications, generalized one-dimensional flow

**Nozzle Flow:** Isentropic flow with area change, Flow with friction (Fanno flow), Flow with heat addition (Rayleigh flow), Method of characteristics (application to one-dimensional unsteady isentropic flow)

**Supersonic Flow:** Velocity Potential Equation, Numerical Techniques for Steady Supersonic Flow, Time Marching Technique for Supersonic Blunt Bodies and Nozzles

**Reading:**

1. Anderson, J.D Jr., Modern Compressible Flows, Tata McGraw Hill, 2012.
2. Yahya, S.M., Fundamentals of Compressible Flow, New age International Pub., 2013.
3. Zucrow, M., Gas Dynamics, Wiley India, 2013.

ME315	ADVANCED WELDING TECHNOLOGY	DEC	3 - 0 - 0	3 Credits
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**Pre-requisites:** ME253 - Manufacturing Science

**Course Outcomes:** At the end of the course, the student will be able to:

CO1	Understand solid state welding processes such as friction stir welding and explosive welding and their applications
CO2	Apply laser beam welding processes to join metals
CO3	Analyze the welded joints fabricated through hybrid welding process
CO4	Examine weldability of cast iron, steel and Aluminum alloys.
CO5	Analyze the welded joint fabricated through cold metal transfer welding process
CO6	Develop plastic components using ultrasonic welding process.

**Course Articulation Matrix:**

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	2	2	-	-	-	-	-	-	2	3
CO2	3	3	3	2	2	2	-	-	-	-	-	-	2	2
CO3	3	3	3	2	2	2	-	-	-	-	-	-	3	2
CO4	3	3	3	2	2	2	-	-	-	-	-	-	3	2
CO5	3	2	2	2	2	2	-	-	-	-	-	-	2	3
CO6	3	3	3	2	2	2	-	-	-	-	-	-	3	2

**Detailed Syllabus:**

**Solid state welding processes :** Classification of solid state welding processes, Review of Friction stir welding, Selection of tool design, Fixture design, modification of tool and features, modeling of friction stir welding, submerged friction stir welding. Friction stir processing, Process variables, Surface modification by friction stir processing, Production of composite by friction stir processing. Adhesive bonding, vacuum brazing, Explosive welding: Process description, process parameters, joint design, advantages and limitations applications.

**Laser Beam welding (LBW):** Laser Beam welding, process parameters, and Laser Beam welding of steels. Hybrid welding processes: GMAW and Laser welding , process, advantages and Limitations, GTAW and Laser beam welding, Cold Metal Transfer welding process, advantages, limitations and applications.

Weldability studies of cast iron and steel. Welding of dissimilar materials: Aluminum to steel, Aluminum to copper.

Ultrasonic welding, ultrasonic spot welding, line welding, continuous seam welding , welding of plastic and Induction welding of plastics, process description, application, advantages and limitations.

**Reading:**

1. Nadkarni S.V., "Modern Welding Technology", Oxford IBH Publishers, 2015.
2. Parmar R. S., "Welding Engineering and Technology", Khanna Publishers, 2014.
3. D. L. Olson, T. A. Siewert, "Metal Hand Book", Vol 06, Welding, Brazing and Soldering, ASM International Hand book Metals Park, Ohio USA, 2015.

ME316	ADVANCED METAL CASTING	DEC	3 - 0 - 0	3 Credits
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**Pre-requisites:** ME253: Manufacturing Science

**Course Outcomes:** At the end of the course, the student will be able to:

CO1	Recommend remedies for the defects in castings.
CO2	Model components for castings using CAD tools.
CO3	Design gating system for metal casting processes
CO4	Perform economic and castability analysis using Auto-CAST software.

**Course Articulation Matrix:**

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	3	-	3	-	-	-	-	-	-	-	3	2
CO2	3	2	2	-	2	-	-	-	-	2	-	-	3	2
CO3	3	2	3	-	3	-	-	-	-	-	-	-	2	3
CO4	3	2	2	-	2	-	-	-	-	2	-	-	1	3

**Detailed syllabus:**

**Metal casting-overview:** Applications and production, historical perspective, casting processes.

**Solid modeling of castings:** casting features, modeling techniques, graphical user interface, model representation model exchange formats, model verification.

**Pattern, mould and core design:** Orientation and parting, mould parting analysis, pattern design, cored features, core print design and analysis, mould cavity layout.

**Feeder design and analysis:** Casting solidification, solidification time and rate, feeder location and shape, feeder and neck design, feed aid design, solidification analysis, vector element method, optimization and validation.



**Gating design and analysis:** Mould filling, gating system and types, gating channel layout, optimal filling time, gating element design, mould filling analysis, numerical simulation, optimization and validation.

**Process planning and costing:** Casting process selection, process steps and parameters, tooling cost estimation, material cost estimation, and conversion cost estimation.

**Design for castability:** Product design for castability, process friendly design, and castability analysis.

**Reading:**

1. B.Ravi, "Metal casting: CAD and Analysis", PH Publication, 2014.
2. P.L.Jain, "Principles of Foundry Technology", 2012.
3. Kalpakjian. S, "Manufacturing Engineering and Technology", Pearson Education India Edition, 2010.

<b>ME351</b>	<b>DESIGN OF TRANSMISSION ELEMENTS</b>	<b>PCC</b>	<b>3 - 1 - 0</b>	<b>4 Credits</b>
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**Pre-requisites:** ME301: Design of Machine Elements

**Course Outcomes:** At the end of the course, the student shall be able to:

<b>CO1</b>	Design the required size of shaft, key and coupling for the given application.
<b>CO2</b>	Select the appropriate gear and Design the gear for the given operating conditions.
<b>CO3</b>	Identify the suitable bearing and design the required size of bearing.
<b>CO4</b>	Design the flexible elements required to transmit the desired power.
<b>CO5</b>	Design the suitable size of I.C. engine parts, clutch and brake.

**Course Articulation Matrix:**

<b>CO \ PO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>	<b>PSO1</b>	<b>PSO2</b>
<b>CO1</b>	3	3	3	3	1	-	2	-	-	-	-	2	3	2
<b>CO2</b>	3	3	3	3	1	-	2	-	-	-	-	2	3	3
<b>CO3</b>	3	3	3	3	1	-	2	-	-	-	-	2	3	2
<b>CO4</b>	3	3	3	3	1	-	2	-	-	-	-	2	3	3
<b>CO5</b>	3	2	3	2	2	-	2	-	-	-	-	2	2	2

**Detailed Syllabus:**

**Design of Shafts, Keys and Couplings:** Types of loading on shafts, Causes of stress concentration in shafts, Design of shafts based on strength, Design of shafts based on rigidity, Use of fatigue and stress concentration factors in Shaft Design, Practical examples, Purpose of Key, Different types of keys, Design - square and flat keys, Kennedy keys and splines, Purpose of shaft couplings, Different types of couplings, Design of rigid couplings - muff coupling, split muff coupling and flanged coupling, Design of Flexible couplings - bushed-pin flexible coupling, Oldhams coupling and Universal coupling.

**Design of Gears:** Classification of Gears, Law of gearing, Terminology of spur gear, Standard Systems of gear tooth, Interference and undercutting, backlash, Stresses produced in a gear tooth, Concept of uniform strength beam, Shape of uniform strength cantilever beam with point load at its free end, Lewis equation, Design of spur gear tooth based on strength, Checking the design under dynamic loading

conditions and wear loading conditions, Terminology and Force analysis - Helical gears, Worm gears and Bevel gears (self-study)

**Design of Friction Bearings:** Conditions of proper lubrication, Mechanism of dry friction, Petroff's law, Assumptions involved in Petrof's law, Hydrodynamic lubrication, Practical examples, hydrodynamic conditions in a bearing, McKeey's equation, Thick and thin film lubrications, Stability of lubrication, Bearing modulus, Heat balance in journal bearing, Design of journal bearings, Sommerfeld number, Introduction of hydrostatic bearings and magnetic bearings.

**Design of Antifriction Bearings:** Advantages and disadvantages over friction bearings, Different types of antifriction bearings, A qualitative comparison of performance of antifriction bearings with journal bearings, Basic static and dynamic load ratings, Equivalent radial load, Selection of bearings from manufacturers catalogue, bearings design.

**Design of Flexible Elements:** Belts and their construction, Flat belts versus V- belts, Open and cross belt arrangement, Ratio of belt tensions, Centrifugal tension, Effect of centrifugal tension, Design of flat belts and V-belts, Selection of wire rope and Pulleys, Introduction to Chain drive - its merits and demerits, Constructional features of a chain drive.

**Design of Brakes and Clutches:** Different types of brakes, Concept of self-energizing and self-locking of brakes, Practical examples, Design of band brakes, block brakes and internal expanding brakes, Necessity of a clutch in an automobile, Types of clutch, friction materials and its properties, Design of single plate, multi-plate and cone clutches based on uniform pressure and uniform wear theories.

**Design of I.C. Engine parts:** Design of engine parts such as Piston, Connecting rod and Crank shaft.

#### **Reading:**

1. Richard G. Budynas, J Keith Nisbett, *Shigley's Mechanical Engineering Design*, McGraw Hill, Ninth edition, 2011.
2. Robert L Norton, *Machine design an integrated approach*, Pearson Education, Second edition, 2009.
3. V B Bhandari, *Design of Machine Elements*, Tata McGraw Hill Education Private Limited, Third Edition, 2012.
4. Black and Adams, *Machine Design*, McGraw Hill and Co, New Delhi, 2002.

<b>ME352</b>	<b>HEAT AND MASS TRANSFER</b>	<b>PCC</b>	<b>3 - 1 - 0</b>	<b>4 Credits</b>
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**Pre-Requisites:** ME201: Thermodynamics

**Course Outcomes:** At the end of the course, student will be able to:

<b>CO1</b>	Understand the basic modes of heat transfer.
<b>CO2</b>	Compute temperature distribution in steady-state and unsteady-state heat conduction.
<b>CO3</b>	Analyze heat transfer through extended surfaces.
<b>CO4</b>	Interpret forced and free convection heat transfer.
<b>CO5</b>	Understand the principles of radiation heat transfer and basics of mass transfer.
<b>CO6</b>	Design and analyze heat exchangers using LMTD and NTU methods.

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	3	2	2	2	2	-	-	-	-	-	-	-	2	1
<b>CO2</b>	3	2	2	2	1	-	-	-	-	-	-	-	2	3
<b>CO3</b>	2	3	2	2	1	-	-	-	-	-	-	-	2	3
<b>CO4</b>	2	3	2	2	1	-	-	-	-	-	-	-	2	2
<b>CO5</b>	3	2	2	1	1	-	-	-	-	-	-	-	2	2
<b>CO6</b>	3	2	2	2	1	-	-	-	-	-	-	-	2	3

**Detailed Syllabus:**

**Introduction:** Heat Transfer - Different Modes, Governing Laws, Applications to Heat Transfer, Numerical Problems.

**General Heat Conduction Equation:** Derivation of the equation in (i) Cartesian, (ii) Polar and (iii) Spherical Co-ordinate Systems.

**Steady-state one-dimensional heat conduction problems in Cartesian System:** Steady-state one-dimensional heat conduction problems (i) with and without heat generation and (ii) with and without varying thermal conductivity - in Cartesian system with various possible boundary conditions, Thermal Resistances in Series and in Parallel, Numerical Problems.

**Steady-state radial heat conduction problems in Polar System:** Steady-state one-dimensional heat conduction problems (i) with and without heat generation and (ii) with and without varying thermal conductivity - in cylindrical system with various possible boundary conditions, Thermal Resistances in Series, Numerical Problems.

**Steady-state radial heat conduction problems in Spherical System:** Steady-state one-dimensional heat conduction problems (i) with and without heat generation and (ii) with and without varying thermal conductivity - in Spherical system with various possible boundary conditions, Thermal Resistances in Series, Numerical Problems.

**Critical Thickness of Insulation:** Concept, Derivation and Numerical Problems.

**Extended Surfaces or Fins:** Classification, Straight Rectangular and Circular Fins, Temperature Distribution and Heat Transfer Calculations, Fin Efficiency and Effectiveness, Applications, Numerical Problems.

**Transient [Unsteady-state] heat conduction:** Definition, Different cases - Negligible internal thermal resistance, negligible surface resistance, comparable internal thermal and surface resistance, Lumped body, Infinite Body and Semi-infinite Body, Numerical Problems, Heisler and Grober charts: Solutions to various one-dimensional problems using the charts, Numerical problems.

**Forced Convection:** Boundary Layer Theory, Velocity and Thermal Boundary Layers, Prandtl number, Governing Equations - Continuity, Navier-Stokes and Energy equations, Boundary layer assumptions, Integral and Analytical solutions to above equations, Turbulent flow, Various empirical solutions, Numerical Problems, Forced convection flow over cylinders and spheres, Internal flows -laminar and turbulent flow solutions, Numerical Problems.

**Free convection:** Laminar and Turbulent flows, Vertical Plates, Vertical Tubes and Horizontal Tubes, Empirical solutions, Numerical Problems.

**Thermal Radiation:** Fundamental principles - Gray, White, Opaque, Transparent and Black bodies, Spectral emissive power, Wien's, Rayleigh-Jeans' and Planck's laws, Hemispherical Emissive Power, Stefan-Boltzmann law for the total emissive power of a black body, Emissivity and Kirchhoff's Laws, View factor, View factor algebra, Net radiation exchange in a two-body enclosure, Typical examples for two-body enclosures, Radiation Shield, Numerical problems.

**Heat Exchangers:** Definition, Classification, LMTD method, Effectiveness - NTU method, Analytical Methods, Numerical Problems, Chart Solution for Heat Exchanger Problems: Correction Factor Charts and Effectiveness-NTU Charts, Numerical Problems.

**Mass Transfer:** Definition, Examples, Fick's law of diffusion, Fick's law as referred to ideal gases, Steady-state isothermal equi-molar counter diffusion of ideal gases, Mass diffusivity.

#### **Reading:**

1. M. Necati Ozisik, Heat Transfer - A Basic Approach, McGraw Hill, New York.
2. Incropera, F. P. and De Witt, D. P., Fundamentals of Heat and Mass Transfer, John Wiley and Sons, New York.
3. Holman, J. P., Heat Transfer, Tata McGraw Hill, New Delhi.
4. Alan J. Chapman, Heat Transfer, Macmillan, New York.

<b>ME353</b>	<b>MACHINING SCIENCE</b>	<b>PCC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-requisites:** MM235: Materials Engineering, ME303: Machine Tools and Metrology, ME305: Mechanical Measurements

**Course Outcomes:** At the end of the course, the student will be able to:

<b>C01</b>	Develop interrelations among ASA, ORS and NRS systems of tool geometry.
<b>C02</b>	Analyze the stresses, cutting forces, temperature, power and specific energy in metal cutting with single point cutting tool.
<b>C03</b>	Select cutting fluids, tool materials and coatings to control temperature and tool wear to improve tool life and machinability
<b>C04</b>	Evaluate cutting speed to minimize production cost and maximize production rate.
<b>C05</b>	Analyze the cutting forces, temperature, power and specific energy in machining with multi point cutting tool.
<b>C06</b>	Select a modern machining process based on the effect of various process parameters on the required performance criteria.

**Course Articulation Matrix:**

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	3	-	-	-	-	-	-	-	-	-	-	-	2	-
<b>CO2</b>	3	3	2	3	-	-	2	-	-	-	-	-	3	-
<b>CO3</b>	3	-	-	-	-	-	2	2	-	-	-	-	3	-
<b>CO4</b>	3	2	-	-	-	-	-	-	-	-	-	-	2	-
<b>CO5</b>	3	3	2	3	-	-	2	2	-	-	-	-	3	-
<b>CO6</b>	3	-	-	-	-	-	-	-	-	-	-	-	3	2

**Detailed Syllabus:**

**Introduction:** Overview of the course, Examination and Evaluation patterns, Classification of Manufacturing Processes, History of Machining, Scope and Significance of Machining.

**Geometry of Cutting Tools:** Geometry of single-point turning tool: Tool-in hand system, ASA system, Significance of various angles of SPTT, Orthogonal Rake System (ORS), Normal Rake System (NRS), Conversions between ASA and ORS systems.

**Mechanics of Machining:** Processes: Orthogonal and Oblique cutting, Mechanics of Chip formation: Types of chips, chip-breakers, Chip reduction coefficient, shear angle, shear strain, Built-Up-Edge and its effect in metal cutting, Merchant's analysis of metal cutting process - Various forces, power and specific energy in cutting, Effect of tool geometry on cutting forces and surface finish.

**Thermal aspects in machining:** Sources of heat generation, Effects of temperature, Determination of cutting temperature using analytical methods, Determination of cutting temperature using experimental methods, Methods of Controlling Cutting Temperature.

**Tool wear, Tool life, Machinability:** Wear Mechanisms, Types of tool wear, Tool Life and Machinability.

**Machining Economics:** A brief treatment for single pass turning operations.

**Cutting Tool Materials:** Desirable Properties of tool materials, Characteristics of Cutting Tool Materials, Indexable inserts, coated tools.

**Cutting Fluids:** Functions, characteristics and types, Selection of cutting fluids.

**Mechanics of Multipoint machining processes:** Mechanics of Milling process, Mechanics of Grinding (plunge grinding and surface grinding).

**Modern Machining Processes:** An overview of modern machining processes - Classification, Mechanical Processes - Ultrasonic, water jet and abrasive jet machining - Working principle, application, economy and process selection, Mechanism of material removal, process parameters, Electrochemical Processes - Chemical machining, electro chemical machining - Working principle, application, economy and process selection, Mechanism of material removal, process parameters, Electric Discharge Machining (sinking EDM and Wire cut EDM) - Working principle, application, economy and process selection, Mechanism of material removal, process parameters.

**Reading:**

1. Kalpakjian S. and Steven R. Schmid, Manufacturing, "Engineering & Technology" Pearson, 2007
2. P. C. Pandey and H. S. Shan, "Modern Machining Processes", TMH, 2002.
3. Amitabha Ghosh and A.K. Mallik, "Manufacturing Science", 2<sup>nd</sup> Edition East-West Press, 2010
4. V. K. Jain, "Advanced manufacturing Processes", Allied Publishers Pvt. Ltd, 2002.
5. B L Juneja and G S Sekhon, "Fundamentals of metal cutting and machine Tools", New Age International publishers, 2001.
6. K. C. Jain and A. K. Chitale, "Production Engineering", PHI, 2014.

<b>ME354</b>	<b>MECHATRONICS</b>	<b>PCC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-requisites:** EC101: Basic Electronic Engineering

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Model and analyze mechatronic systems for an engineering application
<b>CO2</b>	Identify sensors, transducers and actuators to monitor and control the behavior of process or product.
<b>CO3</b>	Develop PLC programs for an engineering application.
<b>CO4</b>	Evaluate the performance of mechatronic systems.

**Course Articulation Matrix:**

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	3	3	3	2	2	-	-	-	2	-	-	2	2	3
<b>CO2</b>	3	2	2	3	2	-	-	-	2	-	2	-	2	2
<b>CO3</b>	3	3	2	2	3	-	2	2	2	-	-	-	2	2
<b>CO4</b>	3	2	2	2	3	-	2	2	2	-	-	2	2	2

**Detailed Syllabus:**

**Introduction:** Overview of the course, Examination and Evaluation patterns, History of Mechatronics, Scope and Significance of Mechatronics systems, elements of mechatronic systems, needs and benefits of mechatronics in manufacturing

**Actuators:**ElectricalActuators: Solenoids, relays, diodes, thyristors, triacs, BJT, FET, DC motor, Servo motor, BLDC Motor, AC Motor, stepper motors. Hydraulic & Pneumatic devices - Power supplies, valves, cylinder sequencing. Design of Hydraulic & Pneumatic circuits. Piezoelectric actuators, Shape memory alloys.

**Basic System Models & Analysis:** Modelling of one and two degrees of freedom Mechanical, Electrical, Fluid and thermal systems, Block diagram representations for these systems.

**Dynamic Responses of System:** Transfer function, Modelling Dynamic systems, first order systems, second order systems.



**Digital Electronics:** Number systems, BCD codes and arithmetic, Gray codes, self-complimenting codes, Error detection and correction principles. Boolean functions using Karnaugh map, Design of combinational circuits, Design of arithmetic circuits. Design of Code converters, Encoders and decoders.

**Signal Conditioning:** Operational amplifiers, inverting amplifier, differential amplifier, Protection, comparator, filters, Multiplexer, Pulse width Modulation Counters, decoders. Data acquisition - Quantizing theory, Analog to digital conversion, digital to analog conversion.

**Controllers:** Classification of control systems, Feedback, closed loop and open loop systems, Continuous and discrete processes, control modes, Two step Proportional, Derivative, Integral, PID controllers.

**PLC Programming:** PLC Principles of operation PLC sizes PLC hardware components I/O section Analog I/O section Analog I/O modules, digital I/O modules CPU Processor memory module Programming. Ladder Programming, ladder diagrams, timers, internal relays and counters, data handling, analogue input and output. Application on real time industrial automation systems.

**Case studies of Mechatronics systems:** Pick and place robot, Bar code, Engine Management system, Washing machine etc.

**Industry 4.0 Concepts:** Introduction, IoT Techniques, Cloud computing, machine learning, Digital Twin.

**Reading:**

1. W. Bolton, "Mechatronics", 5<sup>th</sup> Edition, Addison Wesley Longman Ltd, 2010
2. Devdas Shetty & Richard Kolk, "Mechatronics System Design", 3<sup>rd</sup> Edition. PWS Publishing, 2009.
3. Alciatore David G & Histan Michael B, "Introduction to Mechatronics and Measurement systems", 4<sup>th</sup> Edition, Tata McGraw Hill, 2006.

**Video references:**

1. [http://video\\_demos.colostate.edu/mechatronics](http://video_demos.colostate.edu/mechatronics)
2. <http://mechatronics.me.wisc.edu>

ME355	HEAT TRANSFER AND FUELS LABORATORY	PCC	0 - 1 - 2	2 Credits
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**Pre-Requisites:** ME201: Thermodynamics

**Course Outcomes:** At the end of the lab, student will be able to:

<b>CO1</b>	Measure important properties of fuels and oils.
<b>CO2</b>	Evaluate the variation of volumetric efficiency of a two-stage reciprocating air compressor as a function of receiver pressure.
<b>CO3</b>	Estimate heat transfer coefficient in forced convection and compare with theoretical and empirical values.
<b>CO4</b>	Measure heat transfer coefficient in free convection and compare with empirical values.
<b>CO5</b>	Estimate the efficiency and effectiveness of a pin-fin and equivalent thermal resistance of a composite slab.
<b>CO6</b>	Determine surface emissivity of a test plate and demonstrate working of a Heat Pipe.

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	3	2	2	2	-	-	-	-	-	-	-	1	1	1
<b>CO2</b>	2	2	2	3	-	-	-	-	-	-	-	1	2	2
<b>CO3</b>	2	2	2	2	-	-	-	-	1	1	-	1	2	2
<b>CO4</b>	2	2	2	3	-	-	-	-	-	1	-	1	2	2
<b>CO5</b>	3	2	2	2	-	-	-	-	-	1	-	1	2	2
<b>CO6</b>	3	2	2	2	-	-	-	-	1	1	-	1	2	2

**List of Experiments:**

- 1. Abel's apparatus:** Determination of flash and fire points of a given oil sample.
- 2. Redwood Viscometer No. 1:** Determination of kinematic and absolute viscosities of a given oil sample.
- 3. Distillation apparatus:** Determination of distillation characteristic of a given sample of gasoline.

4. **Two-Stage Reciprocating Air-Compressor:** Determination of volumetric efficiency of the compressor as a function of receiver pressure.
5. **Pin-Fin Apparatus:** Determination of temperature distribution, efficiency and effectiveness of the fin working in forced convection environment.
6. **Natural Convection Apparatus:** Determination of experimental and empirical values of free convection heat transfer coefficient from a Heated Vertical Cylinder.
7. **Composite Slab Apparatus:** Determination of theoretical and experimental values of equivalent thermal resistance of a composite slab.
8. **Forced Convection Apparatus:** Determination of theoretical, experimental and empirical values of forced convection heat transfer coefficient for flow through a circular pipe.
9. **Emissivity Apparatus:** Determination of surface emissivity of a given test plate at a given absolute temperature.
10. **Heat Pipe Demonstrator:** Demonstration of isothermal characteristic exhibited by a heat pipe in comparison to other pipes.
11. **Parallel and Counter flow Heat Exchanger:** Determination of LMTD of parallel and counter flow heat exchanger.

**Reading:**

1. M. Necati Ozisik, Heat Transfer - A Basic Approach, McGraw Hill, New York., 1980
2. Incropera, F. P. and De Witt, D. P., Fundamentals of Heat and Mass Transfer, John Wiley and Sons, New York, 2013
3. Holman, J. P., Heat Transfer, Tata McGraw Hill, New Delhi, 2011

<b>ME356</b>	<b>MEASUREMENTS LABORATORY</b>	<b>PCC</b>	<b>0 - 0 - 2</b>	<b>1 Credit</b>
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**Pre-Requisites:** ME304: Mechanical Measurements

**Course Outcomes:** At the end of the lab, student will be able to:

<b>CO1</b>	Estimate errors and uncertainty in measurements using statistical analysis.
<b>CO2</b>	Calibrate measuring instruments with standards.
<b>CO3</b>	Identify sensors for measurement of specific parameters with required accuracy.

**Course Articulation Matrix:**

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	<b>CO1</b>	2	3	3	1	3	-	-	-	2	1	-	2	2
<b>CO2</b>	1	3	3	1	2	-	-	-	2	1	-	2	2	2
<b>CO3</b>	2	3	3	2	3	-	-	-	3	1	-	2	2	2

**List of Experiments:**

1. Calibrate strain gauge pressure sensor with Bourdon gauge.
2. Determine the mass flow rate of air using hot wire anemometer and pitot tube.
3. Demonstrate the working principle of LVDT and compare with micro meter.
4. Compare the temperature reading recorded by thermocouples, RTD, thermometers.
5. Demonstrate the working of IR thermal transducer and recording high temperatures.
6. Demonstrate torque measurement and do regression analysis.
7. Compare venturi meter, orifice meter and rotameter for flow measurement.

**Reading:**

1. Experimental Methods for Engineers, J P Holman, Tata McGraw Hill publications
2. Mechanical Measurements by Thomas G Beckwith, Pearson publications.
3. Measurement systems by Ernest O Doebelin, Tata McGraw Hill publications

<b>ME361</b>	<b>FINITE ELEMENT METHOD</b>	<b>DEC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Pre-Requisites:** Nil

**Course Outcomes:** At the end of the course, the student shall be able to:

<b>CO1</b>	Apply finite element method to solve problems in solid mechanics and Heat transfer.
<b>CO2</b>	Formulate and solve problems in one dimensional structures including trusses, beams and frames.
<b>CO3</b>	Formulate FE characteristic equations for two dimensional elements and analyse plain stress, plain strain, and axi-symmetric and plate bending problems.
<b>CO4</b>	Implement and solve the finite element formulations using MATLAB.

**Course Articulation Matrix:**

<b>PO</b> <b>CO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>	<b>PSO1</b>	<b>PSO2</b>
<b>CO1</b>	2	2	-	-	3	-	-	-	-	-	-	2	2	2
<b>CO2</b>	3	3	2	2	3	-	-	-	-	-	-	2	2	2
<b>CO3</b>	3	3	2	2	3	-	-	-	-	-	-	2	2	2
<b>CO4</b>	2	2	-	-	3	-	-	-	-	-	-	2	2	3

**Detailed Syllabus:**

**Introduction:** Overview of the course, examination and evaluation patterns, history and basic concept of finite element method and direct FEM.

**Fundamental concepts:** Calculus of variation and solving differential equations, Ritz method, Galerkin method, Least squares, collocation and subdomain methods, Case studies for Ritz and Galerkin methods, Ritz FEM formulation, Galerkin FEM formulation.

**One-Dimensional Problems:** Finite element formulation for 1-D problems, elimination method, penalty method, computer implementation and case studies.

**Trusses:** Introduction, fem formulation, plane trusses, three dimensional trusses, frames and case studies.

**Two-Dimensional Problems:** Finite element formulation for 2-D problems, constant strain triangle, various elements, iso parametric, sub parametric and super parametric elements, interpolation functions, computer implementation and case studies.

**Numerical Integration and 2-D problems of Elasticity:** Introduction to numerical integration, two dimensional integrals, plane stress, plane strain, axisymmetric, plate bending problems.

**Thermal Applications:** Two - dimensional heat conduction analysis, formulation of functional, element matrices and case studies.

**Fluid Mechanics Applications:** Stream function formulation, velocity potential formulation and torsional analysis of a prismatic bar.

**Three Dimensional Problems:** Finite element formulation for 3-D problems, mesh preparation, hexahedral elements, shell elements and case studies.

**Reading:**

1. Seshu P., Textbook of Finite Element Analysis, PHI, 2009
2. Reddy, J.N., Finite Element Method in Engineering, Tata McGraw Hill, 2007.
3. Zeinowicz, The Finite Element Method for Solid and Structural Mechanics, 4<sup>th</sup> Edition, Elsevier 2007.

<b>ME362</b>	<b>THEORY OF ELASTICITY</b>	<b>DEC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Pre-Requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Formulate the stress strain relations in elastic body.
<b>CO2</b>	Develop the governing equation and apply boundary conditions for 2D elastic problems.
<b>CO3</b>	Apply the general theorems to the 3D elastic continuum problems.
<b>CO4</b>	Analyse the stress in the Prismatic Beams of rectangular and circular cross-section

**Course Articulation Matrix:**

PO \ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	3	3	-	-	-	-	-	2	-	-	-	2	-	-
<b>CO2</b>	-	3	3	2	2	-	-	2	-	-	-	2	2	2
<b>CO3</b>	3	3	-	-	3	-	-	2	-	-	-	2	2	2
<b>CO4</b>	-	3	-	2	3	-	-	2	-	-	-	2	3	2

**Detailed Syllabus:**

**Elasticity:** Two dimensional stress analysis - Deformation and Strain Tensor, Traction and Stress Tensor Plane stress - Plane strain - Equations of compatibility - Stress function - Boundary conditions.

**Rectangular Coordinates System:** Stress, Strain and Displacement Transformations, Solution by polynomials - Saint Venent's principles - Determination of displacement - Simple beam problems, Problems in polar coordinates - General equations in polar coordinates - Stress distribution symmetrical about axis - Strain components in polar coordinates - Simple and symmetric problems.

**Three-Dimensional Classical Elasticity Problems:** Principle stresses - Homogeneous deformations - Strain spherical and deviatoric stress - Hydrostatic strain.

**General Theorems:** Differential equations of equilibrium and compatibility - Displacement - Uniqueness of solution - Reciprocal theorem, Boussinesq's Problem, Mindlin's Problem.

**Bending of Prismatic Bars and Elasto dynamics:** Stress function - Bending of cantilever beam - Beam of rectangular cross-section - Beams of circular cross-section, Helmholtz Decomposition, Elastic Wave Propagation in Solids

**Reading:**

1. Theory of Elasticity by Timoshenko, S.P. and Goodier, J.N. McGraw-Hill, 1970.
2. An Engineering Theory of Plasticity by E.P. Unksov. Butterworths, 1961
3. A Treatise on the mathematical Theory of Elasticity, Love. FB & C Limited, 2017
4. Fundamentals of Fracture Mechanics, T. Kundu, Taylor and Francis, 2008

ME363	COMPUTATIONAL FLUID DYNAMICS	DEC	3 - 0 - 0	3 Credits
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**Pre-Requisites:**CE235: Fluid Mechanics and Hydraulic Machines

**Course Outcomes:** At the end of the course, student will be able to:

<b>CO1</b>	Explain the differential equations for flow phenomena and numerical methods for their solution.
<b>CO2</b>	Critically analyze different mathematical models and computational methods for fluid flow and heat transfer simulations.
<b>CO3</b>	Solve computational problems related to fluid flows and heat transfer.
<b>CO4</b>	Analyze the accuracy of a numerical solution by comparison to known solutions of simple test problems and by mesh refinement studies.
<b>CO5</b>	Evaluate forces in both internal and external flows.

**Course Articulation Matrix:**

PO \ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	3	2	-	-	-	-	-	-	-	-	-	2	2	-
<b>CO2</b>	3	3	3	3	3	-	-	-	-	-	-	2	3	2
<b>CO3</b>	3	3	3	-	3	-	-	-	-	-	-	2	3	3
<b>CO4</b>	3	3	2	2	3	-	-	-	-	-	-	2	3	3
<b>CO5</b>	3	3	2	3	3	-	-	-	-	-	-	2	3	2

**Detailed Syllabus:**

**Introduction:** History and Philosophy of computational fluid dynamics, CFD as a design and research tool, Applications of CFD in engineering, Programming fundamentals, MATLAB programming, Numerical Methods

**Governing equations of fluid dynamics:** Models of the flow, The substantial derivative, Physical meaning of the divergence of velocity, The continuity equation, The momentum equation, The energy equation, Navier-Stokes equations for viscous flow, Euler equations for inviscid flow, Physical boundary conditions, Forms of the governing equations suited for CFD, Conservation form of the equations, shock fitting and shock capturing, Time marching and space marching.



**Mathematical behavior of partial differential equations:** Classification of quasi-linear partial differential equations, Methods of determining the classification, General behavior of Hyperbolic, Parabolic and Elliptic equations.

**Basic aspects of discretization:** Introduction to finite differences, Finite difference equations using Taylor series expansion and polynomials, Explicit and implicit approaches, Uniform and unequally spaced grid points.

**Grids with appropriate transformation:** General transformation of the equations, Metrics and Jacobians, The transformed governing equations of the CFD, Boundary fitted coordinate systems, Algebraic and elliptic grid generation techniques, Adaptive grids.

**Parabolic partial differential equations:** Finite difference formulations, Explicit methods - FTCS, Richardson and DuFort-Frankel methods, Implicit methods - Lax-Wendroff, Crank-Nicolson and Beta formulation methods, Approximate factorization, Fractional step methods, Consistency analysis, Linearization.

**Stability analysis:** Discrete Perturbation Stability analysis, von Neumann Stability analysis, Error analysis, Modified equations, Artificial dissipation and dispersion.

**Elliptic equations:** Finite difference formulation, solution algorithms: Jacobi-iteration method, Gauss-Seidel iteration method, point- and line-successive over-relaxation methods, alternative direction implicit methods.

**Hyperbolic equations:** Explicit and implicit finite difference formulations, splitting methods, multi-step methods, applications to linear and nonlinear problems, linear damping, flux corrected transport, monotone and total variation diminishing schemes, TVD formulations, entropy condition, first-order and second-order TVD schemes.

**Scalar representation of Navier-Stokes equations:** Equations of fluid motion, numerical algorithms: FTCS explicit, FTCS implicit, Dufort-Frankel explicit, McCormack explicit and implicit, BTCS and BTCS implicit algorithms, applications.

**Grid generation:** Algebraic Grid Generation, Elliptic Grid Generation, Hyperbolic Grid Generation, Parabolic Grid Generation

**Finite volume method for unstructured grids:** Advantages, Cell Centered and Nodal point Approaches, Solution of Generic Equation with tetrahedral Elements, 2-D Heat conduction with Triangular Elements.

### Reading:

1. Anderson, J.D. (Jr), Computational Fluid Dynamics, McGraw-Hill Book Company, 1995.
2. Hoffman, K.A., and Chiang, S.T., Computational Fluid Dynamics, Vol. I, II and III, Engineering Education System, Kansas, USA, 2000.
3. Chung, T.J., Computational Fluid Dynamics, Cambridge University Press, 2003.
4. Anderson, D.A., Tannehill, J.C., and Pletcher, R.H., Computational Fluid Mechanics and Heat Transfer, McGraw Hill Book Company, 2002.

<b>ME364</b>	<b>AUTOMOBILE ENGINEERING</b>	<b>DEC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-Requisites:**ME101: Basic Mechanical Engineering, ME302: Prime Movers for Automobiles

**Course Outcomes:** At the end of the course, student will be able to:

<b>CO1</b>	Understand the basic lay-out of an automobile.
<b>CO2</b>	Understand the operation of engine cooling, lubrication, ignition, electrical and air conditioning systems.
<b>CO3</b>	Understand the principles of transmission, suspension, steering and braking systems.
<b>CO4</b>	Understand automotive restraint system.
<b>CO5</b>	Study latest developments in automobiles.

**Course Articulation Matrix:**

<b>PO</b> <b>CO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>	<b>PSO1</b>	<b>PSO2</b>
<b>CO1</b>	2	-	2	3	3	-	-	-	-	-	-	-	2	2
<b>CO2</b>	3	3	2	3	3	-	-	-	-	-	-	-	2	2
<b>CO3</b>	3	2	3	2	3	-	-	-	-	-	-	-	2	2
<b>CO4</b>	2	3	3	3	3	-	-	-	-	-	-	-	2	2
<b>CO5</b>	2	3	3	3	3	-	-	-	-	-	-	-	2	2

**Detailed Syllabus:**

**Introduction:** Overview of the course, Examination and Evaluation patterns, History of Automobiles, Classification of Automobiles.

**Power Plant:** Classification, Engine Terminology, Types of Cycles, working principle of an IC engine, advanced classification of Engines- Multi cylinder engines, Engine balance, firing order.

**Fuel System, Ignition System and Electrical system:** Fuel tank, fuel filter, fuel pump, air cleaner/filter, carburetor, direct injection of petrol engines. Compression Ignition engines, Fuel Injection System- air & solid injection system, Pressure charging of engines, super charging and turbo charging, Components of Ignition systems, battery ignition system, magneto ignition system, electronic ignition

and ignition timing. Main electrical circuits, generating & stating circuit, lighting system, indicating devices, warning lights, speedometer.

**Lubricating system and cooling systems:** Functions & properties of lubricants, methods of lubrication-splash type, pressure type, dry sump, and wet sump & mist lubrication. Oil filters, oil pumps, oil coolers. Characteristics of an effective cooling system, types of cooling system, radiator, thermostat, air cooling & water cooling.

**Chassis:** Systems in an automobile, body, chassis frame, parts of the automobile body, terminology, automobile frames, functions, constructions, sub frames, materials and defects in frames.

**Transmission system:** axles, clutches, propeller shafts and differential: Types of gear boxes, automatic transmission, electronic transmission control, functions and types of front and rear axles, types and functions of the clutches, design considerations of Hotchkiss drive torque tube drive, function and parts of differential and traction control.

**Steering System:** functions of steering mechanism, steering gear box types, steering geometry.

**Braking and suspension system:** functions and types of brakes, operation and principle of brakes, constructional and operational classification and parking brake. Types of springs shock absorbers, objectives and types of suspension system, rear axle suspension, electronic control and proactive suspension system.

**Automotive air conditioning:** ventilation, heating, air condition, refrigerant, compressor and evaporator.

**Wheels and tyres:** Wheel quality, assembly, types of wheels, wheel rims. Construction of tyres and tyre specifications.

**Automotive Restraint Systems:** Seat belt, automatic seat belt tightener system, collapsible steering column and air bags.

### **Reading:**

1. Crouse, W.H., and Anglin, D.L., Automotive Mechanics, Tata McGraw Hill, New Delhi, 2005.
2. Heitner, J., Automotive Mechanics, Affiliated South West Press, New Delhi, 2000.
3. Narang, G.B., Automobile Engineering, Khanna Publishers, New Delhi, 2001.
4. Kamaraju Ramakrishna, Automobile Engineering, PHI Learning pvt. Ltd., New delhi-2012.

<b>ME365</b>	<b>NON DESTRUCTIVE TESTING</b>	<b>DEC</b>	<b>3- 0 - 0</b>	<b>3 Credits</b>
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**Pre-requisites:** NIL

**Course Outcomes:** At the end of the course the student will be able to:

<b>CO1</b>	Understand general principles of NDT techniques
<b>CO2</b>	Conduct NDT techniques and interpret the results
<b>CO3</b>	Select appropriate NDT techniques in practical applications
<b>CO4</b>	Apply codes and standards used in NDT techniques

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	3	3	3	-	-	-	-	-	-	-	-	-	3	3
<b>CO2</b>	3	2	3	-	-	-	-	-	-	-	-	-	3	2
<b>CO3</b>	3	3	3	-	-	-	-	-	-	-	-	-	2	2
<b>CO4</b>	3	2	3	-	-	-	-	-	-	-	-	-	2	2

**Detailed syllabus:**

**Introduction to NDT, Liquid Penetrant Test:** Physical Principles, Procedure for penetrant testing, Penetrant testing materials, Penetrant testing methods, sensitivity, Applications and limitations, typical examples.

**Ultrasonic testing:** Basic properties of sound beam, Ultrasonic transducers, Inspection methods, Techniques for normal beam inspection, Techniques for angle beam inspection, Flaw characterization techniques, Applications of ultrasonic testing, Advantages and limitations.

**Thermography:** Basic principle, Detectors and equipment, techniques, applications.

**Radiography:** Basic principle, Electromagnetic radiation sources, radiographic imaging, Inspection techniques, applications, limitations, typical examples.

**Eddy current test:** Principles, instrumentation for ECT, techniques, sensitivity, advanced eddy current test methods, applications, limitations.

**Acoustic Emission:** Principle of AET, Technique, instrumentation, sensitivity, applications, Acoustic emission technique for leak detection.

**Magnetic Particle Inspection:** Principle of MPT, Procedure used for testing a component, sensitivity, limitations.

**Practical NDT:** Principles, procedures, applications, limitations, codes and standards widely used in non-destructive testing (NDT) techniques. Reliability in NDT.

**Reading:**

1. Peter J Shull, "Nondestructive Evaluation: Theory, Techniques and Applications", Marcel Dekkar, 2002.
2. P. McIntire (Ed.), "Non Destructive Testing Hand Book", Vol. 4, American Society for Non Destructive Testing, 2010
3. ASM Metals Hand Book, "Non Destructive Testing and Quality Control", Vol. 17, ASM, 1989.
4. Baldev Raj, M. Thavasimuthu, T. Jaya kumar, "Practical Non-Destructive Testing", 3<sup>rd</sup> Edition, Narosa Publishing House, 2009.

<b>ME366</b>	<b>OPERATIONS RESEARCH</b>	<b>DEC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Understand the concepts of operations research modelling approaches.
<b>CO2</b>	Formulate engineering and managerial situations as LPP, transportation and Assignment problems.
<b>CO3</b>	Solve LPP, Transportation and Assignment problems
<b>CO4</b>	Formulate multi-stage applications into a dynamic programming framework.
<b>CO5</b>	Solve Integer programming problems.

**Course Articulation Matrix:**

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	<b>CO1</b>	3	-	-	-	-	-	-	-	-	-	-	2	3
<b>CO2</b>	3	3	2	-	-	-	-	-	-	-	2	2	3	3
<b>CO3</b>	3	3	3	2	2	2	-	-	-	-	2	2	3	2
<b>CO4</b>	3	3	2	-	2	-	-	-	-	2	3	2	3	2
<b>CO5</b>	3	2	2	-	2	-	-	-	-	2	2	2	3	2

**Detailed syllabus:**

**Introduction:** Historical overview of operations research, fundamentals of OR Modelling Approach.

**Linear Programming:** Basic assumptions, formulation, graphical method, simplex method, duality theory, primal-dual relationships, sensitivity analysis.

**Transportation and Assignment Problems:** Specific features of transportation problem, streamlined simplex method for solving transportation problems, special features of assignment problems, Hungarian method for solving assignment problems.

**Dynamic Programming:** Characteristics, principle of optimality, solution procedure, deterministic problems.

**Integer programming:** Special features, binary integer programming models, branch-and-bound technique, cutting-plane method, introduction to nonlinear programming.

**Reading:**

1. Taha H. A. ,“Operations Research”, 10<sup>th</sup>Edition, Prentice Hall of India, New Delhi, 2017.
2. Hillier F.S.and Lieberman G.J., “Introduction to Operations Research”, 7th Edition, TMH, 2009.

<b>ME367</b>	<b>PRODUCTION PLANNING AND CONTROL</b>	<b>DEC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-requisites:** ME305: Management Science and Productivity.

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Explain production systems and their characteristics.
<b>CO2</b>	Evaluate MRP and JIT systems against traditional inventory control systems.
<b>CO3</b>	Evaluate basics of variability and its role in the performance of a production system.
<b>CO4</b>	Analyze aggregate planning strategies.
<b>CO5</b>	Apply forecasting and scheduling techniques to production systems.
<b>CO6</b>	Apply theory of constraints for effective management of production systems.

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	2	2	2	-	-	-	-	-	2	-	2	2	2	2
<b>CO2</b>	3	3	3	-	3	2	-	-	2	2	2	2	2	2
<b>CO3</b>	2	3	3	-	-	-	-	-	2	-	2	3	2	2
<b>CO4</b>	3	3	3	3	3	-	-	-	2	2	2	2	2	3
<b>CO5</b>	3	3	3	3	3	2	-	-	2	-	2	2	2	3
<b>CO6</b>	2	3	3	2	-	-	-	-	2	-	2	2	2	2

**Detailed Syllabus:**

**Introduction to Production Systems:** Production Systems: Classification & Characterization, Overview of Production Planning and Control issues, Review of EOQ & inventory control systems.

**Material Requirement Planning:** Dependent Demand & Material Requirement Planning, Structure of MRP system, MRP Calculations, Planning Issues, Implementation Issues.



**Just in Time Production Systems:** Just-in-Time System: Evolution, Characteristics of JIT Systems, Continuous Improvement, Kanban System, Strategic Implications of JIT System.

**Factory Physics:** Basic factory dynamics, Variability basics, Push and pull production systems.

**Aggregate Planning:** Aggregate Planning: Purpose & Methods, Reactive and Aggressive Alternatives, Planning Strategies, LP Formulation, Master Production Scheduling.

**Scheduling:** Scheduling in Manufacturing, Sequencing Operations for One Machine, Sequencing Operations for a two-station Flow Shop, Job Shop Dispatching.

**Forecasting Methods:** Demand Forecasting: Principles and Methods, Judgment methods, Causal methods, Time-series methods.

**Theory of Constraints:** Concept of bottleneck, Local and global optima, Five steps of TOC approach, Performance measures.

**Reading:**

1. Krajewski L.J. and Ritzmen L.P., "Operations Management: Strategy and Analysis", 9th Edition, Pearson Education, 2010.
2. Chase R.B. Jacobs F.R. and Aquilano N.J., "Operations Management for Competitive Advantage", 11<sup>th</sup> Edition, Tata McGraw Hill Book Company, New Delhi, 2010.
3. Hopp W. J. and Spearman M. L. "Factory Physics: Foundations of Manufacturing Management", McGraw Hill International Edition, 3<sup>rd</sup> Edition, 2008.
4. Mukhopadhyay S.K., "Production Planning and Control", 2<sup>nd</sup> Edition, PHI, Eastern Economy Edition, 2013.

ME368	DESIGN AND ANALYSIS OF EXPERIMENTS	DEC	3 - 0 - 0	3 Credits
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

CO1	Identify objectives and key factors in designing experiments.
CO2	Develop appropriate experimental design to conduct experiments.
CO3	Analyse experimental data and draw valid conclusions.
CO4	Develop empirical models using experimental data to optimize process parameters.
CO5	Design robust products and processes using parameter design approach.

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	-	-	-	-	-	2	2	2	2	3	2
CO2	3	3	3	3	2	-	-	-	2	-	2	2	3	3
CO3	3	3	2	3	2	-	-	-	2	3	-	2	3	3
CO4	3	3	3	3	3	-	-	-	2	-	2	2	3	2
CO5	3	-	3	-	3	-	-	-	2	-	3	2	3	3

**Detailed Syllabus:**

**Fundamentals of Experimentation:** Role of experimentation in rapid scientific progress, Historical perspective of experimental approaches, Steps in experimentation, Principles of experimentation.

**Simple Comparative Experiments:** Basic concepts of probability and statistics, Comparison of two means and two variances, Comparison of multiple (more than two) means & ANOVA.

**Experimental Designs:** Factorial designs, fractional factorial designs, orthogonal arrays, standard orthogonal arrays & interaction tables, modifying the orthogonal arrays, selection of suitable orthogonal array design, analysis of experimental data.

**Response Surface Methodology:** Concept, linear model, steepest ascent, second order model, regression.

**Taguchi's Parameter Design:** Concept of robustness, noise factors, objective function & S/N ratios, inner-array and outer-array design, data analysis.

**Reading:**

1. Montgomery D. C. "Design and Analysis of Experiments", 7<sup>th</sup> Edition, John Wiley & Sons, 2008.
2. Ross P. J. "Taguchi Techniques for Quality Engineering", McGraw-Hill, NY, 2008.
3. Madhav S. Phadke, "Quality Engineering using Robust Design", Prentice Hall, 1989

SM413	ENGINEERING ECONOMICS AND ACCOUNTANCY	HSC	3 - 0 - 0	3 Credits
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

CO1	Understand various methods of Economic Analysis and apply.
CO2	Calculate Depreciation using various methods.
CO3	Sensitize the student to Macro Economic Environment.
CO4	Analyze the financial statements with ratios for investment decisions.
CO5	Analyze costs and their role in pricing
CO6	Develop effective presentation skills

**Course Articulation Matrix:**

CO \ PO	PO												PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	-	-	-	-	-	2	-	2	-	2	2	1	-	-
CO2	-	-	-	-	-	2	-	2	-	2	3	1	-	-
CO3	-	-	-	-	-	2	-	2	-	2	2	2	-	-
CO4	-	-	-	-	-	2	-	2	-	2	3	1	2	-
CO5	-	-	-	-	-	2	-	2	-	2	2	1	-	-
CO6	-	-	-	-	-	2	-	2	-	3	-	-	-	-

**Detailed Syllabus:**

### Engineering Economics

1. Introduction to Engineering Economics, Fundamental concepts, Time value of money, Cash flow and Time Diagrams, Nominal Rate of Interest Vs effective rate of interest, choosing between alternative investment proposals, Methods of Economic analysis (Pay back, ARR, NPV, IRR and B/C ratio).

2. The Effect of borrowing on investment, Equity Vs Debt Financing, Concept of leverage, Income tax and leverage
3. Depreciation and methods of calculating depreciation (Straight line, Sum of the years digit method, declining Balance Method, Annuity Method, Sinking Fund method).
4. National Income Accounting, Methods of Estimation, Various Concepts of National Income, Significance of National Income Estimation and its limitations.
5. Inflation, Definition, Process and Theories of Inflation and Measures to Control,
6. Balance of payments and its impact on exchange rate.
7. New Economic Policy 1991, LPG.
8. Basics of Union Budget, various deficits such as fiscal deficit and revenue deficit.

### **Accountancy**

9. Analysis of financial statements, income statements and balance sheet (simple ratios).
10. Cost accounting, classification of costs, cost sheet and preparation of cost sheet, breakeven analysis meaning & limitations.

### **Presentations/ Group Discussions on current topics.**

### **Reading:**

1. D N Dwivedi "Managerial Economics", Vikas Publishing House Private Limited, 2010
2. Agrawal AN, "Indian Economy" Wiley Eastern Ltd, New Delhi, 2015
3. R.K Sharma and Sashi K Gupta, "Financial Management", Kalyani Publications, 2014
4. Arora, M.N. "Cost Accounting", Vikas Publication, 2013

### **Source- Internet**

- Capitaline Plus Database - <http://www.capitaline.com/>
- Ministry of Finance - <http://finmin.nic.in/>
- Database of Indian Economy - <http://dbie.rbi.org.in>
- Statistics of India - [www.indiastat.com/](http://www.indiastat.com/) or <http://mospi.nic.in/>
- The Economist Magazine.

<b>ME401</b>	<b>REFRIGERATION AND AIR-CONDITIONING</b>	<b>PCC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-Requisites:** ME201: Thermodynamics

**Course Outcomes:** At the end of the course, student will be able to:

<b>CO1</b>	Understand the principles and applications of refrigeration systems.
<b>CO2</b>	Understand vapour compression refrigeration system and identify methods for performance improvement.
<b>CO3</b>	Study the working principles of air, vapour absorption, thermoelectric and steam-jet refrigeration systems.
<b>CO4</b>	<i>Analyze air-conditioning processes using the principles of psychrometry.</i>
<b>CO5</b>	<i>Evaluate cooling and heating loads in an air-conditioning system.</i>

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	3	3	2	-	-	1	2	-	-	-	-	2	1	-
<b>CO2</b>	3	3	3	3	-	1	2	-	-	-	-	2	1	2
<b>CO3</b>	3	2	2	-	-	1	1	-	-	-	-	2	2	2
<b>CO4</b>	3	3	2	2	-	1	1	-	-	-	-	2	3	2
<b>CO5</b>	3	3	3	3	-	1	2	-	-	-	-	2	3	2

**Detailed Syllabus:**

**Introduction:** Introduction to Refrigeration - Basic Definition.

**Air Refrigeration:** Air Refrigeration Cycles - reversed Carnot cycle, Bell-Coleman cycle analysis, Air Refrigeration systems - merits and demerits, analysis.

**Vapour Compression Refrigeration System(VCRS):** Vapour Compression Refrigeration system - Carnot Vapour compression refrigeration cycle, Working and analysis, Limitations, Standard Vapour Compression Refrigeration system, Working and analysis, Effects of sub cooling and super heating, Multi-Pressure or Compound Vapour Compression Refrigeration Systems - Methods like Flash Gas removal, Flash inter cooling and water inter cooling.

**Refrigerants:** Classification, Selection of Refrigerants and Nomenclature of refrigerants, Desirable Properties of an ideal refrigerant, A discussion on Ozone layer Depletion and Global Warming.

**Refrigeration systems Equipment:** Refrigeration System Equipment - Compressors, Condensers, Expansion Devices and Evaporators, A brief look at other components of the system.

**Vapour Absorption systems:** Other types of Refrigeration systems - Vapour Absorption Refrigeration Systems, Absorbent - Refrigerant combinations, Water-Ammonia Systems, Water-Lithium Bromide System, Contrast between the two systems, Modified Version of Aqua-Ammonia System with Rectifier and Analyser Assembly.

**Other systems:** Brief Discussion on (i) Steam-Jet refrigeration system and (ii) Thermoelectric refrigeration system

**Psychrometry:** Introduction to Air-Conditioning, Basic Definition, Classification, ASHRAE Nomenclature pertaining to Air-Conditioning, Applications of Air-Conditioning, Psychrometry - Air-water vapour mixtures, Psychrometric Properties, Psychrometric or Air-Conditioning processes, Psychrometric Chart.

**Air-Conditioning:** Mathematical Analysis of Air-Conditioning Loads, Related Aspects, Numerical Problems, Different Air-Conditioning Systems-Central - Station Air-Conditioning System, Unitary Air-Conditioning System, Window Air-Conditioner and Packaged Air-Conditioner, Components related to Air-Conditioning Systems.

**Reading:**

1. Roy J. Dossat, Principles of Refrigeration, Wiley Limited
2. Arora, C. P., Refrigeration and Air-Conditioning, Tata McGraw - Hill, New Delhi.
3. Stoecker, W. F., and Jones, J. W., Refrigeration and Air-Conditioning, McGraw - Hill, New Delhi.

**Data Book:** Refrigerant and Psychrometric Properties - Tables and Charts [SI Units], Mathur, M. L., and Mehta, F. S., Jain Brothers.

<b>ME402</b>	<b>COMPUTER AIDED MANUFACTURING</b>	<b>PCC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, student will be able to:

<b>CO1</b>	Develop part programs with G codes and M codes for typical components
<b>CO2</b>	Develop part programs with APT language
<b>CO3</b>	Understand the elements of an automated manufacturing environment
<b>CO4</b>	Apply the knowledge of AM to manufacture custom specific components

**Course Articulation Matrix:**

<b>PO</b> <b>CO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>	<b>PSO1</b>	<b>PSO2</b>
<b>CO1</b>	2	3	-	3	2	-	-	-	-	-	-	-	3	2
<b>CO2</b>	2	2	-	3	2	-	-	-	-	-	-	-	3	2
<b>CO3</b>	2	3	-	-	2	-	-	-	-	-	-	-	3	2
<b>CO4</b>	2	3	-	-	-	-	-	-	-	-	-	-	3	2

**Detailed syllabus:**

**Introduction to Computer Aided Manufacturing (CAM):** Introduction to Numerical Control (NC), Numerical control modes, NC elements, Structure of CNC machine tools, Spindle design, Drivers, Designation of axes, Drives & actuation systems, Feedback devices, CNC tooling, Automatic tool changers & Work holding devices.

**CNC Control Systems:** CNC Machining Centers, CNC turning centers, High-speed machine tools, machine control unit, support systems, touch-trigger probe, Adaptive Control, Introduction to FANUC, SINUMERIC controllers, DNC.

**CNC Programming:** Part programming fundamentals, Process planning, Axes selection, Tool selection, Steps involved in Development of Part Program, Job and Tool Set up Planning, Machining path planning.

**Manual Part Programming:** Manual part programming Methods, Preparatory functions, G- Codes, Miscellaneous Functions M Codes, Writing Part programs for typical components, Tool length compensation, Canned cycles, Cutter radius compensation,

**Computer Aided Part Programming:** Concept of CAP, APT Language, Geometry Commands, Motion Commands like point to point Continuous path commands, Post processor commands, Compilation of control commands, Writing complete Part programs for typical components with APT.

**Robotics:** Anatomy & configuration of robot, Characteristics of robots, Grippers, Application of robots in manufacturing, Robot programming.

**Group Technology:** Introduction to Group technology, Part classification & coding systems: OPITZ, MICLASS coding systems, production flow analysis.

**Computer Aided Process Planning (CAPP):** Introduction to CAPP, Variant & Generative methods of CAPP, advantages of CAPP.

**Flexible Manufacturing System (FMS):** Components of FMS, FMS equipment & control, FMS case studies.

**Computer Integrated Manufacturing (CIM):** Elements of CIM, CIM case studies.

**Computer Aided Inspection and Quality Control:** Inspection and testing Coordinate Measuring Machine, Non-Contact Inspection, and Machine Vision

**Additive Manufacturing (AM):** Introduction to Additive Manufacturing (AM), Need for Additive Manufacturing, Generic AM process, Distinction between AM and CNC, Classification of AM Processes, Steps in AM process, Advantages of AM, Major Applications.

**Reading:**

1. P.N. Rao, "CAD/CAM Principles and Applications", 3<sup>rd</sup> Edition, Tata McGraw Hill, New Delhi, 2010.
2. Grover M. P. and Zimmers E.W. "CAD/CAM: Computer Aided Design and Manufacturing", Prentice Hall of India, 2010.
3. YoramKoren, "Computer Control of Manufacturing Systems", McGraw Hill Publications, 2005.
4. T.C. Chang, R.A. Wysk, H.P. Wang "Computer Aided Manufacturing", 3<sup>rd</sup> Edition, Pearson Prentice Hall, 2006.
5. Chua Chee Kai, Leong Kah Fai, "3D Printing and Additive Manufacturing: Principles & Applications", 4th Edition, World Scientific, 2015.



<b>ME403</b>	<b>CAE Lab</b>	<b>PCC</b>	<b>0 - 0 - 2</b>	<b>1 Credit</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student shall be able to:

<b>CO1</b>	Generate code in MATLAB software to solve various engineering problems
<b>CO2</b>	Develop programs for simulation and visualization of mathematical models and experimental results
<b>CO3</b>	Solve different structural engineering elements using FEA software
<b>CO4</b>	Execute mini projects involving programming knowledge, modelling and analysis

**Course Articulation Matrix:**

PO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	2	2	-	-	3	-	-	-	2	2	-	2	2	3
<b>CO2</b>	2	-	-	-	2	-	-	-	2	3	-	2	3	3
<b>CO3</b>	2	2	-	-	3	-	-	-	2	2	-	2	2	3
<b>CO4</b>	3	3	3	-	3	-	-	-	3	3	-	2	3	3

**Detailed syllabus:**

**a. Computer Aided Simulation Exercises:**

1. Arithmetic operations, control loops and functions
2. Solving Linear, non-linear equations, curve fitting and interpolation
3. Visualization and plotting
4. Solving engineering problems involving ODE' s and PDE's
5. Solve problems involving Vibrations, Optimization
6. Solve problems involving FEM, and Heat transfer
7. Introduction to Simulink

**b. Computer Aided Analysis Exercises:**

1. Introduction to FEA software-Ansys
2. Solving truss problems using Ansys
3. Solving problems of Beams and Frames using Ansys
4. Solving problems involving triangular elements
5. Analysing 3D Problems using Ansys
6. Harmonic analysis of a Cantilever beam
7. Mini Project

<b>ME404</b>	<b>CAM Lab</b>	<b>PCC</b>	<b>0 - 0 - 2</b>	<b>1 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student shall be able to:

<b>CO1</b>	Develop manual part programs for 2D-complex profiles for Fanuc and Siemens controller using CNC Simulator and Sinutrain Software.
<b>CO2</b>	Generate CNC program for turning and milling of component using Master CAM and Edge CAM software.
<b>CO3</b>	Generate and verify CNC code using Virtual CNC software.
<b>CO4</b>	Machine complex profiles on CNC machine using auto generated CNC code.
<b>CO5</b>	Verify STL files and print 3D parts by AM machines

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	3	-	3	2	-	3	-	2	-	3	-	2	2	2
<b>CO2</b>	3	-	3	3	-	3	-	2	-	3	-	2	2	2
<b>CO3</b>	3	-	3	3	-	3	-	2	-	3	-	2	2	2
<b>CO4</b>	3	-	3	3	-	3	-	2	-	3	-	2	2	2
<b>CO5</b>	3	-	3	3	-	3	-	2	-	3	-	2	2	2

**Detailed syllabus:**

Manual Part programming for Fanuc and Siemens Controller using CNC Simulator and Sinutrain,

CNC programming for turned and milled components using Edge CAM, Sinutrain and Master CAM, Training on CNC machines.

**List of experiments:**

Simulation of turn components on CNC Simulator. (3-4 Exercises)

Turning of components on spinner.com Lathe. (3-4 Exercises)

Turning of components on VDF lathe. (3-4 Exercises)

Milling simulation of 2D profiles on CNC Simulator. (3-4 Exercises)

Milling Simulation of Turbine blade on CNC Simulator.

Milling of 2D profiles on Max Mill CNC milling Machine. (2-4 Exercises)

Milling of 2D / 3D profiles using Master Cam. (2-4 Exercises)

Milling of 2D / 3D profiles using Edge Cam. (2-4 Exercises)

Generate and visualize CNC code using Virtual CNC Software. (2-4 Exercises)

Design and fabrication of components using 3D printer.

**Reading:**

1. NITW CNC Lab Manual,
2. John Stenerson and Kelly Curran, "Computer Numerical Control: Operation and Programming", PHI, New Delhi, 2009.
3. T. C. Chang, R.A.Wysk and H. P. Wang, "Computer Aided Manufacturing", PHI, New Delhi, 2009.

<b>ME405</b>	<b>MECHATRONICS LAB</b>	<b>PCC</b>	<b>0 - 0 - 2</b>	<b>1 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Measure load, displacement and temperature using analogue and digital sensors.
<b>CO2</b>	Develop PLC programs for control of traffic lights, water level, lifts and conveyor belts.
<b>CO3</b>	Develop microcontroller programming to guide a robot.
<b>CO4</b>	Simulate and analyze PID controllers for a physical system using MATLAB.
<b>CO5</b>	Develop pneumatic and hydraulic circuits using Automation studio.

**Course Articulation Matrix:**

<b>PO</b> <b>CO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>	<b>PSO1</b>	<b>PSO2</b>
<b>CO1</b>	3	2	3	2	-	-	-	-	3	3	3	2	3	2
<b>CO2</b>	2	-	3	2	3	-	-	-	3	3	2	2	3	2
<b>CO3</b>	2	-	3	2	3	-	-	-	3	3	2	2	3	2
<b>CO4</b>	2	-	3	3	3	-	-	-	3	3	2	2	3	2
<b>CO5</b>	2	-	3	2	3	-	-	-	3	3	2	2	3	2

**List of Experiments:**

**1. DYNA 1750 Transducers Kit:-**

1. Characteristics of LVDT
2. Principle & Characteristics of Strain Gauge
3. Characteristics of Summing Amplifier
4. Characteristics of Reflective Opto Transducer

**2. Mobile Robot with P89V51RD2microcontroller**

1. Program for Operating Buzzer Beep

2. Program for Operating Motion control
3. Program for Operating Direction control
4. Program for Operating White line follower for the given arena

### **3. PLC PROGRAMMING**

1. Ladder programming on Logic gates, Timers & counters
2. Ladder Programming for digital & Analogy sensors
3. Ladder programming for Traffic Light control, Water level control and Lift control Modules

### **4. AUTOMATION STUDIO software**

1. Introduction to Automation studio & its control
2. Draw & Simulate the Hydraulic circuit for series & parallel cylinders connection
3. Draw & Simulate Meter-in, Meter-out and hydraulic press and clamping.

### **5. MATLAB Programming**

1. Sample programs on Matlab
2. Simulation and analysis of PID controller using SIMULINK

<b>ME411</b>	<b>CONDITION MONITORING</b>	<b>DEC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Understand effective maintenance schemes in industries
<b>CO2</b>	Diagnose the mechanical systems by applying vibration monitoring techniques
<b>CO3</b>	Apply oil analysis technique to diagnose the wear debris.
<b>CO4</b>	Identify nonconventional methods for machine diagnoses.
<b>CO5</b>	Develop modern technologies for effective plant maintenance.

**Course Articulation Matrix:**

PO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	-	3	-	-	-	-	-	2	2	-	-	2	3	-
<b>CO2</b>	3	2	2	-	3	-	-	2	2	-	-	2	3	3
<b>CO3</b>	3	2	2	-	3	-	-	2	2	-	-	2	3	-
<b>CO4</b>	-	3	-	-	3	-	-	2	2	-	-	2	-	-
<b>CO5</b>	3	-	3	3	-	-	-	2	2	-	-	2	3	3

**Detailed Syllabus:**

**Introduction:** Failures - System, component and services failures - classification and its causes, Maintenance Schemes - objectives - types and economic benefits, break down, preventive and predictive monitoring.

**Vibration Monitoring** - causes and effects of vibration, review of mechanical vibration concepts - free and forced vibrations, vibration signature of active systems - measurement of amplitude, frequency and phase.

**Vibration monitoring equipment-** vibration sensors (contact and non-contact type) -factors affecting the choice of sensors, signal conditioners, recording and display elements, vibration meter and analyzers, measurement of overall vibration levels.

**Contaminant analysis:** Contaminants in used lubricating oils - monitoring techniques (wear debris) - SOAP technique, Ferrography, X-ray spectrometry, Particle classification.

Temperature Monitoring - Various techniques - thermograph, pyrometers, indicating paint and NDT methods.

**Special Techniques:** Ultrasonic measurement method, shock pulse measurement, Kurtosis, Acoustic Emission mentoring, critical speed analysis, shaft orbit analysis, Cepstrum analysis. Non-destructive techniques, Structural health monitoring weldments for surface and subsurface cracks

**Reading:**

1. Rao J. S., Vibration Condition Monitoring, Narosa Publishing House, 2/e 2000.
2. Isermann R., Fault Diagnosis Application, Springer-Verlag Berlin, 2011.
3. Allan Davis, Hand book of Condition Monitoring, Chapman and Hall, 2000.
4. Choudary K K., Instrumentation, Measurement and Analysis, Tata McGraw Hill, 2012
5. Collacott, R. A., Mechanical Faults Diagnosis, Chapman and Hall, London, 1990

ME412	TRIBOLOGY	DEC	3 - 0 - 0	3 credits
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**Pre-Requisites:** Nil

**Course Outcomes:** At the end of the course, the student shall be able to:

CO1	Analyze properties of lubricant and selection of proper lubricant for the given application.
CO2	Identify the lubrication regime for the given mechanical application.
CO3	Determine tribological performance parameters of sliding contact in hydrodynamic lubrication regimes.
CO4	Evaluate the friction and wear behavior of the given materials.

**Course Articulation Matrix:**

PO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	2	2	1	-	-	-	-	2	3	2
CO2	3	2	2	2	3	2	1	-	-	-	-	2	3	3
CO3	3	2	3	3	3	2	1	-	-	-	-	2	3	3
CO4	3	3	3	3	3	2	1	-	-	-	-	2	3	3

**Detailed Syllabus:**

**Introduction:** History and basic concept of friction wear and lubrication, Types of lubricants, Objectives and selection of lubricant, Physical properties of lubricants.

**Lubrication:** Regimes of lubrication - hydrodynamic, Elasto-hydrodynamic, mixed and boundary lubrication, Reynolds' equation, Hydrodynamic lubrication of roughened surfaces.

**Theories of other Lubrication:** Externally pressurized lubrication, Squeeze-film lubrication, Elasto-hydrodynamic lubrication, Rheological lubrication regime, Functional lubrication regime.

**Applications of hydrodynamic lubrication theory** - Journal bearing, inclined thrust pad bearing, Rayleigh step bearing.



**Friction and Wear:** Origin of sliding friction, Causes of Friction, Laws of Rolling Friction. Friction Instability, Contact between two bodies in relative motion, Wear classification - Wear between solids - Wear between solid and liquid - Factors affecting wear - Measurement of wear, Types of wear and their mechanisms - Adhesive wear-adhesion junction growth, Abrasive wear, Wear due to surface fatigue and wear due to chemical reactions, wear of metallic materials.

**Reading:**

1. Stachowiak, G.W., Batchelor, A.W., *Engineering Tribology*, 3<sup>rd</sup> Ed., Elsevier, 2010.
2. Majumdar B.C, *Introduction to bearings*, S. Chand & Co., Wheeler publishing, 1999.
3. Andras Z. Szeri, *Fluid film lubrication theory and design*, Cambridge University press, 1998.
4. Stolarski TA, *Tribology in Machine Design*, Butterworth Heinemann, 2000.

ME413	NON-CONVENTIONAL ENERGY SOURCES	DEC	3 - 0 - 0	3 Credits
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**PreRequisites:** Nil

**Course Outcomes:** At the end of the course, student will be able to:

<b>CO1</b>	Identify renewable energy sources and their utilization..
<b>CO2</b>	Identify methods of energy storage for specific applications.
<b>CO3</b>	Understand the basic concepts of solar radiation and analyze the working of solar PV and thermal systems.
<b>CO4</b>	Understand principles of energy conversion from alternate sources including wind, geothermal, ocean, biomass, biogas and hydrogen.
<b>CO5</b>	Understand the concepts and applications of fuel cells, thermoelectric convertor and MHD generator.

**Course Articulation Matrix:**

PO \ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	2	2	-	1	-	3	3	-	-	-	-	2	1	-
<b>CO2</b>	3	3	3	2	-	1	3	-	-	-	-	2	3	2
<b>CO3</b>	3	3	3	3	2	1	3	-	-	-	-	2	3	3
<b>CO4</b>	3	3	3	1	2	1	3	-	-	-	-	2	2	3
<b>CO5</b>	2	3	2	1	1	1	3	-	-	-	-	2	2	2

**Detailed Syllabus:**

**Introduction:** Overview of the course; Examination and Evaluation patterns; Basic concepts of energy; Introduction to Renewable Energy Technologies; Energy and Environment: Global warming, acid rains, Depletion of ozone layer; Global and Indian Scenario of renewable energy sources

**Energy Storage:** Introduction; Necessity of Energy Storage; Energy Storage Methods

**Solar Energy:** Fundamentals; Solar Radiation; Estimation of solar radiation on horizontal and inclined surfaces; Measurement of solar radiation data

**Solar Thermal systems:** Introduction; Basics of thermodynamics and heat transfer; Flat plate collector; Evacuated Tubular Collector; Solar air collector; Solar concentrator; Solar distillation; Solar cooker; Solar refrigeration and air conditioning; Thermal energy storage systems

**Solar Photovoltaic systems:** Introduction; Solar cell Fundamentals; Characteristics and classification; Solar cell: Module, panel and Array construction; Photovoltaic thermal systems

**Wind Energy: Introduction:** Origin and nature of winds; Wind turbine siting; Basics of fluid mechanics; Wind turbine aerodynamics; wind turbine types and their construction; Wind energy conversion systems

**Fuel cells:** Overview; Classification of fuel cells; operating principles; Fuel cell thermodynamics

**Biomass Energy:** Introduction; Photosynthesis Process; Biofuels; Biomass Resources; Biomass conversion technologies; Urban waste to energy conversion; Biomass gasification.

**Other forms of Energy:** Introduction: Nuclear, ocean and geothermal energy applications; Origin and their types; Working principles.

**Reading:**

1. Sukhatme S.P. and J.K.Nayak, Solar Energy - Principles of Thermal Collection and Storage, Tata McGraw Hill, New Delhi, 2008.
2. Khan B.H., Non-Conventional Energy Resources, Tata McGraw Hill, New Delhi, 2006.
3. J.A. Duffie and W.A. Beckman, Solar Energy - Thermal Processes, John Wiley, 2001.

<b>ME414</b>	<b>ADVANCED IC ENGINES</b>	<b>DEC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-Requisites:**ME201: Thermodynamics, ME302: Prime Movers for Automobiles

**Course Outcomes:** At the end of the course, student will be able to:

<b>CO1</b>	Understand the importance of IC engine as a prime mover and compare its performance on the basis of thermodynamic cycles and combustion process.
<b>CO2</b>	Identify harmful IC engine emissions and use viable alternate fuels in engines.
<b>CO3</b>	Analyze and evaluate engine performance and adopt improvement devices and new combustion concepts.
<b>CO4</b>	Classify and analyze alternate power sources for automobiles.

**Course Articulation Matrix:**

<b>PO</b> <b>CO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>	<b>PSO1</b>	<b>PSO2</b>
<b>CO1</b>	3	2	2	-	1	-	-	-	-	-	-	1	2	3
<b>CO2</b>	-	2	3	2	-	2	2	-	-	-	-	1	3	2
<b>CO3</b>	3	2	2	-	2	-	1	-	-	-	-	1	3	3
<b>CO4</b>	2	-	2	-	-	1	2	-	-	-	-	1	2	2

**Detailed Syllabus:**

**Introduction to IC engines:** Overview of the course, Examination and Evaluation patterns-Classification of Prime Movers; IC Engines as Prime Movers; Historical Perspective-Contribution of IC Engines for Global Warming. Concept of charge, Differences between EC Engines and IC Engines-Classification, Mechanical cycle and Thermodynamic cycle, Air standard cycles-Diesel, Otto, Dual and Miller cycles. Classification of 2-S cycle engines based on scavenging, Differences between 2-S and 4-S cycle engines, Differences between SI and CI engines.

**Spark Ignition Engines:** Flame Propagation- Combustion phenomena (Normal and Abnormal), Factors affecting, Detonation, Ignition quality, HUCR-Carburetion and fuel injection systems for SI Engines.

**Compression Ignition Engines:** Advantages of CI engines-Importance of air motion and Compression Ratio, Mixture Preparation inside the CC. Normal and abnormal combustion - Ignition Quality-Cetane number-Characteristics of a Good Combustion Chamber-Classification of Combustion Chambers (DI

and IDI).Description of Fuel injection Systems -Individual, Unit and Common Rail (CRDI), Fuel Injectors-Nozzle types, Electronic Control Unit (ECU)-Numerical problems on fuel injection.

**Supercharging of IC Engines:** Need of Supercharging and advantages, Configurations of Supercharging-Numerical problems on turbocharging.

**Pollutant emissions from IC Engines:** Introduction to clean air, Pollutants from SI and CI Engines: Carbon monoxide, UBHCs, Oxides of nitrogen (NO-NOx) and Particulate Matter. Mechanism of formation of pollutants, Factors affecting pollutant formation. Measurement of engine emissions-instrumentation, Pollution Control Strategies, Emission norms-EURO and Bharat stage norms.

**Performance of IC Engines:** Classification of engine performance parameters-Measurement of brake power, indicated power and friction power. Factors affecting performance, Heat loss, Air-fuel ratio, Pumping loss, Energy Balance: Pi and Sankey diagrams Numerical problems.

**Alternate Fuels:** Need for Alternate fuels, Desirable Characteristics of good Alternate Fuel-Liquid and Gaseous fuels for SI and CI Engines, Kerosene, LPG, Alcohols, Bio-fuels, Natural gas, Hydrogen and use of these fuels in engines.

**Batteries:** Battery: lead-acid battery, advantages of lead- acid battery- Battery parameters: battery capacity, discharge rate, state of charge, state of discharge, depth of discharge, Technical characteristics-Ragone plots.

**Electric vehicles:** Introduction: Limitations of IC Engines as prime mover, History of EVs, EV system, components of EV-DC and AC electric machines: Introduction and basic structure-Electric vehicle drive train-advantages and limitations, Permanent magnet and switched reluctance motors-EV motor sizing: Initial acceleration, rated vehicle velocity, Maximum velocity and maximum gradability.

**Hybrid vehicle:** Configurations of hybrids, advantages and limitations-Hybrid drive trains, sizing of components Initial acceleration, rated vehicle velocity, Maximum velocity and maximum gradability-Hydrogen: Production-Hydrogen storage systems-reformers.

**Fuel Cell vehicles:** Fuel cells: Introduction-Fuel cell characteristics, Thermodynamics of fuel cells-Fuel cell types: emphasis on PEM fuel cell.

### Reading:

1. J.B. Heywood Internal Combustion Engine Fundamentals, McGraw Hill Co.1988.
2. W.W.Pulkrabek Engineering Fundamentals of IC Engine, PHI Pvt.Ltd 2002.
3. SethLeitman and Bob Brant Build your own electric vehicle McGraw Hill Co.2009.
4. F.Barbir PEM Fuel Cells-Theory and Practice Elsevier Academic Press-2005.

<b>ME415</b>	<b>TOOL DESIGN</b>	<b>DEC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-requisites:** ME253: Manufacturing Science, ME301: Design of Machine Elements, ME303: Machine Tools and Metrology, ME353: Machining Science

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Design Locating and Clamping systems for the given component based on geometrical and dimensional features.
<b>CO2</b>	Select and design progressive, compound or combination dies for producing a given component.
<b>CO3</b>	Design single point and multipoint cutting tools for conventional and CNC Machining.
<b>CO4</b>	Design jigs and fixtures for conventional and NC machining.

**Course Articulation Matrix:**

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	<b>CO1</b>	3	2	-	-	-	2	-	-	-	-	-	-	3
<b>CO2</b>	3	2	-	-	-	2	-	-	-	-	-	-	3	2
<b>CO3</b>	3	-	-	-	-	2	-	-	-	-	-	-	3	2
<b>CO4</b>	3	2	-	-	2	2	-	-	-	-	-	-	3	2

**Detailed Syllabus:**

**Introduction:** Tool design - An overview, Introduction to Jigs and fixtures.

**Work holding devices:** Basic principle of six point location, Locating methods and devices, Principle of clamping and Types of clamps.

**Design of jigs:** Type of Drill bushes, Classification of drill jigs, Design of drill jigs.

**Design of fixtures:** Design of milling fixtures, Design of turning fixtures.

**Introduction of press tool design:** Introduction to Die cutting operations, Introduction to press and classifications, Die set assembly with components, Introduction to Centre of pressure, Examples of center of pressure, Design of piercing die, Design of blanking die, Progressive, Compound and Combination dies.

**Design of cutting tools:** Introduction to cutting tools, Design of single point tool, Design of drill bit, Design of milling cutter.

**Brief introduction of NC machines work holding devices:** Tool design for NC machines- An introduction, Fixture design for NC Machine, Cutting tools for NC Machine, Tool holding methods for NC Machine, ATC and APC for NC Machine, Tool presetting for NC Machine.

**Reading:**

1. F. W. Wilson, "Fundamentals of Tool Design", ASME, PHI, New Delhi, 2010
2. Donaldson C. , G. H. Lecain and V. C. Goold, "Tool Design", TMH, New Delhi, 2010
3. Prakash Joshi, "Jigs and Fixtures Design Manual", 2<sup>nd</sup> Edition, McGraw-Hill Professional, 2002.
4. K. Venkataraman, "Design of Jigs, Fixtures and Press Tools", 1<sup>st</sup> Edition, Wiley; Athena Academic, 2015.

<b>ME416</b>	<b>THEORY OF PLASTICITY</b>	<b>DEC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-requisites:** ME253: Manufacturing Science

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Differentiate elastic and plastic behavior from stress-strain curves
<b>CO2</b>	Identify plastic yield criteria to establish constitutive modeling
<b>CO3</b>	Interpret material constants in mathematical formulation of constitutive relationship
<b>CO4</b>	Analyze boundary value problems with elasto-plastic properties

**Course Articulation Matrix:**

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	3	2	2	2	-	-	-	-	-	-	-	-	3
CO2	3	2	2	2	-	-	-	-	-	-	-	-	3	3
CO3	2	3	2	-	-	-	-	-	-	-	-	-	3	3
CO4	2	3	2	-	-	-	-	-	-	-	-	-	3	3

**Detailed syllabus:**

Introduction to the concept of plastic deformation - Role of microstructure and thermodynamics in plastic deformation - Constitutive responses: elastic, viscoelastic, plastic, visco plastic, anisotropy etc.

Physical overview of crystal plasticity, plasticity of granular media, plasticity in rubber-like materials, etc. (Rate independent plastic deformation) - Rate dependent and rate independent plasticity - Plastic strain, incremental strain, objective rates, and hardening variables - Yield criteria - Plastic work (Drucker's postulate) - Maximum dissipation and normality rule (Associated flow rules) - Hardening rules (isotropic and kinematic) - Non-associated flow rules

Axisymmetric problems in plasticity - Basic equations of plane strain and plane stress - Slip lines and their properties - Limit analysis and shakedown theorems (Plastic stability and waves) - Concept of plastic stability - Global stability criteria according to Hill - Elastoplastic column buckling - Local stability criteria (localization, shear bands, ellipticity)



Introduction to dynamic plasticity - One-dimensional - Phase transformation and plasticity, strain-gradient plasticity, dislocation plasticity, crystal plasticity.

**Reading:**

1. J. Lubliner, "Plasticity Theory", Dover Publishing, 2008.
2. L. M. Kachanov, "Fundamentals of the theory of plasticity", Dover Publishing, 1990.
3. D. Bigoni, "Nonlinear Solid Mechanics", Cambridge University Press, 2012
4. P. M. Dixit and U. S. Dixit, "Plasticity: Fundamentals and applications", CRC Press; (2014)
5. J. Chakrabarty, "Theory of Plasticity", 3<sup>rd</sup> Edition, Butterworth-Heinemann, 2006.
6. R Narayanasamy and R Ponalagusamy, "Theory of Engineering Plasticity", Ahuja Book Company, 2000.

ME417	TOTAL QUALITY MANAGEMENT	DEC	3 - 0 - 0	3 Credits
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

CO1	Understand quality management philosophies, techniques, and frameworks
CO2	Adopt TQM methodologies for continuous quality improvement
CO3	Identify the areas of improvement through measurement of cost of poor quality, effectiveness and efficiency of processes
CO4	Apply TQM process and concepts to enhance the performance of systems
CO5	Understand the implications of quality management standards and systems

#### Course Articulation Matrix

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	-	-	-	-	-	-	3	2	2	2	2	2	2
CO2	2	-	-	-	-	2	-	3	2	2	2	2	2	2
CO3	2	-	-	-	2	3	-	3	2	2	2	2	3	2
CO4	2	2	-	3	3	2	-	3	3	3	3	2	2	3
CO5	2	2	-	-	2	2	-	3	2	2	2	2	3	2

#### Detailed syllabus:

**Introduction:** Definition of Quality, Dimensions of Quality, Definition of Total quality management, Quality Planning, Quality costs - Analysis, Techniques for Quality Costs, and Basic concepts of Total Quality Management.

**Historical Review:** Quality Council. Quality Statements, Strategic Planning, Deming Philosophy, Barriers to TQM Implementation, Benefits of TQM, Characteristics of successful quality leader, Contributions of Gurus of TQM, Case studies.

**TQM Principles:** Customer satisfaction - Customer Perception of Quality, Customer Complaints, Service Quality. Customer Retention, Employee Involvement - Motivation, Empowerment teams, Continuous Process Improvement - Juran Trilogy, PDCA Cycle, Kaizen, Supplier Partnership - Partnering, sourcing, Supplier Selection, Supplier Rating, Relationship Development, Performance Measures - Basic Concepts, Strategy, Performance Measure, Case studies.

**TQM Tools:** Benchmarking - Reasons to Benchmark, Benchmarking Process, Quality Function Deployment (QFD) - House of Quality, QFD Process, Benefits, Taguchi Quality Loss Function, Taguchi Quality Philosophy- Robust Design Concept, Orthogonal Arrays, Total Productive Maintenance (TPM) - Concept, Improvement Needs, FMEA - Stages of FMEA, The seven tools of quality, Process capability, Concept of six sigma, New seven management tools, Case studies.

**Quality Systems:** Need for ISO 9000 and Other Quality Systems, ISO 9000:2000 Quality System - Elements, Implementation of Quality System, Documentation, Quality Auditing, QS 9000, ISO 14000 - Concept, Requirements and Benefits, Case Studies

**Reading:**

1. Dale H. Besterfield, "Total Quality Management", Pearson Education, Delhi, 2006.
2. Subburaj Ramasamy, "Total Quality Management", Tata McGraw Hill Publishing Company Ltd., New Delhi, 2005.
3. Narayana V and Sreenivasan N.S., "Quality Management - Concepts and Tasks", New Age International, Delhi, 1996.

<b>ME418</b>	<b>ENTREPRENEURSHIP</b>	<b>DEC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-requisites:** Nil.

**Course Outcomes:** At the end of the course, student will be able to:

<b>CO1</b>	Understand entrepreneurship and entrepreneurial process and its significance in economic development.
<b>CO2</b>	Develop an idea of the support structure and promotional agencies assisting ethical entrepreneurship.
<b>CO3</b>	Identify entrepreneurial opportunities, support and resource requirements to launch a new venture within legal and formal frame work.
<b>CO4</b>	Develop a framework for technical, economic and financial feasibility.
<b>CO5</b>	Evaluate an opportunity and prepare a written business plan to communicate business ideas effectively.
<b>CO6</b>	Understand the stages of establishment, growth, barriers, and causes of sickness in industry to initiate appropriate strategies for operation, stabilization and growth.

**Course Articulation Matrix:**

CO \ PO	PO												PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	-	-	-	-	-	3	-	2	-	3	3	2	3	-
<b>CO2</b>	-	-	-	-	-	2	3	3	-	3	2	2	2	-
<b>CO3</b>	-	-	-	-	-	2	-	3	-	3	2	2	2	-
<b>CO4</b>	-	-	-	-	-	2	3	3	-	3	3	2	-	-
<b>CO5</b>	-	-	-	-	-	-	-	3	2	3	2	2	2	-
<b>CO6</b>	-	-	-	-	-	-	-	2	2	-	3	2	2	-

**Detailed syllabus:**

**Entrepreneur and Entrepreneurship:** Introduction; Entrepreneur and Entrepreneurship; Role of entrepreneurship in economic development; Entrepreneurial competencies and motivation; Institutional Interface for Small Scale Industry/Enterprises.

**Establishing Small Scale Enterprise:** Opportunity Scanning and Identification; Creativity and product development process; Market survey and assessment; choice of technology and selection of site.

**Planning a Small Scale Enterprise:** Financing new/small enterprises; Techno Economic Feasibility Assessment; Preparation of Business Plan; Forms of business organization/ownership.

**Operational Issues in SSE:** Financial management issues; Operational/project management issues in SSE; Marketing management issues in SSE; Relevant business and industrial Laws.

**Performance appraisal and growth strategies:** Management performance assessment and control; Causes of Sickness in SSI, Strategies for Stabilization and Growth.

**Reading:**

1. G.G. Meredith, R.E.Nelson and P.A. Neek, "The Practice of Entrepreneurship", ILO, 1982.
2. Dr. Vasant Desai, "Management of Small Scale Enterprises", Himalaya Publishing House, 2004.
3. "A Handbook for New Entrepreneurs", Entrepreneurship Development Institute of India, Ahmedabad, 1998.
4. Bruce R Barringer and R Duane Ireland, "Entrepreneurship: Successfully Launching New Ventures", 3rd Edition, Pearson Education, 2013.

<b>ME449</b>	<b>PROJECT WORK PART - A</b>	<b>PRC</b>	<b>0 - 0 - 4</b>	<b>2 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Identify a topic in advanced areas of Mechanical Engineering.
<b>CO2</b>	Review literature to identify gaps and define objectives & scope of the work.
<b>CO3</b>	Generate and implement innovative ideas for social benefit.
<b>CO4</b>	Develop a prototypes/models, experimental set-up and software systems necessary to meet the objectives.

**Course Articulation Matrix:**

PO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	3	2	-	-	2	1	-	1	3	2	1	2	3	3
<b>CO2</b>	2	2	-	-	1	2	1	1	2	2	-	2	3	3
<b>CO3</b>	2	2	1	2	2	2	2	1	2	2	-	2	3	3
<b>CO4</b>	2	2	3	3	3	2	2	2	2	1	1	2	3	3

## RUBRICS

Task	Performance indicators	Good 4	Satisfactory 3	Average 2	Poor 1
Selection of Topic	Selection of Topic	Selection of the topic by referring literature discussion with guide in two weeks.	Selection of the topic by referring research journals in a month	Selection of the topic by referring research journals in more than a month	Selection of the topic with the help of the guide
	Developing Project Plan & Distribution of work	Splitting the project into small tasks and scheduling them to finish it	Splitting the project into small tasks and scheduling them to finish it in	Splitting the project into small tasks is not sufficient and sharing different	Not able to split the project into small tasks. Needs lot of work to be done.

		in time and division of the work among the members of the team is good and coordination in the team is good.	time and different tasks of the job shared among the members of the team with satisfactory coordination.	tasks among the team members needs some more attention	
Literature Survey	Collection of Literature	Collected related research articles are Good and sufficient for the project work.	Collected related research articles are satisfactory for the project work.	Need some more research articles for the project work and need time.	Not collected relevant articles.
Performance of the task	Experiment Analysis/ Industrial Problem	Work completed in all aspects and is ready to prepare the dissertation.	Work completed 80%. Can start preparing, the dissertation.	Work completed only 50-60%. Need more attention to compete the tasks.	Work not completed. Need lot of attention.
	Team Work	Coordinates team efforts and communication among members is good.	Coordinates team efforts and communication among members is satisfactory.	Requires more coordination and communication among the team	No proper coordination among the team
Review	Presentation	Presentation should be good with results and with good figures	Presentation is satisfactory with the results.	Presentation needs some improvement	Presentation is incomplete in all aspects.
	Understanding	Understanding the task fully. Knowing all the tasks of the project. 100%.	Ability of correlating the theoretical aspects with the practical aspects is in between 60-80%	Ability of correlating the theoretical aspects with the practical aspects is in between 50-60%	Ability of correlating the theoretical aspects with the practical aspects is less than 50%

Dissertation Preparation	Dissertation Preparation	Dissertation prepared with neat sketches, and complete with all the necessary calculations or analysis, contents of the dissertation are well planned and coverage of all the topics is good	Dissertation prepared with neat sketches, and complete with all the necessary calculations or analysis, contents of the dissertation are well planned and coverage of all the topics is satisfactory	Dissertation prepared with sketches and required calculations but needs improvement	Dissertation prepared is not complete in all aspects and the coverage of all the contents is poor
	Viva-voce	Understanding	Answering 100% questions related to the project	Answering 80% questions related to the project	Answering about 60% of questions related to the project
	Response	Responding immediately with confidence	Responding and answering to the satisfactory level	Responding with much delay and answering about 50% of the questions	Not able to respond. Understanding the concepts is poor



ME461	ROBOTICS	DEC	3 - 0 - 0	3 Credits
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**Pre-requisites:** Nil.

**Course Outcomes:** At the end of the course, the student will be able to:

CO1	Understand the basic components of robots, classification and robot grippers.
CO2	Model forward and inverse kinematics of robot manipulators.
CO3	Analyze forces in links and joints of a robot.
CO4	Programme a robot to perform tasks in industrial applications.
CO5	Design intelligent robots using sensors.

**Course Articulation Matrix:**

PO \ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	-	-	-	1	-	-	-	-	-	2	1	1
CO2	3	2	2	2	2	2	-	-	-	-	-	2	2	2
CO3	3	2	2	2	2	2	-	-	-	-	-	2	2	2
CO4	3	3	3	3	3	3	-	-	-	-	-	2	3	3
CO5	3	2	3	3	3	3	-	-	-	-	-	2	3	3

**Detailed Syllabus:**

**Introduction:** Robotics-classification, Sensors-Position sensors, Velocity sensors, Proximity sensors, Touch and Slip Sensors, Force and Torque sensors. Grippers and Manipulators-Gripper joints, Gripper force, Serial manipulator, Parallel Manipulator, selection of Robot-Selection based on the Application

**Kinematics:** Manipulators Kinematics, Rotation Matrix, Homogenous Transformation Matrix, Direct and Inverse Kinematics for industrial robots for Position and orientation.

**Statics & dynamics:** Differential Kinematics and static- Dynamics-Lagrangian Formulation, Newton Euler Formulation for RR & RP Manipulators,

**Trajectory planning:** Motion Control- Interaction control, Rigid Body mechanics.

**Control:** architecture- position, path velocity and force control systems, computed torque control, Adaptivecontrol, and Servo system for robot control.

**Robot programming:** Programming of Robots and Vision System- overview of various programming Languages.

**Applications:** Application of Robots in production systems- Application of robot in welding, machine tools, material handling, and assembly operations parts sorting and parts inspection.

**Reading:**

1. Craig, J.J., *Introduction to Robotics Mechanics and Control*, AddisonWesley, 1999.
2. Saha, Subir Kumar. *Introduction to robotics*. Tata McGraw-Hill Education, 2014.
3. Spong, Mark W., Seth Hutchinson, and MathukumalliVidyasagar. *Robot modeling and control*. Vol. 3. New York: Wiley, 2006.

<b>ME462</b>	<b>ROTOR DYNAMICS</b>	<b>DEC</b>	<b>3-0-0</b>	<b>3 credits</b>
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**Pre-Requisites:** ME251: Dynamics of Machinery

**Course Outcomes:** At the end of the course, the student shall be able to:

<b>CO1</b>	Model the Rotor bearing systems and formulate the governing equations.
<b>CO2</b>	Understand the role of damping, gyroscopic, centrifugal, stiffness and inertial effects on rotors.
<b>CO3</b>	Compute the critical speeds and stability limits for rotors under axial, transverse and torsional modes.
<b>CO4</b>	Analyse the rotor bearing systems using transfer matrix method and Finite Element Method.
<b>CO5</b>	Compute the transient response of rotors.

**Course Articulation Matrix:**

<b>CO \ PO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>	<b>PSO1</b>	<b>PSO2</b>
<b>CO1</b>	3	2	2	-	2	-	-	-	-	-	-	2	3	2
<b>CO2</b>	3	3	1	-	-	-	-	-	-	-	-	2	2	1
<b>CO3</b>	3	2	2	-	2	-	-	-	-	-	-	2	3	2
<b>CO4</b>	2	2	2	-	1	-	-	-	-	-	-	2	3	3
<b>CO5</b>	1	-	2	-	2	-	-	-	-	-	-	2	3	3

**Detailed Syllabus:**

**Introduction:** Introduction to rotor dynamics & smart rotor systems, Review of momentum principles, Hamilton's principle and Lagrange's equations, Rotating and reciprocating unbalances, Classification of Discrete and continuous systems, Review of free and forced vibrations of single and multi-degree of freedom systems.

**Linear Rotor Dynamics:** Equation of motion, Rotating systems, Complex coordinate representation, Undamped Jeffcott Rotor - Free whirling, Unbalance response, Shaft Bow Jeffcott Rotor with viscous damping - Free whirling, Unbalance response, Shaft Bow With structural damping - Free whirling, Unbalance response, frequency dependent loss factors with non-synchronous damping, Effect of Bearing Compliance, Stability in supercritical region.

**Modelling with Four Degrees of Freedom:**

Generalised coordinates and equations of motion in real and complex coordinates, Static and couple unbalance and their effects, uncoupled gyroscopic systems, Free whirling of coupled undamped systems, Unbalance response and Shaft bow. Model uncoupling of gyroscopic systems, Configuration and state space approaches. Disc gyroscopic, synchronous and nonsynchronous whirl, forward and backward whirl.

### **Discrete multi-degree of freedom:**

Introduction, Transfer matrix approach for undamped systems, Damped systems, the finite element method for rotors, Beam elements, spring elements, Mass elements, Assembly and constraints, damping matrices, Choice of coordinates: fixed Vs Rotating and Real Vs Complex coordinates, Computation of critical speeds, Computation of unbalance response. Campbell and root locus diagrams, Reduction of DOF: Nodal reduction, model reduction and component mode synthesis.

**Transmission Shafts:** Modelling of rotors as continuous systems, Euler-Bernoulli and Timoshenko beam models, Dynamic stiffness, Analytical and approximate solutions.

### **Anisotropy of rotors and supports:**

Isotropic rotors on Anisotropic supports - Influence of damping, non-isotropic rotors on isotropic supports.

### **Torsional and Axial Dynamics:**

Free and forced Torsional vibrations and critical speeds, Axial Vibration of rotors

### **Rotor-Bearing Interaction:**

Rigid body and flexural modes, Linearization of bearing Characteristics, Rolling element bearings, Fluid film bearings, Magnetic bearings, bearing alignment in multi rotor bearings

### **Reading:**

1. Giancarlo Genta, Dynamics of Rotating Systems, Springer, 2009
2. Rao, J.S., Rotor Dynamics, 3 Ed. New Age International, 2003
3. Maurice L. Adams, Jr., Rotating Machinery Vibrations, Marcel Dekker, Inc., New York, 2001
4. Chong-Won Lee, Vibration Analysis of Rotors, Kluwer Academic Publishers, London, 1995
5. Muszynska A, Rotor dynamics, Taylor & Francis, New York, 2005

ME463	ENGINEERING ACOUSTICS	DEC	3 - 0 - 0	3 Credits
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

CO1	Understand wave propagation, absorption, transmission, reflection and radiation.
CO2	Formulate acoustic problems for reduction of sound levels.
CO3	Analyze and design resonant systems including pipes, mufflers, Helmholtz resonators.
CO4	Evaluate architectural acoustics reverberation time, direct echoes and acoustical amplification.
CO5	Analyze the acoustic levels and analytical predictions.

**Course Articulation Matrix:**

PO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	-	1	-	-	-	-	-	-	-	2	2	1
CO2	3	3	3	1	1	-	-	-	-	-	-	1	3	2
CO3	2	2	2	2	2	-	-	-	-	-	-	2	3	2
CO4	2	1	1	2	-	-	-	-	-	-	-		3	3
CO5	2	2	2	2	1	-	-	-	-	-	-	1	3	2

**Detailed Syllabus:**

**Introduction:** Review of vibrations, resonance and frequency, Sound pressure, power and intensity and its measurement, Concept of Monopoles, Dipoles and Quadrupoles, Sound Power measurement, Transmission loss, Longitudinal and Transverse wave equations, Spherical and cylindrical wave equation, Acoustic intensity, decibel scales, Sound wave generators.

**Acoustic wave propagation:** Transmission/reflection of waves in different media, radiation and reception of acoustic waves, absorption and attenuation of sound, Cavities and waveguides. Wave types in fluids and solids. Modes of vibrations in solids.

**Pipes, Resonators, and Filters:** Resonance in pipes, standing waves, Absorption of sound, Helmholtz resonator, acoustic impedance, acoustic filters.

**Damping Attenuation and Absorption:** Viscous attenuation of sound, absorption by atmosphere, attenuation in water, absorption in fluid filled pipes, damping in solids.

**Architectural Acoustics:** Sound in enclosures, direct and reverberant sounds, sound absorption materials, acoustic factors in architectural design, standing waves and normal modes in enclosures.

**Noise Control:** The auditory system, Effects of noise on humans, noise measurement and criterion, treatment at source and treatment of transmission path, Analysis and design of mufflers for automotive applications, Noise measurement and instrumentation standards. Noise Control approaches.

**Reading:**

1. Robert D Finch. Introduction to acoustics, PHI2008
2. Michael Moser, Michael Maser, S. Zimmermann, Engineering Acoustics: An introduction to Noise Control, 2/e, Springer, 2009.
3. Frank J Fahy, Foundations of Engineering Acoustics, Academic Press, 2000.
4. Michael Moeser, Michael Maser, Engineering Acoustics: An Introduction to Noise Control, Springer, 2004.

<b>ME464</b>	<b>MECHANICS OF COMPOSITE MATERIALS</b>	<b>DEC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Pre Requisite:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Understand the industrial need for composite materials.
<b>CO2</b>	Identify suitable processes to develop fiber reinforced composite materials.
<b>CO3</b>	Apply the micro and macro mechanics for fiber reinforced composite materials.
<b>CO4</b>	Develop governing equation for Bending, Buckling, and Vibration of Laminated plates.
<b>CO5</b>	Design the composite structures with the help of computers.

**Course Articulation Matrix:**

PO \ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	-	2	-	-	-	2	3	2	-	3	-	2	-
CO2	-	2	3	3	3	2	3	2	-	3	-	2	-	-
CO3	3	3	-	-	-	-	-	2	-	-	-	2	3	2
CO4	3	3	-	-	-	-	-	2	-	-	-	2	3	-
CO5	-	-	3	-	3	-	3	2	-	-	-	2	3	3

**Detailed Syllabus:**

**Introduction to composite materials:** Introduction, What is a composite material, Current and potential advantages of fibre reinforced composites, Applications of composite materials, Military, civil, space, automotive and commercial applications

**Macro and micro mechanical behaviour of a lamina:** Stress strain relations for anisotropic materials, Restrictions on engineering constants, Strengths of an orthotropic lamina, biaxial strength criteria for orthotropic lamina

**Micro mechanical behaviour of lamina and laminates:** Mechanical of material approach to stiffness, Elasticity approach to stiffness, Classification lamination theory, Special cases, strength of laminates

**Bending, Buckling and Vibration of laminated plates:** Governing equations for bending buckling and vibration of laminated plates, Deflection of simply supported laminated plates, Vibration of simply supported laminated plates

**Design of composite structures:** Introduction, design philosophy, Anisotropic analysis, Bending extension coupling, Micromechanics, Nonlinear behaviour, Inter-laminar stresses, transverse shearing, Laminate optimization

**Reading:**

1. Ronald F. Gibson, Principles of composite material mechanics, CRC Press, 2011.
2. Robert M Jones, Mechanics of Composite Materials, Taylor & Francis, 2000.
3. Lawrence E. Nielsen, Nielson, Paul Nielsen, Mechanical Properties of Polymers and Composites, Second Edition, CRC press, 2000



<b>ME465</b>	<b>INNOVATIVE DESIGN</b>	<b>DEC</b>	<b>3-0-0</b>	<b>3 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to

<b>CO1</b>	Understand the conceptual development techniques to find solution for a critical design issue.
<b>CO2</b>	Apply embodiment principles to translate the conceptual ideas to engineering design.
<b>CO3</b>	Apply environmental, ethical and social issues during innovative design process.
<b>CO4</b>	Design and develop innovative engineering products for industrial needs using robust design philosophy.

**Course Articulation Matrix:**

<b>PO</b> <b>CO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>	<b>PSO1</b>	<b>PSO2</b>
<b>CO1</b>	-	-	2	-	3	2	2	2	-	-	-	2	1	3
<b>CO2</b>	-	-	2	-	3	2	2	2	-	-	-	2	1	3
<b>CO3</b>	-	-	-	-	3	3	3	3	-	-	-	2	1	3
<b>CO4</b>	-	-	2	-	3	3	2	3	3	-	-	2	1	3

**Detailed Syllabus:**

**Introduction:** Modern product development and design, State of art, Understanding the opportunity, Develop a concept, implement a concept, Reverse engineering and redesign methodology, Comparison between scientific method and design method.

**Need Identification and Problem definition:** Wheelwright Clark model, constructing a survey instrument, Kano diagram, Establishing Engineering Characteristics, Benchmarking, Evaluating Customer Requirements, Quality Function Deployment (QFD) and Product Design Specification (PDS).

**Information Gathering:** types, sources, Copy rights and Intellectual property systems, Journals and patent writing, Codes and Standards.

**Concept generalization:** Creativity and problem solving, Models of brain, Creative methods and barriers, Theory of Inventive Problem Solving (TRIZ), Physical and Functional Decomposition, Morphological analysis, Axiomatic design.

Concept evaluation and decision making- Decision Theory, Evaluation methods, Pugh's concept, weighted decision matrix, Analytic hierarchy process (AHP)

**Embodiment design:** Phases, Significance, Product architecture, Configuration and Parametric design, detailed design, Design for X: Manufacturing, Assembly, Environment, Robustness

**Ethical Issues and Team Management:** Ethical issues during Engineering design process, Product liability, Tort law, functioning, discharge, Team Dynamics and problem solving tools in design, Case studies.

**Reading:**

1. Engineering Design by George E Dieter
2. GenrichAltshuller, The Innovation Algorithm, Technical Innovation Centre, 2011.
3. Nigel Cross, Engineering Design Methods, John Wiley, 2009.

ME466	CONVECTIVE HEAT TRANSFER	DEC	3 - 0 - 0	3 Credits
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**Pre-Requisites:**ME201: Thermodynamics; ME352: Heat and mass transfer

**Course Outcomes:** At the end of the course, student will be able to:

CO1	Understand principles of forced and free convection heat transfer processes.
CO2	Formulate and solve convective heat transfer problems.
CO3	Estimate heat dissipation from heat transfer devices.
CO4	Evaluate energy requirements for operating a flow system with heat transfer.
CO5	Understand current challenges in the field of convective heat transfer.

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	1	3	2	-	-	-	-	-	-	-	3	3
CO2	3	3	3	2	2	-	-	-	-	-	-	1	2	2
CO3	3	2	2	2	1	-	-	-	-	-	-	1	2	2
CO4	3	2	3	2	1	-	-	-	-	-	-	1	2	3
CO5	3	2	1	2	2	-	-	-	-	-	-	2	2	1

**Detailed Syllabus:**

**Introduction:** Course structure, Basics of Thermodynamics, Fluid mechanics and Heat transfer.

**Fundamental Principles:** Continuity, momentum and energy equations, Reynolds transport theorem, Second law of TD, Rules of Scale analysis, Concept of Heat line visualization.

**Laminar forced convection:** External flows: Boundary layer concept, velocity and thermal boundary layer, Governing equations, Similarity solutions, various wall heating conditions, Flow over sphere, wedge and stagnation flow.

**Laminar forced convection:** Internal flows: Fully developed laminar flow: Constant heat flux, Constant wall temperature, developing length.

**External Natural convection:** Governing equations for natural convection, Boussinesq approximation, Dimensional Analysis, Boundary layer equations, Scale analysis, Low and high Prandtl number fluids, vertical walls, horizontal walls, sphere.

**Internal Natural Convection:** Natural convection in enclosures: isothermal and constant heatflux. Sidewalls, triangular enclosures, heated from below, inclined enclosures, annular space between horizontal cylinders.

**Turbulent boundary layer flow:** Boundary layer equations, mixing length model, flow over single cylinder, crossflow over array of cylinders, Natural convection along vertical walls, turbulent duct flow.

**Reading:**

1. Bejan, A., Convection Heat Transfer, John Willey and Sons, New York, 2001.
2. Louis, C. Burmeister, Convective Heat Transfer, John Willey and Sons, New York, 2003.
3. Kays, W.M. and Crawford, M. E., Convective Heat and Mass Transfer, McGraw Hill, 2001.

ME467	ALTERNATE FUELS	DEC	3 - 0 - 0	3 Credits
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**Pre-Requisites:**ME201: Thermodynamics, ME302: Prime Movers for Automobiles

**Course Outcomes:** At the end of the course, student will be able to:

<b>CO1</b>	Categorize, interpret and understand the essential properties of fuels for IC engines.
<b>CO2</b>	Identify the need for alternate fuels and characterize prospective alternate fuels.
<b>CO3</b>	Evaluate the storage and dispensing facility requirements.
<b>CO4</b>	Analyze the implement limitations with regard to performance, emission and materials compatibility.

**Course Articulation Matrix:**

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	3	2	2	-	-	1		-	-	-	-	1	2
CO2	-	-	3	-	-	2	2	-	-	-	-	1	3	2
CO3	2	1	-	-	-	-	-	-	-	-	-	1	3	3
CO4	3	3	2	2	-	2	2	-	-	-	-	1	2	2

**Detailed Syllabus:**

**Introduction:** Estimation of petroleum reserve - Need for alternate fuels - Availability and properties of alternate fuels, ASTM standards.

**Alcohols:** General Use of Alcohols - Properties as Engine fuel - Gasoline and alcohol blends - Performance in SI Engine - Methanol and Gasoline blend - Combustion Characteristics in engine - emission characteristics.

**Vegetable oils:** Soyabean, Jathropa, Pongamia, Rice bran, Mahuaetc as alternate fuel and their properties, Esterification of oils.

**Natural Gas, LPG:** Availability of CNG, properties, modification required to use in engines - performance and emission characteristics of CNG using LPG in SI & CI engines.

**Hydrogen:** Hydrogen production, Hydrogen as an alternative fuel, fuel cell

**Automobile emissions & its control:** need for emission control -Classification/ categories of emissions -Major pollutants -control of emissions - Evaluating vehicle emissions - EURO I, II, III, IV standards - Indian standards.

**Reading:**

1. Richard L. Bechhold, P.E. Alternate Fuels Guide Book, Society of Automotive Engineers, 1997.
2. Joseph M Norbeck, Hydrogen fuel for surface transportation, Society of Automotive Engineers, 1996.
3. Earnest Henry Wakefield, History of the Electric Automobile: Hybrid Electric Vehicles, Society of Automotive Engineers, 1998.
4. Pundir B.P., Engine Emissions: Pollutant formation and advances in control Technology, Narosa Publishing House, 2007.
5. S.C. Bhatia, Air Pollution and its Control, Atlantic Publications, 2008.
6. James D. Halderman, James Linder. Automotive Fuel and Emission Control system, Prentice Hall, 2005.

ME468	JET PROPULSION AND ROCKETRY	DEC	3 - 0 - 0	3 Credits
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**Pre-Requisites:**ME201: Thermodynamics, ME252: Turbomachines

**Course Outcomes:** At the end of the course, student will be able to:

CO1	Understand the applications of jet and rocket propulsion and their energy requirements.
CO2	Identify propellants available and factors influencing their burn rate and performance.
CO3	Classify nozzles and their requirements for the development of thrust and impulse.
CO4	Understand the principles of rocket propulsion, staging and boosting.
CO5	Evaluate burn rate, propulsive power, thrust and energy requirements in ideal cases of propulsion devices.

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	3	2	1	-	-	-	-	-	-	1	2	2
CO2	3	3	2	3	-	-	-	-	-	-	-	1	2	2
CO3	3	3	2	2	2	-	-	-	-	-	-	1	-	2
CO4	3	3	3	2	2	-	-	-	-	-	-	1	2	2
CO5	3	3	3	3	2	-	-	-	-	-	-	1	2	2

**Detailed Syllabus:**

**Motion In Space-Requirements of Orbit:** Introduction, Motion of Bodies in Space and Laws of Motion; Parameters describing Motion of Bodies, Newton's laws of Motion, Universal Law of Gravitational Force, Gravitational Field; Requirements for Motion in Space, Geosynchronous and Geostationary Orbits, Eccentricity and Inclination of Orbits, Energy and Velocity Requirements to reach a Particular Orbit; Escape Velocity, Freely Falling Bodies, Means of Providing the Required Velocities, small problems.

**Theory of Rocket Propulsion:** Illustration by an Example of Motion of Sled Initially at Rest, Motion of Giant Squid in Deep Seas; Rocket Principle and the Rocket Equation, Mass Ratio of a

Rocket, Desirable Parameters of a Rocket, Propulsive Efficiency of a Rocket, Performance Parameters of a Rocket, Staging and Clustering of Rockets, Classification of Rockets, problems.

**Rocket Nozzle and Performance:** Expansion of gas from a high pressure chamber, Shape of the Nozzle, Nozzle area Ratio, Performance loss in a conical Nozzle, Flow Separation in Nozzles Contour or Bell Nozzles, Unconventional Nozzles Mass Flow rates and characteristic Velocity, Thrust developed by a Rocket; Thrust Coefficient Efficiencies, Specific Impulse and Correlation with  $C^*$  and  $C_F$  General Trends.

**Chemical Propellants:** Small Values of Molecular Mass and Specific Heat Ratio, Energy Release during Combustion of Propellants, Criterion for Choice of Propellants, Solid Propellants, Liquid Propellants, Hybrid Propellants.

**Solid Propellant Rockets:** Mechanism of Burning and Burn Rate, Choice of Index  $n$  for Stable Operation of Solid Propellant Rockets, Propellant Grain Configuration, Ignition of Solid Propellant Rockets, Pressure Decay in the chamber after propellant Burns Out, Action time and Burn Time, Factors influencing Burn Rate Components of a Solid Propellant Rocket.

**Liquid Propellant Rockets:** Propellant Feed system, Thrust Chamber, Performance and Choice of Feed System Cycle, Turbo-pumps, Gas requirements for draining of propellants from storage tanks, draining under microgravity conditions, Complexity of Liquid Propellant Rockets and simulation, Trends in the development of liquid propellant rockets.

**Liquid Monopropellant rockets:** Hydrazine, Monopropellant rockets, Catalyst bed loading, Performance and applications.

**Hybrid Rockets:** Working Principle, Choice of Fuels and Oxidizers, Future of Hybrid Rockets.

**Combustion Instability:** Bulk and wave modes of Combustion Instability, Analysis procedure for bulk mode of combustion, Instability in liquid propellant rockets, Bulk mode of combustion instability in solid Propellant Rockets, Wave mode of combustion instability, Wave mode instability in solid propellant rockets, Evaluation of the growth constant of solid propellant using T burner, Conversion of growth constant derived from T burner for application in a solid propellant rocket, Wave mode instability in liquid propellant rockets, Non-linear combustion instability, Process induced combustion instability, Pogo instability due to interaction of propulsion and structure, Combustion Instability: Suppression and Control.

#### **Reading:**

1. Barrere, M., Rocket Propulsion, Elsevier Pub. Co., 1990.
2. Sutton, G. P., Rocket Propulsion Elements, John Wiley, New York, 1993.
3. Ramamurthi K., Rocket Propulsion, Macmillan Publishers India Ltd., 2010.
4. Feedesiev, V. I. and Siniarev, G. B., Introduction to Rocket Technology, Academic Press, New York, 2000.
5. Sarvanamuttoo, H.I.H., Rogers, G. F. C. and Cohen, H., Gas Turbine Theory, 6th Edition, Pearson Prentice Hall, 2008.



ME469	HEATING, VENTILATION & AIR-CONDITIONING	DEC	3 - 0 - 0	3 Credits
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**Pre-Requisites:**ME201: Thermodynamics

**Course Outcomes:** At the end of the course, student will be able to:

<b>CO1</b>	Understand the fundamentals of Psychrometry
<b>CO2</b>	Apply human comfort indices and comfort chart to design indoor conditions of HVAC systems.
<b>CO3</b>	Estimate heating and cooling loads for buildings according to ASHRAE procedures/standards.
<b>CO4</b>	Design and evaluate complete air distribution system including fan, duct, and installation requirements for a typical HVAC system.

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	3	3	-	-	-	-	-	-	-	-	-	2	1	1
<b>CO2</b>	3	3	3	-	-	2	2	-	2	-	2	2	2	2
<b>CO3</b>	3	3	3	-	-	-	3	-	3	-	-	3	2	2
<b>CO4</b>	3	3	3	-	-	-	3	-	3	-	-	3	3	3

**Detailed Syllabus:**

**Introduction:** Brief history of air conditioning and impact of air conditioning. HVAC systems and classifications, Heat Pumps

**Psychrometry of Air Conditioning Processes:** Thermodynamic properties of moist air, Important Psychrometry properties, Psychrometric chart; Psychrometric process in air conditioning equipment, applied Psychrometry, air conditioning processes, air washers.

**Comfort Air Conditioning:** Thermodynamics of human body, metabolic rate, energy balance and models, thermoregulatory mechanism. Comfort & Comfort chart, Effective temperature, Factors governing optimum effective temperature, Design consideration. Selection of outside and inside design conditions.

**Heat Transfer Through Building Structures:** Solar radiation; basic concepts, sun-earth relationship, different angles, measurement of solar load, Periodic heat transfer through walls and roofs. Empirical methods to calculate heat transfer through walls and roofs using decrement factor and time lag method. Infiltration, stack effect, wind effect. CLTD/ETD method - Use of tables, Numerical and other methods, Heat transfer through penetration - Governing equations, SHGF/SC/CLF Tables

**Load Calculation:** Types of air-conditioning systems, General consideration, internal heat gains, system heat gain, cooling and heating load estimate.

**Ventilation System:** Introduction- Fundamentals of good indoor air quality, need for building ventilation, Types of ventilation system, Air Inlet system. Filters heating & cooling equipment, Fans, Duct design, Grills, Diffusers for distribution of air in the work place.

**Reading:**

1. F.C. McQuiston & J.D. Parker, "Heating Ventilating and Air Conditioning- Analysis and Design", 5<sup>th</sup> Ed., John Wiley & Sons, 2001.
2. J.L. Threlkeld, "Thermal Environmental Engineering", 2<sup>nd</sup> Ed., Prentice-Hall, Inc., 1970.
3. ASHRAE Handbooks: Fundamentals, HVAC Applications, HVAC Systems & Equipment.
4. R.C. Arora, "Refrigeration & Air conditioning", PHI, 2010.

ME470	CRYOGENICS	DEC	3 - 0 - 0	3 Credits
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**Pre-Requisites:** Nil

**Course Outcomes:** At the end of the course, student will be able to:

CO1	Understand principles of cryogenic systems.
CO2	Understand air and helium liquefaction processes.
CO3	Classify cascade refrigeration systems.
CO4	Understand principles of ultra-low temperature systems and their applications.
CO5	Evaluate storage systems used in cryogenic applications.

**Course Articulation Matrix:**

PO \ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	-	-	-	-	-	-	-	-	-	-	2	2
CO2	3	3	3	3	3	-	-	-	-	-	-	-	3	2
CO3	3	3	3	-	3	-	-	-	-	-	-	-	3	3
CO4	3	3	2	2	3	-	-	-	-	-	-	-	3	3
CO5	3	3	2	3	3	-	-	-	-	-	-	-	3	2

**Detailed Syllabus:**

**Introduction:** Definition and Engineering Applications of Cryogenics, Properties of solids for cryogenic systems.

**Refrigeration and Liquefaction:** Simple Linde cycle, Pre-cooled Joule-Thomson cycle, dual-pressure cycle, Simon helium liquefier, classical cascade cycle, mixed-refrigerant cascade cycle.

**Ultra-low-temperature refrigerators:** Definition and Fundamentals regarding ultra-low-temperature refrigerators, Equipment associated with low-temperature systems, Various Advantages and Disadvantages.

**Storage and Handling of Cryogenic Refrigerants:** Storage and Transfer systems, Insulation, Various Types of Insulation typically employed, Poly Urethane Foams (PUFs) and Polystyrene Foams (PSFs), Vacuum Insulation, and so on.

**Applications:** Broad Applications of Cryogenic Refrigerants in various engineering systems.

**Reading:**

1. MamataMukhopadhyay, Fundamentals of Cryogenic Engineering, PHI, 2010.
2. Thomas Flynn, Cryogenic Engineering, Revised and Expanded, CRC, 2004.
3. Arora and Domukundwar, Refrigeration and Air-conditioning, Dhanpat Roy & Co., 2018.
4. A. R. Jha, Cryogenic Technology and Applications, Butterworth-Heinemann, 2005.
5. Timmerhaus et. al., Cryogenic Engineering, Fifty Years of Progress, Springer, 2007.

ME471	MICRO-SCALE HEAT TRANSFER	DEC	3 - 0 - 0	3 Credits
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**Pre-Requisites:**CE235: Fluid mechanics and Hydraulic Machines,  
ME352: Heat and Mass Transfer

**Course Outcomes:** At the end of the course, student will be able to:

CO1	Apply scaling laws for heat transfer and flow phenomenon.
CO2	Analyse surface tension dominated flows.
CO3	Analyse systems with micro-scale heat conduction and micro-scale heat convection.
CO4	Apply microfabrication techniques for the manufacture of micro-scale systems.
CO5	Identify techniques for measuring micro-scale flow and heat transfer

**Course Articulation Matrix:**

PO \ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	1	-	-	-	-	-	-	2	2	2
CO2	3	3	3	2	1	-	-	-	-	-	-	2	2	2
CO3	3	3	3	2	1	-	-	-	-	-	-	2	2	2
CO4	3	3	3	3	2	-	-	-	-	-	-	2	2	2
CO5	3	3	3	3	2	-	-	-	-	-	-	2	2	2

**Detailed Syllabus:**

**Introduction:** Historical Perspectives, Definition, Biological Systems, Analogy with computational platforms, Benefits, Application Examples: Micro Electro-Mechanical Systems (MEMS), Lab on a Chip, Micro reactor, Micro heat pipes, Micro sensors, Micro actuators, Micro Pumps, Drug delivery systems.

**Scaling Analysis:** Natural systems, Parallel plate capacitor for sensor, Micro droplets, Micro resonator, Micro reactor, Micro heat exchangers

**Channel Flow:** N-S equations, Dimensional Analysis, Hydraulic resistance, arbitrary shaped channel flow, Elliptic, Equilateral and Rectangular channel flow, Dissipation effect, Compliance of channel wall.

**Transport Laws:** Boundary slip, Momentum accommodation coefficient, Thermal accommodation coefficient, Thermal creep, Knudsen Compressor, Slip flow boundary condition in liquids and gases, Physical parameters affecting Slip, Slip Model Derivation, Compressibility effect, Slip flow between parallel plates and Couette flow, Introduction to molecular modeling, Deterministic molecular modeling, Statistical molecular modeling, Boltzmann Equation, Direct Simulation Monte-Carlo (DSMC) Method.

**Diffusion, Dispersion and Mixing:** Random walk model of diffusion, Stokes-Einstein Law, Fick's law, governing equation of multicomponent system, Characteristic non-dimensional parameters, fixed planar source diffusion, Constant planar source diffusion, Convection-diffusion equation, Taylor dispersion, Micromixer examples, Soluble or rapidly reacting wall, Reverse osmosis channel flow.

**Surface Tension Dominated Flows:** Microscopic model of surface tension, Gibbs free energy, Young-Laplace equation, Contact angle (Static and Dynamic), Wetting, Super hydrophobicity and hydrophilicity, Coating flows, Thermo-capillary flows, Thermo capillary pump, Diffuso-capillary flows, Electro-wetting, Taylor flows, Two-phase liquid flows, Clogging pressure, Digital microfluidics, Marangoni convection and instability.

**Microscale Heat Conduction:** Energy Carriers, Time and length scales, Scale effects, Fourier's law, Hyperbolic heat conduction, Kinetic theory, Electron thermal conductivity in metals, Lattice thermal conductivity, Scale effects of thermal conductivity, Boltzmann transport theory, Heat transport in thin films and at solid-solid interfaces, Heat conduction in semiconductor devices and interconnects, Laser heating.

**Microscale Convection:** Scaling laws, Temperature jump boundary condition, Convection in parallel plate channel flow and Couette flow with and without viscous dissipation, Similarity and dimensionless parameters, Flow boiling in micro channels, Mini-channel versus micro-channel, Nucleate and convective boiling, Dryout incipience quality, Saturated and sub-cooled flow boiling, Condensation heat transfer in mini-micro channels, Micro heat pipes.

**Micro Fabrication:** Functional materials, Lithography, Subtractive technique, Etching, Wet etching, Dry etching, Deep reactive ion etching, Additive techniques, Physical vapor deposition, Chemical vapor deposition, PDMS based molding, Bonding, Laser micro fabrication technique.

**Measurements:** Micro scale velocimetry, Microscale thermometry.

### Reading:

1. P. Tabeling "Introduction to Microfluidics", Oxford University Press, 2005.
2. G. Karniadakis, A. Beskok and N. Aluru, "Microflows&Nanoflows: Fundamental and Simulation", Springer Publication, 2005.
3. J. Berthier and P. Silberzan, "Microfluidics for Biotechnology", Artech House, 2006.
4. H. Bruus, "Theoretical Microfluidics", Oxford University Press, 2008.
5. N.T. Nguyen and S.T. Wereley, "Fundamentals and Applications of Microfluidics", 2<sup>nd</sup> edition, Artech House, 2006.

ME472	POWER PLANT ENGINEERING	DEC	3 - 0 - 0	3 Credits
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**Pre-Requisites:**ME201: Thermodynamics

**Course Outcomes:** At the end of the course, student will be able to:

CO1	Understand functions of the components of power plant.
CO2	Understand the working of nuclear, thermal and gas based power plants.
CO3	Evaluate the design layout and working of hydroelectric power plants.
CO4	Evaluate economic feasibility and its implications on power generating units.

**Course Articulation Matrix:**

PO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	-	2	1	-	-	-	-	2	2	2
CO2	3	3	3	2	-	2	1	-	-	-	-	2	2	2
CO3	3	3	3	2	-	2	1	-	-	-	-	2	2	2
CO4	3	3	3	3	-	1	1	-	-	-	2	2	2	2

**Detailed Syllabus:**

**Analysis of Steam Cycles:** Introduction to the course, Power plant layout and essential feature Rankine cycle, Reheating and regeneration, Problems on Rankine Cycle, Combined cycle power generation, Binary vapour cycles.

**Fuels and Combustion:** Basics on fuels and combustion, Mass and energy balance of steam generator, Draught system, Enthalpy of combustion.

**Steam generators, accessories and Condensers:** Different types of boilers, description, working procedures, High pressure Boilers, Accessories, fluidized bed boiler. Direct Contact Condenser Surface Condensers, Effect of various parameters on condenser performance, Design of condensers, cooling towers and cooling ponds.

**Hydroelectric power plant:** Introduction, Hydrological Cycle and hydrographs, Design construction and operation.

**Nuclear power plants:** Introduction, concepts of nuclear fusion and nuclear fission, types of reactors and their operation.

**Energy storage:** Need of storage, types of energy storage, options and limitations.

**Non-conventional power generation:** Basics of different non-conventional power generation types, operation, limitations.

**Power plant economics and other issues:** Load duration curves, Power plant economics, estimation of tariff. Diesel and gas plants, Pollution and control, Greenhouse effect and control, Peak load plants.

**Reading:**

1. Arora & Domkundwar, "Power plant engineering", Dhanpat Rai & Sons, New Delhi, 2008.
2. M.M.Ei-Wakil, "Power plant Technology", McGraw Hill Com., 1985.
3. P C Sharma, "Power plant engineering", S.K. Kataria & Sons, New Delhi, 2010.



ME473	COMBUSTION	DEC	3 - 0 - 0	3 Credits
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**Pre-Requisites:**ME201: Thermodynamics

**Course Outcomes:** At the end of the course, student will be able to:

CO1	Understand the concepts of combustion phenomena in energy conversion devices.
CO2	Apply the knowledge of adiabatic flame temperature in the design of combustion devices.
CO3	Identify the phenomenon of flame stabilization in laminar and turbulent flames.
CO4	Analyze the pollution formation mechanisms in combustion of solid, liquid and gaseous fuels.

**Course Articulation Matrix:**

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	3	3	2	2	-	-	-	-	-	-	-	2	2
CO2	2	2	2	2	-	-	-	-	-	-	-	1	1	1
CO3	3	3	3	2	-	-	-	-	-	-	-	1	2	2
CO4	3	3	2	2	-	-	-	-	-	-	-	2	2	2

**Detailed Syllabus:**

**Introduction:** Overview of the course-Thermo chemistry of combustion-Concept of Adiabatic Flame Temperature-Numerical Problems

**Chemical Kinetics:** Differences between equilibrium and rate controlled reactions- Global versus Elementary Reactions. Elementary reaction rates, bimolecular reactions and collision theory, other elementary reactions, Relation between rate coefficients and equilibrium constants, Steady-state Approximation. The mechanism for Uni-molecular reactions, Chain and Chain-Branching reactions.

**Introduction to species Mass Transfer:** Rudiments of Mass Transfer, Mass Transfer Rate Laws, Species Conservation. The Stefan Problem, Liquid-vapor interface boundary conditions, Droplet evaporation, Numerical.

**Simplified Conservation Equations for Reacting Flows:** Overview-Overall Mass Conservation (Continuity) Species mass Conservation (Species Continuity) Momentum

Conservation, 1-D and 2-D forms, Energy Conservation-General 1-D Form, Shvab- Zeldovich Forms, Definition of Mixture Fraction.

**Laminar Premixed Flames:** Physical Description, Definition, Principal characteristics, Typical Laboratory Flames. Simplified Analysis, Assumptions, Conservation Laws, Solution, Factors Influencing flame velocity and Thickness: temperature, pressure, Equivalence ratio, fuel type, Flame speed Correlations for Selected fuels, Quenching, Flammability, and Ignition Flame lift-off (Blow-off) and flash back, Concept of Flame stretch-Karlovitz number, Flame Stabilization.

**Introduction to Turbulent Flames:** Turbulent length and time scales, Weak turbulent flames. Wrinkled Reaction Sheets, Distributed Reaction zones.

**Pollutant Emissions:** Effects of emissions, Quantification of Emissions, Emission Indices, Corrected concentrations, Various Specific emission measures-Emissions from Premixed Combustion: Oxides of Nitrogen, Carbon Monoxide, Unburned Hydrocarbons, Catalytic After-treatment, Particulate Matter. Emissions from non-Premixed Combustion: Oxides of Nitrogen, Unburned Hydrocarbons and Carbon Monoxide, Particulate Matter and Oxides of Sulfur, Numerical Problems.

#### **Reading:**

1. Stephen, R. Turns., Combustion, McGraw Hill, 2005.
2. Mishra, D.P., Introduction to Combustion, Prentice Hall, 2009.
3. Sharma, S. P., Fuels and Combustion, Tata McGraw Hill, New Delhi, 2001.
4. Heywood Internal Combustion Engine Fundamentals, McGraw Hill Co. 1988
5. Warnatz, Ulrich Maas and Robert W. Dibble Combustion: Physical and Chemical Fundamentals, Modelling and Simulation, Experiments, Pollutant Formation, 1999.

<b>ME474</b>	<b>ADVANCED METAL FORMING</b>	<b>DEC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-requisites:** ME253: Manufacturing Science

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Solve for strain rates, temperatures and metallurgical states in forming problems using constitutive relations.
<b>CO2</b>	Develop process maps for metal forming processes using plasticity principles.
<b>CO3</b>	Estimate formability limits for sheets and bulk metals.
<b>CO4</b>	Analyze the deformation process parameters for different engineering components.

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	3	3	3	-	-	-	-	-	-	-	-	-	3	3
<b>CO2</b>	3	3	3	2	2	2	2	-	-	-	-	-	3	3
<b>CO3</b>	3	3	3	2	2	2	2	-	-	-	-	-	3	3
<b>CO4</b>	3	3	3	-	-	-	-	-	-	-	-	-	3	3

**Detailed Syllabus:**

**Introduction:** Introduction of metal forming as a manufacturing process and its relation with other processes, Metal Forming from systems point of view, Advantages of metal forming as a manufacturing process, Classifications of metal forming processes, Forming equipment, Presses (mechanical, hydraulic).

**Theoretical analysis:** Theory of plasticity, Stress-strain relationship, Strain hardening, Material incompressibility, Work of plastic deformation, Work hardening, Yield criteria, Flow rule, Yield criterion and flow rule for Anisotropic material, Initiation and extent of plastic flow-Upper Bound - Slip-Line-Slab Analysis - Problems.

**Bulk Forming Processes:** Forging; open-die forging, closed-die forging, coining, nosing, upsetting, heading, extrusion and tooling, Rod, wire and tube drawing, Rolling; flat rolling, shape rolling and tooling, spinning, hydro forming, rubber-pad forming, explosive forming, problems.

**Sheet Forming Processes:** Blanking, piercing, press bending, deep drawing, stretch forming, formability tests, forming limit diagrams, process simulation for deep drawing and numerical approaches, Case studies.

Problems & Case Studies: Case studies on the manufacturing aspects of products using the lessons learnt.

**Reading:**

1. R. Narayanasamy, R Ponalagusamy, "Theory of Engineering Plasticity", Ahuja Book Company, 2000.
2. Henry S. Valberg, "Applied Metal Forming - Including FEM Analysis", Cambridge University Press, 2010.
3. G.K. Lal, P.M. Dixit and N.Venkat Reddy, "Modeling Techniques for Metal Forming Processes", Alpha Science, 2011

<b>ME475</b>	<b>MACHINE TOOL DESIGN</b>	<b>DEC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-requisites:** ME301: Design of Machine Elements, ME303: Machine Tools and Metrology, ME353: Machining Science

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Design and analyze kinematic motions in a machine tool.
<b>CO2</b>	Design and analyze speed and feed gear boxes.
<b>CO3</b>	Design machine tool structures for strength and rigidity.
<b>CO4</b>	Analyze machine tool vibration and chatter.
<b>CO5</b>	Select alignment tests to be performed on a machine tool for quality assurance.

**Course Articulation Matrix:**

<b>PO</b> <b>CO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>	<b>PSO1</b>	<b>PSO2</b>
<b>CO1</b>	3	-	3	3	-	-	-	-	-	-	-	-	3	2
<b>CO2</b>	3	-	3	3	-	-	-	-	-	-	-	-	3	2
<b>CO3</b>	3	2	3	3	-	-	-	-	-	-	-	-	3	2
<b>CO4</b>	3	3	3	2	-	-	-	-	-	-	-	-	3	2
<b>CO5</b>	3	-	3	2	-	-	-	-	-	-	-	-	3	2

**Detailed syllabus:**

**Introduction to Machine Tool Drives and Mechanisms:** Introduction to the course, Working and Auxiliary Motions in Machine Tools, Kinematics of Machine Tools, Motion Transmission.

**Regulation of Speeds and Feeds:** Aim of Speed and Feed Regulation, Stepped Regulation of Speeds, Multiple Speed Motors, Ray Diagrams and Design Considerations, Design of Speed Gear Boxes, Feed Drives, Feed Box Design.

**Design of Machine Tool Structures:** Functions of Machine Tool Structures and their Requirements, Design for Strength, Design for Rigidity, Materials for Machine Tool Structures,

Machine Tool Constructional Features, Beds and Housings, Columns and Tables, Saddles and Carriages.

**Design of Guideways, Power Screws and Spindles:** Functions and Types of Guideways, Design of Guideways, Design of Aerostatic Slideways, Design of Anti-Friction Guideways, Combination Guideways, Design of Power Screws.

**Design of Spindles and Spindle Supports:** Functions of Spindles and Requirements, Effect of Machine Tool Compliance on Machining Accuracy, Design of Spindles, Antifriction Bearings.

**Dynamics of Machine Tools:** Machine Tool Elastic System, Static and Dynamic Stiffness.

**Acceptance Tests:** Alignment tests on lathe, drilling and milling machines.

**Reading:**

1. N.K. Mehta, "Machine Tool Design and Numerical Control", TMH, New Delhi, 2010.
2. G.C. Sen and A. Bhattacharya, "Principles of Machine Tools", New Central Book Agency, 2009.
3. D. K Pal, S. K. Basu, "Design of Machine Tools", 5<sup>th</sup> Edition, Oxford IBH, 2008.
4. N. S. Acherkhan, "Machine Tool Design", Vol. I, II, III and IV, MIR publications, 1968.

ME476	MICRO AND NANO MANUFACTURING	DEC	3 - 0 - 0	3 Credits
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

CO1	Understand manufacturing considerations at the micro and nano scale.
CO2	Create and characterize nanostructures for a particular industrial application
CO3	Select appropriate manufacturing methods to create micro sized components
CO4	Design and select industrially-viable processes, equipment and manufacturing tools for specific industrial products

**Course Articulation Matrix:**

PO \ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	3	-	-	-	-	-	-	-	2	2
CO2	2	2	2	3	2	-	-	-	-	-	-	-	2	2
CO3	3	2	2	2	3	-	-	-	-	-	-	-	2	3
CO4	3	3	3	2	3	-	-	-	-	-	-	-	2	3

**Detailed Syllabus:**

**Introduction:** Importance of Nano-technology, Emergence of Nanotechnology, Bottom-up and Top-down approaches, challenges in Nanotechnology.

**Nano materials Synthesis and Processing:** Methods for creating Nanostructures; Processes for producing ultra-fine powders - Mechanical grinding; Wet Chemical Synthesis of nanomaterials - sol-gel process, Liquid solid reactions; Gas Phase synthesis of nanomaterials- Furnace, Flame assisted ultrasonic spray pyrolysis; Gas Condensation Processing (GPC), Chemical Vapour Condensation (CVC)- Cold Plasma Methods, Laser ablation, Vapour - liquid -solid growth, particle precipitation aided CVD, summary of Gas Condensation Processing (GPC).

**Structural Characterization:** X-ray diffraction, Small angle X-ray Scattering, Optical Microscope and their description, Scanning Electron Microscopy (SEM), Scanning Probe

Microscopy (SPM), TEM and EDAX analysis, Scanning Tunneling Microscopy (STM), Atomic force Microscopy (AFM).

**Microfabrication Techniques:** Lithography, Thin Film Deposition and Doping, Etching and Substrate Removal, Substrate Bonding. MEMS Fabrication Techniques, Bulk Micromachining: Processes used for shaping and sizing of microproducts and macro products and Nano finishing techniques , Surface Micromachining, High- Aspect-Ratio Micromachining.

**Nanofabrication Techniques:** E-Beam and Nano-Imprint Fabrication, Epitaxy and Strain Engineering, Scanned Probe Techniques, Self-Assembly and Template Manufacturing.

**MEMS devices and applications:** Pressure sensor, inertial sensor, Optical MEMS and RF-MEMS, Micro-actuators for dual-stage servosystems.

#### **Reading:**

1. Tai-Ran Hsu, "MEMS and Microsystems: Design and Manufacture," McGraw- Hill, 2008.
2. V. K. Jain, "Introduction to Micromachining", 2<sup>nd</sup> Edition, Alpha Science, 2014.
3. Mark James Jackson, "Microfabrication and Nanomanufacturing", CRC Press, 2005.
4. Gabor L. Hornyak, H.F.Tibbals, Joydeep Dutta & John J Moore, "Introduction to Nanoscience and Nanotechnology", CRC Press, 2009.
5. Ray F. Edgerton, "Physical Principles of Electron Microscopy: An Introduction to TEM, SEM, and AEM", Springer, 2005.
6. B.D. Cullity, "Elements of X-Ray Diffraction", 3<sup>rd</sup> Edition, Prentice Hall, 2002.



ME477	DESIGN FOR MANUFACTURING AND ASSEMBLY	DEC	3-0-0	3 Credits
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**Pre-requisites:** MM 235: Materials Engineering, ME303: Machine Tools and Metrology

**Course Outcomes:** At the end of the course, the student will be able to:

CO1	Utilize Design-for-Manufacturing concepts for effective product development
CO2	Estimate the cost of dies, molds and machined components based on die life.
CO3	Formulate appropriate design rules for forging, sheet metal forming, machining and powder metallurgy processes
CO4	Propose manual and automated assembly sequences using appropriate design rules

**Course Articulation Matrix:**

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	CO1	3	2	2	2	-	-	-	-	-	-	-	-	2
CO2	3	2	2	2	-	-	-	-	-	-	-	-	2	2
CO3	3	2	2	2	-	-	-	-	-	-	-	-	2	2
CO4	3	2	2	2	-	-	-	-	-	-	-	-	2	2

**Detailed syllabus:**

**Introduction:** Overview of the course, Design for manufacturing, Typical Case studies, Innovative product and service designs.

**Material Selection:** Requirements for material selection, systematic selection of processes and materials, ASHBY charts

**Designfor Casting:** Basic characteristics and Mold preparation, Sand casting alloys, Design rules for and castings, Example calculations, Investment casting overview, Cost estimation, Number of parts per cluster, Ready to pour liquid metal cast, Design guidelines for Investment casting, Die casting cycle, Determination of optimum number of cavities, appropriate machine size, Die cost estimation, Design principles.

**Design for Injection molding:** Injection molding systems, Molds, molding cycle time, mold cost estimation, estimation of optimum number of cavities, Assembly techniques, Design Guidelines.

**Design for Hot Forging:** Characteristics of the forging process, forging allowances, flash removal, die cost estimation, die life and tool replacement costs.

**Design for Sheet metal working:** Press selection, press brake operations, Design rules.

**Design for Powder Metal processing:** Powder metallurgy, tooling and presses for Compaction, Sintering, materials, heat treatments, Design guidelines.

**Design for machining:** Machining using single point cutting tools, multipoint cutting tools, abrasive wheels, Assembly, cost estimation for machined components, Design guidelines.

**Design for Assembly:** Historical Development, Choice of Assembly method, Social effects of automation, Design guidelines for Manual assembly, Analysis of an assembly, Development of a systematic DFA analysis method, DFA index, classification system for manual handling, Manual insertion and Fastening.

#### **Reading:**

1. Geoffrey Boothroyd, Dewhurst P., Knight W., "Product design for manufacture and assembly", CRC press, 2002
2. George E. Dieter, "Engineering Design - A material processing approach", 5<sup>th</sup> Edition, McGraw Hill International, 2003.
3. ASM Handbook, "Design for manufacture", 2000.

ME478	DESIGN AND ANALYSIS OF ENGINEERING MATERIALS	DEC	3 - 0 - 0	3 Credits
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

CO1	Understand the principles of materials selection and design.
CO2	Design components using appropriate attribute limits and material indices.
CO3	Establish the criteria for material qualification and acceptance.
CO4	Apply design principles for manufacturing of different engineering components.

**Course ArticulationMatrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	2	-	-	-	-	-	-	2	3	2
CO2	3	3	2	2	2	-	-	-	-	-	-	2	2	2
CO3	3	3	2	2	2	-	-	-	-	-	-	2	-	2
CO4	3	3	2	2	2	-	-	-	-	-	-	2	2	2

**Detailed Syllabus:**

**Introduction:** The families of engineering materials. The Design process, types of design, Design tools and materials data.

**Material Selection-The basic and case studies:** Introduction and synopsis, the selection strategy, attribute limits and material indices, the selection procedure, computer-aided selection, the structural index, summary and conclusions, case studies.

**Selection of material and shape, case studies:** Introduction and synopsis, shape factors, Microscopic or Micro-structural shape factors, limits to shape efficiency, exploring and comparing structural sections, material indices that include shape, co-selecting material and shape, summary and conclusions, case studies.

**Designing Hybrid Materials and case studies:** Introduction and synopsis, filling holes in material property space, hybrids of type 1, 2, 3, 4. Summary and conclusions, case studies.

**Reading:**

1. G.S. Ramaswamy, "Design and Construction of Concrete Shell Roofs", 1<sup>st</sup> Edition, CBS Publishers, 2005.
2. R. Szilard, "Theory and Analysis of Plates - Classical and Numerical Methods", Prentice Hall, 1974.
3. Timoshenko and Krieger, "Theory of Plates and Shells", 2<sup>nd</sup> Edition, Tata McGraw Hill, 2010.

ME479	ADDITIVE MANUFACTURING	DEC	3 - 0 - 0	3 Credits
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, student will be able to:

CO1	Understand the working principle and process parameters of AM processes
CO2	Apply the suitable process for fabricating a given product
CO3	Use suitable post processes based on product application
CO4	Explore the applications of AM processes in various fields

**Course Articulation Matrix:**

CO \ PO	PO												PSO1	PSO2
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12		
CO1	2	2	-	-	2	-	-	-	-	-	-	-	3	2
CO2	2	3	-	-	2	-	-	-	-	-	-	-	3	2
CO3	2	2	-	-	2	3	-	-	-	-	-	-	3	2
CO4	2	3	-	-	2	3	-	-	3	-	-	3	3	2

**Detailed syllabus:**

**Introduction to Additive Manufacturing (AM):** Need for Additive Manufacturing, Generic AM process, Distinction between AM and CNC, Classification of AM Processes, Steps in AM process, Advantages of AM, Major Applications.

**Vat Photopolymerization AM Processes:** Stereolithography (SL), Materials, SL resin curing process, Micro-stereolithography, Process Benefits and Drawbacks, Applications of Photopolymerization Processes.

**Material Jetting AM Processes:** Evolution of Printing as an Additive Manufacturing Process, Materials, Process Benefits and Drawbacks, Applications of Material Jetting Processes.

**Binder Jetting AM Processes:** Materials, Process Benefits and Drawbacks, Research achievements in printing deposition, Technical challenges in printing, Applications of Binder Jetting Processes.

**Extrusion-Based AM Processes:** Fused Deposition Modelling (FDM), Principles, Materials, Plotting and path control, Bio-Extrusion, Process Benefits and Drawbacks, Applications of Extrusion-Based Processes.

**Sheet Lamination AM Processes:** Materials, Laminated Object Manufacturing (LOM), Ultrasonic Consolidation (UC), Gluing, Thermal bonding, LOM and UC applications.

**Powder Bed Fusion AM Processes:** Selective laser Sintering (SLS), Materials, Powder fusion mechanism, SLS Metal and ceramic part creation, Electron Beam melting (EBM), Process Benefits and Drawbacks, Applications of Powder Bed Fusion Processes.

**Directed Energy Deposition AM Processes:** Process Description, Laser Engineered Net Shaping (LENS), Direct Metal Deposition (DMD), Electron Beam Based Metal Deposition, Benefits and drawbacks, Applications of Directed Energy Deposition Processes.

**Post Processing of AM Parts:** Support Material Removal, Surface Texture Improvement, Accuracy Improvement, Aesthetic Improvement, Preparation for use as a Pattern, Property Enhancements using Non-thermal and Thermal Techniques

**AM Applications:** Functional models, Pattern for investment and vacuum casting, Medical models, art models, Engineering analysis models, Rapid tooling, new materials development, Bi-metallic parts, Re-manufacturing. Application examples for Aerospace, defense, automobile, Bio-medical and general engineering industries.

#### **Reading:**

1. Ian Gibson, David W Rosen, Brent Stucker, "Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing", 2<sup>nd</sup> Edition, Springer, 2015.
2. Chua Chee Kai, Leong Kah Fai, "3D Printing and Additive Manufacturing: Principles & Applications", 4<sup>th</sup> Edition, World Scientific, 2015.
3. Ali K. Kamrani, EmandAbouel Nasr, "Rapid Prototyping: Theory & Practice", Springer, 2006.
4. D.T. Pham, S.S. Dimov, "Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling", Springer 2001.
5. RafiqNoorani, "Rapid Prototyping: Principles and Applications in Manufacturing", John Wiley & Sons, 2006.

ME480	INDUSTRIAL AUTOMATION	DEC	3-0-0	3 Credits
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Understand principles, strategies and advantages of industrial automation.
<b>CO2</b>	Design material handling and material storage systems for an automated factory.
<b>CO3</b>	Devise automated shop floor controls and part identification methods.
<b>CO4</b>	Outline the IoT Technologies used in a manufacturing plant and their role in Industry.

**Course Articulation Matrix:**

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	3	2	-	-	2	-	-	-	2	-	-	-	2	2
<b>CO2</b>	3	2	3	3	2	-	-	-	2	-	-	-	2	2
<b>CO3</b>	3	2	-	3	2	-	-	-	2	-	-	-	2	2
<b>CO4</b>	3	2	-	-	2	-	-	-	2	-	-	-	2	2

**Detailed syllabus:**

**Principles and Strategies of Automation:** Power to Accomplish the Automated Process, program of Instruction, Control System, Advanced automation Functions: safety Monitoring, maintenance and repair Diagnostics, error Detection and Recovery, levels of automations, Merits and Demerits of automation.

**Material Handling systems and Design:** Introduction to Material Handling, Material Transport Equipment, analysis of Material Transport Systems, Storage systems-Storage System Performance and Location Strategies, Conventional Storage Methods and Equipment, Automation Storage Systems, Engineering Analysis of Storage Systems.

**Automatic identification methods:** Overview of Automatic Identification Methods, Bar Code Technology, Radio Frequency Identification, Other AIDC Technologies.

**Industrial control systems:** Process Industries Vs Discrete Manufacturing Industries, Levels of Automation in the two industries, Variables and Parameters in the two industries. Continuous Vs Discrete control- Continuous Control System, Discrete Control System. Control system components-Sensors, Actuators, Analog-to-Digital Convertors, Digital-to-Analog Convertors, Input/output Devices for Discrete Data.

**Industry 4.0:** Introduction, IoT Techniques, Cloud computing, machine learning, Digital Twin.

**Reading:**

1. Groover M. P., "Automation production Systems and Computer Integrated Manufacturing", Pearson Education, 2013.
2. Krishna Kant, "Computer Based Industrial Control", Prentice Hall of India, New Delhi, 2010.
3. Tiess Chiu Chang and Richard A. W., "An Introduction to Automated Process Planning Systems", Tata McGraw-Hill Publishing Company, New Delhi, 2012.
4. Klaffer, R.D., Chmielewski, T. A. and Negin M., "Robot Engineering-An Integrated Approach", Prentice Hall of India, New Delhi, 2012.
5. Craig J. J., "Introduction to Robotics Mechanics and Control", 3<sup>rd</sup> Edition, Pearson Higher Education, 2014.



<b>ME481</b>	<b>ADVANCED OPERATIONS RESEARCH</b>	<b>DEC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Understand game, queuing and decision theories
<b>CO2</b>	Apply queuing theory for performance evaluation of engineering and management systems.
<b>CO3</b>	Simulate and analyse engineering and managerial problems
<b>CO4</b>	Solve optimization problems using evolutionary computing methods

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	3	-	-	-	2	-	-	-	2	2	3	2	2	2
<b>CO2</b>	3	3	3	-	2	2	2	-	2	2	3	2	3	2
<b>CO3</b>	3	3	2	-	3	-	-	-	2	2	3	2	2	3
<b>CO4</b>	3	3	2	-	3	-	-	-	2	2	3	2	2	3

**Detailed syllabus:**

**Game Theory:** Formulation of two-person zero-sum games, games with mixed strategies, graphical solution procedure, solving by linear programming.

**Decision Analysis:** Decision making with and without experimentation, decision trees, utility theory.

**Queuing Theory and simulation:** Basic structure of queuing models, birth-and-death process, basic queuing models, blocking models, priority-discipline models, queuing networks, essence of simulation, generation of random numbers and observations, outline of simulation study.

**Evolutionary optimization methods:** Meta-heuristics, Tabu search, simulated annealing, genetic algorithms.

**Reading:**

1. Taha H.A., "Operations Research", 10<sup>th</sup> Edition, Prentice Hall of India, New Delhi, 2016.
2. Hillier F.S. and Lieberman G.J., "Introduction to Operations Research", 7<sup>th</sup> Edition, TMH, 2009.
3. Kalyanmoy Deb, "Multi-objective Optimization using Evolutionary Algorithms", John Wiley & sons, 2001.

<b>ME482</b>	<b>SUPPLY CHAIN MANAGEMENT</b>	<b>DEC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to

<b>CO1</b>	Relate competitive and supply chain strategies.
<b>CO2</b>	Identify drivers of supply chain performance.
<b>CO3</b>	Analyze factors influencing network design.
<b>CO4</b>	Analyze the influence of forecasting in a supply chain.
<b>CO5</b>	Evaluate the role of aggregate planning, inventory, IT and coordination in a supply chain.

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	3	-	-	-	-	2	2	-	-	2	2	2	2	2
<b>CO2</b>	3	-	-	-	-	2	2	2	-	2	2	2	2	2
<b>CO3</b>	3	3	3	3		2	2	2	2	2	2	2	2	3
<b>CO4</b>	3	3	3	3	3	3	2	2	3	2	2	2	3	3
<b>CO5</b>	3	2	3	-	3	3	2	2	3	2	2	2	3	3

**Detailed syllabus:**

**Strategic Framework:** Introduction to Supply Chain Management, Decision phases in a supply chain, Process views of a supply chain: push/pull and cycle views, Achieving Strategic fit, Expanding strategic scope.

**Supply Chain Drivers and Metrics:** Drivers of supply chain performance, Framework for structuring Drivers, Obstacles to achieving strategic fit.

**Designing Supply Chain Network:** Factors influencing Distribution Network Design, Design options for a Distribution network, E-Business and Distribution network, Framework for Network Design Decisions, Models for Facility Location and Capacity Allocation.

**Forecasting in SC:** Role of forecasting in a supply chain, Components of a forecast and forecasting methods, Risk management in forecasting.

**Aggregate Planning and Inventories in SC:** Aggregate planning problem in SC, Aggregate Planning Strategies, Planning Supply and Demand in a SC, Managing uncertainty in a SC: Safety Inventory.

**Coordination in SC:** Modes of Transportation and their performance characteristics, Supply Chain IT framework, Coordination in a SC and Bullwhip Effect

**Reading:**

1. Sunil Chopra and Peter Meindl, "Supply Chain Management - Strategy, Planning and Operation", 6<sup>th</sup> Edition, Pearson Education Asia, 2016.
2. David Simchi-Levi, Philip Kaminsky and Edith Simchi Levy, "Designing and Managing the Supply Chain - Concepts Strategies and Case Studies", 3<sup>rd</sup> Edition, TMH, 2008.

<b>ME483</b>	<b>PROJECT MANAGEMENT</b>	<b>DEC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Understand the importance of projects and its phases.
<b>CO2</b>	Analyze projects from marketing, operational and financial perspectives.
<b>CO3</b>	Evaluate projects based on discount and non-discount methods.
<b>CO4</b>	Develop network diagrams for planning and execution of a given project.
<b>CO5</b>	Apply crashing procedures for time and cost optimization.

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	-	-	-	-	-	2	-	2	-	-	3	2	3	2
<b>CO2</b>	3	2	-	-	-	-	-	2	-	-	3	2	3	2
<b>CO3</b>	3	2	3	3	-	-	-	-	-	-	3	2	3	2
<b>CO4</b>	-	3	3	3	2	-	-	-	3	-	3	2	3	3
<b>CO5</b>	3	3	3	3	2	-	-	-	-	-	3	2	3	3

**Detailed syllabus:**

**Introduction:** Introduction to Project Management, History of Project Management, Project Life Cycle.

**Project Analysis:** Facets of Project Analysis, Strategy and Resource Allocation, Market and Demand Analysis, Technical Analysis, Economic and Ecological Analysis.

**Financial Analysis:** Financial Estimates and Projections, Investment Criteria, Financing of Projects.

**Network Methods in PM:** Origin of Network Techniques, AON and AOA differentiation, CPM network, PERT network, other network models.

**Optimisation in PM:** Time and Cost trade-off in CPM, Crashing procedure, Scheduling when resources are limited.

**Project Risk Management:** Scope Management, Work Breakdown Structure, Earned Value Management, Project Risk Management.

**Reading:**

1. Prasanna Chandra, "Project: A Planning Analysis", Tata McGraw Hill Book Company, New Delhi, 4th Edition, 2009.
2. Cleland, Gray and Laudon, "Project Management", Tata McGraw Hill Book Company, New Delhi, 3<sup>rd</sup> Edition, 2007.
3. Jack R. Meredith and Samuel J., Jr. Mantel, "Project Management - A Managerial Approach", John Wiley, 6th Edition, 2011.

<b>ME484</b>	<b>RELIABILITY ENGINEERING</b>	<b>DEC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-requisites:** Nil.

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Understand the concepts of reliability, availability and maintainability
<b>CO2</b>	Develop hazard-rate models to know the behaviour of components
<b>CO3</b>	Build system reliability models for different configurations
<b>CO4</b>	Asses reliability of components and systems using field and test data
<b>CO5</b>	Implement strategies for improving reliability of repairable and non-repairable systems

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	3	-	-	-	-	-	-	-	-	3	3	-	3	-
<b>CO2</b>	3	-	3	-	-	3	3	2	3	-	-	-	2	-
<b>CO3</b>	3	3	3	2	-	3	3	3	3	-	-	3	2	-
<b>CO4</b>	3	2	2	3	-	3	3	2	2	-	-	-	2	-
<b>CO5</b>	3	3	-	3	-	2	3	2	-	-	-	-	3	-

**Detailed syllabus:**

**Introduction:** Probabilistic reliability, failures and failure modes, repairable and non-repairable items, pattern of failures with time, reliability economics.

**Component Reliability Models:** Basics of probability & statistics, hazard rate & failure rate, constant hazard rate model, increasing hazard rate models, decreasing hazard rate model, time-dependent & stress-dependent hazard models, bath-tub curve.

**System Reliability Models:** Systems with components in series, systems with parallel components, combined series-parallel systems, k-out-of-m systems, standby models, load-sharing models, stress-strength models, reliability block diagram.

**Life Testing & Reliability Assessment:** Censored and uncensored field data, burn-in testing, acceptance testing, accelerated testing, identifying failure distributions & estimation of parameters, reliability assessment of components and systems.

**Reliability Analysis & Allocation:** Reliability specification and allocation, failure modes and effects and criticality analysis (FMECA), fault tree analysis, cut sets & tie sets approaches; Maintainability Analysis: Repair time distribution, MTBF, MTTR, availability, maintainability, preventive maintenance.

**Reading:**

1. Ebeling C. E. "An Introduction to Reliability and Maintainability Engineering", TMH, New Delhi, 2004.
2. O'Connor P and Kleymer A, "Practical Reliability Engineering", Wiley, 2012.

<b>ME485</b>	<b>THEORY OF CONSTRAINTS</b>	<b>DEC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Understand the philosophy of TOC.
<b>CO2</b>	Assess the system performance using throughput accounting.
<b>CO3</b>	Apply DBR and OPT methodologies for manufacturing scheduling.
<b>CO4</b>	Implement critical chain methodology for project scheduling
<b>CO5</b>	Understand TOC thinking process tools including CRT, EC, FRT and PRT

**Course ArticulationMatrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	3	-	-	-	-	-	-	3	-	-	-	-	2	-
<b>CO2</b>	3	3	-	-	-	-	-	3	-	-	2	-	3	-
<b>CO3</b>	3	3	3	-	-	-	-	2	3	-	-	-	2	-
<b>CO4</b>	3	3	3	-	-	3	-	3	3	-	3	-	2	-
<b>CO5</b>	3	-	-	-	3	-	-	-	-	-	3	-	-	-

**Detailed syllabus:**

**Introduction:** Basic philosophy, local and global optima, five focusing steps of TOC, comparison with TQM & JIT philosophies.

**Throughput Accounting:** Financial and operating measures, local and global performance measures, throughput, inventory, operating expenses, linking concepts of throughput accounting with financial accounting.

**Manufacturing Scheduling:** Line and job shop processes, make-to-stock and make-to-order environments, scheduling rules, DBR methodology for scheduling line processes, OPT



methodology for scheduling job shops, buffering and types of buffers, buffer management;  
**Project Scheduling:** Critical chain methodology, developing single-project critical chain plan, developing multi-project critical chain plan, buffer and threshold sizing, project risk management.

**TOC Thinking Process:** Current reality tree, evaporating clouds, future reality tree, Pre-requisite tree, transition tree.

**Reading:**

1. Dettmer H. W., "Goldratt's Theory of Constraints: A Systems Approach to Continuous Improvement", ASQ Quality Press, Wisconsin, 1997.
2. Leach L.P., "Critical Chain Project Management", 2<sup>nd</sup> Edition, Artech House Inc, London, 2005.

<b>ME486</b>	<b>ADVANCED MATERIALS PROCESSING</b>	<b>DEC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-requisites:** Manufacturing Science

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Understand the different processing techniques for engineering materials.
<b>CO2</b>	Analyze the principles of casting for the manufacturing of MMC.
<b>CO3</b>	Utilize appropriate manufacturing methods for powder metallurgical components.
<b>CO4</b>	Apply laser for processing of engineering materials.
<b>CO5</b>	Analyze the processing of ceramics.

**Course Articulation Matrix:**

CO \ PO	PO												PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	3	3	3	2	2	2	-	-	-	-	-	-	2	2
<b>CO2</b>	3	3	3	2	2	2	-	-	-	-	-	-	3	3
<b>CO3</b>	3	3	3	2	2	2	-	-	-	-	-	-	2	2
<b>CO4</b>	3	3	3	2	2	2	-	-	-	-	-	-	2	3
<b>CO5</b>	3	2	2	2	2	2	-	-	-	-	-	-	2	2

**Detailed Syllabus:**

**Processing of Metallic materials:** Introduction to solidification process, single crystal and poly crystalline materials, grain growth, temperature distribution during solidification process, Zone refining, Effect of inoculation in casting of various materials, Production of MMC through stir casting and centrifugal casting processes and its characterization, advantages, limitations and applications.

**Powder Metallurgy techniques in processing of materials:** Introduction to powder metallurgy, various processes in powder metallurgy, Production of composites.

**Ceramics:** Classification of ceramics, Applications, fabrication and Processing of ceramics, Rheological behavior of composites, Characterization of composites before and after processing.

**Laser processing of materials:** Laser hardening, laser heat treatment, and laser forming

**Forming of metals, plastics and ceramics:** Hot and cold Processing, Forming of glass, forming of ceramics, Processing of polymers, Defective analysis of formed glass, ceramics and polymers, Characterization of composites before and after processing.

**Reading:**

1. Michel Ashby, "Materials Engineering Science Processing and Design", Butterworth-Heinemann, 2017.
2. Y. Waseda, A. Muramatsu and Yoshio Waseda, "Morphology Control of Materials and Nanoparticles: Advanced Materials Processing and Characterization", Springer, 2014.

### **Mandatory Audit Course (Self Study)**

*Student is required to complete at least one course offered by the following agencies. The student is required to take prior approval from the Department, before registering for any course. The student can register for such a course either in 6<sup>th</sup> Semester or 7<sup>th</sup> semester. Unless the student submits a pass certificate, he/she shall not be eligible for the award of degree.*

*ASME: American Society of Mechanical Engineer Certification Program - [www.asme.org](http://www.asme.org)*

*SWAYAM: [www.swayam.gov.in](http://www.swayam.gov.in)*

*NPTEL: [www.onlinecourse.nptel.ac.in](http://www.onlinecourse.nptel.ac.in)*

*Course Era: [www.coursera.org](http://www.coursera.org)*

*Free Online Courses: [www.edx.org](http://www.edx.org)*

*MIT Open Course ware: [www.ocw.mit.edu](http://www.ocw.mit.edu)*

<b>ME499</b>	<b>PROJECT WORK PART - B</b>	<b>PRC</b>	<b>0 - 0 - 6</b>	<b>4 Credits</b>
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**Pre-requisites:** Nil.

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Identify methods and materials to carry out experiments/develop code.
<b>CO2</b>	Reorganize the procedures with a concern for society, environment and ethics.
<b>CO3</b>	Analyze and discuss the results to draw valid conclusions.
<b>CO4</b>	Prepare a report as per recommended format and defend the work.
<b>CO5</b>	Explore the possibility of publishing papers in peer reviewed journals/conference proceedings.

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	2	2	1	-	2	2	1	1	2	2	1	2	3	3
<b>CO2</b>	1	1	2	2	-	-	2	2	1	2	1	2	3	3
<b>CO3</b>	2	2	-	3	-	-	-	-	2	2	-	1	3	3
<b>CO4</b>	-	-	-	2	-	-	-	2	2	3	-	1	3	3
<b>CO5</b>	-	1	-	2	2	-	-	2	2	3	-	1	3	3

**RUBRICS:**

Task	Performance indicators	Good 4	Satisfactory 3	Average 2	Poor 1
Selection of Topic	Selection of Topic	Selection of the topic by referring literature discussion with guide in two weeks.	Selection of the topic by referring research journals in a month	Selection of the topic by referring research journals in more than a month	Selection of the topic with the help of the guide

	Developing Project Plan & Distribution of work	Splitting the project into small tasks and scheduling them to finish it in time and division of the work among the members of the team is good and coordination in the team is good.	Splitting the project into small tasks and scheduling them to finish it in time and different tasks of the job shared among the members of the team with satisfactory coordination.	Splitting the project into small tasks is not sufficient and sharing different tasks among the team members needs some more attention	Not able to split the project into small tasks. Needs lot of work to be done.
Literature Survey	Collection of Literature	Collected related research articles are Good and sufficient for the project work.	Collected related research articles are satisfactory for the project work.	Need some more research articles for the project work and need time.	Not collected relevant articles.
Performance of the task	Experiment Analysis/ Industrial Problem	Work completed in all aspects and is ready to prepare the dissertation.	Work completed 80%. Can start preparing, the dissertation.	Work completed only 50-60%. Need more attention to compete the tasks.	Work not completed. Need lot of attention.
	Team Work	Coordinates team efforts and communication among members is good.	Coordinates team efforts and communication among members is satisfactory.	Requires more coordination and communication among the team	No proper coordination among the team
Review	Presentation	Presentation should be good with results and with good figures	Presentation is satisfactory with the results.	Presentation needs some improvement	Presentation is incomplete in all aspects.

	Understanding	Understanding the task fully. Knowing all the tasks of the project. 100%.	Ability of correlating the theoretical aspects with the practical aspects is in between 60-80%	Ability of correlating the theoretical aspects with the practical aspects is in between 50-60%	Ability of correlating the theoretical aspects with the practical aspects is less than 50%
Dissertation Preparation	Dissertation Preparation	Dissertation prepared with neat sketches, and complete with all the necessary calculations or analysis, contents of the dissertation are well planned and coverage of all the topics is good	Dissertation prepared with neat sketches, and complete with all the necessary calculations or analysis, contents of the dissertation are well planned and coverage of all the topics is satisfactory	Dissertation prepared with sketches and required calculations but needs improvement	Dissertation prepared is not complete in all aspects and the coverage of all the contents is poor
Viva-voce	Understanding	Answering 100% questions related to the project	Answering 80% questions related to the project	Answering about 60% of questions related to the project	Answering, less than 50% of the questions related to the project
	Response	Responding immediately with confidence	Responding and answering to the satisfactory level	Responding with much delay and answering about 50% of the questions	Not able to respond. Understanding the concepts is poor

## OPEN ELECTIVES

(Offered to Other Department Students)

<b>ME390</b>	<b>AUTOMOTIVE MECHANICS</b>	<b>OPC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, student will be able to:

<b>CO1</b>	Analyze operation and performance indicators of transmission systems, internal combustion engines and after treatment devices.
<b>CO2</b>	Understand operation of engine cooling system, lubrication system, electrical system and ignition system.
<b>CO3</b>	Understand fuel supply systems in an diesel and petrol vehicles
<b>CO4</b>	Analyze current and projected future environmental legislation and its impact on design, operation and performance of automotive power train systems.
<b>CO5</b>	Understand operation and performance of suspension, steering and braking system.
<b>CO6</b>	Understand layout of automotive electrical and electronics systems.

**Course Articulation Matrix:**

PO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	3	2	-	-	-	-	-	-	-	-	-	-	-	-
<b>CO2</b>	2	-	-	-	-	-	-	-	-	-	-	-	-	-
<b>CO3</b>	2	-	-	-	-	-	-	-	-	-	-	-	-	-
<b>CO4</b>	3	2	-	-	-	3	3	-	-	-	-	-	-	-
<b>CO5</b>	2	-	-	-	-	-	-	-	-	-	-	-	-	-
<b>CO6</b>	2	-	-	-	-	-	-	-	-	-	-	-	-	-

**Detailed syllabus:**

**Introduction:** Layout of an automotive chassis, engine classification.

**Cooling Systems:** Air cooling, air cleaners, Water cooling: Thermosyphon and pump circulation systems, Components of water cooling systems- Radiator, thermostat etc.



**Engine Lubrication:** Petroils system, Splash system, Pressure lubrication and dry sump system

Ignition System: Battery, Magneto and Electronic, Engine Starting drives

**Fuel supply system:** Components in fuel supply system, types of feed pumps, air cleaners, fuel and oil filters, pressure and dry sump systems.

**Engine testing and Performance:** Performance parameters, constant and variable speed test, heat balance test, performance characteristics. Engine Emissions: SI and CI engine emissions, emission control methods

**Automotive electrical and electronics:** Electrical layout of an automobile, ECU, sensors, windscreen wiper, Electric horn.

**Transmission:** Clutch- Single and multi-plate clutch, semi & centrifugal clutch and fluid flywheel, Gear box: Sliding mesh, constant mesh and synchromesh gear box, selector mechanism, over drive, Propeller shaft and Differential.

**Suspension System:** Front and rear suspension, shock absorbers, Rear Axles mountings, Front Axle. Steering Mechanism: Manual and power steering systems, Braking System: Mechanical, Hydraulic and Air braking systems.

**Engine service:** Engine service procedure.

#### **Reading:**

1. S. Srinivasan, Automotive Mechanics, Tata McGraw-Hill, 2004.
2. K.M.Gupta, Automobile Engineering, Vol.1 and Vol.2, Umesh Publications, 2002
3. Kirpal Singh, Automobile Engineering, Vol.1 and Vol.2, Standard Publishers, 2003.
4. William H.Crouse and Donald L. Anglin, Automotive Mechanics, Tata McGraw-Hill, 2004
5. Joseph Heitner, Automotive Mechanics, East-West Press, 2000.

<b>ME391</b>	<b>NEW VENTURE CREATION</b>	<b>DEC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to

<b>CO1</b>	Understand entrepreneurship and entrepreneurial process and its significance in economic development.
<b>CO2</b>	Develop an idea of the support structure and promotional agencies assisting ethical entrepreneurship.
<b>CO3</b>	Identify entrepreneurial opportunities, support and resource requirements to launch a new venture within legal and formal frame work.
<b>CO4</b>	Develop a framework for technical, economic and financial feasibility.
<b>CO5</b>	Evaluate an opportunity and prepare a written business plan to communicate business ideas effectively.
<b>CO6</b>	Understand the stages of establishment, growth, barriers, and causes of sickness in industry to initiate appropriate strategies for operation, stabilization and growth.

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	-	-	-	-	-	3	1	3	2	2	3	-	-	-
<b>CO2</b>	-	-	-	-	-	3	1	3	2	2	3	-	-	-
<b>CO3</b>	-	-	-	-	-	3	1	3	2	2	3	-	-	-
<b>CO4</b>	-	-	-	-	-	3	1	3	2	2	3	-	-	-
<b>CO5</b>	-	-	-	-	-	3	1	3	2	2	3	-	-	-
<b>CO6</b>	-	-	-	-	-	3	1	3	2	2	3	-	-	-

**Detailed syllabus:**

**Entrepreneur and Entrepreneurship:** Introduction; Entrepreneur and Entrepreneurship; Role of entrepreneurship in economic development; Entrepreneurial competencies and motivation; Institutional Interface for Small Scale Industry/Enterprises.

**Establishing Small Scale Enterprise:** Opportunity Scanning and Identification; Creativity and product development process; Market survey and assessment; choice of technology and selection of site.

**Planning a Small Scale Enterprise:** Financing new/small enterprises; Techno Economic Feasibility Assessment; Preparation of Business Plan; Forms of business organization/ownership.

**Operational Issues in SSE:** Financial management issues; Operational/project management issues in SSE; Marketing management issues in SSE; Relevant business and industrial Laws.

**Performance appraisal and growth strategies:** Management performance assessment and control; Causes of Sickness in SSI, Strategies for Stabilization and Growth.

**Reading:**

1. Bruce R Barringer and R Duane Ireland, "Entrepreneurship: Successfully Launching New Ventures", 3rd Edition, Pearson Education, 2013.
2. D.F. Kuratko and T.V. Rao, "Entrepreneurship: A South-Asian Perspective", Cengage Learning, 2013.
3. Dr. S.S. Khanka, "Entrepreneurial Development", 4<sup>th</sup> Edition, S Chand & Company Ltd., 2012.
4. Dr. Vasant Desai, "Management of Small Scale Enterprises", Himalaya Publishing House, 2004.

<b>ME440</b>	<b>ALTERNATIVE SOURCES OF ENERGY</b>	<b>OPC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**(Offered to Other Department Students)**

**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Identify renewable energy sources and their utilization.
<b>CO2</b>	Understand basic concepts of solar radiation and analyze solar thermal systems for its utilization.
<b>CO3</b>	Understand working of solar cells and its modern manufacturing technologies.
<b>CO4</b>	Understand concepts of Fuel cells and their applications
<b>CO5</b>	Identify methods of energy storage.
<b>CO6</b>	Compare energy utilization from wind energy, geothermal energy, biomass, biogas and hydrogen.

**Course Articulation Matrix:**

<b>CO \ PO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>	<b>PSO1</b>	<b>PSO2</b>
	<b>CO1</b>	2	2	-	1	-	3	3	-	-	-	-	2	-
<b>CO2</b>	3	3	3	2	-	1	3	-	-	-	-	2	-	-
<b>CO3</b>	3	3	3	3	2	1	3	-	-	-	-	2	-	-
<b>CO4</b>	3	3	3	1	2	1	3	-	-	-	-	2	-	-
<b>CO5</b>	2	3	2	1	1	1	3	-	-	-	-	2	-	-
<b>CO6</b>	2	3	2	1	1	1	3	-	-	-	-	2	-	-

**Detailed Syllabus:**

**Introduction:** Overview of the course; Examination and Evaluation patterns; Global warming; Introduction to Renewable Energy Technologies

**Energy Storage:** Introduction; Necessity of Energy Storage; Energy Storage Methods

**Solar Energy:** Fundamentals; Solar Radiation; Estimation of solar radiation on horizontal and inclined surfaces; Measurement of solar radiation data

**Solar Thermal systems:** Introduction; Basics of thermodynamics and heat transfer; Flat plate collector; Evacuated Tubular Collector; Solar air collector; Solar concentrator; Solar distillation; Solar cooker; Solar refrigeration and air conditioning; Thermal energy storage systems

**Solar Photovoltaic systems:** Introduction; Solar cell Fundamentals; Characteristics and classification; Solar cell: Module, panel and Array construction; Photovoltaic thermal systems.

**Wind Energy:** Introduction; Origin and nature of winds; Wind turbine siting; Basics of fluid mechanics; Wind turbine aerodynamics; wind turbine types and their construction; Wind energy conversion systems

**Fuel cells:** Overview; Classification of fuel cells; operating principles; Fuel cell thermodynamics  
**Biomass Energy:** Introduction; Photosynthesis Process; Biofuels; Biomass Resources; Biomass conversion technologies; Urban waste to energy conversion; Biomass gasification.

**Other forms of Energy:** Introduction: Nuclear, ocean and geothermal energy applications; Origin and their types; Working principles

**Reading:**

1. Sukhatme S.P. and J.K.Nayak, Solar Energy - Principles of Thermal Collection and Storage, Tata McGraw Hill, New Delhi, 2008.
2. Khan B.H., Non-Conventional Energy Resources, Tata McGraw Hill, New Delhi, 2006.
3. J.A. Duffie and W.A. Beckman, Solar Energy - Thermal Processes, John Wiley, 2001.

<b>ME441</b>	<b>ROBUST DESIGN</b>	<b>OPC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**(Offered to Other Department Students)**

**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, student will be able to:

<b>CO1</b>	Understand stages in engineering design and concept of robust design.
<b>CO2</b>	Develop quality loss functions and S/N ratios for S, N and L type objective functions.
<b>CO3</b>	Identify control and noise factors for a given product or process.
<b>CO4</b>	Conduct experiments using DOE concepts to decide the optimal setting of parameters
<b>CO5</b>	Apply quality loss function approach for fixing the component tolerances.

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	3	-	2	-	-	-	-	-	-	-	-	2	-	-
<b>CO2</b>	3	-	-	3	-	2	2	-	-	-	-	2	-	-
<b>CO3</b>	3	3	-	2	-	-	-	-	-	-	-	2	-	-
<b>CO4</b>	3	3	3	3	3	-	-	-	-	-	-	2	-	-
<b>CO5</b>	3	2	-	-	-	2	2	-	-	-	-	2	-	-

**Detailed syllabus:**

**Introduction:** Taguchi's quality philosophy, causes of performance variation, concept of robust design, stages in product/process design, need for experimentation, QFD, process flow analysis, cause and effect diagram.

**Design of Experiments:** Principles of experimentation, Basic concepts of probability and statistics, Comparison of two means and two variances, Comparison of multiple (more than two) means & ANOVA, Factorial designs, fractional factorial designs, orthogonal arrays, standard

orthogonal arrays & interaction tables, modifying the orthogonal arrays, selection of suitable orthogonal array design, analysis of experimental data.

**Parameter Design:** Loss function, average quality loss, S/N ratios, objective functions, selection of control & noise factors and their levels, strategy for systematic sampling of noise, classification of control factors, inner-array and outer-array design, data analysis, selection of optimum levels/values for parameters.

**Tolerance Design:** Experiments, selection of tolerances to be tightened, fixing the final tolerances.

**Reading:**

1. Taguchi G, Chowdhury S and Taguchi S, Robust Engineering, TMH, 2000.
2. Ross PJ, Taguchi Techniques for Quality Engineering, TMH, 2005.

<b>CE390</b>	<b>ENVIRONMENTAL IMPACT ANALYSIS</b>	<b>OPC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, student will be able to:

<b>CO1</b>	Identify the environmental attributes to be considered for the EIA study.
<b>CO2</b>	Formulate objectives of the EIA studies.
<b>CO3</b>	Identify the suitable methodology and prepare Rapid EIA.
<b>CO4</b>	Prepare EIA reports and environmental management plans.
<b>CO5</b>	Plan the methodology to monitor and review the relief and rehabilitation works.

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	2	1	2	-	-	3	3	1	-	2	1	-	2	-
<b>CO2</b>	2	1	2	-	-	3	3	1	-	2	1	-	-	-
<b>CO3</b>	2	1	2	-	-	3	3	1	-	2	1	-	-	-
<b>CO4</b>	2	1	2	-	-	3	3	1	-	2	1	-	1	-
<b>CO5</b>	2	1	2	-	-	3	3	1	-	2	1	-	1	-

**Detailed Syllabus:**

**Introduction:** The Need for EIA, Indian Policies Requiring EIA, The EIA Cycle and Procedures, Screening, Scoping, Baseline Data, Impact Prediction, Assessment of Alternatives, Delineation of Mitigation Measure and EIA Report, Public Hearing, Decision Making, Monitoring the Clearance Conditions, Components of EIA, Roles in the EIA Process. Government of India Ministry of Environment and Forest Notification (2000), List of projects requiring Environmental clearance, Application form, Composition of Expert Committee, Ecological sensitive places, International agreements.

**Identifying the Key Issues:** Key Elements of an Initial Project Description and Scoping, Project Location(s), Land Use Impacts, Consideration of Alternatives, Process selection: Construction



Phase, Input Requirements, Wastes and Emissions, Air Emissions, Liquid Effluents, Solid Wastes, Risks to Environment and Human, Health, Socio-Economic Impacts, Ecological Impacts, Global Environmental Issues.

**EIA Methodologies:** Criteria for the selection of EIA methodology, impact identification, impact measurement, impact interpretation & Evaluation, impact communication, Methods-Adhoc methods, Checklists methods, Matrices methods, Networks methods, Overlays methods, Environmental index using factor analysis, Cost/benefit analysis, Predictive or Simulation methods. Rapid assessment of Pollution sources method, predictive models for impact assessment, Applications for RS and GIS.

**Reviewing the EIA Report:** Scope, Baseline Conditions, Site and Process alternatives, Public hearing. Construction Stage Impacts, Project Resource Requirements and Related Impacts, Prediction of Environmental Media Quality, Socio-economic Impacts, Ecological Impacts, Occupational Health Impact, Major Hazard/ Risk Assessment, Impact on Transport System, Integrated Impact Assessment.

**Review of EMP and Monitoring:** Environmental Management Plan, Identification of Significant or Unacceptable Impacts Requiring Mitigation, Mitigation Plans and Relief & Rehabilitation, Stipulating the Conditions, What should be monitored? Monitoring Methods, Who should monitor? Pre-Appraisal and Appraisal.

**Case Studies:** Preparation of EIA for developmental projects- Factors to be considered in making assessment decisions, Water Resources Project, Pharmaceutical industry, thermal plant, Nuclear fuel complex, Highway project, Sewage treatment plant, Municipal Solid waste processing plant, Tannery industry.

**Reading:**

1. Jain R.K., Urban L.V., Stracy G.S., *Environmental Impact Analysis*, Van Nostrand Reinhold Co., New York, 1991.
2. Barthwal R. R., *Environmental Impact Assessment*, New Age International Publishers, 2002
3. Rau J.G. and Wooten D.C., *Environmental Impact Assessment*, McGraw Hill Pub. Co., New York, 1996.
4. Anjaneyulu Y., and Manickam V., *Environmental Impact Assessment Methodologies*, B.S. Publications, Hyderabad, 2007.
5. Wathern P., *Environmental Impact Assessment- Theory and Practice*, Routledge Publishers, London, 2004.

EE390	<b>LINEAR CONTROL SYSTEMS</b>	<b>OPC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, student will be able to:

<b>CO1</b>	Analyze electromechanical systems using mathematical modelling
<b>CO2</b>	Determine Transient and Steady State behavior of systems using standard test signals
<b>CO3</b>	Analyze linear systems for steady state errors, absolute stability and relative stability
<b>CO4</b>	Design a stable control system satisfying requirements of stability and reduced steady state error

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	3	3	2	-	-	1	-	-	-	-	-	-	2	2
<b>CO2</b>	3	3	2	-	-	1	-	-	-	-	-	-	1	-
<b>CO3</b>	3	3	2	-	-	1	-	-	-	-	-	-	2	2
<b>CO4</b>	3	3	2	-	-	1	-	-	-	-	-	-	2	-

**Detailed syllabus:**

**Introduction:** Control system, types, feedback and its effects-linearization

**Mathematical Modeling of Physical Systems:** Block diagram Concept and use of Transfer function. Signal Flow Graphs, Mason's gain formula.

**Time Domain Analysis of Control Systems** - BIBO stability, absolute stability, Routh-Hurwitz Criterion.

P, PI and PID controllers. Root Locus Techniques - Root loci theory, application to system stability studies.

Introduction to state variables technique, Analysis of R-L, R-L-C networks.

Frequency Domain Analysis of Control Systems - polar plots, Nyquist stability criterion, Bode plots, application of Bode plots.

**Reading:**

1. B.C.Kuo, Automatic Control Systems, 7<sup>th</sup> Edition, Prentice Hall of India, 2009.
2. I.J. Nagarath and M. Gopal: Control Systems Engineering, 2<sup>nd</sup> Edition, New Age Pub. Co.2008.

EE391	<b>SOFT COMPUTING TECHNIQUES</b>	<b>OPC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, student will be able to:

<b>CO1</b>	Understand the concepts of population based optimization techniques
<b>CO2</b>	Examine the importance of exploration and exploitation in heuristic optimization techniques to attain near-global optimal solution
<b>CO3</b>	Evaluate the importance of parameters in heuristic optimization techniques
<b>CO4</b>	Apply for the solution of multi-objective optimization

**Course Articulation Matrix:**

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	<b>CO1</b>	3	3	1	2	2	-	-	-	-	-	-	-	-
<b>CO2</b>	3	3	1	2	2	-	-	-	-	-	-	-	-	2
<b>CO3</b>	3	3	1	2	2	-	-	-	-	-	-	-	-	2
<b>CO4</b>	3	3	1	2	2	-	-	-	-	-	-	-	-	2

**Detailed syllabus:**

**Fundamentals Of Soft Computing Techniques:** Definition-Classification of optimization problems- Unconstrained and Constrained optimization Optimality conditions- Introduction to intelligent systems- Soft computing techniques- Classification of meta-heuristic techniques - Single solution based and population based algorithms - Exploitation and exploration in population based algorithms - Properties of Swarm intelligent Systems - Application domain - Discrete and continuous problems - Single objective and multi-objective problems.

**Genetic Algorithm And Particle Swarm Optimization:** Genetic algorithms- Genetic Algorithm versus Conventional Optimization Techniques-Genetic representations and selection mechanisms; Genetic operators- different types of crossover and mutation operators -Bird flocking and Fish Schooling - anatomy of a particle- equations based on velocity and positions - PSO topologies - control parameters. Application to SINX maximization problem.

**Ant Colony Optimization And Artificial Bee Colony Algorithms:** Biological ant colony system - Artificial ants and assumptions - Stigmergic communications - Pheromone updating-local-global - Pheromone evaporation - ant colony system- ACO models-Touring ant colony system-max min ant system - Concept of elistic ants-Task partitioning in honey bees - Balancing foragers and receivers - Artificial bee colony (ABC) algorithms-binary ABC algorithms.

**Shuffled Frog-Leaping Algorithm and Bat Optimization Algorithm:** Bat Algorithm- Echolocation of bats- Behavior of microbats- Acoustics of Echolocation-Movement of Virtual Bats-Loudness and Pulse Emission-Shuffled frog algorithm-virtual population of frogs-comparison of memes and genes-memplex formation-memplex updation.

Application to multi-modal function optimization

Introduction to Multi-Objective optimization; Concept of Pareto optimality.

### **Reading:**

1. Xin-She Yang, "Recent Advances in Swarm Intelligence and Evolutionary Computation", Springer International Publishing, Switzerland, 2015.
2. Kalyanmoy Deb "Multi-Objective Optimization using Evolutionary Algorithms", John Wiley & Sons, 2001.
3. James Kennedy and Russel E Eberheart, "Swarm Intelligence", The Morgan Kaufmann Series in Evolutionary Computation, 2001.
4. Eric Bonabeau, Marco Dorigo and Guy Theraulaz, "Swarm Intelligence-From natural to Artificial Systems", Oxford university Press, 1999.
5. David Goldberg, "Genetic Algorithms in Search, Optimization and Machine Learning", Pearson Education, 2007.
6. Konstantinos E. Parsopoulos and Michael N. Vrahatis, "Particle Swarm Optimization and Intelligence: Advances and Applications", Information science reference, IGI Global, 2010.
7. N P Padhy, "Artificial Intelligence and Intelligent Systems", Oxford University Press, 2005.

EC390	COMMUNICATION SYSTEMS	OPC	3 - 0 - 0	3 Credits
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, student will be able to:

<b>CO1</b>	Understand different modulation and demodulation schemes for analog communications.
<b>CO2</b>	Design analog communication systems to meet desired application requirements
<b>CO3</b>	Evaluate fundamental communication system parameters, such as bandwidth, power, signal to quantization noise ratio etc.
<b>CO4</b>	Elucidate design tradeoffs and performance of communications systems.

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	-	-	1	1	-	-	-	-	-	-	-	1
CO2	1	1	-	-	1	1	-	-	-	-	-	-	-	1
CO3	1	1	-	-	1	1	-	-	-	-	-	-	-	1
CO4	1	1	-	-	1	1	-	-	-	-	-	-	-	1

**Detailed syllabus:**

**Signal Analysis:** Communication Process, Sources of Information, Communication Channels, Modulation Process, Types of Communication, Random Process, Gaussian Process, Correlation Function, Power Spectral Density, Transmission of Random Process through an LTI Filter.

**Noise Analysis:** External Noise, Internal Noise, White Noise, Narrow Band Noise, Representation of Narrow Band noise In phase and Quadrature Components, Noise Figure, Noise Bandwidth, Noise Temperature.

**Amplitude (Linear) Modulation:** Linear Modulation Schemes, Generation of AM, Envelope Detector, DSB-SC Product Modulator, Switching Modulator, Ring Modulator, Coherent Detection, Costas receiver, SSB Signal Representation, Filtering Method, Phase Shift Method, Coherent Demodulation, VSB Modulator and Demodulator, Carrier Acquisition using Squaring Loop and Costas Loop, Receiver Model, SNR, Noise in SSB and DSB receivers using coherent detection, Noise in AM Receiver using Envelope detection, Threshold Effect.

**Angle (Exponential) Modulation:** Types of Angle Modulation, Relation between FM and PM, Narrow Band FM, Wideband FM, Transmission Bandwidth of FM Signals, Generation of FM using Direct and Indirect methods, FM Demodulation using Slope Circuit, Frequency Discriminator, Interference in Angle Modulation, Noise in FM Receiver, FM Threshold Effect, Pre-emphasis and De-emphasis in FM, Model of PLL for FM Demodulation.

**Pulse Modulation:** Sampling Process, PAM, PWM, PPM, Quantization, PCM, TDM, Digital Multiplexer Hierarchy, DM, DSM, Linear Prediction, DPCM, ADPCM, Noise in PCM System, Companding, Comparison of the Noise Performance of AM, FM, PCM and DM.

**Information Theory:** Uncertainty, Information, Entropy, Source Coding Theorem, Data Compaction, Mutual information, Channel Capacity, BSC Channel, Information Capacity Theorem, Bandwidth - Power Tradeoff, Huffman Coding.

### **Reading:**

1. S. Haykin, Communication Systems, 4<sup>th</sup>Edn, John Wiley & Sons, Singapore, 2001.
2. B.P. Lathi, Modern Digital & Analog Communication Systems, 3<sup>rd</sup> Edition, Oxford University Press, Chennai, 1998.
3. Leon W. Couch II, Digital and Analog Communication Systems, 6<sup>th</sup> Edition, Pearson Education Inc., New Delhi, 2001.
4. A Bruce Carlson, PB Crilly, J C Rutledge, Communication Systems, 4<sup>th</sup> Edition, MGH, New York, 2002.

EC391	MICROPROCESSOR SYSTEMS	OPC	3 - 0 - 0	3 Credits
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, student will be able to:

<b>CO1</b>	Develop basic understanding of microprocessor architecture.
<b>CO2</b>	Design Microprocessor and Microcontroller based systems.
<b>CO3</b>	Understand C, C++ and assembly language programming
<b>CO4</b>	Understand concept of interfacing of peripheral devices and their applications

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	1	1	1	-	2	-	-	-	-	-	-	-	-	-
<b>CO2</b>	1	1	1	-	2	-	-	-	-	-	-	-	-	2
<b>CO3</b>	1	1	1	-	2	-	-	-	-	-	-	-	-	2
<b>CO4</b>	1	1	1	-	2	-	-	-	-	-	-	-	-	2

**Detailed syllabus:**

**Microcomputer Organization:** CPU, Memory, I/O, Operating System, Multiprogramming, Multithreading, MS Windows

**80386 Micro Processors:** Review of 8086, salient features of 80386, Architecture and Signal Description of 80386, Register Organization of 80386, Addressing Modes, 80386 Memory management, Protected mode, Segmentation, Paging, Virtual 8086 Mode, Enhanced Instruction set of 80386, the Co- Processor 80387

**Pentium & Pentium-pro Microprocessor:** Salient features of Pentium microprocessor, Pentium architecture, Special Pentium registers, Instruction Translation look aside buffer and branch Prediction, Rapid Execution module, Memory management, hyper-threading technology, Extended Instruction set in advanced Pentium Processors

**Microcontrollers:** Overview of micro controllers-8051 family microcontrollers, 80196 microcontrollers family architecture, instruction set, pin out, memory interfacing.

ARM Processor Fundamentals: Registers, current Program Status Registers, Pipeline Exceptions, Interrupts and Vector Table, Architecture Revisions, ARM Processor families, ARM instruction set, Thumb Instruction set-Exceptions Handling, Interrupts, Interrupt Handling schemes, firmware, Embedded operating systems, Caches-cache architecture, Cache policy, Introduction to DSP on the ARM, DSP on the ARM7TDMI, ARM9TDMI.

**Case study:** Industry Application of Microcontrollers

**Reading:**

1. Barry B.Brey: Intel Microprocessor Architecture, Programming and Interfacing-8086/8088,80186,80286,80386 and 80486,PHI,1995.
2. Muhammad Ali Mazidi and Mazidi:The 8051 Microcontrollers and Embedded systems,PHI,2008
3. Intel and ARM Data Books on Microcontrollers.



MM364	FUNDAMENTALS OF MATERIALS PROCESSING TECHNOLOGY	OPC	3 - 0 -0	03 Credits
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, student will be able to:

CO1	Describe engineering materials.
CO2	Appreciate material processing techniques.
CO3	Select material processing technique for a given material and application.
CO4	Explain surface engineering techniques and their engineering significance.

**Course Articulation Matrix:**

CO \ PO	PO												PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	-	-	1	1	-	-	-	-	-	1	-
CO2	3	3	2	-	-	1	1	-	-	-	-	-	2	-
CO3	3	3	2	-	-	1	1	-	-	-	-	-	2	-
CO4	3	3	2	-	-	1	1	-	-	-	-	-	2	-

**Detailed syllabus:**

**Introduction to engineering materials:** Metals, alloys and phase diagrams, ferrous metals, non-ferrous metals, super alloys, guide to processing of metals; ceramics-structure and properties of ceramics, traditional ceramics, new ceramics, glass, some important elements related to ceramics; polymers-fundamentals of polymer science and technology, thermoplastic and thermosetting polymers, elastomers; composite materials-classification of composite materials, metal matrix, polymer matrix and ceramic matrix composites.

**Fundamental properties of materials:** mechanical properties-stress-strain relationships, hardness, tensile properties, effect of temperature on properties, visco-elastic behaviour of polymers, thermal properties and electrical properties of metals, polymers, ceramics and composites.

**Metal casting fundamentals and metal casting processes:** Overview of casting technology, melting and pouring, solidification and casting, sand casting, other expendable-mold casting processes, permanent-mold casting processes, casting quality, metals for casting.

Particulate processing of metals and ceramics: Powder metallurgy-characterization of engineering powders, production of metallic powders, conventional processing and sintering, alternative processing and sintering techniques, materials and products for powder metallurgy, design considerations in powder metallurgy, processing of traditional ceramics, processing of new ceramics, cermets and their processing.

**Fundamentals of metal forming and shaping processes** (rolling, forging, extrusion, drawing, sheet metal forming) : Overview of metal forming, friction and lubrication in metal forming; bulk deformation processes in metal forming-rolling, other deformation processes related to rolling, forging, other deformation processes related to forging, extrusion, wire and bar drawing; cutting and bending operations, sheet-metal drawing, other sheet metal forming operations, dies and presses for sheet-metal processes, sheet-metal operations not performed in presses.

**Fundamentals welding:** Overview of welding technology, the weld joint, physics of welding, features of a fusion-welded joint; Welding processes-arc welding, resistance welding, oxy-fuel gas welding, other fusion welding processes, solid-state welding, weld quality, weldability; brazing, soldering and adhesive bonding.

**Surface engineering and tribology:** Importance of surface engineering, classification of surface engineering processes, introduction to thermal, mechanical, thermo-chemical and electro-chemical surface engineering processes with their advantages, limitations and applications.

**Reading:**

1. Kalpakjian and Schmid, Manufacturing Engineering and Technology, Prentice Hall, New Jersey, 2013.
2. Mikell P. Groover, Fundamentals of Modern Manufacturing, John Wiley & Sons, Inc, New Jersey, 2010.
3. DeGarmo, Black, and Kohser, Materials and Processes in Manufacturing, John Wiley & Sons, Inc, New York, 2011.
4. R. S. Parmar, Welding processes and Technology, Khanna Publishers, 2010.
5. H.S. Bawa, Manufacturing Technology-I, Tata McGraw Hill Publishers New Delhi, 2007.
6. SeropeKalpakjian, Manufacturing processes for Engineering Materials, Addison Wesley, 2001.

CH390	NANOTECHNOLOGY AND APPLICATIONS	OPC	3 - 0 - 0	3 Credits
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

CO1	Understand the properties of nanomaterials
CO2	Synthesize nanoparticles
CO3	Characterize nanomaterials.
CO4	Scale up the production of nanoparticles
CO5	Evaluate safety and health related issues of nanoparticles

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	-	-	-	-	-	-	-	-	-	-	-	2	-
CO2	2	-	2	3	-	-	-	-	-	-	-	-	2	-
CO3	-	-	-	-	-	-	-	-	-	-	-	-	2	-
CO4	2	-	2	-	-	-	-	-	-	-	-	-	2	-
CO5	-	-	-	-	-	3	2	-	-	-	-	-	2	-

**Detailed Syllabus:**

**Introduction to Nanotechnology:** Introduction to nanotechnology and materials, Nanomaterials, Introduction to nanosizes and properties comparison with the bulk materials, Different shapes and sizes and morphology.

**Fabrication of Nanomaterials:** Top Down Approach Grinding, Planetary milling and Comparison of particles, Bottom Up Approach, Wet Chemical Synthesis Methods, Microemulsion Approach, Colloidal Nanoparticles Production, Sol Gel Methods, Sonochemical

Approach, Microwave and Atomization, Gas phase Production Methods : Chemical Vapour Depositions.

**Kinetics at Nanoscale:** Nucleation and growth of particles, Issues of Aggregation of Particles, Oswald Ripening, Stearic hindrance, Layers of surface charges, Zeta Potential and pH.

**Carbon Nanomaterials:** Synthesis of carbon bucky-balls, List of stable carbon allotropes extended, fullerenes, metallofullerenes, solid C<sub>60</sub>, bucky onions, nanotubes, nanocones.

**Quantum mechanics:** Quantum dots and its Importance, Pauli exclusion principle, Schrödinger's equation, Application of quantum Dots: quantum well, wire, dot, characteristics of quantum dots, Synthesis of quantum dots Semi-conductor quantum dots

**Nanomaterials characterization:** Fractionation principles of Particle size measurements, Particle size and its distribution, XRD, Zeta potential, Electronic band structure Electron statistics Application: Optical transitions in solids, photonic crystals, Microscopies SEM, TEM, Atomic Forced Microscopy, Scanning and Tunneling Microscopy.

**Applications:** Self-assembly and molecular manufacturing, Surfactant based system Colloidal system applications, Functional materials Applications, commercial processes of synthesis of nanomaterials.

Nanoinorganic materials of CaCO<sub>3</sub> synthesis, Hybrid Waste Water Treatments systems, Electronic Nanodevices,

**Nanobiology:** Biological synthesis of nanoparticles and applications in drug delivery, Nanocontainers and Responsive Release of active agents, Layer by Layer assembly for nanospheres, Safety and health Issues of nano materials, Environmental Impacts, Case Study for Environmental and Societal Impacts

### **Reading:**

1. KulkarniSulabha K, Nanotechnology: Principles and Practices, Capital Publishing Company, 2007
2. Stuart M. Lindsay, Introduction to Nanoscience, Oxford University Press, 2009.
3. Robert Kelsall, Ian Hamley, Mark Geoghegan, Nanoscale Science and Technology, John Wiley & Sons, 2005.
4. Gabor L. Hornyak, H.F. Tibbals, JoydeepDutta, John J. Moore, Introduction to Nanoscience and Nanotechnology, CRC Press, 2008.
5. Davies, J.H., The Physics of Low Dimensional Semiconductors: An Introduction, Cambridge University Press, 1998.

CH391	INDUSTRIAL SAFETY MANAGEMENT	OPC	3 - 0 - 0	3 Credits
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**Pre-requisites:** Nil.

**Course Outcomes:** At the end of the course the student will be able to:

CO1	Analyze the effects of release of toxic substances.
CO2	Select the methods of prevention of fires and explosions.
CO3	Understand the methods of hazard identification and prevention.
CO4	Assess the risks using fault tree diagram.

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	-	-	-	-	-	3	2	1	-	-	-	-	2	-
CO2	-	-	-	-	-	3	2	1	-	-	-	-	2	-
CO3	-	-	-	-	-	3	2	1	-	-	-	-	2	-
CO4	-	-	-	-	-	3	2	1	-	-	-	-	2	2

**Detailed syllabus:**

**Introduction:** Safety Programs, Engineering Ethics, Accident and Loss Statistics, Acceptable Risk, Public Perceptions, the Nature of the Accident Process, Inherent Safety.

**Industrial Hygiene:** Anticipation and Identification, Hygiene Evaluation, Hygiene Control.

Toxic Release and Dispersion Models-Parameters Affecting Dispersion, Neutrally Buoyant Dispersion Models, Dense Gas Dispersion, Toxic Effect Criteria, Effect of Release Momentum and Buoyancy, Release Mitigation.

**Fires and Explosions:** The Fire Triangle, Distinction between Fires and Explosions, Flammability Characteristics of Liquids and Vapors, Limiting Oxygen Concentration and Inerting, Flammability Diagram

**Hazards Identification:** Process Hazards Checklists, Hazards Surveys, Hazards and Operability Studies, Safety Reviews.

**Risk Assessment:** Review of Probability Theory, Event Trees, Fault Trees.

**Safety Procedures:** Process Safety Hierarchy, Managing Safety, Best Practices, Procedures-Operating, Procedures-Permits, Procedures-Safety Reviews and Accident Investigations.

**Reading:**

1. D. A. Crowl and J.F. Louvar, Chemical Process Safety (Fundamentals with Applications), Prentice Hall, 2011.
2. R.K. Sinnott, Coulson & Richardson's Chemical Engineering, Elsevier India, Volume 6, 2006.

CH392	INDUSTRIAL POLLUTION CONTROL	OPC	3 - 0 - 0	3 Credits
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

CO1	Analyze the effects of pollutants on the environment.
CO2	Distinguish air pollution control methods
CO3	Assess treatment technologies for wastewater
CO4	Identify treatment technologies for solid waste
CO5	Select treatment methodologies for hazardous and E-waste

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	-	-	-	-	-	3	2	-	-	-	-	-	2	-
CO2	-	-	-	-	-	3	2	-	-	-	-	-	2	-
CO3	-	-	-	-	-	3	2	-	-	-	-	-	2	-
CO4	-	-	-	-	-	3	2	-	-	-	-	-	2	-
CO5	-	-	-	-	-	3	2	-	-	-	-	-	2	2

**Detailed Syllabus:**

**Introduction:** Biosphere, Hydrological cycle, Nutrient cycle, Consequences of population growth, Pollution of air, Water and soil.

**Air pollution sources & effects:** Classification and properties of air pollutants, Emission sources, Behavior and fate of air pollutants, Effect of air pollution.

**Meteorological aspects of air pollutant dispersion:** Temperature lapse rates and stability, Wind velocity and turbulence, Plume behavior, Dispersion of air pollutants, Estimation of plume rise.

**Air pollution sampling and measurement:** Types of pollutant sampling and measurement, ambient air sampling, Stack sampling, Analysis of air pollutants.

**Air pollution control methods & equipment:** Control methods, Source correction methods, Cleaning of gaseous effluents, Particulate emission control, Selection of a particulate collector, Control of gaseous emissions, Design methods for control equipment. Control of specific gaseous pollutants: Control of NO<sub>x</sub> emissions, Control of hydrocarbons and mobile sources.

**Water pollution:** Water resources, Origin of wastewater, types of water pollutants and their effects.

**Waste water sampling, analysis and treatment:** Sampling, Methods of analysis, Determination of organic matter, Determination of inorganic substances, Physical characteristics, Bacteriological measurement, Basic processes of water treatment, Primary treatment, Secondary treatment, advanced wastewater treatment, Recovery of materials from process effluents.

**Solid waste management:** Sources and classification, Public health aspects, Methods of collection, Disposal Methods, Potential methods of disposal.

Hazardous waste management: Definition and sources, Hazardous waste classification, Treatment methods, Disposal methods.

**E-waste:** Sources, environmental and social issues, management practices

**Reading:**

1. Rao C.S., Environmental Pollution Control Engineering, Wiley Eastern Limited, India, 1993.
2. Noel de Nevers, Air Pollution and Control Engineering, McGraw Hill, 2000.
3. Glynn Henry J. and Gary W. Heinke, Environmental Science and Engineering, Prentice Hall of India, 2<sup>nd</sup> Edition, 2004.
4. Rao M.N., Rao H.V.N, Air Pollution, Tata McGraw Hill Publishing Ltd., 1993.
5. De A.K., Environmental Chemistry, Tata McGraw Hill Publishing Ltd., 1999.
6. George Tchobanoglous, Franklin Louis Burton, H. David Stensel, Metcalf & Eddy, Inc., Franklin Burton, Waste Water Engineering: Treatment and Reuse, McGraw Hill Education; 4<sup>th</sup> Edition, 2003.
7. E-waste recycling, NPCS Board of consultants and Engineers, Asia pacific business press Inc. 2015



<b>CS390</b>	<b>OBJECT ORIENTED PROGRAMMING</b>	<b>OPC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Understand fundamental concepts in object oriented approach.
<b>CO2</b>	Analyze design issues in developing OOP applications.
<b>CO3</b>	Write computer programs to solve real world problems in Java.
<b>CO4</b>	Analyze source codeAPI documentations.
<b>CO5</b>	Create GUI based applications.

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	3	3	-	-	2	-	-	-	-	-	-	-	-	2
<b>CO2</b>	3	3	-	-	2	-	-	-	-	-	-	-	-	2
<b>CO3</b>	3	3	-	-	2	-	-	-	-	-	-	-	-	2
<b>CO4</b>	3	3	-	-	2	-	-	-	-	-	-	-	-	2
<b>CO5</b>	3	3	-	-	2	-	-	-	-	-	-	-	-	2

**Detailed Syllabus:**

Object- oriented thinking, History of object-oriented programming, overview of java, Object-oriented design, Structure of java program. Types and modifiers, Classes, declaring objects in classes, Methods, constructors, garbage collection, Method overloading, passing objects as parameters, Inheritance, various forms and types of inheritance, Multilevel hierarchy, use of super, method overriding, Applications of method overriding, abstract classes, Packages with examples

Interfaces and implementation, Exception handling, types, throwing, creating own exceptions, Multithreading and concepts, its usage and examples, Input/output streams, String operations and examples, Collection classes-array, stack collection, bitset collection, Utility classes-string tokenizer, bitset, date, Applets- methods, creation, designing and examples, Event handling-event classes, Event listener interfaces, AWT classes, working with frames, AWT controls-layout manager, user interface components, Graphics programming

**Reading:**

1. Timothy Budd, "Understanding object-oriented programming with Java", Pearson, 2000.
2. Herbert Schildt, "The complete reference Java 2", TMH, 2017.

<b>BT390</b>	<b>GREEN TECHNOLOGY</b>	<b>OPC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-requisites:** Chemistry

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Address smart energy, green infrastructure and non-renewable energy challenges
<b>CO2</b>	Build models that simulate sustainable and renewable green technology systems
<b>CO3</b>	Understand history, global, environmental & economic impacts of green technology
<b>CO4</b>	Explore the usage of microorganism for the bioremediation
<b>CO5</b>	Synthesis the nanoparticles by various biological methods
<b>CO6</b>	Apply the green techniques for the production of renewable fuels

**Course Articulation Matrix:**

CO \ PO	PO												PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	3	2	2	-	1	2	-	-	-	-	-	-	1	-
<b>CO2</b>	3	2	2	-	1	2	-	-	-	-	-	-	1	-
<b>CO3</b>	3	2	2	-	1	2	-	-	-	-	-	-	1	-
<b>CO4</b>	3	2	2	-	1	2	-	-	-	-	-	-	2	-
<b>CO5</b>	1	-	-	1	-	2	-	-	-	-	-	-	2	-
<b>CO6</b>	-	2	-	2	-	-	3	-	-	-	-	-	2	-

**Detailed Syllabus:**

Green Technology definition, factors affecting green technologies, co/green technologies for addressing the problems of Water, Energy, Health, Agriculture and Biodiversity- WEHAB (eco-restoration/ phyto-remediation, ecological sanitation, renewable energy technologies, industrial ecology, agro ecology and other appropriate green technologies); design for sustainability reuse, recovery, recycle, raw material substitution, cleaner production, ISO 14000, wealth from waste, case studies.

Clean Technology: Biotechnology and Microbiology of Degradation of coal - Aerobic and Anaerobic pathway of coal degradation, Biogas technology, Microbial and biochemical aspects, Operating parameters for biogas production, kinetics and mechanism - Dry and wet fermentation. Digesters for rural application - High rate digesters for industrial waste water treatment.

Biomass energy: Concept of biomass energy utilization, types of biomass energy, conversion processes, Wind Energy, energy conversion technologies, their principles, equipment and suitability in Indian context; tidal and geothermal energy, Design and operation of Fixed and Fluidized Bed Gasifiers. Biomass as a major source of energy in India: Fuel-wood use in rural households. Consequences for ecosystems. Future energy scenario in rural areas. Utilization of biomass in industrial and semi-industrial settings. Future utilization of biomass in India. Future of landscape management: optimal management.

Nano particles preparation techniques, Greener Nano synthesis: Greener Synthetic Methods for Functionalized Metal Nan particles, Greener Preparations of Semiconductor and Inorganic Oxide Nano particles, green synthesis of Metal nanoparticles, Nanoparticle characterization methods, Green materials: biomaterials, biopolymers, bioplastics, and composites. Nanomaterials for Fuel Cells and Hydrogen; Generation and storage, Nano-structures for efficient solar hydrogen production, Metal Nanoclusters in Hydrogen Storage Applications, Metal Nanoparticles as Electro-catalysts in Fuel Cells, Nanowires as Hydrogen Sensors.

**Reading:**

1. Ristinen, Robert Kraushaar, Jack J.A Kraushaar, Jack P. Ristinen, Robert A., Energy and the Environment, 2<sup>nd</sup> Edition, John Wiley, 2006.
2. B. R Wilson & W J Jones, Energy, Ecology and the Environment, Academic Press Inc, 2005.
3. Sarkar S, Fuels and combustion, 2nd ed., University Press, 2009.

<b>SM390</b>	<b>MARKETING MANAGEMENT</b>	<b>OPC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Understand concepts and scope of marketing and market oriented strategic planning
<b>CO2</b>	Analyze macro level environment
<b>CO3</b>	Identify factors influencing consumer behavior in competitive global business environment
<b>CO4</b>	Identify tools and techniques for marketing management through integrated marketing communication systems.

**Course Articulation Matrix:**

CO \ PO	PO												PS	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PS02
<b>CO1</b>	2	2	-	-	-	-	-	-	2	1	2	-	2	-
<b>CO2</b>	2	2	-	-	-	-	-	-	2	1	2	-	2	-
<b>CO3</b>	2	2	-	-	-	-	-	-	2	1	2	-	2	-
<b>CO4</b>	2	2	-	-	-	-	-	-	2	1	2	-	-	2

**Detailed Syllabus:**

Importance of Marketing, Scope of Marketing, Core Marketing concepts company orientation towards market place-production concept, Product concept, selling concept and Marketing concept.

Market oriented Strategic planning-Defining corporate Mission and Vision Statement at Corporate level and at Business unit level. Assigning resources to Strategic Business units through B.C.G Matrix and G.E Model.

Analyzing Macro environment-Demographic environment.Economic Environment, Technical Environment, Social-Cultural Environment and political - Legal Environment.

Components of Marketing information systems- Internal Records, Marketing intelligence, Marketing research and Marketing Decision support system.

Consumer Behavior- Buying Decision process and the factors influencing consumer Behavior- Psychological factors, social factors, cultural factors and personal factors.

Importance of Market segmentation, Target market selection and positioning.

Importance of new product development process and the various stages involved.

The concept of product lifecycle and the various strategies used by the marketer in each stage.

Product characteristics and classification, Product mix and product line decisions Branding Decisions, Building Brand Equity.

Importance of Pricing, Factors influencing pricing decisions. Various pricing methods-cost based and demand based methods.

Role of Marketing channels-Channel functions and channel levels channel Design and channel Management Decisions, Managing Retailing. Wholesaling and logistics.Importance of Electronic channels.

Importance of integrated Marketing communication.Advantages and Disadvantages of Various promotional tools- Advertising, Sales promotion, personal selling, publicity and public Relations and Direct marketing.

**Reading:**

1. Philip Kotler, Marketing Management, PHI, 14<sup>th</sup> Edition, 2013.
2. William Stonton & Etzel, Marketing Management, TMH, 13<sup>th</sup> Edition, 2013.
3. Rama Swamy & Namakumari, Marketing Management, McMillan, 2013.

<b>MA390</b>	<b>NUMERICAL SOLUTION OF DIFFERENTIAL EQUATIONS</b>	<b>OPC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Solve nonlinear differential equations by numerical methods.
<b>CO2</b>	Determine the convergence region for a finite difference method.
<b>CO3</b>	Solve elliptic PDE by finite difference method
<b>CO4</b>	Solve a parabolic PDE by finite difference method
<b>CO5</b>	Solve a hyperbolic PDE by finite difference method

**Course Articulation Matrix:**

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
	<b>CO1</b>	3	3	1	1	1	-	-	-	-	-	-	2	-
<b>CO2</b>	3	3	1	1	1	-	-	-	-	-	-	2	-	2
<b>CO3</b>	3	3	1	1	1	-	-	-	-	-	-	2	-	2
<b>CO4</b>	3	3	1	1	1	-	-	-	-	-	-	2	-	2
<b>CO5</b>	3	3	1	1	1	-	-	-	-	-	-	2	-	2

**Detailed Syllabus:**

**Ordinary Differential Equations:** Multistep (explicit and implicit) methods for initial value problems, Stability and Convergence analysis, Linear and nonlinear boundary value problems, Quasi-linearization, Shooting methods

**Finite difference methods:** Finite difference approximations for derivatives, boundary value problems with explicit boundary conditions, implicit boundary conditions, error analysis, stability analysis, convergence analysis.

**Partial Differential Equations:** Classification of partial differential equations, finite difference approximations for partial derivatives and finite difference schemes for Parabolic equations, Schmidt's two level, multilevel explicit methods, Crank-Nicolson's two level, multilevel implicit methods, Dirichlet's problem, Neumann problem, mixed boundary value problem, stability analysis.

**Hyperbolic Equations:** Explicit methods, implicit methods, one space dimension, two space dimensions, ADI methods.

**Elliptic equations:** Laplace equation, Poisson equation, iterative schemes, Dirichlet's problem, Neumann problem, mixed boundary value problem, ADI methods.

**Reading:**

1. M.K. Jain, Numerical Solution of Differential Equations, Wiley Eastern, 1984.
2. G.D. Smith, Numerical Solution of Partial Differential Equations, Oxford Univ. Press, 2004.
3. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Computational Methods for Partial Differential Equations, Wiley Eastern, 2005.



<b>MA391</b>	<b>FUZZY MATHEMATICS AND APPLICATIONS</b>	<b>OPC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Apply operations on Fuzzy sets
<b>CO2</b>	Solve problems related to Propositional Logic.
<b>CO3</b>	Apply Fuzzy relations to cylindric extensions.
<b>CO4</b>	Apply logic of Boolean Algebra to switching circuits.
<b>CO5</b>	Develop Fuzzy logic controllers

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	3	3	1	1	2	1	-	-	-	-	-	-	-	2
<b>CO2</b>	3	3	1	1	2	1	-	-	-	-	-	-	-	2
<b>CO3</b>	3	3	1	1	2	1	-	-	-	-	-	-	-	2
<b>CO4</b>	3	3	1	1	2	1	-	-	-	-	-	-	-	2
<b>CO5</b>	3	3	1	1	2	1	-	-	-	-	-	-	-	2

**Detailed Syllabus:**

**Crisp set theory (CST):** Introduction, Relations between sets, Operations on sets, Characteristic functions, Cartesian products of crisp sets, crisp relations on sets.

**Fuzzy set theory (FST):** Introduction, concept of fuzzy set (FS), Relation between FS, operations on FS, properties of standard operations, certain numbers associated with a FS, certain crisp sets associated with FS, Certain FS associated with given FS, Extension principle.

**Propositional Logic (PL1):** Introduction, Syntax of PL1, Semantics of PL1, certain properties satisfied by connectives, inference rules, Derivation, Resolution.

**Predicate Logic (PL2):** Introduction, Syntax of PL2, Semantics of PL2, certain properties satisfied by connectives and quantifiers, inference rules, Derivation, Resolution

**Fuzzy Relations (FR):** Introduction, Operations on FR, cuts of FR, Composition of FR, Projections of FR, Cylindric extensions, cylindric closure, FR on a domain.

**Fuzzy Logic (FL):** Introduction, Three-valued logics, N-valued logics and infinite valued logics, Fuzzy logics, Fuzzy propositions and their interpretations in terms of fuzzy sets, Fuzzy rules and their interpretations in terms of FR, fuzzy inference, More on fuzzy inference, Generalizations of FL.

**Switching functions (SF) and Switching circuits (SC):** Introduction, SF, Disjunctive normal form, SC, Relation between SF and SC, Equivalence and simplification of circuits, Introduction of Boolean Algebra BA, Identification, Complete Disjunctive normal form.

**Applications:** Introduction to fuzzy logic controller (FLC), Fuzzy expert systems, classical control theory versus fuzzy control, examples, working of FLC through examples, Details of FLC, Mathematical formulation of FLC, Introduction of fuzzy methods in decision making.

**Reading:**

1. M. Ganesh, Introduction to Fuzzy Sets and Fuzzy Logic, PHI, 2001.
2. G.J. Klir and B.Yuan, Fuzzy sets and Fuzzy Logic-Theory and Applications, PHI, 1997.
3. T. J. Ross, Fuzzy Logic with Engineering Applications, McGraw-Hill, 1995.

PH390	MEDICAL INSTRUMENTATION	OPC	3 - 0 - 0	3 Credits
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Understand the origin of bio-potentials and their physical significance.
<b>CO2</b>	Understand anatomy and functioning of human heart and its common problems.
<b>CO3</b>	Analyze ECG, ENG and EMG signals and instrumentation.
<b>CO4</b>	Compare different techniques of measuring blood pressure, blood flow and volume.
<b>CO5</b>	Interpret the principle and operation of therapeutic and prosthetic devices.
<b>CO6</b>	Differentiate between the various techniques for measurement of parameters.

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	3	2	2	-	1	2	-	-	-	-	-	-	-	-
<b>CO2</b>	3	2	2	-	1	2	-	-	-	-	-	-	-	-
<b>CO3</b>	3	2	2	-	1	2	-	-	-	-	-	-	2	3
<b>CO4</b>	3	2	2	-	1	2	-	-	-	-	-	-	2	3
<b>CO5</b>	3	2	2	-	1	2	-	-	-	-	-	-	-	-
<b>CO6</b>	3	2	2	-	1	2	-	-	-	-	-	-	-	3

**Detailed Syllabus:**

**General Introduction:** The cell, body fluids, Musculoskeletal system, respiratory system, gastrointestinal system, Nervous system, endocrine system and circulatory system.

**Origin of Bio potentials:** electrical activity of Excitable cells: the resting state, The active state, Volume conductor fields, Functional organization of the peripheral nervous system: Reflex arc & Junctional transmission.

**The Electroneurogram (ENG):** The H-Reflex, The Electromyogram (EMG), The Electrocardiogram (ECG), heart and the circulatory system, Electro conduction system of the heart and heart problems, ECG waveform and Physical significance of its wave features, Electrical behavior of cardiac cells, The standard lead system, The ECG preamplifier, DC ECG Amplifier, Defibrillator protection circuit, Electro surgery Unit filtering, Functional blocks of ECG system, Multichannel physiological monitoring system, Common problems encountered and remedial techniques.

**Blood Pressure:** indirect measurement of blood pressure, korotkoff sounds, auscultatory method using sphygmo manometer, Oscillometric and ultrasonic noninvasive pressure measurement, Direct measurement of blood pressure H<sub>2</sub>O manometers, electronic manometry, Pressure transducers, Pressure amplifier designs, Systolic, diastolic mean detector circuits

**Blood flow and Volume Measurement:** indicator dilution methods, Transit time flow meter, DC flow meter, Electromagnetic flow meter AC electromagnetic flow meter, Quadrature suppression flow meter, Ultrasonic flow meter, Continuous-wave Doppler flow meter, Electric impedance plethysmography, chamber plethysmography, Photo plethysmography.

**Pulse Oximeter:** Principles of Operation, Absorption Spectrum, Sensor design, Pulse oximeter, Therapeutic and Prosthetic Devices.

**Cardiac Pacemakers:** Lead wires and electrodes, Synchronous Pacemakers, rate responsive pacemaking, Defibrillators, cardioverters, Electro surgical unit, Therapeutic applications of laser, Lithotripsy Haemodialysis.

**Reading:**

1. John G Webster, Medical Instrumentation: Application and Design, John Wiley, 3<sup>rd</sup> Edition, 2012.
2. Joseph J. Carr & John M. Brown, Introduction to biomedical Equipment Technology, 4<sup>th</sup> Edition, Prentice Hall India, 2001

PH391	ADVANCED MATERIALS	OPC	3 - 0 - 0	3 Credits
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

CO1	Understand the synthesis and properties of nanomaterials
CO2	Evaluate the usefulness of nanomaterials in medicine, biology and sensing
CO3	Understand modeling of composite materials by finite element analysis
CO4	Differentiate superconducting materials
CO5	Understand the characteristics and uses of functional materials

**Course Articulation Matrix:**

PO \ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	-	-	1	-	-	-	-	-	-	-	1
CO2	3	3	3	-	-	1	-	-	-	-	-	-	2	1
CO3	3	3	3	-	-	1	-	-	-	-	-	-	2	3
CO4	3	3	3	-	-	1	-	-	-	-	-	-	-	1
CO5	3	3	3	-	-	1	-	-	-	-	-	-	-	1

**Detailed Syllabus:**

**Nano Materials:** Origin of nanotechnology, Classification of nanomaterials, Physical, chemical, electrical, mechanical properties of nanomaterials. Preparation of nanomaterials by plasma arcing, physical vapour deposition, chemical vapour deposition (CVD), Sol-Gel, electro deposition, ball milling, carbon-nano tubes(CNT).Synthesis, preparation of nanotubes, nanosensors, Quantum dots, nanowires, nanobiology, nanomedicines.

**Biomaterials:** Overview of biomaterials. Biomaterials, bio ceramics, biopolymers, tissue grafts, soft tissue applications, cardiovascular implants, biomaterials in ophthalmology, orthopedic implants, dental materials.

**Composites:** General characteristics of composites, composites classes, PMCs, MMCs, CMCs, CCCs, IMCs, hybrid composites, fibers and matrices, different types of fibers, whiskers, different matrices materials, polymers, metal, ceramic matrices, toughening mechanism, interfaces, blending and adhesion, composite modeling, finite element analysis and design.

**Optical materials:** Mechanisms of optical absorption in metals, semiconductors and insulators. Nonlinear optical materials, optical modulators, optical fibers. Display devices and materials photo-emissive, photovoltaic cells, charge coupled devices (CCD), laser materials.

**Super conducting materials:** Types of super conductors, an account of mechanism of superconductors, effects of magnetic field currents, thermal energy, energy gap, acoustic attenuation, penetration depth, BCS theory, DC and AC Josephson effects, high T<sub>c</sub> superconductors, potential applications of superconductivity, electrical switching element, superconductor power transmission and transformers, magnetic mirror, bearings, superconductor motors, generators, SQUIDS etc.

**Smart materials:** An introduction, principles of smart materials, input - output decision ability, devices based on conductivity changes, devices based on changes in optical response, biological systems smart materials. Devices based on magnetization, artificial structures, surfaces, hetero structures, polycrystalline, amorphous, liquid crystalline materials.

**Surface Acoustic Wave (SAW) Materials and Electrets:** Delay lines, frequency filters, resonators, pressure and temperature sensors, Sonar transducers. Comparison of electrets with permanent magnets, Preparation of electrets, Application of electrets.

**Reading:**

1. T. Pradeep, Nano: The Essentials; TATA McGraw-Hill, 2008.
2. B.S. Murthy et al., Textbook of Nano science and Nanotechnology, University press, 2012.
3. Krishan K Chawla, Composite Materials; 2<sup>nd</sup> Edition, Springer 2006.

CY390	<b>INSTRUMENTAL METHODS IN CHEMICAL ANALYSIS</b>	OPC	3 - 0 - 0	3 Credits
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Understand the concepts of ultraviolet and visible absorption and fluorescence techniques for material characterization.
<b>CO2</b>	Understand the various liquid, gas and size-exclusion chromatographic techniques the automated continuous analysis of environmental, industrial, production-line materials
<b>CO3</b>	Understand the concepts of various electroanalytical techniques for characterization of interfaces and traces of surface adsorbed-materials.
<b>CO4</b>	Understands the principles of thermogravimetry and differential thermal analyses (TGA and DTA) for applications into pharmaceuticals, drugs, polymers, minerals, toxins and in Finger Print Analysis
<b>CO5</b>	Identification of suitable analytical technique for characterization of chemical, inorganic and engineering materials

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	3	3	-	3	1	1	1	-	-	-	-	-	-	2
<b>CO2</b>	3	3	-	3	1	1	1	-	-	-	-	-	-	2
<b>CO3</b>	3	3	-	3	1	1	1	-	-	-	-	-	-	2
<b>CO4</b>	3	3	-	3	1	1	1	-	-	-	-	-	-	
<b>CO5</b>	3	3	-	3	1	1	1	-	-	-	-	-	-	2

**Detailed Syllabus:**

**UV-Visible Spectrophotometry and Fluorescence:** Beer-Lambert's law, limitations, Molecular fluorescence, influencing factors, basic instruments, standardization, quantitative methods, applications.

**Atomic spectrometry, atomic absorption, X-ray fluorescence methods:** Flame atomic emission and absorption, flame emission photometer, flame absorption spectrometer, spectral interferences, quantitative aspects, X-ray fluorescence principle, instrumentation, quantitative analysis.

**Chromatography methods:** Gas chromatography, High performance liquid chromatography, size exclusion chromatography, Principle, Basic instrumentation, terminology, NPC, RPC, Qualitative and Quantitative applications. Capillary Electrophoresis: Principle and application.

**Thermoanalytical methods:** Thermogravimetry, Differential thermal analysis, differential scanning calorimetry, Principle, Block diagram, Applications, Quantitative determinations

**Electroanalytical methods:** Coulometric methods, Polarography, Pulse voltametric methods, Amperometry, Principles, Applications, Electrochemical sensors, Ion selective, Potentiometric and amperometric Sensors, Applications.

**Spectroscopic methods:** Molecular absorption, Woodward rules, applications, Infrared absorption, functional group analysis, qualitative analysis, <sup>1</sup>H- and <sup>13</sup>C-NMR spectroscopy, Principle, Basic instrumentation, terminology, Interpretation of data, Quantitative applications

Mass spectrometry: Principles, Instrumentation, Ionization techniques, Characterization and applications.

#### **Reading:**

1. Gurdeep Chatwal and Sham Anand, Instrumental Methods of Chemical Analysis, Himalaya Publishing House, 1986.
2. Skoog, Holler and Kouch, Instrumental methods of analysis, Thomson, 2007.
3. Mendham, Denny, Barnes and Thomas, Vogel: Text book of quantitative chemical analysis, Pearson, 6Edotion, 2007.
4. William Kemp, Organic spectroscopy, McMillan Education, UK, 1991.
5. Instrumental methods of analysis - Willard, Meritt and Dean, PHI, 2005.



<b>HS390</b>	<b>SOFT SKILLS</b>	<b>OPC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Understand corporate communication culture
<b>CO2</b>	Prepare business reports and proposals expected of a corporate professional
<b>CO3</b>	Employ appropriate speech in formal business situations
<b>CO4</b>	Exhibit corporate social responsibility and ethics
<b>CO5</b>	Acquire corporate email, mobile and telephone etiquette

#### Course Articulation Matrix

PO \ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	-	-	-	-	-	-	-	3	1	3	2	-	-	-
<b>CO2</b>	-	-	-	-	-	-	-	3	1	3	2	-	-	-
<b>CO3</b>	-	-	-	-	-	-	-	3	1	3	2	-	-	-
<b>CO4</b>	-	-	-	-	-	-	-	3	1	3	2	-	-	-
<b>CO5</b>	-	-	-	-	-	-	-	3	1	3	2	-	-	2

#### Detailed Syllabus:

**English Language Enhancement:** Verbs and tenses, Phrasal verbs, Synonyms, Antonyms, Homonyms - Descriptive Words, Combining Sentences, Business Idioms, Indianisms in English. Art of Communication, Communication process- Non-verbal Communication- Effective Listening.

**Interpersonal and Intra Personal Communication Skills:** Self-Awareness, Self-Esteem and Confidence- Assertiveness and Confidence- Dealing with Emotions-Team Concept- Elements of Teamwork- Stages of Team Formation- Effective Team-Team Player Styles-Leadership.

Campus to Company- Dressing and Grooming- The Corporate Fit- Business Etiquette- Communication; media etiquette- Group Discussions, Interviews, and Presentation Skills.

**Interview handling skills:** Effective Resume-- Common Interview Mistakes- Body-language- Content Aid, Visual Aids- Entrepreneurial Skills Development.

**Reading:**

1. Robert M.Sherfield, Developing Soft Skills, Montgomery and Moody 4<sup>th</sup> Edition, Pearson, 2009.
2. K.Alex, Soft Skills: Know Yourself & Know The world, S. Chand; 2009.
3. Robert Bramson, Coping with Difficult People, Dell, 2009.

<b>CE440</b>	<b>BUILDING TECHNOLOGY</b>	<b>OPC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-requisites:** Nil.

**Course Outcomes:** At the end of the course the student will be able to:

<b>CO1</b>	Apply basic principles to develop stable, sustainable and cost-effective building plans
<b>CO2</b>	Identify different materials, quality and methods of fabrication & construction.
<b>CO3</b>	Adopt standard building provisions for natural ventilation and lighting.
<b>CO4</b>	Identify effective measures for fire proofing, damp proofing, and thermal insulation.

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	2	2	1	-	-	1	1	-	-	-	-	-	2	-
<b>CO2</b>	2	2	1	-	-	1	1	-	-	-	-	-	2	-
<b>CO3</b>	2	2	1	-	-	1	1	-	-	-	-	-	2	-
<b>CO4</b>	2	2	1	-	-	1	1	-	-	-	-	-	2	-

**Detailed Syllabus:**

**Overview of the course:** basic definitions, Buildings-Types, components, economy and design, Principles of planning of buildings and their importance. Definitions and importance of Grouping and circulation; Lighting and ventilation; How to consider these aspects during planning of building.

**Termite proofing:** Inspection, control measures and precautions, Lightning protection of buildings: General principles of design of openings, various types of fire protection measures to be considered while planning a building.

General requirements and extra requirements for safety against fire, special precautions, Vertical transportation in building-types of vertical transportation, Stairs, different forms of stairs, planning of stair cases, Other modes of vertical transportation- lifts, ramps, escalators.

**Prefabrication systems in residential buildings:** walls, openings, cupboards, shelves etc., planning and modules and sizes of components in prefabrication. Planning and designing of residential buildings against the earthquake forces, Principles, Seismic forces and their effect on buildings.

**Air conditioning:** process and classification of air conditioning, Dehumidification. Systems of air-conditioning, ventilation, functional requirements of ventilation.

**Acoustics:** effect of noise, properties of noise and its measurements, Principles of acoustics of building. Sound insulation - importance and measures.

**Plumbing services:** water supply system, maintenance of building pipe line, Sanitary fittings, principles governing design of building drainage.

**Reading:**

1. Building Construction - Varghese, PHI Learning Private Limited, 2008.
2. Building Construction - Punmia, B C, Jain, A J and Jain A J, Laxmi Publications, 2005.
3. Building Construction by S.P. Arora and S.P. Bindra - Dhanpatrai and Sons, New Delhi, 1996.
4. Building Construction - Technical Teachers Training Institute, Madras, Tata McGraw Hill, 1992.
5. National Building code of India, Bureau of Indian Standards, 2005.

<b>EE440</b>	<b>NEW VENTURE CREATION</b>	<b>OPC</b>	<b>3-0- 0</b>	<b>3 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Understand the process and practice of entrepreneurship and new venture creation
<b>CO2</b>	Identify entrepreneurial opportunities, preparation of a business plan for launching a new venture
<b>CO3</b>	Explore the opportunities in the domain of respective engineering disciplines for launching a new venture
<b>CO4</b>	Expose the students with the functional management issues of running a new venture

**Course Articulation Matrix:**

<b>PO</b> <b>CO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>	<b>PSO1</b>	<b>PSO2</b>
<b>CO1</b>	-	-	-	-	-	3	1	3	2	2	3	-	1	3
<b>CO2</b>	-	-	-	-	-	3	1	3	2	2	3	-	1	2
<b>CO3</b>	-	-	-	-	-	3	1	3	2	2	3	-	2	2
<b>CO4</b>	-	-	-	-	-	3	1	3	2	2	3	-	1	

**Detailed syllabus:**

Entrepreneur and entrepreneurship: **Entrepreneurship and Small Scale Enterprises (SSE), Role in Economic Development, Entrepreneurial Competencies, and Institutional Interface for SSE.**

**Establishing the Small Scale Enterprise:** Opportunity Scanning and Identification, Market Assessment for SSE, Choice of Technology and Selection of Site, Financing the New/Small Enterprises, Preparation of the Business Plan, Ownership Structures and Organizational Framework.

**Operating the Small Scale Enterprises:** Financial Management Issues in SSE, Operational Management Issues in SSE, Marketing Management Issues in SSE, and Organizational Relations in SSE.

**Reading:**

1. Holt, Entrepreneurship: New Venture Creation, PHI (P), Ltd., 2001.
2. Madhulika Kaushik: Management of New & Small Enterprises, IGNOU course material, 1995
3. B S Rathore S Saini: Entrepreneurship Development Training Material, TTTI, Chandigarh, 1988.
4. P.C. Jain: A Hand Book for New Entrepreneurs, EDI-Faculty & External Experts, EDII, Ahmedabad, 1986.
5. J.B. Patel, D.G Allampalli: A Manual on How to Prepare a Project Report, EDII, Ahmedabad, 1991.
6. J B Patel, S SModi, A Manual on Business Opportunity Identification and Selection, EDII, Ahmedabad, 1995.

EE441	PRINCIPLES OF ELECTRIC POWER CONVERSION	OPC	3-0-0	3 Credits
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Understand the basics in the electric power conversion using power switching devices
<b>CO2</b>	Evaluate the conversion for range of renewable energy sources with the help of available electrical machines drives
<b>CO3</b>	Analyze the different energy storage systems
<b>CO4</b>	Identify the various Industrial and domestic applications

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	1	2	1	1	1	1	1	-	-	-	-	-	2	-
<b>CO2</b>	1	2	1	1	1	1	1	-	-	-	-	-	2	-
<b>CO3</b>	1	2	1	1	1	1	1	-	-	-	-	-	2	-
<b>CO4</b>	1	2	1	1	1	1	1	-	-	-	-	-	2	-

**Detailed syllabus:**

**Power Electronic Devices and Converters:** V-I characteristics of SCR, MOSFET and IGBT. Phase controlled rectifiers, DC-DC converters and Inverters.

**Applications to Electric Drives:** Speed control of DC motor, Induction motors, PMSM and BLDC drives

**Applications to Renewable Energy:** Introduction to solar cell, solar panels, MPPT, wind and other renewable energy sources, Integration of renewable energy sources to the grid.

**Energy Storage Systems:** Study of automotive batteries, SMF, pumped storage systems, super-capacitors, fly wheels - applications, Li-ion batteries and applications to electric vehicles.

**Domestic And Industrial Applications:** Induction heating, melting, hardening, lighting applications and their control, UPS, battery chargers

**Reading:**

1. M.H.Rashid: Power Electronics-circuits, Devices and applications, Prentice Hall India, New Delhi, 2009.
2. P.S.Bhimbra: Power Electronics, Khanna publishers, New Delhi, 2012.
3. Ned Mohan, Undeland and Robbin: Power electronics converters, applications and design, John Willey & Sons, Inc. New York, 2006.



EC440	<b>ELECTRONIC MEASUREMENTS AND INSTRUMENTATION</b>	OPC	3 - 0 - 0	3 Credits
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, student will be able to:

<b>CO1</b>	Apply knowledge of instruments for effective use
<b>CO2</b>	Select suitable instruments for typical measurements.
<b>CO3</b>	Identify various transducers to measure strain, temperature and displacement.
<b>CO4</b>	Understand data acquisition system and general purpose interfacing bus.

**Course Articulation Matrix:**

PO \ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	2	2	1	-	1	1	1	-	-	-	-	-	2	-
<b>CO2</b>	2	2	1	-	1	1	1	-	-	-	-	-	2	-
<b>CO3</b>	2	2	1	-	1	1	1	-	-	-	-	-	2	-
<b>CO4</b>	2	2	1	-	1	1	1	-	-	-	-	-	2	-

**Detailed syllabus:**

**Measurement And Error:** Sensitivity, Resolution, Accuracy and precision, absolute and Relative types of errors, Statistical analysis, Probability of and Limiting errors, Linearity.

**Instruments:** D'Arsonval movement and basic principles of Measurement of Voltage, Current and Resistance in instruments. Analog and Digital Multimeters, Measurement of time and Frequency - Digital Frequency Meter and applications.

**Impedance Measurement:** Kelvin Bridge; Megger; Maxwell, Hay and Shering Bridges. Q-meter; Noise and Interference reduction techniques in Measurement Systems.

**Oscilloscopes:** Block diagram, probes, Deflection amplifier and delay line, Trigger Generator, Coupling, Automatic Time Base and Dual Trace Oscilloscopes, Pulse Measurements, Delayed Time Base, Analog Storage, Sampling and Digital Storage Oscilloscopes.

**Special instruments:** Wave Analyzer, Harmonic Distortion Analyzer, Spectrum Analyzer, FFT Analyzer.

**Transducers** (Qualitative Treatment Only): Classification and selection of Transducers, Introduction to strain, Load, force, Displacement, Velocity, Acceleration, Pressure and Temperature Measurements.

**Introduction to Data Acquisition Systems (DAS):** Block Diagram, Specifications and various components of DAS.

**General purpose Instrumentation Bus (GP-IB):** Protocol, SCPI Commands and Applications to DSO and DMM.

**Reading:**

1. Oliver and Cage, Electronic Measurements and Instrumentation, McGraw Hill, 2009
2. Helfrick Albert D. and Cooper William D., Electronic Instrumentation & Measurement Techniques, PHI, 2008.
3. D.A. Bell, Electronic Instrumentation and Measurements, 3<sup>rd</sup> Edition, Oxford, 2013.

MM499	METALLURGY FOR NON-METALLURGISTS	OPC	3-0-0	03 Credits
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, student will be able to:

<b>CO1</b>	Discuss the characteristics and applications of metals and alloys.
<b>CO2</b>	Explain different fabrication techniques.
<b>CO3</b>	Correlate the microstructure, properties, processing and performance of materials.
<b>CO4</b>	Select metal/alloy for engineering applications.

**Course Articulation Matrix:**

CO \ PO	PO												PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	2	2	1	-	1	1	1	-	-	-	-	-	2	-
<b>CO2</b>	2	2	1	-	1	1	1	-	-	-	-	-	2	-
<b>CO3</b>	2	2	1	-	1	1	1	-	-	-	-	-	2	-
<b>CO4</b>	2	2	1	-	1	1	1	-	-	-	-	-	2	-

**Detailed syllabus:**

**Introduction to Metallurgy:** Metals and Alloys classification, engineering applications of metals/alloys.

**Structure of Metals and Alloys:** Nature of Metallic Bonding, Crystal Structures of Metals, Structure of Alloys, Imperfections in Crystals.

**Mechanical Properties:** Plastic Deformation Mechanisms, Tensile, Creep, Fatigue, Fracture Strengthening Mechanisms: Strain Hardening, Grain Size Refinement, Solid Solution Strengthening, Precipitation Hardening

**Fabrication and Finishing of metal products:** Metal Working and Machining

**Testing of Metals:** Destructive and Non-Destructive Testing, Inspection and Quality Control of Metals.

**Engineering Alloys:** Steel Products and Properties, Cast Irons, Tool Steels and High Speed Steels, Stainless Steels, selective non-ferrous metals and alloys.

**Heat Treatment:** Annealing, Normalizing, Hardening and Tempering.

**Material selection processes:** Case studies

**Reading:**

1. M. F. Ashby, Engineering Metals, 4<sup>th</sup> Edition, Elsevier, 2005.
2. R. Balasubramaniam (Adapted): Calister's Materials Science and Engineering, 7<sup>th</sup> Edition, Wiley India (P) Ltd, 2007.
3. R. Abbaschian, L. Abbaschian, R.E. Reed-Hill, Physical Metallurgy Principles, East-West Press, 2009.
4. V Raghavan, Elements of Materials Science and Engineering- A First Course, 5<sup>th</sup> Edition, PHI Publications, 2011

<b>CH440</b>	<b>DATA DRIVEN MODELLING</b>	<b>DEC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Identify disturbance models
<b>CO2</b>	Estimate parametric and non-parametric models
<b>CO3</b>	Determine the model structure
<b>CO4</b>	Validate the developed models

**Course Articulation Matrix:**

<b>PO</b> <b>CO</b>	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PO12</b>	<b>PSO1</b>	<b>PSO2</b>
<b>CO1</b>	2	2	1	2	2	-	-	-	-	-	-	1	1	-
<b>CO2</b>	2	2	1	2	2	-	-	-	-	-	-	1	1	-
<b>CO3</b>	2	2	1	2	2	-	-	-	-	-	-	1	1	-
<b>CO4</b>	2	2	1	2	2	-	-	-	-	-	-	1	1	-

**Detailed syllabus:**

System Identification - Motivation and Overview. Models of Discrete-Time LTI Systems - Convolution equation. Difference equations, Transfer functions, State-space models, Discretization, Sampling and Hold operations, sampling theorem.

Disturbance models - random processes, representation of stationary processes, white-noise process, auto-covariance function (ACF), ARMA models. Parametric model structures - ARX, ARMAX, OE, BJ and PEM - structures and their applicability in real-time.

Linear Regression - Least Squares estimates, Statistical properties of LS Estimates. Weighted Least Squares, Recursive Least Squares, Maximum Likelihood Estimation and properties.

Estimation of non-parametric models - impulse / step response coefficients, frequency response models.

Estimation of parametric models - notions of prediction and simulation, predictors for parametric models, prediction-error methods, Instrumental Variable method.

Model Structure Selection and Diagnostics -estimation of delay and order, residual checks, properties of parameter estimates, model comparison and selection, model validation.

**Reading:**

1. Arun K. Tangirala. System Identification: Theory and Practice, CRC Press, 2014.
2. Karel J. Keesman, System Identification - An Introduction, Springer, 2011.
3. Nelles, O. Nonlinear System Identification, Springer-Verlag, Berlin, 2001.
4. Zhu, Y. Multivariable System Identification for Process Control, Pergamon, 2001.
5. Ljung, L. System Identification: Theory for the User, Prentice-Hall, 2<sup>nd</sup> Edition, 1999.
6. J. R. Raol, G. Girija, J. Singh, Modeling and Parameter Estimation of Dynamic Systems, The Institution of Electrical Engineers, 2004.
7. Rolf Johansson, System Modeling and Identification, Prentice Hall, 1993.

<b>CH441</b>	<b>FUEL CELL TECHNOLOGY</b>	<b>OPC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-requisites:** Nil.

**Course Outcomes:** At the end of the course the student will be able to:

<b>CO1</b>	Understand fuel cell fundamentals.
<b>CO2</b>	Analyze the performance of fuel cell systems.
<b>CO3</b>	Demonstrate the operation of fuel cell stack and fuel cell system.
<b>CO4</b>	Apply the modeling techniques for fuel cell systems

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	2	2	-	-	-	-	-	-	-	-	-	-	-	-
<b>CO2</b>	2	2	-	2	-	-	-	-	-	-	-	-	2	-
<b>CO3</b>	2	2	-	3	-	-	-	-	-	-	-	-	2	-
<b>CO4</b>	2	2	-	-	-	-	-	-	-	-	-	-	3	2

**Detailed syllabus:**

**Overview of Fuel Cells:** What is a fuel cell, brief history, classification, how does it work, why do we need fuel cells, Fuel cell basic chemistry and thermodynamics, heat of reaction, theoretical electrical work and potential, theoretical fuel cell efficiency.

**Fuels for Fuel Cells:** Hydrogen, Hydrocarbon fuels, effect of impurities such as CO, S and others.

**Fuel cell electrochemistry:** electrode kinetics, types of voltage losses, polarization curve, fuel cell efficiency, Tafel equation, exchange currents.

**Fuel cell process design:** Main PEM fuel cell components, materials, properties and processes: membrane, electrode, gas diffusion layer, bi-polar plates, Fuel cell operating conditions: pressure, temperature, flow rates, humidity.

Main components of solid-oxide fuel cells, Cell stack and designs, Electrode polarization, testing of electrodes, cells and short stacks, Cell, stack and system modeling

**Fuel processing:** Direct and in-direct internal reforming, Reformation of hydrocarbons by steam, CO<sub>2</sub> and partial oxidation, Direct electro-catalytic oxidation of hydrocarbons, carbon decomposition, Sulphur tolerance and removal, Using renewable fuels for SOFCs

**Reading:**

1. Hoogers G, Fuel Cell Technology Hand Book, CRC Press, 2003.
2. O'Hayre, R. P., S. Cha, W. Colella, F. B. Prinz, Fuel Cell Fundamentals, Wiley, 2006.
3. F. Barbir, PEM Fuel Cells: Theory and Practice, Elsevier/Academic Press, 2<sup>nd</sup> Edition, 2013.
4. Subhash C. Singal and Kevin Kendall, High Temperature Fuel Cells: Fundamentals, Design and Applications
5. Laminie J, Dicks A, Fuel Cell Systems Explained, 2<sup>nd</sup> Edition, John Wiley, New York, 2003.



CH442	DESIGN OF EXPERIMENTS	OPC	3 - 0 - 0	3 Credits
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

CO1	Design experiments for a critical comparison of outputs
CO2	Propose hypothesis from experimental data
CO3	Implement factorial and randomized sampling from experiments
CO4	Estimate parameters by multi-dimensional optimization

**Course Articulation Matrix:**

PO \ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	-	-	-	3	2	-	-	-	-	-	-	2	-	-
CO2	3	3	-	3		-	-	-	-	-	-	2	-	-
CO3	3	-	-	3	2	-	-	-	-	-	-	2	-	2
CO4	-	-	-	3	2	-	-	-	-	-	-	2	-	2

**Detailed syllabus:**

**Introduction:** Strategy of experimentation, basic principles, guidelines for designing experiments.

**Simple Comparative Experiments:** Basic statistical concepts, sampling and sampling distribution, inferences about the differences in means: Hypothesis testing, Choice of samples size, Confidence intervals, Randomized and paired comparison design.

**Experiments with Single Factor:** An example, The analysis of variance, Analysis of the fixed effect model, Model adequacy checking, Practical interpretation of results, Sample computer output, Determining sample size, Discovering dispersion effect, The regression approach to the analysis of variance, Nonparametric methods in the analysis of variance, Problems.

**Design of Experiments:** Introduction, Basic principles: Randomization, Replication, Blocking, Degrees of freedom, Confounding, Design resolution, Metrology considerations for industrial designed experiments, Selection of quality characteristics for industrial experiments, Parameter Estimation.

**Response Surface Methods:** Introduction, The methods of steepest ascent, Analysis of a second-order response surface, Experimental designs for fitting response surfaces: Designs for fitting the first-order model, Designs for fitting the second-order model, Blocking in response surface designs, Computer-generated (Optimal) designs, Mixture experiments, Evolutionary operation, Robust design, Problems.

**Design and Analysis:** Introduction, Preliminary examination of subject of research, Screening experiments: Preliminary ranking of the factors, active screening experiment-method of random balance, active screening experiment Plackett-Burman designs, Completely randomized block design, Latin squares, Graeco-Latin Square, Youdens Squares, Basic experiment-mathematical modeling, Statistical Analysis, Experimental optimization of research subject: Problem of optimization, Gradient optimization methods, Nongradient methods of optimization, Simplex sum rotatable design, Canonical analysis of the response surface, Examples of complex optimizations.

**Reading:**

1. Lazic Z. R., Design of Experiments in Chemical Engineering, A Practical Guide, Wiley, 2005.
2. Antony J., Design of Experiments for Engineers and Scientists, Butterworth Heinemann, 2004.
3. Montgomery D. C., Design and Analysis of Experiments, Wiley, 5<sup>th</sup> Edition, 2010.
4. Doebelin E. O., Engineering Experimentation: Planning, Execution, Reporting, McGraw-Hill, 1995.

CH443	<b>CARBON CAPTURE, SEQUESTRATION AND UTILIZATION</b>	DEC	3 - 0 - 0	3 Credits
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Identify the necessity of CO <sub>2</sub> capture, storage and utilization
<b>CO2</b>	Distinguish the CO <sub>2</sub> capture techniques
<b>CO3</b>	Evaluate CO <sub>2</sub> Storage and sequestration methods
<b>CO4</b>	Assess Environmental impact of CO <sub>2</sub> capture and utilization

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	-	-	-	-	-	2	2	-	-	-	-	-	1	-
<b>CO2</b>	-	-	-	-	-	2	2	-	-	-	-	-	1	-
<b>CO3</b>	-	-	-	-	-	2	2	-	-	-	-	-	1	-
<b>CO4</b>	-	-	-	-	-	2	2	2	-	-	-	-	1	-

**Detailed syllabus:**

**Introduction:** Global status of CO<sub>2</sub> emission trends, Policy and Regulatory interventions in abatement of carbon footprint, carbon capture, storage and utilization (CCS&U)

**CO<sub>2</sub> capture technologies from power plants:** Post-combustion capture, Pre-combustion capture, Oxy-fuel combustion, chemical looping combustion, calcium looping combustion

**CO<sub>2</sub> capture agents and processes:** Capture processes, CO<sub>2</sub> capture agents, adsorption, ionic liquids, metal organic frameworks

**CO<sub>2</sub> storage and sequestration:** Geological sequestration methods, Biomimetic carbon sequestration

**CO<sub>2</sub> Utilization:** CO<sub>2</sub> derived fuels for energy storage, polymers from CO<sub>2</sub>, CO<sub>2</sub> based solvents, CO<sub>2</sub> to oxygenated organics, Conversion into higher carbon fuels, High temperature catalysis

**Environmental assessment of CO<sub>2</sub> capture and utilization:** Need for assessment, Green chemistry and environmental assessment tools, Life cycle assessment (LCA), ISO standardization of LCA, Method of conducting an LCA for CO<sub>2</sub> capture and Utilization.

**Reading:**

1. Peter Styring, Elsje Alessandra Quadrelli, Katy Armstrong, Carbon dioxide utilization: Closing the Carbon Cycle, Elsevier, 2015.
2. Goel M, Sudhakar M, Shahi RV, Carbon Capture, Storage and, Utilization: A Possible Climate Change Solution for Energy Industry, TERI, Energy and Resources Institute, 2015.
3. Amitava Bandyopadhyay, Carbon Capture and Storage, CO<sub>2</sub> Management Technologies, CRC Press, 1<sup>st</sup> Edition, 2014.
4. Fennell P, Anthony B, Calcium and Chemical Looping Technology for Power Generation and Carbon Dioxide (CO<sub>2</sub>) Capture, Woodhead Publishing Series in Energy: No. 82, 2015.
5. Mercedes Maroto-Valer M, Developments in Innovation in Carbon Dioxide Capture and Storage Technology: Carbon Dioxide Storage and Utilization, Vol 2, Woodhead Publishing Series in Energy, 1<sup>st</sup> Edition, 2014.

<b>CS440</b>	<b>MANAGEMENT INFORMATION SYSTEMS</b>	<b>OPC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course the student will be able to:

<b>CO1</b>	Determine key terminologies and concepts including IT, marketing, management, economics, accounting, finance in the major areas of business.
<b>CO2</b>	Design, develop and implement Information Technology solutions for business problems.
<b>CO3</b>	Analysis of computing systems and telecommunication networks for business information systems.
<b>CO4</b>	Understand ethical issues that occur in business, evaluate alternative courses of actions and evaluate the implications of those actions.
<b>CO5</b>	Plan projects, work in team settings and deliver project outcomes in time.

**Course Articulation Matrix:**

CO \ PO	PO												PS	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	-	-	1	-	3	-	-	2	-	-	2	-	2	1
<b>CO2</b>	-	-	1	-	3	-	-	2	-	-	2	-	2	1
<b>CO3</b>	-	-	1	-	3	-	-	2	-	-	2	-	2	1
<b>CO4</b>	-	-	1	-	3	-	-	3	-	-	2	-	2	1
<b>CO5</b>	-	-	1	-	3	-	-	2	-	-	3	-	2	1

**Detailed syllabus:**

Organization and Information Systems, Foundation Concepts, Information Systems in Business, Components of Information Systems, Competing with Information Technology, Fundamentals of Strategic Advantage, Using Information Technology for Strategic Advantage.

Changing Environment and its impact on Business, Kinds of Information Systems.

Computer Fundamentals, Computer Hardware, Computer Systems: End User and Enterprise Computing, Computer Peripherals: Input, Output, and Storage Technologies, Computer Software, Application Software, System Software, Computer System Management, Data Resource Management, Technical Foundations of Database Management, Managing Data Resources

Telecommunication and Networks, Telecommunications and Networks, The Networked Enterprise, Telecommunications Network Alternatives

System Analysis and Development and Models, Developing Business/IT Strategies, Planning Fundamentals, Implementation Challenges, Developing Business/IT Solutions, Developing Business Systems, Implementing Business Systems

Manufacturing and Service Systems Information systems for Accounting, Finance, Production and Manufacturing, Marketing and HRM functions, Enterprise Resources Planning (ERP), Choice of IT, Nature of IT decision, Managing Information Technology, Managing Global IT, Security and Ethical Challenges, Security and Ethical Challenges, Security and Ethical, and Societal Challenges of IT, Security Management of Information Technology, Enterprise and Global Management of Information Technology.

**Reading:**

1. Kenneth J Laudon, Jane P. Laudon, Management Information Systems, 10<sup>th</sup> Edition, Pearson/PHI, 2007.
2. W. S. Jawadekar, Management Information Systems, 3<sup>rd</sup> Edition, TMH, 2004.

<b>BT440</b>	<b>BIOSENSORS</b>	<b>OPC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Understand bio-sensing and transducing techniques
<b>CO2</b>	Understand principles of linking cell components and biological pathways with energy transduction, sensing and detection
<b>CO3</b>	Demonstrate appreciation for the technical limits of performance of biosensor
<b>CO4</b>	Apply principles of engineering to develop bio-analytical devices and design of biosensors

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	3	2	2	-	1	2	-	-	-	-	-	-	1	-
<b>CO2</b>	3	2	2	-	1	2	-	-	-	-	-	-	1	-
<b>CO3</b>	3	2	2	-	1	2	-	-	-	-	-	-	1	-
<b>CO4</b>	3	2	2	-	1	2	-	-	-	-	-	-	2	-

**Detailed Syllabus:**

**General principles:** A historical perspective; Signal transduction; Physico-chemical and biological transducers; Sensor types and technologies, Definitions and Concepts Terminology and working vocabulary; Main technical definitions: calibration, selectivity, sensitivity, reproducibility, detection limits, response time.

**Physico-chemical transducers:** Electrochemical transducers (amperometric, potentiometric, conductimetric); optical transducers (absorption, fluorescence, SPR); Thermal transducers; piezoelectric transducers.

**Biorecognition systems and Biosensor Engineering:** Enzymes; Oligonucleotides and Nucleic Acids; Membrane receptors, Cells; Immunoreceptors; Limitations & problems.

Immobilization of biomolecules, Methods for biosensors fabrication: self-assembled monolayers, screen printing, photolithography, micro-contact printing, MEMS.

**Application of modern sensor technologies:** Clinical chemistry; Test-strips for glucose monitoring; Urea determination; Implantable sensors for long-term monitoring; Environmental monitoring; Technological process control; Food quality control; Forensic science benefits; Problems & limitations.

**Reading:**

1. Donald G. Buerk, Biosensors: Theory and Applications, 1<sup>st</sup> Edition, CRC Press, 2009.
2. Alice Cunningham, Introduction to Bioanalytical Sensors, John Wiley & Sons, 1998.  
Brian R. Eggins, Chemical Sensors and Biosensors, John Wiley & Sons, 2003.



<b>SM440</b>	<b>HUMAN RESOURCE MANAGEMENT</b>	<b>OPC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Understand principles, processes and practices of human resource management.
<b>CO2</b>	Apply HR concepts and techniques in strategic planning to improve organizational performance.
<b>CO3</b>	Understand tools to manage HR systems and procedures.

**Course Articulation Matrix:**

CO \ PO	PO												PS	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PS02
<b>CO1</b>	2	2	-	-	-	-	-	-	2	1	2	-	-	1
<b>CO2</b>	2	2	-	-	-	-	-	-	2	1	2	-	-	1
<b>CO3</b>	2	2	-	-	-	-	-	-	2	1	2	-	-	1

**Detailed Syllabus:**

**Introduction to Human Resource Management:** Objectives, Scope and Significance of HRM, Functions of HRM, Problems and Prospects in HRM, Environmental scanning.

**Human Resource Planning:** Demand Forecasting Techniques, Supply Forecasting Techniques, Analyzing work and designing jobs, Recruitment and Selection, Interviewing Candidates.

**Human Resource Development:** Orientation, Training and Development, Management, Development, Performance Appraisal and Employee Compensation, Factors Influencing, Employee Remuneration and Challenges of Remuneration.

Industrial Relations, Industrial Disputes and Discipline, Managing Ethical Issues in Human Resource Management, Workers Participation in Management, Employee safety and health, Managing Global Human Resources and Trade Unions

International HRM, Future of HRM and Human Resource Information Systems

**Reading:**

1. Aswathappa, Human Resource Management -TMH, 2010.
2. Garry Dessler and BijuVarkkey, Human Resource Management, PEA, 2011.
3. Noe & Raymond, HRM: Gaining a Competitive Advantage, TMH, 2008.
4. Bohlander George W, Snell Scott A, Human Resource Management, Cengage, 2009.

<b>MA440</b>	<b>OPTIMIZATION TECHNIQUES</b>	<b>OPC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Formulate and solve linear Programming Problems
<b>CO2</b>	Determine the optimum solution to constrained and unconstrained
<b>CO3</b>	Apply dynamic programming principle to Linear programming problems.
<b>CO4</b>	Determine the integer solutions to Linear Programming Problems.

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	3	3	1	1	2	-	-	-	-	-	-	-	2	1
<b>CO2</b>	3	3	1	1	2	-	-	-	-	-	-	-	2	1
<b>CO3</b>	3	3	1	1	2	-	-	-	-	-	-	-	2	1
<b>CO4</b>	3	3	1	1	2	-	-	-	-	-	-	-	2	1

**Detailed Syllabus:**

**Linear Programming:** Introduction and formulation of models, Convexity, Simplex method, Big-M method, Two-phase method, Degeneracy, non-existent and unbounded solutions, revised simplex method, duality in LPP, dual simplex method, sensitivity analysis, transportation and assignment problems, traveling salesman problem .

**Nonlinear Programming:** Introduction and formulation of models, Classical optimization methods, equality and inequality constraints, Lagrange multipliers and Kuhn-Tucker conditions, quadratic forms, quadratic programming problem, Wolfe's method.

**Dynamic Programming:** Principle of optimality, recursive relations, solution of LPP.

**Integer Linear Programming:** Gomory's cutting plane method, Branch and bound algorithm, Knapsack problem, linear 0-1 problem.

**Reading:**

1. Kanti Swarup, Man Mohan and P.K.Gupta, Introduction to Operations Research, S.Chand & Co., 2006
2. J.C. Pant, Introduction to Operations Research, Jain Brothers, New Delhi, 2008.
3. N.S. Kambo, Mathematical Programming Techniques, East-West Pub., Delhi, 1991.

<b>MA441</b>	<b>OPERATIONS RESEARCH</b>	<b>OPC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Formulate and solve linear programming problems
<b>CO2</b>	Determine optimum solution to transportation problem
<b>CO3</b>	Determine average queue length and waiting times of queuing models.
<b>CO4</b>	Determine optimum inventory and cost in inventory models.

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	3	3	1	1	2	-	-	-	-	-	-	-	1	1
<b>CO2</b>	3	3	1	1	2	-	-	-	-	-	-	-	2	1
<b>CO3</b>	3	3	1	1	2	-	-	-	-	-	-	-	2	1
<b>CO4</b>	3	3	1	1	2	-	-	-	-	-	-	-	2	1

**Detailed Syllabus:**

**Linear Programming:** Formulation and graphical solution of LPP's. The general LPP, slack, surplus and artificial variables. Reduction of a LPP to the standard form. Simplex computational procedure, Big-M method, Two-phase method. Solution in case of unrestricted variables. Dual linear programming problem. Solution of the primal problem from the solution of the dual problems.

**Transportation Problems:** Balanced and unbalanced Transportation problems. Initial basic feasible solution using N-W corner rule, row minimum method, column minimum, least cost entry method and Vogel's approximation method. Optimal solutions. Degeneracy in Transportation problems. Queuing Theory: Poisson process and exponential distribution. Poisson queues - Model (M/M/1): ( $\infty$ /FIFO) and its characteristics.

**Elements of Inventory Control:** Economic lot size problems - Fundamental problems of EOQ. The problem of EOQ with finite rate of replenishment. Problems of EOQ with shortages - production instantaneous, replenishment of the inventory with finite rate. Stochastic problems with uniform demand (discrete case only).

**Reading:**

1. K. Swarup, Manmohan & P.K.Gupta, Introduction to Operations Research, S.Chand & Co., 2006
2. J.C. Pant, Introduction to Operations Research, Jain Brothers, New Delhi, 2008.
3. N.S. Kambo, Mathematical Programming Techniques, East-West Pub., Delhi, 1991.

PH440	NANOMATERIALS AND TECHNOLOGY	OPC	3 - 0 - 0	3 Credits
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Understand synthesis and properties of nanostructured materials.
<b>CO2</b>	Analyze magnetic and electronic properties of quantum dots.
<b>CO3</b>	Understand structure, properties and applications of Fullerenes and Carbon nanotubes.
<b>CO4</b>	Understand applications of nanoparticles in nanobiology and nanomedicine.

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	3	1	1	1	-	-	-	-	-	-	-	-	1	-
<b>CO2</b>	3	1	1	1	-	-	-	-	-	-	-	-	2	-
<b>CO3</b>	3	1	1	1	-	-	-	-	-	-	-	-	1	-
<b>CO4</b>	3	1	1	1	-	-	-	-	-	-	-	-	1	-

**Detailed Syllabus:**

**General properties of Nano materials:** Origin of nanotechnology. Classification of nanomaterials. Fullerene, carbon nanotubes (CNT's), Nanoparticles. Physical, Chemical, Electrical, Optical, Magnetic and mechanical properties of nanomaterials.

**Fullerenes and Carbon Nanotubes (CNT's):** Introduction: Synthesis and purification. Preparation of fullerenes in the condensed phase, Transport, mechanical, physical properties of CNT's.

**Investigation and manipulating materials in the Nanoscale:** Electron microscope, scanning probe microscopes, optical microscopes for Nanoscience and Technology, X-Ray Diffraction.

SAMs and clusters: Growth process. Patterning monolayers. Types of clusters. Bonding and properties of clusters.

**Semi conducting Quantum Dots:** Introduction: Synthesis of Quantum Dots. Electronic structure of Nanocrystals, properties.

**Nanobiology:** Interaction between Biomolecules and Nanoparticle surfaces. Different types of Inorganic materials used for the synthesis of Hybrid Nano-bio assemblies. Nanoprobes for Analytical Applications.

**Nanosensors:** Nanosensors based on optical properties. Nanosensors based on quantum size effects. Nanobiosensors.

**Nanomedicines:** Developments of nanomedicines. Nanotechnology in Diagnostic Applications, materials for use in Diagnostic and therapeutic Applications.

**Reading:**

1. T.Pradeep, Nano: The Essentials; Tata McGraw-Hill, 2008.
2. W.R.Fahrner, Nano technology and Nanoelectronics; Springer, 2006.
3. Richard Booker and Earl Boysen, Nanotechnology, Willey, 2006.

PH441	BIOMATERIALS AND TECHNOLOGY	OPC	3 - 0 - 0	3 Credits
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course the student will be able to:

<b>CO1</b>	Understand the structure and properties of biomaterials
<b>CO2</b>	Classify implant biomaterials
<b>CO3</b>	Evaluate biocompatibility of implants
<b>CO4</b>	Identify appropriate biomaterials for specific medical applications

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	3	3	1	1	-	1	2	1	-	-	-	-	1	-
<b>CO2</b>	3	3	1	1	-	1	2	1	-	-	-	-	1	-
<b>CO3</b>	3	3	1	1	-	1	2	1	-	-	-	-	2	-
<b>CO4</b>	3	3	1	1	-	1	2	1	-	-	-	-	2	-

**Detailed Syllabus:**

**Overview of biomaterials:** Historical developments, impact of biomaterials, interfacial phenomena, tissue responses to implants.

**Structure and properties of biomaterials:** Crystal structure of solids, phase changes, imperfections in solids, non-crystalline solids, surface properties of solids, mechanical properties, surface improvements.

**Types of biomaterials:** Metallic implant materials, ceramic implant materials, polymeric implant materials composites as biomaterials.

**Characterization of materials:** Electric properties, optical properties, X-ray absorption, acoustic and ultrasonic properties.

**Bio implantation materials:** Materials in ophthalmology, orthopedic implants, dental materials and cardiovascular implant materials.

**Tissue response to implants:** Normal wound healing processes, body response to implants, blood compatibility, structure - property relationship of tissues.

**Reading:**

1. JoonPark, R.S. Lakes, Biomaterials an introduction; 3<sup>rd</sup> Edition, Springer, 2007
2. Sujatha V Bhat, Biomaterials; 2<sup>nd</sup> Edition, NarosaPublishing House, 2006.

CY441	CHEMISTRY OF NANOMATERIALS	OPC	3 - 0 - 0	3 Credits
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Demonstrate a systematic knowledge of the range and breadth of application of nanomaterials.
<b>CO2</b>	Review critically the potential impact, in all classes of materials, of the control of nanostructure
<b>CO3</b>	Describe the methods for the synthesis and nano structural characterization of such materials.
<b>CO4</b>	Identify the possible opportunities for nanomaterials in society development and enhancement.

**Course Articulation Matrix:**

CO \ PO	PO													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	3	1	1	1	-	2	2	-	-	-	-	-	1	-
<b>CO2</b>	3	1	1	1	-	2	2	-	-	-	-	-	1	-
<b>CO3</b>	3	1	1	1	-	2	2	-	-	-	-	-	1	-
<b>CO4</b>	3	1	1	1	-	2	2	-	-	-	-	-	2	-

**Detailed Syllabus:**

**Introduction:** Review the scope of nanoscience and nanotechnology, understand the nanoscience in nature, classification of nanostructured materials and importance of nano materials.

**Synthetic Methods:** Teach the basic principles for the synthesis of Nanostructure materials by Chemical Routes (Bottom-Up approach):-Sol-gel synthesis, microemulsions or reverse micelles, solvothermal synthesis, microwave heating synthesis and sonochemical synthesis and Physical methods (Top-Down approach):- Inert gas condensation, plasma arc technique, ion sputtering, Laser ablation, laser pyrolysis, and chemical vapour deposition method.



**Techniques for characterization:** Learning of characterization method by various techniques like, Diffraction Technique:-Powder X-ray diffraction for particle size analysis, Spectroscopy Techniques:-Operational principle and applications of spectroscopy techniques for the analysis of nano materials, UV-VIS spectro photometers and its application for band gap measurement, Electron Microscopy Techniques:-Scanning electron microscopy (SEM) and EDAX analysis, transmission electron microscopy (TEM), scanning probe microscopy (SPM) BET method for surface area determination and Dynamic light scattering technique for particle size analysis.

**Studies of nano-structured Materials:** Synthesis, properties and applications of the following nanomaterials: fullerenes, carbon nanotubes, core-shell nanoparticles, nanoshells, self- assembled monolayers, and monolayer protected metal nanoparticles, nanocrystalline materials.

**Reading:**

1. T Pradeep, NANO: The Essentials, McGraw-Hill, 2007.
2. B S Murty, P Shankar, Baldev Rai, B B Rath and James Murday, Textbook of Nanoscience and nanotechnology, Univ. Press, 2012.
3. Guozhong Cao, Nanostructures & Nanomaterials; Synthesis, Properties & Applications, Imperial College Press, 2007.
4. M.A. Shah and Tokeer Ahmad, Principles of Nanoscience and Nanotechnology, Narosa Pub., 2010.
5. Manasi Karkare, Nanotechnology: Fundamentals and Applications, IK International, 2008.
6. C.N.R. Rao, Achim Muller, K. Cheetham, Nanomaterials Chemistry, Wiley-VCH, 2007.

<b>HS440</b>	<b>CORPORATE COMMUNICATION</b>	<b>OPC</b>	<b>3 - 0 - 0</b>	<b>3 Credits</b>
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**Pre-requisites:** Nil

**Course Outcomes:** At the end of the course, the student will be able to:

<b>CO1</b>	Understand corporate communication culture
<b>CO2</b>	Prepare business letters, memos and reports
<b>CO3</b>	Communicate effectively in formal business situations
<b>CO4</b>	Exhibit corporate social responsibility and ethics
<b>CO5</b>	Practice corporate email, mobile and telephone etiquette
<b>CO6</b>	Develop good listening skills and leadership qualities

**Course Articulation Matrix:**

CO \ PO	PO												PSO	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	-	-	-	-	-	-	-	3	1	3	2	-	1	-
<b>CO2</b>	-	-	-	-	-	-	-	3	1	3	2	-	1	-
<b>CO3</b>	-	-	-	-	-	-	-	3	1	3	2	-	1	-
<b>CO4</b>	-	-	-	-	-	-	-	3	1	3	2	-	1	-
<b>CO5</b>	-	-	-	-	-	-	-	3	1	3	2	-	1	-
<b>CO6</b>	-	-	-	-	-	-	-	3	1	3	2	-	1	-

**Detailed Syllabus:**

**Importance of Corporate communication:** Introduction to and definition of corporates - Communication, process, patterns and channels of communication- Barriers to communication and strategies to overcome them- Evolution of corporate culture- Role and contribution of individual group and organization - Role of psychology in communication.

**Oral Communication:** Techniques for improving oral fluency-Speech mechanics-Group Dynamics and Group Discussion - Debate and oral presentations.

**Written Communication:** Types and purposes- Writing business reports, and business proposals- Memos, minutes of meetings- Circulars, persuasive letters- Letters of complaint- ; language and formats used for drafting different forms of communication. Internal and external communication.

**Corporate responsibility:** Circulating to employees vision and mission statements- ethical practices- Human rights -Labour rights-Environment- governance- Moral and ethical debates surrounding -Public Relations - Building trust with stakeholders.

**Corporate Ethics and Business Etiquette:** Integrity in communication-Harmful practices and communication breakdown- Teaching how to deal with tough clients through soft skills. Body language- Grooming- Introducing oneself- Use of polite language- Avoiding grapevine and card pushing - Etiquette in e-mail, mobile and telephone.

**Listening Skills:** Listening- for information and content- Kinds of listening- Factors affecting listening and techniques to overcome them- retention of facts, data and figures- Role of speaker in listening.

**Leadership Communication Styles:** Business leadership -Aspects of leadership-qualities of leader- training for leadership-delegation of powers and ways to do it-humour-commitment.

**Reading:**

1. Raymond V. Lesikar, John D. Pettit, Marie E. Flatley Lesikar's Basic Business Communication - 7th Edition: Irwin, 1993
2. Krishna Mohanand Meera Banerji, Developing Communication Skills: Macmillan Publishers India, 2000
3. R.C. Sharma & Krishna Mohan Business Correspondence and Report Writing: - 3rd Edition Tata McGraw-Hill, 2008
4. Antony Jay & Ross Jay, Effective Presentation, University Press, 1999.
5. Shirley Taylor, Communication for Business, Longman, 1999