

Savitribai Phule Pune University

UG CHOICE BASED CREDIT SYSTEM



RULES AND REGULATIONS

FOR
UNDER GRADUATE PROGRAMME IN ENGINEERING
UNDER
FACULTY OF SCIENCE AND TECHNOLOGY
WITH EFFECTIVE FROM A.Y. 2019-20

Course Structure, Guidelines, Rules and Regulations

Preamble

Economic progress of country is strongly linked with quality of technical education. Engineering education is gaining new heights and it contributes substantial share in overall education system. Engineering graduates are to be educated and trained with a view of employability and sustainability. With the advent of technology and ever-changing expectations from the Industry and Society, revision of curriculum is need of the day, making it contemporary and relevant. In a bid to fine tune our technical education system to the global standards & practices, the Credit-Grade based performance and assessment system has been already implemented with effect from June 2015 onwards for all the Under Graduate Programme (UG) under the Faculty of Science & Technology.

To fulfill the necessities, the youngsters pursuing engineering studies need to be well equipped and acquaint with the latest technological trends and industrial requirements. This is possible only when the students undergo studies with an updated and evolving curriculum to match global scenario. The faculty of Science & Technology has shouldered the idea of incorporating latest advances and to upgrade the course contents with latest and relevant topics and know-how. Accordingly the new structure and curriculum are being introduced to be implemented from the academic year 2019-20 for First Year Engineering and the process will continue for subsequent years for second, third and fourth year engineering.

General Guidelines

1. All undergraduate programmes in Engineering under faculty of Science & Technology will be of **four years** duration and **eight semesters**.
2. The total number of credits required to earn for the **completion of the programme is 170 credits** in a minimum period of **eight semesters**.
3. All UG programme, under Faculty of Science & Technology shall be offered with **170 credit**; one credit is approximately equivalent to 15 contact hours.
4. Assessments in Choice based Credit System consists of
 - A) In-semester examination
 - B) End-semester examination
 - C) Continuous assessment for various examination heads.Assessment and Evaluation is to be done as per guidelines provided by competent authority.
5. Semester 1 and semester 2 will be part of First Year of Engineering (FE), Semester 3 and semester 4 will be part of Second Year of Engineering (SE), Semester 5 and semester 6 will be part of Third Year of Engineering (TE), Semester 7 and semester 8 will be part of Final Year of Engineering (BE)
6. **Induction Program**

Induction programme for first year students is introduced to familiarize them to the new environment and encourage them to learn beyond classrooms. Objective is to help new students adjust and feel comfortable in the new environment, inculcate in them the ethos and culture of the institution, help them build bonds with other students and faculty members, and expose them to a sense of larger purpose and self exploration. Induction Program should be preferably of 3 weeks (**2 weeks at beginning first semester and 1 week at the beginning of second semester**). In order to implement the (SIP) in the College the following activities can be taken at College.

- Physical Activity: - This would involve a daily routine of physical activity with games and sports.
- Creative Arts: - Every students would chose one skill related to arts whether visual arts or performing arts.
- Mentoring and Universal Human values:-Mentoring and connecting the students with faculty members and other students is the most important part of student induction. This can be effectively done by forming a group of 22-24 students with a

faculty mentor each. This can be implemented through group discussion and real life activities rather than only lecturing.

- Familiarization with College, Department and Branch :-The incoming student should be told about the credit, grading system and scheme of the examination. They should be explained how the study in College differs from the study in school. They should be taken on College tour and shown important facilities such as library, canteen, gymkhana etc. They should be shown their own department.
- Literary Activity:-Literary Activity would compass reading book, writing a summary, debating, enacting a play etc.
- Proficiency modules: - The modules can be designed to overcome some critical lacunas that students might have like English Speaking, Computer familiarity etc.
- Lectures by Eminent People: - The lectures of Eminent people be organized to expose the students to social activity and public life.
- Visit to local Area:-A couple of visits to the landmarks of the city or a hospital or orphanage could be organized.
- Extracurricular activities in College:-The new students should be introduced to the extracurricular activities at the College.
- Feedback and Report on the program:-Students should be asked to give their mid program Feedback wherein each group of 22-24 students should be asked to prepare a single report on their experience of the program.

To summarize the above activity the sequence of activities can be planned as given below:

- Address by Principal, HOD's and other functionaries and welcome the new students along with their parents.
- The branch wise allocation of students to be done and a group of 22-24 students is to be formed along with one faculty as mentor.
- A detail time table of various activities is to be prepared and displayed for all students. The timetable should give details of location and details of faculty in charge of the activity.
- The visit to local areas can be arranged on Saturdays.
- The various activities to be carried out can be divided into three phases :-
 1. Initial phase:- Which may include Address by Principal, HOD's and other functionaries College and Dept Visit, interaction with parents Forming of students group and assigning of mentor mentee.
 2. Regular Phase:- This phase may include the activities such as creative arts / universal Human values Games & Sports in the morning session and in the afternoon session. Literary activities, Proficiency module, Lectures & workshop, Extracurricular Activities etc. can be scheduled.
 3. Closing Phase:- This phase may include taking feedback of students, preparation of Report by each group, Test of creative Arts, Human Values can be taken.

These are summarized guidelines to be given to the student inducing induction programme (SIP). Please refer SIP Manual published by AICTE for detail guidelines[2].

7. **Project based Learning:**

For better learning experience, along with traditional classroom teaching and laboratory work based learning, project based learning has been introduced with an objective to motivate students to learn by working in group (**5 to 6 students per group**) courteously to

solve a problem. Students may undertake a problem which can be theoretical, practical, social, technical, symbolic, cultural and/or scientific and grows out of students' wondering within different disciplines and professional environments. A chosen problem has to be **exemplary**. The problem may involve an interdisciplinary approach in both the analysis and solving phases. Such practice will also increase their capacity and learning through shared cognition. [3] [5].

8. **Laboratory Course:**

The laboratory work will be based on completion of experiments/ lab assignments confined to the related companion courses of the semester.

9. **Seminar:**

Seminar shall be on state-of-the-art topic selected by student and approved by the authority. The student shall submit the duly certified seminar report in standard format, for satisfactory completion of the work by the concerned Guide and head of the department/institute.

10. **Project Work at Final Year:**

Project work in the seventh semester is an integral part of the project work. The project work shall be based on the knowledge acquired by the student during the graduation and preferably it should meet and contribute towards the needs of the society. The project aims to provide an opportunity of designing and building complete system or subsystems based on area where the student likes to acquire specialized skills. The student shall prepare the duly certified final report of project work in standard format for satisfactory completion of the work by the concerned guide and head of the Department/Institute.

11. **Internship**

Internships are educational and career development opportunities, providing practical experience in a field or discipline. Internships are far more important as employers are looking for employees who are properly skilled. They are structured, short-term, supervised placements often focused around particular tasks or projects with defined time scales. Core objective is to expose technical students to the industrial environment, which cannot be simulated/experienced in the classroom and hence creating competent professionals in the industry and to understand the social, economic and administrative considerations that influence the working environment of industrial organizations. Student may choose to undergo Internship at Industry/Govt./NGO/MSME/Rural Internship/ Innovation/ IPR/Entrepreneurship. Student may choose either to work on innovation or entrepreneurial activities resulting in start-up or undergo internship with industry/NGO's/Government organizations/Micro/Small/ Medium enterprises to make themselves ready for the industry [4]. Conduction, monitoring, assessment, and evaluation is to be done as per guidelines provided by AICTE [4].

12. **Abbreviations:**

TW: Term Work **TH:** Theory **OR:** Oral **TUT:** Tutorial **PR:** Practical
Sem: Semester, **PROJ:** Project Work, **ESE:** End Semester Examination **ISE:** In Semester Examination, **CA:** Continuous Assessment, **DW:** Drawing.

Definition of Credit [1]:**

1 Hour Lecture (L) per week	1 credit for 1 Hour
Tutorial (T) per week	1 credit for 1 Hour
Practical (P) per week 2 Hours Practical(Lab)/week	1 credit for 2 Hours

** The head of Tutorial and Practical (as a special case) may be merged for common credit with the permission of authority.

This document includes following sections-

- I. Undergraduate Engineering Programme Structure
 - II. Examination Scheme
 - III. Structure of Question Paper
 - IV. Assessment
 - V. Rules of Passing
 - VI. Rules of ATKT (Allowed To Keep Term)
 - VII. Assessment and Grade Point Average
 - VIII. Performance Indices
 - IX. Result
- References

1) UG Programme Structure and Credit Distribution:

Each B.E. / B. Tech. programme is of 4 years duration. The minimum total number of credit requirement for each programme is 170. In the structure, the credits are distributed over 8 semesters. The open elective included, gives the student a wide choice of subjects from other programme. The Credit structure for Bachelor of Engineering programme is given below in Table 1.

TABLE 1: Credit Structure for UG programme in Engineering

Credits offered									
Course Work	Semester								Total
	I	II	III	IV	V	VI	VII	VIII	
Professional Theory Courses *	17	16	15	15	12	06	06	06	90
Elective Courses [^]	-	-	-	-	03	03	06	06	18
Laboratory Courses/ continuous assessment/TW	05	04	07	05	05	05	06	02	42
Seminar & Communication Skills	-	-	-		01	01		-	02
Project Work	-	-	-	-	-	02	02	06	10
Project Based Learning		02		02	--	--	--	--	04
Internship ^{\$}	--	--	--	--		04	--	--	04
Total	22	22	22	22	21	21	20	20	170
Mandatory Non_Credit_Graded_Audit Course [#] per semester									
Induction Program at first year Engineering	3 week duration (2 week at the beginning of Sem-I & 1 week at the beginning of Sem -II)								

*: Professional Courses include - Engineering Science Courses including Workshop, Drawing, basics of Electrical/Electronics/Mechanical/Computer/Civil Engineering, Humanities and Social Sciences including Management/Finance Management courses, Basic Science courses and Professional core courses.

[^]: Professional Elective courses relevant to chosen specialization/branch and Open Electives (interdisciplinary and /or emerging technology)

[#]: There will be mandatory **Non_Credit Course** per Semester viz- Environmental Studies, Indian Constitution, Essence of Indian Traditional Knowledge, financial Management and courses introduced time to time by university or apex bodies.

^{\$}: Internship to be completed after semester 5 and to be assessed in semester 6. Internship will be of 4 to 6 weeks maximum.

TABLE -2 First Engineering _Structure for Semester-I

Course Code	Course Name	Teaching Scheme (Hours/Week)			Examination Scheme and Marks						Credits			
		Theory	Practical	Tutorial	ISE	ESE	TW	PR	OR	Total	TH	PR	TUT	Total
107001	Engineering Mathematics-I	03	--	01	30	70	25	--	--	125	03	--	01	04
107002/ 107009	Engineering Physics / Engineering Chemistry	04	02	--	30	70	--	25	--	125	04	01	--	05
102003	Systems in Mechanical Engineering	03	02	--	30	70	--	25	--	125	03	01	--	04
103004/ 104010	Basic Electrical Engineering / Basic Electronics Engineering	03	02	--	30	70	--	25	--	125	03	01	--	04
110005/ 101011	Programming and Problem Solving / Engineering Mechanics	03	02	--	30	70	--	25	--	125	03	01	--	04
111006	Workshop [@]	--	02	--	--	--	--	25	--	25	--	01	--	01
Total		16	10	01	150	350	25	125	--	650	16	05	01	22
101007	Audit Course 1 ^{&}	02	Environmental Studies-I											

Induction Program : 2 weeks at the beginning of semester-I and 1 week at the beginning of semester-II

TABLE -3 First Engineering _Structure for Semester-II

Course Code	Course Name	Teaching Scheme (Hours/Week)			Examination Scheme and Marks						Credits			
		Theory	Practical	Tutorial	ISE	ESE	TW	PR	OR	Total	TH	PR	TUT	Total
107008	Engineering Mathematics-II	04	--	01	30	70	25	--	--	125	04	--	01	05
107002/ 107009	Engineering Physics/ Engineering Chemistry	04	02	--	30	70	--	25	--	125	04	01	--	05
103004/ 104010	Basic Electrical Engineering / Basic Electronics Engineering	03	02	--	30	70	--	25	--	125	03	01	--	04
110005/ 101011	Programming and Problem Solving / Engineering Mechanics	03	02	--	30	70	--	25	--	125	03	01	--	04
102012	Engineering Graphics ^Ω	01	02	01	--	50	25		--	75	01	01		02
110013	Project Based Learning [§]	--	04	--	--	--	25	50	--	75	--	02	--	02
Total		15	12	02	120	330	75	125	--	650	15	05	02	22
101014	Audit Course 2 ^{&}	02	Environmental Studies-II											
107015		--	Physical Education-Exercise and Field Activities											

Instructions:

- PR/Tutorial must be conducted in three batches per division.
- Minimum number of required Experiments/Assignments in PR/ Tutorial shall be carried out as mentioned in the syllabi of respective subjects.
- Every Student should appear for Engineering Physics, Engineering Chemistry, Engineering Mechanics, Basic Electrical Engineering, Basic Electronics Engineering, Programming and Problem solving during the year.
- College is allowed to distribute Teaching workload of subjects Engineering Physics, Engineering Chemistry, Basic Electrical Engineering, Basic Electronics Engineering, Engineering Mechanics, Programming and Problem solving in semester I and II dividing number of FE divisions into two appropriate groups.
- Assessment of tutorial work has to be carried out as term-work examination. Term-work Examination and Practical Examination at first year of engineering course **shall be internal continuous assessment only.**

Ω 1 Credit for Engineering Graphics theory has to be awarded on the basis of End semester examination of 50 marks while 1 credit of tutorial and practical **shall be awarded on internal continuous assessment only.**

@ Credit for the course of workshop practical is to be awarded on the basis of continuous assessment / submission of job work.

§ Project based learning (PBL) requires continuous mentoring by faculty throughout the semester for successful completion of the tasks selected by the students per batch. While assigning the teaching workload a load of 2 Hrs/week/batch needs to be considered for the faculty involved. The Batch needs to be divided into sub-groups of 5 to 6 students. Assignments / activities / models/ projects etc. under project based learning is carried throughout semester and Credit for PBL has to be awarded on the basis of internal continuous assessment and evaluation at the end of semester.

& Audit course for Environmental Studies and II (As per D.O.No.F.13-1/2000 (EA/ENV/COS-I) dated 14 May, 2019) is mandatory but non-credit course. Examination has to be conducted at the end of Sem I & II respectively for award of grade at college level. Grade awarded for audit course shall not be calculated for grade point & CGPA.

Audit course for Physical education is mandatory non-credit course. Examination has to be conducted at the end of Semester for award of grade at college level. Grade awarded for audit course shall not be calculated for grade point & CGPA.

TABLE -4 Structure for Semester-III

Subject Head	Duration (Hrs/week)	ISE	ESE	PR/OR Marks	TW Marks	Credits
Theory	15	150	350			15
PR/OR/Tut	14			100	100	07
Total	29	150	350	100	100	22

TABLE -5 Structure for Semester-IV

Subject Head	Duration (Hrs/week)	ISE	ESE	PR/OR Marks	TW Marks	Credits
Theory	15	150	350			15
PR/OR/Tut	10			100	50	05
Project based learning	04				50	02
Total	29	150	350	100	100	22

TABLE -6 Structure for Semester-V

Subject Head	Duration (Hrs/week)	ISE	ESE	PR/OR Marks	TW Marks	Credits
Theory	15	150	350			15
PR/OR/Tut	10			100	50	05
Seminar	01				50	01
Total	26	150	350	100	100	21

TABLE -7 Structure for Semester-VI

Subject Head	Duration (Hrs/week)	ISE	ESE	PR/OR Marks	TW Marks	Credits
Theory	12	120	280			12
PR/OR/Tut	10			100	100	05
Internship	04				100	04
Total	26	120	280	100	200	21

TABLE -8 Structure for Semester-VII

Subject Head	Duration (Hrs/week)	ISE	ESE	PR/OR Marks	TW Marks	Credits
Theory	12	120	280			12
PR/OR/Tut	08			100	50	04
Moocs etc.					50	02
Project Stage-1	04			50	50	02
Total	24	120	280	150	150	20
Credits of MOOCs Courses shall be awarded based on completion of relevant course (recommended by college / University) of equivalent or more credits and submission of Certificate to college. College shall submit the same to university through online process to be followed in due course.						

TABLE -9 Structure for Semester-VIII

Subject Head	Duration (Hrs/week)	ISE	ESE	PR/OR Marks	TW Marks	Credits
Theory	12	120	280			12
PR/OR/Tut	04			100	50	02
Project Stage-2	12			50	100	06
Total	28	120	280	150	150	20

Note: Any Course offered (Semester-III to Semester-VIII) should be of minimum 2 credits.

2. Examination Scheme:

R.21

The theory examination shall be conducted in two phases for all the subjects of semester-I to semester-VIII.

R2.1.1: Phases of Examination

Phase I as In-Semester Examination of 30 marks written theory examination based on Unit-1 and Unit-2 of course syllabus scheduled by university

Phase II as End-Semester Examination of 70 marks written theory examination based on unit number 3, 4, 5, 6 of course syllabus scheduled by university.

3. Structure of Question Paper:

R3.1 Two units (Unit1 and Unit 2) will be covered for 30 Marks for Phase 1 (ISE). Equal weightage will be given to both the units (15 Marks each)

R3.2 Four units (Unit 3, Unit 4, Unit 5 and Unit 6) shall have weightage of 70 Marks for Phase 2 (ESE). Marks weightage for the unit 3, unit 4, unit 5 and unit 6 shall be as shown in Table no.10

- Marks weightage to be given for questions per unit is as –

TABLE -10. Marks weightage per unit for examination

Unit Number	Phase I ISE Marks Weightage	Phase II ESE Marks Weightage
1	15	--
2	15	--
3		18
4	-	17
5	--	18
6	-	17

R3.3 Paper will have only one section and two questions for ISE and four questions for ESE. For each question there will be alternate Question based on same unit and of the same marks.

R3.4 Framing of questions should be according to Anderson/Blooms Taxonomy and disseminated through the question papers with a mention of course outcomes as well.

4. Assessment

A. Theory:

R4.1

ISE assessment will be done at the centralized assessment programme (CAP) Centre of the College by the Expert who is appointed as an examiner for the courses as per 48(3) panel of Maharashtra public university act 2016.

R4.2

ESE assessment will be done at the CAP Centre designated by the University by the Expert who is appointed as an examiner for the subject as per 48(3) panel.

B. Term work:

R4.3

Term Work assessment shall be conducted for the Lab Practice, Project, Tutorials and Seminar. Term work is continuous assessment based on work done, submission of work in the form of report/journal, timely completion, attendance, and understanding. It should be assessed by subject teacher of the institute for first to sixth semester and by the external examiner at seventh and eighth semester. At the end of the semester, the final grade for a Term Work shall be assigned based on the performance of the student and is to be submitted to the Savitribai Phule Pune University (SPPU). A student who fails in the Term Work on account of unsatisfactory performance shall be given F grade and on the account of inadequate attendance shall be given FX grade. Failing in a particular course Term Work shall not be the criteria for detention in the semester.

C. Practical/Oral/Presentation:

R.4.5

Practical/Oral/presentation is to be conducted and assessed jointly by internal and external examiners. The performance in the Practical/Oral/Presentation examination shall be assessed by at

least one pair of examiners appointed as examiners by the Savitribai Phule Pune University. The examiners will prepare the mark / grade sheet in the format as specified by the Savitribai Phule Pune University and authenticate it.

D. Project Based Learning

R4.6

It is recommended that the all activities are to be record and regularly, regular assessment of work to be done and proper documents are to be maintained at college end by both students as well as mentor (you may call it PBL work book). Continuous Assessment Sheet (CAS) is to be maintained by all mentors/department and institutes.

Recommended parameters for assessment, evaluation and weightage:

- Idea Inception (5%)
- Outcomes of PBL/ Problem Solving Skills/ Solution provided/ Final product (50%) (Individual assessment and team assessment)
- Documentation (Gathering requirements, design & modeling, implementation/execution, use of technology and final report, other documents) (25%)
- Demonstration (Presentation, User Interface, Usability etc) (10%)
- Contest Participation/ publication (5%)
- Awareness /Consideration of -Environment/ Social /Ethics/ Safety measures/Legal aspects (5%)

PBL workbook will serve the purpose and facilitate the job of students, mentor and project coordinator. This workbook will reflect accountability, punctuality, technical writing ability and work flow of the work undertaken.

E. Internship

R4.7

Student may choose to undergo Internship at Industry/Govt./NGO/MSME/Rural Internship/ Innovation/ IPR/Entrepreneurship. Student may choose either to work on innovation or entrepreneurial activities resulting in start-up or undergo internship with industry/NGO's/Government organizations/Micro/Small/ Medium enterprises to make themselves ready for the industry[4].

Every student is required to prepare a maintain documentary proofs of the activities done by him. The evaluation of these activities will be done by Programme Head/Cell In-charge/ Project Head/ faculty mentor or Industry Supervisor based on- Overall compilation of internship activities, sub-activities, the level of achievement expected, evidence needed to assign the points and the duration for certain activities.

Based on internship the assessment and evaluation parameters may include as-

- Working for consultancy/ research project,
- Participation at Events (Technical / Business)
- Participation in innovation related completions for e.g. Hackathon etc.),
- Contribution in Incubation/ Innovation/ Entrepreneurship Cell/ Institutional Innovation Council,
- Learning at Departmental Lab/Tinkering Lab/ Institutional workshop,
- Development of new product/ Business Plan/ registration of start-up,
- Participation in IPR workshop/Leadership Talks/ Idea/ Design/ Innovation/ Business Completion/ Technical Expos.

It is necessary to produce participation certificate, if applicable.

F. Seminar and Communication Skills

R4.8

Seminar is the first formal curricular activity at the UG level, where students are supposed to exhibit their communication skills and knowledge by undertaking the study of the chosen topics. Core objective is to explore the basic principles of communication (verbal and non-verbal) and

active, empathetic listening, speaking and writing techniques. It exposes the student to new technologies, researches, products, and services.

Authorities/ examiner (optional) along with a guide would be assessing the seminar work based on various parameters which may include- Topic selection, Contents and Presentation, regularity, Punctuality and Timely Completion, Question and Answers, Report, Paper Presentation/Publication, Attendance and Active Participation in overall class activity.

G. Project Work at Final Year

R4.9

Progress of project work is monitored regularly on weekly project slot/project day. Regular interval presentations are to be arranged to review and assess the work. During process of monitoring and continuous assessment AND evaluation the individual and team performance is to be measured.

Project work is monitored and continuous assessment is done by guide and authorities. During university examination Internal examiner (preferably the guide) and External examiners jointly, evaluate the project work. Recommended performance measure parameters may include-Problem definition and scope of the project, Literature Survey, Appropriate Engineering approach used, Exhaustive and Rational Requirement Analysis, Comprehensive Implementation- Design, modeling, documentation, Usability, Optimization considerations(Time, Resources, Costing), Thorough Testing, Project Presentation and Demonstration(ease of use and usability), Social and environment aspects, Presentation of work in the form of Project Report(s), Understanding individual capacity, Role & involvement in the project, Team Work (Distribution of work, intra-team communication and togetherness), Participation in various contests, Publications and IPR, Manuals(Project Report, Quick reference, System, Installation guide) among other parameters.

5. Rules of Passing

R5.1

To pass the Term Work / Practical / Oral/ presentation the student has to earn Minimum of 40 percent marks in each respective examination head.

R5.2

To pass the Theory Subject head the student has to earn minimum of 40 percent marks in End-Semester examination and 40 percent total marks (In-Semester Examination and End-Semester Examination).

R5.3

The failing student can repeat the End-semester examination to pass the head in any semester and the In-Semester Examination marks will be retained as it is. OR the failing student can repeat for the End-Semester Examination as well as In-semester examination for the head of Even semester in the Even semester only and for the head of Odd semester in the Odd semester only for the theory head

R5.4

To earn credits of a course (Theory/term work/practical/oral/presentation) student must pass the course with minimum passing marks/grade.

R5.5

Student can apply only for the Revaluation/Photocopying of End-Semester theory examination.

6. Rules of ATKT (Allowed To Keep Term):

R6.1

A student can register for the third semester (SE), if he/she earns minimum 50% credits of the total of first and second semesters (FE).

R6.2

A student can register for the fifth semester (TE), if he/she earns minimum 50% credits of the total of third and fourth semesters (SE) and all the credits of first and second semester (FE).

R6.3

A student can register for the seventh semester(BE), if he/she earns minimum 50% credits of the total of fifth and sixth semesters(TE) and all the credits of third and fourth semester(SE).

R6.4

A student will be awarded the bachelor's degree if he/she earns 170 credits and clears all the mandatory non credit courses in respective semesters

7. Assessment and Grade Point Average:

R7.1 Marks/Grade/Grade Point

A grade is assigned to each head based on marks obtained by a student in examination of the course. The marks obtained in In-semester and end-semester examination are considered together to calculate the grade of the course. These grades, their equivalent grade points are given in Table 11.

TABLE 11. Grade and Grade Point

Grade	Grade Point	Percentage of Marks Obtained	Remarks
O	10	90-100	Outstanding
A	9	80-89	Very Good
B	8	70-79	Good
C	7	60-69	Fair
D	6	50-59	Average
E	5	40-49	Below Average
F	0	Below 40	Fail
FX	0	--	Detained, Repeat the Course
IC	0	--	Incomplete Course-- Absent for Exam but continue for the course
AC	--	--	Audit Course Completed
ACN	--	--	Audit Course Not Completed

7. Passing Grade:

- The grades O, A, B, C, D, E are passing grades.
- A candidate acquiring any one of these grades in a course shall be declared as PASS. And student shall earn the credits for a course only if the student gets passing grade in that course.
- F Grade -The grade F shall be treated as a failure grade.
- The student with F grade will have to pass the concerned course by re-appearing for the examination.
- The student with F grade for any stage of the Project Work, will have to carry out additional work/ improvement as suggested by the examiners and re-appear for the examination.
- AC and ACN Grade -The student registered for audit course shall be awarded the grade AC after satisfactory completion of audit course and shall be included in the Semester grade report for that course, provided student has the minimum attendance as prescribed by the SPPU and satisfactory In-semester performance and secured a passing grade in that course. Student who is unable to complete audit course will be awarded as ACN grade.
- FX Grade-The grade FX in a course is awarded by the college, if a student does not maintain the minimum attendance in the Lecture / Tutorial class as prescribed by the SPPU and/or his performance during the semester is not satisfactory and/or he/she fails in the Term Work head of that course.
- The student with FX grade in a given course is not permitted to take the end of semester examination in that course. Such a student will have to re-register for the course.
- The student with F / FX in a course shall not be awarded any credits for that course.

8. Performance Indices:

R8.1

The semester end grade sheet will contain grades for the courses along with titles and SGPA. Final grade sheet and transcript shall contain CGPA.

R8.2

SGPA -The performance of a student in a semester is indicated by a number called the Semester Grade Point Average (SGPA). The SGPA is the weighted average of the grade points obtained in all the courses, seminars and projects registered by the student during the semester.

$$\text{Semester Grade Point Average (SGPA)} = \frac{\sum_{i=1}^p C_i G_i}{\sum_{i=1}^p C_i}$$

$$\text{SGPA} = \frac{\sum \text{GradePointsEarned} \times \text{CreditsForEachCourse}}{\text{TotalCredits}}$$

For Example: suppose in a given semester a student has registered for five courses having credits C1, C2, C3, C4, C5 and his / her grade points in those courses are G1, G2, G3, G4, G5 respectively. Then students

$$\text{SGPA} = \frac{C1G1+C2G2+C3G3+C4G4+C5G5}{C1+C2+C3+C4+C5}$$

SGPA and CGPA is calculated up to two decimal places by rounding off.

R8.3

CGPA- The CGPA is the weighted average of the grade points obtained in all the courses (Theory/term work/practical/oral/presentation) of first semester to eighth semester for the students admitted in the First year and third to eighth semester for the students directly admitted at Second year.

CGPA is calculated in the same manner as the SGPA.

R8.4

In case of a student passing a failed course or in case of improvement, the earlier grade would be replaced by the new grade in calculation of the SGPA and CGPA.

9. Result:

R9.1

Based on the performance of the student in the semester examinations, the Savitribai Phule Pune University will declare the results and issue the Semester Grade sheets. The class shall be awarded to a student on the CGPA calculated. The award of the class shall be as per Table 12.

Table 12. CGPA and Class awarded

Sr. No.	CGPA	Class of the Degree Awarded
1.	7.75 or More than 7.75	First Class with Distinction
2.	6.75 or more but less than 7.75	First Class
3.	6.25 or more but less than 6.75	Higher Second Class
4.	5.5 or more but less than 6.25	Second Class

X. References

- [1] https://www.aicte-india.org/sites/default/files/Vol.%20I_UG.pdf
- [2] [https://www.aicte-india.org/sites/default/files/induction-guide-jun17-aicte%20\(1\).pdf](https://www.aicte-india.org/sites/default/files/induction-guide-jun17-aicte%20(1).pdf)
- [3] <https://www.aicteindia.org/sites/default/files/FINAL%20BEST%20PRACTICES%20IN%20AICTE%20APPROVED%20INSTITUTIONS.pdf>
- [4] <https://www.aicte-india.org/sites/default/files/AICTE%20Internship%20Policy.pdf>
- [5] <https://www.aicte-india.org/sites/default/files/ExaminationReforms.pdf>
- [6] <https://www.aicte-india.org/education/model-syllabus>

Savitribai Phule Pune University

Faculty of Science & Technology



Curriculum/Syllabus
for
Second Year
Bachelor of Engineering
(Choice Based Credit System)
Mechanical Engineering and Automobile Engineering
(2019 Course)

Board of Studies - Automobile and Mechanical Engineering
(With Effect from Academic Year 2020-21)

Savitribai Phule Pune University
Board of Studies - Automobile and Mechanical Engineering
Undergraduate Program - Automobile Engineering & Mechanical Engineering (2019 pattern)

Course Code	Course Name	Teaching Scheme (Hours/Week)			Examination Scheme and Marks						Credit			
		TH	PR	TUT	ISE	ESE	TW	PR	OR	TOTAL	TH	PR	TUT	TOTAL
Semester-III														
202041	Solid Mechanics	4	2	-	30	70	-	50	-	150	4	1	-	5
202042	Solid Modeling and Drafting	3	2	-	30	70	-	50	-	150	3	1	-	4
202043	Engineering Thermodynamics	3	2	-	30	70	-	-	25	125	3	1	-	4
202044	Engineering Materials and Metallurgy	3	2	-	30	70	25	-	-	125	3	1	-	4
203156	Electrical and Electronics Engineering	3	2	-	30	70	25	-	-	125	3	1	-	4
202045	Geometric Dimensioning and Tolerancing Lab	-	2	-	-	-	25	-	-	25	-	1	-	1
202046	Audit Course - III	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	16	12	-	150	350	75	100	25	700	16	6	-	22
Semester-IV														
207002	Engineering Mathematics - III	3	-	1	30	70	25	-	-	125	3	-	1	4
202047	Kinematics of Machinery	3	2	-	30	70	-	-	25	125	3	1	-	4
202048	Applied Thermodynamics	3	2	-	30	70	-	-	25	125	3	1	-	4
202049	Fluid Mechanics	3	2	-	30	70	-	-	25	125	3	1	-	4
202050	Manufacturing Processes	3	-	-	30	70	-	-	-	100	3	-	-	3
202051	Machine Shop	-	2	-	-	-	50	-	-	50	-	1	-	1
202052	Project Based Learning - II	-	4	-	-	-	50	-	-	50	-	2	-	2
202053	Audit Course - IV	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	15	12	1	150	350	125	-	75	700	15	6	1	22
<p>Abbreviations: TH: Theory, PR: Practical, TUT: Tutorial, ISE: In-Semester Exam, ESE: End-Semester Exam, TW: Term Work, OR: Oral</p>														
<p>Note: Interested students of SE (Automobile Engineering and Mechanical Engineering) can opt for any one of the audit course from the list of audit courses prescribed by BoS (Automobile and Mechanical Engineering)</p>														
<p>Instructions</p> <ul style="list-style-type: none"> • Practical/Tutorial must be conducted in three batches per division only. • Minimum number of required Experiments/Assignments in PR/ Tutorial shall be carried out as mentioned in the syllabi of respective subjects. • Assessment of tutorial work has to be carried out as a term-work examination. Term-work Examination at second year of engineering course shall be internal continuous assessment only. • Project based learning (PBL) requires continuous mentoring by faculty throughout the semester for successful completion of the tasks selected by the students per batch. While assigning the teaching workload of 2 Hrs/week/batch needs to be considered for the faculty involved. The Batch needs to be divided into sub-groups of 5 to 6 students. Assignments / activities / models/ projects etc. under project based learning is carried throughout semester and Credit for PBL has to be awarded on the basis of internal continuous assessment and evaluation at the end of semester. • Audit course is mandatory but non-credit course. Examination has to be conducted at the end of Semesters for award of grade at institute level. Grade awarded for audit course shall not be calculated for grade point & CGPA. 														

202041 - Solid Mechanics		
Teaching Scheme	Credits	Examination Scheme
Theory : 04 Hr./Week Practical : 02 Hr./Week	05 Theory : 04 Practical : 01	In-Semester : 30 Marks End-Semester : 70 Marks Practical : 50 Marks
Prerequisite Courses Engineering Mathematics- I and II, Systems in Mechanical Engineering, Engineering Mechanics		
Course Objectives <ol style="list-style-type: none"> 1. To acquire basic knowledge of stress, strain due to various types of loading. 2. To draw Shear Force and Bending Moment Diagram for transverse loading. 3. To determine Bending, Shear stress, Slope and Deflection on Beam. 4. To solve problems of Torsional shear stress for shaft and Buckling for the column. 5. To apply the concept of Principal Stresses and Theories of Failure. 6. To utilize the concepts of Solid Mechanics on application based combined mode of loading. 		
Course Outcomes On completion of the course, learner will be able to <ol style="list-style-type: none"> CO1. DEFINE various types of stresses and strain developed on determinate and indeterminate members. CO2. DRAW Shear force and bending moment diagram for various types of transverse loading and support. CO3. COMPUTE the slope & deflection, bending stresses and shear stresses on a beam. CO4. CALCULATE torsional shear stress in shaft and buckling on the column. CO5. APPLY the concept of principal stresses and theories of failure to determine stresses on a 2-D element. CO6. UTILIZE the concepts of SFD & BMD, torsion and principal stresses to solve combined loading application based problems. 		
Course Contents		
Unit I	Simple stresses & strains	[10 Hr.]
Simple Stress & Strain: Introduction to types of loads (Static, Dynamic & Impact Loading) and various types of stresses with applications, Hooke's law, Poisson's ratio, Modulus of Elasticity, Modulus of Rigidity, Bulk Modulus. Interrelation between elastic constants, Stress-strain diagram for ductile and brittle materials, factor of safety, Stresses and strains in determinate and indeterminate beam, homogeneous and composite bars under concentrated loads and self-weight, Thermal stresses in plain and composite members		
Unit II	Shear Force & Bending Moment Diagrams	[08 Hr.]
SFD & BMD: Introduction to SFD, BMD with application, SFD & BMD for statically determinate beam due to concentrated load, uniformly distributed load, uniformly varying load, couple and combined loading, Relationship between rate of loading, shear force and bending moment, Concept of zero shear force, Maximum bending moment, point of contra-flexure		
Unit III	Stresses, Slope & Deflection on Beams	[12 Hr.]
Bending Stress on a Beam: Introduction to bending stress on a beam with application, Theory of Simple bending, assumptions in pure bending, derivation of flexural formula, Moment of inertia of common cross section (Circular, Hollow circular, Rectangular, I & T), Bending stress distribution along the same cross-section Shear Stress on a Beam: Introduction to transverse shear stress on a beam with application, shear stress distribution diagram along the Circular, Hollow circular, Rectangular, I & T cross-section Slope & Deflection on a Beam: Introduction to slope & deflection on a beam with application, slope, deflection and Radius of Curvature, Macaulay's Method, Slope and Deflection for all standard beams		

Unit IV	Torsion, Buckling	[08 Hr.]
<p>Torsion of circular shafts: Introduction to torsion on a shaft with application, Basic torsion formulae and assumption in torsion theory, Torsion in stepped and composite shafts, Torque transmission on strength and rigidity basis, Torsional Resilience</p> <p>Torsion on Thin-Walled Tubes: Introduction of Torsion on Thin-Walled Tubes Shaft and its application</p> <p>Buckling of columns: Introduction to buckling of column with its application, Different column conditions and critical, safe load determination by Euler's theory. Limitations of Euler's Theory</p>		
Unit V	Principal Stresses, Theories of Failure	[08 Hr.]
<p>Principal Stresses: Introduction to principal stresses with application, Transformation of Plane Stress, Principal Stresses and planes (Analytical method and Mohr's Circle), Stresses due to combined Normal and Shear stresses</p> <p>Theories of Elastic failure: Introduction to theories of failure with application, Maximum principal stress theory, Maximum shear stress theory, Maximum distortion energy theory, Maximum principal strain theory, Maximum strain energy theory</p>		
Unit VI	Application based combined loading & stresses (Based on load and stress condition studied in Unit I to Unit V)	[08 Hr.]
<p>Introduction to the Combined Loading and various stresses with application, Free Body Diagram and condition of Equilibrium for determining internal reaction forces, couples for 2-D system, Combined stresses at any cross-section or at any particular point for Industrial and Real life example for the following cases: Combined problem of Normal type of Stresses (Tensile, Compressive and Bending stress), Combined problem of Shear type of stresses (Direct and Torsional Shear stresses), Combined problem of Normal and Shear type of Stresses</p>		
Books & Other Resources		
Text Books		
<ol style="list-style-type: none"> 1. R. K. Bansal, "Strength of Materials", Laxmi Publication 2. S. Ramamurtham, "Strength of material", Dhanpat Rai Publication 3. S.S. Rattan, "Strength of Material", Tata McGraw Hill Publication Co. Ltd. 4. B.K. Sarkar, "Strength of Material", McGraw Hill New Delhi 5. Singer and Pytel, "Strength of materials", Harper and row Publication 6. R. C. Hibbeler, "Mechanics of Materials", Prentice Hall Publication 		
Reference Books		
<ol style="list-style-type: none"> 1. Egor. P. Popov, "Introduction to Mechanics of Solids", Prentice Hall Publication 2. G. H. Ryder, "Strength of Materials", Macmillan Publication 3. Beer and Johnston, "Strength of materials", CBS Publication 4. James M. Gere, "Mechanics of Materials", CL Engineering 5. Timoshenko and Young, "Strength of Materials", CBS Publication, Singapore 6. Prof. S.K. Bhattacharyya, IIT Kharagpur, "NPTEL Web course material" https://drive.google.com/file/d/1N2Eyv9ofPimIT2OSMZeMrSxe68Ulclei/view?usp=sharing 		
Guidelines for Laboratory Conduction		
The student shall complete the following activity as a Term Work		
<p><i>The Termwork shall consist of completion of Practicals, Self-learning Study Assignments and Presentations. Practical examination shall be based on the Termwork undertaken during the semester.</i></p> <p>Practical (Any 6 experiments out of experiment no 1 to 8 from the following list whereas experiment no. 9 and 10 are mandatory. Minimum One experiment must be performed on IoT platform- Virtual Lab):</p> <ol style="list-style-type: none"> 1. Tension test for Ductile material using extensometer on Universal Testing Machine. 2. Compression test for Brittle material on Universal Testing Machine. 3. Shear test of ductile material on Universal Testing Machine. 4. Tension test of Plastic/Composite material on low load capacity Tensile Testing Machine. 5. Measurement of stresses and strains using strain gauges. 		

6. Experimental verification of flexural formula in bending for cantilever, Simple supported beam.
7. Study and interpretations of stress distribution pattern using Polariscope for Plastic/Acrylic.
8. Experimental verification of torsion formula for circular bar.
9. Verification of results of any two from experiments no 1-8 using any FEA software tools.
10. **Self-learning study practical:** *Following topics are distributed among the group of 3-5 Students and groups need to present and also submit the slides/poster on TW file.*
 - a. Experimental stress analysis, Strain Gauges rosette with case study.
 - b. Residual stresses and Fatigue life with case study.
 - c. Effect of heat treatment on the mechanical properties of a metal with case study.
 - d. Mechanical properties of materials, Stresses and Design of components with case study.
 - e. Failure Mode Analysis and Stresses with case study.

202042 - Solid Modeling and Drafting

Teaching Scheme	Credits	Examination Scheme
Theory : 03 Hr./Week Practical : 02 Hr./Week	04 Theory : 03 Practical : 01	In-Semester : 30 Marks End-Semester : 70 Marks Practical : 50 Marks

Prerequisite Courses

Systems in Mechanical Engineering, Engineering Graphics, Engineering Mathematics - I and II

Course Objectives

1. To understand basic structure of CAD systems and their use to create geometric models of simple engineering parts
2. To introduce the curves and surfaces and their implement in geometric modeling
3. To apply basic concepts of 3D modeling, viewing and evaluate mass properties of components and assemblies
4. To apply geometrical transformations in CAD models
5. To understand data exchange standards and translators for various applications
6. To create engineering drawings, design documentation and use in manufacturing activities

Course Outcomes

On completion of the course, learner will be able to

- CO1. UNDERSTAND basic concepts of CAD system, need and scope in Product Lifecycle Management
- CO2. UTILIZE knowledge of curves and surfacing features and methods to create complex solid geometry
- CO3. CONSTRUCT solid models, assemblies using various modeling techniques & PERFORM mass property analysis, including creating and using a coordinate system
- CO4. APPLY geometric transformations to simple 2D geometries
- CO5. USE CAD model data for various CAD based engineering applications viz. production drawings, 3D printing, FEA, CFD, MBD, CAE, CAM, etc.
- CO6. USE PMI & MBD approach for communication

Course Contents

Unit I Fundamentals of 3D Modeling [08 Hr.]

Introduction, Product Life Cycle, CAD tools in the design process of Product Cycle, Scope of CAD, Software Modules - Operating System (OS) module, Geometric module, application module, programming module, communication module, Computer Aided Design - Features, requirements and applications

3D Modeling approach - Primitive, Features and Sketching, Types of Geometric models - 2½ extrusions, axisymmetric, composite, 3D objects, difference between wireframe, surface & solid modeling, Modeling strategies

Model viewing: VRML web-based viewing

Unit II Curves & Surfaces [08 Hr.]

Curves: Methods of defining Point, Line and Circle, Curve representation - Cartesian and Parametric space, Analytical and Synthetic curves, Parametric equation of line, circle, ellipse, Continuity (C^0 , C^1 & C^2), Synthetic Curves - Hermit Cubic Spline, Bezier, B-Spline Curve, Non-Uniform Rational B-Spline curves (NURBS)

Surfaces: Surface representation, Types of Surfaces, Bezier, B-Spline, NURBS Surface, Coons patch surface, Surface Modeling

Reverse Engineering: Introduction, Point Cloud Data (PCD), PCD file formats, Quality issues in PCD, Requirements for conversion of surface models into solid models, Applications of PCD

Unit III Solid Modeling [08 Hr.]

Introduction, Geometry and Topology, Solid entities, Solid representation, Fundamentals of Solid modeling, Half spaces, Boundary representation (B-Rep), Constructive Solid Geometry (CSG), Sweep representation, Analytical solid modeling, Parametric solid modeling, feature based modeling,

etc., Euler Equation (Validity of 3D solids), Mass Property Calculations

Introduction to Assembly Modeling, Assemblies (Top-down and Bottom-up approach), Design for Manufacturing [DFM], Design for Easy Assembly & Disassembly [DFA], Design for Safety

Unit IV Geometric Transformation [08 Hr.]

Introduction, Geometric Transformations, Translation, Scaling, Rotation, Reflection/Mirror, Shear, Homogeneous Transformation, Inverse Transformation, Concatenated Transformation (limited to 2D objects with maximum 3 points only), Coordinate systems - Model (MCS), Working (WCS), Screen (SCS) coordinate system, Mapping of coordinate systems

Projections of geometric models - Orthographic and Perspective projections, Design and Engineering applications

Unit V CAD Data Exchange [08 Hr.]

Introduction, CAD Kernels, CAD Data File, Data interoperability, CAD Data Conversions, challenges in CAD data conversions/remedies, Direct Data Translators, Neutral 3D CAD file formats (DXF, IGES, PDES, STEP, ACIS, Parasolid, STL, etc.), Data Quality

Requirements of CAD file format for 3D Printing (Additive Manufacturing), CAE, FEA, CFD, CAM (Subtractive Manufacturing), Multi-Body Dynamics (Motion Simulations), Computer Aided Inspection (CAI), Computer Aided Technologies (CAx), AR/VR applications, etc., Introduction to CAD Geometry Clean-up for different applications

Unit VI CAD Customization & Automation [08 Hr.]

Introduction, Limitations of 2D drawings, Introduction to Product and Manufacturing Information (PMI), Model Based Definitions (MBD), Applications of PMI & MBD

CAD Customization: Introduction, advantages and disadvantages, Applications of Customization Interfaces, Product Customization Approaches - Part Modeling Customization, Assembly Modeling Customization, Drawing sheets & PMI Customization, CAD Automation

Introduction to Application Programming Interface (API), Structures of APIs, Coding/Scripting for customization, Introduction to CAD API Development, CAD Files & application handling

Books & Other Resources

Text Books

1. Zeid, I and Sivasubramania, R., (2009), "CAD/CAM : Theory and Practice", 2nd edition, McGraw Hill Education, ISBN-13: 978-0070151345
2. Rao, P. N., (2017), "CAD/CAM: Principles and Applications", 3rd edition, McGraw Hill Education, ISBN-13: 978-0070681934
3. Chang, Kuang-Hua, (2015), "e-Design: Computer-Aided Engineering Design", Academic Press, ISBN-13: 978-0123820389

Reference Books

1. Lee, Kunwoo, (1999), "Principles of CAD/CAM/CAE Systems", Pearson/Addison-Wesley, ISBN-13: 978-0201380361
2. Bordegoni, Monica and Rizzi, Caterina, (2011), "Innovation in Product Design: From CAD to Virtual Prototyping", Springer, ISBN-13: 978-1447161875
3. Vukašinovic, Nikola and Duhovnik, Jože, (2019), "Advanced CAD Modeling: Explicit, Parametric, Free-Form CAD and Re-engineering", Springer, ISBN-13: 978-3030023980
4. Um, Dugan, (2018), "Solid Modeling and Applications: Rapid Prototyping, CAD and CAE Theory", 2nd edition, Springer, ISBN-13: 978-3319745930
5. Rogers, D. and Adams, J. A., (2017), "Mathematical Elements for Computer Graphics", 2nd edition, McGraw Hill Education, ISBN-13: 978-0070486775
6. Hearn, D. D. and Baker, M. P., (2013), "Computer Graphics with OpenGL", 4th edition, Pearson Education India, ISBN-13: 978-9332518711
7. Gokhale, N. S., Deshpande, S. S., Bedekar, S. V. and Thite, A. N., (2008), "Practical Finite Element Analysis", Finite to Infinite, Pune, India, ISBN-13: 978-8190619509
8. Lee Ambrosius, (2015), "AutoCAD[®] Platform Customization: User Interface, AutoLISP[®], VBA, and Beyond", John Wiley & Sons, Inc., IN, ISBN-13: 978-1118798904

9. Bucalo, Joe and Bucalo, Neil, (2007), “Customizing SolidWorks for Greater Productivity”, Sheet Metal Guy, LLC, ISBN-13: 978-0979566608
10. Ziethen, Dieter R. (2012), “CATIA V5: Macro Programming with Visual Basic Script”, McGraw-Hill Companies, Inc./Carl Hanser Verlag München, ISBN-13: 978-0071800020, ISBN: 978-007180003-7
11. Programming Manuals of Softwares

Guidelines for Laboratory Conduction

The student shall complete the following activity as a Term Work Journal

Practical

The student shall complete the following Practical in laboratory using suitable CAD modeling software. Learner will demonstrate skills to communicate drawings as per industry standards.

1. 2-D sketching with geometrical and dimensional constraints
2. Solid & Surface modeling for simple mechanical components (Output file as Production drawing and Model Based Definition (MBD))
 - (a) Sheet-Metal
 - (b) Machining
 - (c) Fabrication
 - (d) Casting
 - (e) Forgings
 - (f) Plastic Molding
3. Assembly modeling (Output file as Assembly drawing and detailing) of the parts modeled in Practical assignment-2 using proper assembly constraint conditions and generation of exploded view for assemblies like Couplings, Clutches, Gear Assemblies, Engine/Pump/Turbine Components, Valves, Machine Tools, Automobile Components, Gear-Box, Pressure Vessels, etc.
4. Reverse Engineering of surface/solid modeling using Point Cloud Data.
5. Assembly Modeling by importing parts/components from free online resources like CAD and Product development software websites, forums, blogs, etc.
6. Demonstration on CAD Customization (with introduction to programming languages, interfacing)

202043 - Engineering Thermodynamics

Teaching Scheme	Credits	Examination Scheme
Theory : 03 Hr./Week Practical : 02 Hr./Week	04 Theory : 03 Practical : 01	In-Semester : 30 Marks End-Semester : 70 Marks Oral : 25 Marks

Prerequisite Courses

Higher Secondary Science courses, Engineering Mathematics - I and II, Engineering Physics, Engineering Chemistry

Course Objectives

1. To introduce the fundamentals of thermodynamics.
2. To understand the concepts of laws of thermodynamics.
3. To apply the concepts of thermodynamics towards open and closed systems.
4. To be acquainted with Entropy generation and Exergy Analysis.
5. To understand the behaviour of a Pure substance and to analyze Vapour power cycles.
6. To undertake the performance analysis of a steam generator.

Course Outcomes

On completion of the course, learner will be able to

- CO1. DESCRIBE the basics of thermodynamics with heat and work interactions.
- CO2. APPLY laws of thermodynamics to steady flow and non-flow processes.
- CO3. APPLY entropy, available and non available energy for an Open and Closed System,
- CO4. DETERMINE the properties of steam and their effect on performance of vapour power cycle.
- CO5. ANALYSE the fuel combustion process and products of combustion.
- CO6. SELECT various instrumentations required for safe and efficient operation of steam generator.

Course Contents

Unit I Fundamentals of Thermodynamics [07 Hr.]

Introduction, Review of basic definitions, Zeroth law of Thermodynamics, Macro and Microscopic Approach, State Postulate, State, Path, Process and Cycles, Point function and Path function, quasi static process, Equilibrium, **Temperature** (concepts, scales, international fixed points and measurement of temperature), Constant volume gas thermometer and constant pressure gas thermometer, mercury in glass thermometer.

First Law of Thermodynamics: Concept of heat and work, Sign convention and its conversion. First law of thermodynamics, Joules experiments, Equivalence of heat and work. Application of first law to flow and non-flow Processes and Cycles. Steady flow energy equation (SFEE), Applications of SFEE to various devices such as Nozzle, Turbine, Compressors, Boilers etc. PMM-I kind.

Unit II Ideal Gas and Second law of Thermodynamics [08 Hr.]

Properties and Processes of Ideal Gas: Ideal Gas definition, Gas Laws: Boyle's law, Charle's law, Avagadro's Law, Equation of State, Ideal Gas constant and Universal Gas constant, Ideal gas Processes- on P-v and T-s diagrams, Constant Pressure, Constant Volume, Isothermal, Adiabatic, Polytropic, Throttling Processes (Open and Closed systems), Calculations of Heat transfer, Work done, Internal Energy.

Second Law of Thermodynamics: Limitations of first law of thermodynamics, Thermal reservoir, Heat Engine, Refrigerator and Heat pump: Schematic representation, Efficiency and Coefficient of Performance (COP), Kelvin-Planck & Clausius Statement of the Second law of Thermodynamics; PMM-II kind, Equivalence of the two statements; Clausius Inequality, Concept of Reversibility and Irreversibility, Carnot Theorem/Principles, Carnot Cycle.

Unit III Entropy and Availability [08 Hr.]

Entropy: Entropy as a property, Clausius Inequality, Principle of increase of Entropy Principle, Entropy changes for an Open and Closed System, Change of Entropy for an ideal gas and Pure Substance, Concept of Entropy generation. Entropy - a measure of Disorder.

Availability: Available and Unavailable Energy, Concept of Availability, Availability of heat source at constant temperature and variable temperature, Availability of non-flow and steady-flow Systems.

Unit IV Properties of Pure substances & Thermodynamics of Vapour Cycle [07 Hr.]

Properties of Pure substances: Formation of steam, Phase changes, Properties of steam, Use of Steam Tables, Study of P-v, T-s and h-s plots (Mollier Chart) for steam, Dryness fraction and its determination, Study of steam calorimeters (Barrel, Separating, Throttling and combined) Non-flow and Steady flow Vapour Processes, Change of Properties, Work and Heat transfer.

Thermodynamics of Vapour Cycle: Rankine Cycle, Comparison of Carnot cycle and Rankine cycle, Introduction to Steam power Plant, Efficiency of Rankine Cycle, Relative Efficiency, Effect of Varying operating parameters like Superheat, Boiler and Condenser Pressure on performance of Rankine cycle, Modified Rankine Cycle.

Unit V Fuels and Combustion [07 Hr.]

Types of fuels, Proximate and ultimate analysis of fuel, Combustion theory, Combustion Equations, Theoretical and Excess air requirements, Equivalence ratio, Analysis of products of combustion, Calorific value - HCV & LCV. Bomb and Boys gas Calorimeters. Flue Gas Analysis using Orsat Apparatus, Exhaust Gas analyser, Enthalpy of formation, Adiabatic flame temperature.

Unit VI Steam Generators & Boiler Draught [08 Hr.]

Steam Generators: Classification, Constructional details of low pressure boilers, Primary Features of high pressure (Power) boilers, Location, Construction and working principle of boiler, Boiler mountings and accessories, Instrumentations required for safe and efficient operation, Introduction to IBR Act, Boiler performance Calculations-Equivalent Evaporation, Boiler efficiency, Heat balance Sheet.

Boiler Draught: Classification, Necessity of Draught, Natural draught, Determination of Height of chimney, Diameter of chimney, condition for maximum discharge, Forced draught, Induced draught, Balanced draught, Draught losses.

Books & Other Resources

Text Books

1. P. K. Nag, "Engineering Thermodynamics", Tata McGraw Hill Publications
2. R. K. Rajput, "Engineering Thermodynamics", EVSS Thermo, Laxmi Publications
3. P. L Ballaney, "Thermal Engineering", Khanna Publishers
4. C.P. Arora, "Thermodynamics", Tata McGraw Hill
5. Domkundwar, Kothandaraman and Domkundwar, "Thermal Engineering", Dhanpat Rai Publishers
6. M M Rathore, "Thermal Engineering", Tata McGraw-Hill

Reference Books

1. Rayner Joel, "Basic Engineering Thermodynamics", AWL-Addison Wesley
2. Cengel and Boles, "Thermodynamics an Engineering Approach", McGraw Hill
3. G.VanWylen, R.Sonntag and C.Borgnakke, "Fundamentals of Classical Thermodynamics", John Wiley & Sons
4. Holman J.P, "Thermodynamics", McGraw Hill
5. M Achuthan, "Engineering Thermodynamics", PHI
6. Steam Tables/Data book

Guidelines for Laboratory Conduction

The student shall complete the following activity as Term Work

The Term work shall consist of successful completion of Practicals, and Industrial Visits. Oral Examination shall be based on the term work.

Practical

1. Joule's experiment to validate, first law of thermodynamics.
2. Survey of temperature sensors used in various thermal systems.
3. Determination of dryness fraction of steam using combined separating and throttling calorimeter.
4. Determination of HCV of solid or gaseous fuel using Bomb or Junker's calorimeter respectively.

5. Demonstration on Orsat Apparatus.
6. Trial on boiler to determine boiler efficiency, equivalent evaporation and Energy Balance.
7. Thermodynamic Analysis of any System / Model by using any Computer Software.
8. Energy and Exergy analysis of contemporary steam generator.

Industrial Visits

Visit to any Process Industry/Plant having Boiler equipped with Accessories.

The visit report consists of

- Details about the Industry/Process Plant.
- Operational description of the Equipment with specification, its use, capacity, application etc.

202044 - Engineering Materials and Metallurgy		
Teaching Scheme	Credits	Examination Scheme
Theory : 03 Hr./Week Practical : 02 Hr./Week	04 Theory : 03 Practical : 01	In-Semester : 30 Marks End-Semester : 70 Marks Term Work : 25 Marks
Prerequisite Courses Higher Secondary Science courses, Engineering Physics, Engineering Chemistry, Systems in Mechanical Engineering		
Course Objectives <ol style="list-style-type: none"> To impart fundamental knowledge of material science and engineering. To establish significance of structure property relationship. To explain various characterization techniques. To indicate the importance of heat treatment on structure and properties of materials. To explain the material selection process. 		
Course Outcomes On completion of the course, learner will be able to CO1. COMPARE crystal structures and ASSESS different lattice parameters. CO2. CORRELATE crystal structures and imperfections in crystals with mechanical behaviour of materials. CO3. DIFFERENTIATE and DETERMINE mechanical properties using destructive and non-destructive testing of materials. CO4. IDENTIFY & ESTIMATE different parameters of the system viz., phases, variables, component, grains, grain boundary, and degree of freedom. etc. CO5. ANALYSE effect of alloying element & heat treatment on properties of ferrous & nonferrous alloy. CO6. SELECT appropriate materials for various applications.		
Course Contents		
Unit I	Crystal Structures and Deformation of Materials	[08 Hr.]
Crystal Structures: Study of Crystal structures BCC, FCC, HCP and lattice parameters & properties, Miller indices, Crystal imperfections, and Diffusion Mechanisms Material Properties: Mechanical (Impact, hardness, etc.), Electrical, optical and Magnetic properties Deformation of Materials: Elastic deformation, Plastic deformation: slip, twinning, work hardening, baushinger effect, recovery, re-crystallization and grain growth, Fracture: Types of fractures (brittle, ductile), Creep & Fatigue failures		
Unit II	Material Testing and Characterization Techniques	[06 Hr.]
Destructive Testing: Impact test, Cupping test and Hardness test Non-Destructive Testing: Eddy current test, Sonic & Ultrasonic testing, X-ray Radiography testing (Principle and Applications only) Microscopic Techniques: Sample Preparation and etching procedure, optical microscopy, Electronic microscopy - only SEM, TEM and X-ray diffraction (Principle and Applications only) Macroscopy: Sulphur printing, flow line observation, spark test		
Unit III	Phase Diagrams and Iron-Carbon Diagram	[09 Hr.]
Solid solutions: Introduction, Types, Humerothery rule for substitutional solid solutions Solidification: Nucleation & crystal growth, solidification of pure metals, solidification of alloys. Phase Diagrams: Cooling curves, types of phase diagrams, Gibbs phase rules Iron-Carbon Diagram: Iron-carbon equilibrium diagrams in detail with emphasis in the invariant reactions		

Unit IV	Heat Treatments	[08 Hr.]
<p>Austenite transformation in steel: Time temperature transformation diagrams, continuous cooling transformation diagrams. Retained austenite and its effect</p> <p>Steps in Heat treatment and Cooling Medium</p> <p>Heat Treatment Processes: Introduction, Annealing (Full annealing, Process annealing, Spheroidise annealing, isothermal annealing, stress relief annealing), Normalising, Hardening, Tempering, Austempering, Martempering, Sub-Zero Treatment, Hardenability</p> <p>Surface Hardening: Classification, Flame hardening, Induction hardening, Carburising, Nitriding, Carbonitriding</p>		
Unit V	Ferrous Materials	[07 Hr.]
<p>Carbon Steel: Classification, types & their composition, properties and Industrial application</p> <p>Alloy Steels: Classification of alloy steels & Effect of alloying elements, examples of alloy steels, (Stainless steel, Tool steel) sensitization of stainless steel</p> <p>Designation of carbon steel and alloy steels as per IS, AISI, SAE Standards</p> <p>Cast Iron: Classification, types & their composition, properties and Industrial application of (White CI, Gray CI, SG CI, Malleable Cast and alloy Cast Iron)</p> <p>Microstructure and property relationship of various ferrous Materials</p>		
Unit VI	Non-Ferrous Materials	[07 Hr.]
<p>Classification of Non-Ferrous Metals: Study of Non-ferrous alloys with Designation, Composition, Microstructure</p> <p>Mechanical & other properties for Industrial Applications: Copper and its Alloys (Gilding Metal, Cartridge Brass, Muntz Metal, Tin Bronze, Beryllium Bronze), Aluminium and its Alloy (LM5, Duralumin, Y-Alloy, Hinduminium), Nickel and its Alloys (Invar, Inconel), Titanium and its Alloys (α Alloys, α-β Alloys), Cobalt and its Alloys (Stellite Alloys, Alnico), Bearing Alloys (Classification, lead based alloys, tin based alloys), Age Hardening</p> <p>Microstructure and Property relationship of various Non-ferrous Materials</p> <p>Recent Material used in Additive Manufacturing: Properties, Composition and Application only</p>		
Books & Other Resources		
Text Books		
<ol style="list-style-type: none"> 1. Dr. V. D. Kodgire & S. V. Kodgire, “Material Science & Metallurgy For Engineers”, Everest Publication. 2. William D. Callister, “Materials Science and Engineering an Introduction”, Jr, John Wiley & Sons, Inc. 		
Reference Books		
<ol style="list-style-type: none"> 1. A. K. Bhargava, C.P. Sharma, “Mechanical Behaviour & Testing of Materials”, P H I Learning Private Ltd. 2. Raghvan V., “Material Science & Engineering”, Prentice Hall of India, New Delhi. 2003 3. Avner, S.H., “Introduction to Physical Metallurgy”, Tata McGraw-Hill, 1997. 4. Higgins R. A., “Engineering Metallurgy”, Viva books Pvt. Ltd. 5. George Ellwood Dieter, “Mechanical Metallurgy”, McGraw-Hill 1988 6. Smith, W.F, Hashemi, J., and Prakash, R., “Materials Science and Engineering in SI Units”, Tata McGraw Hill Education Pvt. Ltd. 		
Guidelines for Laboratory Conduction		
The student shall complete the following activity as a Term Work Journal		
<p><i>Total 10 experiments from the following list must be performed. Term Work of the Student is evaluated based on the completion of Practical, Assignments, and Industrial Visits.</i></p> <p>Practical (Any Seven)</p> <ol style="list-style-type: none"> 1. Destructive testing - Hardness testing (Rockwell/Vickers) Hardness conversion number 2. Brinell and Poldi hardness Test 		

3. Impact Test for Steel, Aluminum, Brass and Copper (Charpy/Izod)
4. Non Destructive testing - Dye Penetrant Test/ Magnetic Particle test/ Ultrasonic Test
5. Steps for Specimen Preparation for microscopic examination & Demonstration of Optical Metallurgical microscope
6. Observation and Drawing of Microstructure of Steels, Cast Iron of various compositions
7. Observation and Drawing of Microstructure of Non Ferrous Metals of various compositions
8. Heat Treatment of steels based on relative hardness
9. Jominy End Quench Test for hardenability

Miniature commitment or Assignments (*Any Two*)

1. Exploration of engineering Alloy (Name, composition, properties, microstructure, Heat treatment, Designation & specific applications)- One student one Alloy or material
2. Examine aspects of component form material and manufacturing process point of view (Name, Material, Drawing, Manufacturing Process, properties, microstructure, Heat treatment, & specific applications) - For example spur gear, Needle etc. One student one component
3. Creep and Fatigue Test (Virtual Lab IIT Bombay)
4. Fluorescence Microscope (Virtual Lab IIT Bombay)

Industrial Visits

To provide awareness and understanding of the course, Compulsory Industrial Visit must be arranged for the students.

The Industrial Visit must be preferably to

- Material & Metallurgy related like Engineering Cluster, NDT Lab, and Nearby NABL lab or
- Any manufacturing unit with material orientation

Student must submit a properly documented Industrial Visit Report.

Guidelines for Instructor's Manual

The Instructor's Manual should contain following related to every experiment:

1. Brief theory related to the experiment
2. Apparatus with their detailed specifications
3. Standard ASME/ IS numbers of test procedure
4. Schematic, Layout/diagram
5. Observation table/graphs.
6. Sample calculations for one/two reading
7. Result table, Graph and Conclusions.
8. 3/4 questions related to the experiment
9. Relevance of practical in industry with recent software of image analysis

Guidelines for Student's Lab Journal

The Student's Lab Journal should contain following related to every experiment:

1. Theory related to the experiment
2. Apparatus with their detailed specifications
3. Schematic, Layout/diagram
4. Observation table/simulation plots/graphs
5. Sample calculations for one/two reading
6. Result table. Graph and Conclusions
7. 3/4 questions related to the experiment
8. Attach Photo of experiment or image related to Experiment

Guidelines for Lab/TW Assessment

1. There should be continuous assessment for the TW
2. Assessment must be based on understanding of theory, attentiveness during practical, and understanding
3. Session, how efficiently the student is able to do connections and get the results
4. Online evolutions of practical with objective type of Questions
5. Timely submission of journal

203156 - Electrical and Electronics Engineering

Teaching Scheme	Credits	Examination Scheme
Theory : 03 Hr./Week Practical : 02 Hr./Week	04 Theory : 03 Practical : 01	In-Semester : 30 Marks End-Semester : 70 Marks Term Work : 25 Marks

Prerequisite Courses

Basic Electrical Engineering, Basic Electronics Engineering, Systems in Mechanical Engineering

Course Objectives

1. To understand Arduino IDE; an open source platform and its basic programming features
2. To interface Atmega328 based Arduino board with different devices and sensors
3. To study principle of operation of DC machines and speed control of DC motors
4. To know about three phase induction motor working and its applications
5. To get acquainted with Electric Vehicle (EV) technology and subsystems
6. To get familiar with various energy storage devices and electrical drives

Course Outcomes

On completion of the course, learner will be able to

- CO1. APPLY programming concepts to UNDERSTAND role of Microprocessor and Microcontroller in embedded systems
- CO2. DEVELOP interfacing of different types of sensors and other hardware devices with Atmega328 based Arduino Board
- CO3. UNDERSTAND the operation of DC motor, its speed control methods and braking
- CO4. DISTINGUISH between types of three phase induction motor and its characteristic features
- CO5. EXPLAIN about emerging technology of Electric Vehicle (EV) and its modular subsystems
- CO6. CHOOSE energy storage devices and electrical drives for EVs

Course Contents**Unit I Introduction to Arduino [08 Hr.]**

Introduction to microcontroller and microprocessors, role of embedded systems, open source embedded platforms, Introduction to Arduino IDE- features, IDE overview, Programming concepts: variables, functions, conditional statements, Concept of GPIO in Atmega328 based Arduino board, digital input and output

Unit II Peripheral Interface [07 Hr.]

Interfacing of Atmega328 based Arduino board with LED and LCD/serial monitor, serial communication using Arduino IDE, Concept of ADC in Atmega328 based Arduino board, interfacing of Atmega328 based Arduino board with temperature sensor (LM35), LVDT, strain gauge

Unit III DC Machines [08 Hr.]

Generating and motoring action, Constructional features of a DC machine, EMF equation of DC machine and its significance in motor

Concept of torque developed by motor and its equation, Concept of load torque, Types of loads and dynamics of motor and load combination, Characteristics of DC shunt motor, Speed control methods of DC shunt motor, Reversal of direction of rotation of DC motor, Braking in DC motor and its types, Regenerative braking in DC shunt motor

Unit IV Three Phase Induction Motors [07 Hr.]

Constructional features, working principle of three phase induction motor, types, torque equation, torque-slip characteristics, effect of rotor resistance on characteristics, modification in squirrel cage motor with deep bar rotor construction

Power stages, efficiency, starters (DOL starter and Star Delta starter), Methods of speed control-voltage and frequency control, variable frequency drive, applications

<p>Unit V</p> <p>Brief history of Electric Vehicle (EV), Components of EV, Benefits of EV</p> <p>Types of EVs such as Battery EV, Hybrid EV, Plug-in EV, Fuel Cell EV and their comparison, Challenges faced by EV technology</p> <p>Subsystems and configurations of EV, Subsystems of Hybrid EV, Configurations of series, parallel and series-parallel Hybrid EV</p> <p>Impact of EV on grid, Vehicle to grid technology- block diagram</p>	<p>Electric Vehicle (EV) Technology</p>	<p>[08 Hr.]</p>
<p>Unit VI</p> <p>Storage Devices: Cell construction and working of batteries like Lithium- Iron Phosphate (LFP), Lithium Nickel-Manganese-Cobalt (NMC) and Lithium- Manganese Oxide (LMO), Voltage, Impedance, Ah and Wh Capacity, Cycle Life, Energy density, Power, C-rate and safety aspects</p> <p>Use of supercapacitor and hydrogen fuel cell in EVs- necessity, advantages and specifications</p> <p>Factors used in selection of energy storage device in case of EVs, Vehicle Battery Management System - block diagram</p> <p>Electric Drives: Factors used for selection of the electric motor in EVs</p> <p>BLDC hub motor drive for EVs, characteristics and speed control of BLDC motor, three phase induction motor drive for EVs</p>	<p>Energy Storage Devices and Electric Drives</p>	<p>[07 Hr.]</p>
<p>Books & Other Resources</p>		
<p>Text Books</p> <ol style="list-style-type: none"> 1. Barret Steven F, “Arduino Microcontroller Processing for Everyone!”, 3rd Ed, Morgan and Claypool Publishers 2. Michael Margolis, “Arduino Cookbook”, 2nd Ed, O'Reilly Media 3. Hughes Edward, “Electrical and Electronic Technology”, Pearson Education 4. Ashfaq Husain, “Electric Machines”, 3rd Ed, Dhanpat Rai & Sons 5. Bhattacharya S. K., “Electrical Machine”, 3rd Ed, Tata McGraw Hill 6. Nagrath & Kothari, “Electrical Machines”, Tata McGraw Hill 7. Iqbal Hussein, “Electric and Hybrid Vehicles: Design Fundamentals”, CRC Press 8. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, “Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design”, 2nd Ed, CRC Press 		
<p>Reference Books</p> <ol style="list-style-type: none"> 1. Deshmukh Ajay, “Microcontrollers Theory and Applications”, Tata McGraw Hill 2. Massimo Banzi, “Getting Started with Arduino”, 2nd Ed, Maker Media, Inc. 3. Brad Kendall, “Getting Started With Arduino: A Beginner's Guide”, Justin Pot and Angela Alcorn (Editors) 4. Lowe, “Electrical Machines”, Nelson Publications 5. [A.E. Fitzgerald, Charles Kingsley, Stephen D. Umans, “Electrical Machines”, 5th Ed, Tata McGraw Hill 6. Pillai S. K., “A First Course on Electrical Drives”, New Age International (P) Ltd. 7. James Larminie, John Lowry, , “Electric Vehicle Technology Explained”, Wiley 8. Dhameja Sandeep, “Electric Vehicle Battery Systems”, Newnes 9. R. Krishnan, “Permanent Magnet Synchronous and Brushless DC Motor Drives”, CRC Press 		
<p>Web References</p> <ol style="list-style-type: none"> 1. www.arduino.cc (for downloading Arduino IDE and information) 2. www.alldatasheet.com (for datasheets of components) 3. https://spoken-tutorial.org/tutorial-search/ (for video tutorials on Arduino) 4. https://swayam.gov.in/NPTEL (for e-learning courses and video lectures) 		

Guidelines for Laboratory Conduction

The student shall complete the following activity as a Term Work

Total 10 experiments from the following list must be performed. Term Work of the Student is evaluated based on the completion of Practical, Assignments using Virtual Laboratory & Detailed Industrial Visit Report and Group Assignment using Case Study/Product Survey.

Practical - Electronics Engineering Laboratory (Any four experiments to be performed)

Atmega328 based Arduino board can be used for following interfaces:

1. Interfacing of LED to blink after every 1 sec
2. Display data using serial communication with PC
3. Interfacing of LCD to display given message
4. Interfacing of temperature sensor (LM35) and display output on LCD/serial monitor
5. Interfacing of strain gauge sensor to measure parameters like pressure, weight, etc., and display the measured value
6. Interfacing of LVDT sensor to measure the displacement and display the measured value

Practical - Electrical Engineering Laboratory (Any four experiments to be performed)

7. Demonstration of use of starters for DC motor and three phase induction motor along with understanding of specifications on name plates of these machines
8. Brake test on DC shunt motor
9. Study of power electronic converter based DC motor drive
10. Study of electrical braking of DC shunt motor (Rheostatic/ Plugging/regenerative)
11. Load test on three phase induction motor
12. Torque- speed characteristics of three phase induction motor

Assignments using Virtual Laboratory

Virtual Labs project is an initiative of the Ministry of Human Resource Development (MHRD), Government of India under the aegis of National Mission on Education through Information and Communication Technology (NMEICT). Please visit the following link for exploring experiments on Electrical Machines: <http://www.vlab.co.in/broad-area-electrical-engineering>

Assign following experiments by applying Virtual Labs:

1. Speed control of DC shunt motor by armature and field resistance control
2. Speed control of slip ring induction motor by rotor resistance control

Please refer http://vlabs.iitb.ac.in/vlabs-dev/vlab_bootcamp/bootcamp/Sadhya/experimentlist.html

Assignments using Case Study/Product Survey

Each group consisting of maximum five number of students should carry out a case study/product survey focused on various EVs available in Indian market. *Forming groups and allotment of specific task to the students group should be done at the beginning of semester so that students get sufficient time to carry out the survey and prepare a presentation.*

Students must

- Compare various models in each class.
- Study various main components of EVs
- A formal presentation on case study/product survey must be arranged before class/batch.

Industrial Visits

An industrial visit must be arranged to one of the following establishments during the semester.

The Industrial Visit must be preferably to

- Automation/Manufacturing industries
- Battery/EV Charging Stations
- Retro-fitting Workshops of ICE vehicle to EVs
- EV Service Stations

Student must submit properly documented Detailed Industrial Visit Report in his/her own words.

Instructions for Laboratory Conduction

Electronics Engineering Laboratory

1. The instructor is expected to shortlist necessary experiments from the suggested list of experiments.

2. During the practical session the instructor may divide the total students in groups of 4 to 5 students and assign them different experiments.
3. Each student in the group is supposed to execute the program.
4. The faculty should check the result of all the groups.

Electrical Engineering Laboratory

1. Check whether the MCB / ELCB / main switch is off while preparing the set-up.
2. Make connections as per circuit diagram. Use flexible wire for connection of voltmeter and pressure coil connection of wattmeter. For the rest of the connections, use thick wires. Do not keep the connections loose. Get it checked by the faculty / Lab Assistant.
3. Perform the experiment only in presence of faculty or Lab Assistant.
4. Do the calculations and get these checked from the faculty.
5. After completion of experiment, switch off the MCB / ELCB / main switch.
6. Write the experiment in the journal and get it checked regularly after conducting

Guidelines for Instructor's Manual

The Instructor's Manual should contain following related to every experiment:

1. Brief theory related to the experiment.
2. Connection diagram /circuit diagram
3. Observation table
4. Sample calculations for one reading
5. Result table
6. Graph and Conclusions.
7. Data sheets of the ICs used(if any)

Guidelines for Student's Lab Journal

Electronics Engineering Laboratory

1. Title of the program should be mentioned
2. The algorithm of the program must be written
3. Flow Chart for each program has to be drawn on separate page
4. Input data has to be specified
5. Result of the program should be highlighted

Electrical Engineering Laboratory

1. Lab journal should be hand written
2. Circuit diagrams can be drawn on graph paper
3. Specifications of the instruments/machines used for conduction of practical should be mentioned in respective write-up
4. Conclusion of each experiment should be written by student at the end

Guidelines for Lab/TW/PR Assessment

1. Continuous assessment should be carried out time to time.
2. During assessment, faculty should put the remark by writing the word "Complete" and not simply "C". Put the signature along with the date at the end of experiment and also in the index.
3. Assess each laboratory experiment/virtual lab assignment/report of industrial visit/case study for 10 marks each as per following details:
Attendance in practical - 02 marks
Timely completion of journal -03 marks
Presentation of write-up and results - 02 marks
Depth of understanding - 03 marks
4. Maintain a continuous assessment sheet on the basis of which final TW marks can be offered.

202045 - Geometric Dimensioning and Tolerancing Lab

Teaching Scheme	Credits	Examination Scheme
Practical : 02 Hr./Week	01 Practical : 01	Term Work : 25 Marks

Prerequisite Courses

Systems in Mechanical Engineering, Project Based Learning - I, Workshop Practise, Engineering Graphics

Course Objectives

1. To understand requirements of industrial drawings
2. To read, understand and explain basic Geometric Dimensioning & Tolerancing concepts
3. To apply various geometric and dimension tolerances based on type of fit
4. To include surface roughness symbols based on manufacturing process
5. To measure and verify position tolerances with applied material conditions
6. To understand requirements for manufacturing and assembly

Course Outcomes

On completion of the course, learner will be able to

- CO1. SELECT appropriate IS and ASME standards for drawing
 CO2. READ & ANALYSE variety of industrial drawings
 CO3. APPLY geometric and dimensional tolerance, surface finish symbols in drawing
 CO4. EVALUATE dimensional tolerance based on type of fit, etc.
 CO5. SELECT an appropriate manufacturing process using DFM, DFA, etc.

Guidelines for Laboratory Conduction

The student shall complete the following activity as a Term Work Journal

Total 9 Practical Assignments from the following list must be performed. Term Work of the Student is evaluated based on the completion of Practical, Industrial Visit Report and Group Assignment.

Practical (Assignment # 1 to 6 & 10 are compulsory; Select any Two from Assignment # 7 to 9)

The student shall complete the following Practical in laboratory. Learner will demonstrate skills to communicate drawings as per industry standards:

1. Study of drawing sheet layout, Principles of Drawing and various IS Standards & Conventions in Machine Drawing, Dimensioning practices - Terminology & Basic Rules, Styles, Conventions [02 Hr.]
2. GD&T -
 - (a) Terminology, Maximum and Minimum Material conditions, Features, Rules for GD&T, Datum Control [02 Hr.]
 - (b) Adding GD&T to a Design, Form Tolerances [02 Hr.]
 - (c) Orientation Tolerances, Profile Tolerances [02 Hr.]
 - (d) Location Tolerances, Run out Tolerances [02 Hr.]
3. Surface finish, Welding symbols [02 Hr.]
4. Study and reading of Industrial Drawings to understand standard industrial practices viz. Dimensioning, GD&T, Surface finish, welding symbols, etc. [04 Hr.]
 - (a) Machine Drawing, (b) Production Drawing, (c) Part Drawing,
 - (d) Assembly Drawing - (i) Assembly Drawing for Design, (ii) Assembly Drawing for Instruction Manuals, (iii) Exploded Assembly Drawing, (iv) Schematic Assembly Drawing, (v) Patent Drawing, etc.
5. Calculation of Tolerances based on Type of Fits in Assembly [02 Hr.]
6. Tolerance Stacks-Up with suitable examples [02 Hr.]
7. Design for Manufacturing (DFM) with suitable examples [02 Hr.]
8. Design for Assembly and Dis-assembly with suitable examples [02 Hr.]
9. Design for Safety with suitable examples [02 Hr.]
10. Industrial visit / Case study

Books & Other Resources

Text Books

1. Standards: ASME Y14.5 – 2018
2. Narayana, K. L., Kannaiah, P., Venkata Reddy, K., (2016), “Machine Drawing”, 2nd edition, New Age International Publishers, New Delhi, India, ISBN-13: 978-8122440546
3. Bhatt, N. D. and Panchal, V. M., (2014), “Machine Drawing”, Charotar Publishing House Pvt. Ltd, Anand, India, ISBN-13: 978-9385039232

Reference Books

1. Cogorno, G. R., (2020), "Geometric Dimensioning and Tolerancing for Mechanical Design", 3rd edition, McGraw-Hill Education
2. Blokdyk, Gerardus, (2019), "Geometric Dimensioning and Tolerancing: A Complete Guide - 2020 Edition", 5STARCOoks
3. Standards: ISO/TR 23605:2018, ISO 1101:2017, SP 46, IS 15054(2001)

202046 - Audit Course - III

Teaching Scheme	Credits	Examination Scheme
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GUIDELINES FOR CONDUCTION OF AUDIT COURSE

Faculty mentor shall be allotted for individual courses and he/she shall monitor the progress for successful accomplishment of the course. Such monitoring is necessary for ensuring that the concept of self learning is being pursued by the students 'in true letter and spirit'.

- If any course through Swayam/ NPTEL/ virtual platform is selected the minimum duration shall be of 8 weeks.
- However if any of the course duration is less than the desired (8 weeks) the mentor shall ensure that other activities in form of assignments, quizzes, group discussion etc. (allied with the course) for the balance duration should be undertaken.

In addition to credits courses, it is mandatory that there should be an audit course (non-credit course) from second year of Engineering. The student will be awarded grade as AP on successful completion of the audit course. The student may opt for any one of the audit courses in each semester. Such audit courses can help the student to get awareness of different issues which make an impact on human lives and enhance their skill sets to improve their employability. List of audit courses offered in the semester is provided in the curriculum. Students can choose one of the audit courses from the list of courses mentioned. Evaluation of the audit course will be done at institute level.

The student registered for audit course shall be awarded the grade AP and shall be included such grade in the Semester grade report for that course, provided student has the minimum attendance as prescribed by the Savitribai Phule Pune University and satisfactory in-semester performance and secured a passing grade in that audit course. No grade points are associated with this 'AP' grade and performance in these courses is not considered in the calculation of the performance indices SGPA and CGPA. Evaluation of the audit course will be done at institute level itself.

Selecting an Audit Course

List of Courses to be opted (Any one) under Audit Course III

- Technical English For Engineers
 - Entrepreneurship Development
 - Developing soft skills and personality
 - Design Thinking
 - Foreign Language (preferably German/ Japanese)
 - Science, Technology and Society
- # The titles indicated above are subject to change in time to come and such an alteration (if any) should be brought to the notice of the BoS.

Using NPTEL Platform: (preferable)

NPTEL is an initiative by MHRD to enhance learning effectiveness in the field of technical education by developing curriculum based video courses and web based e-courses. The details of NPTEL courses are available on its official website www.nptel.ac.in

- Students can select any one of the courses mentioned above and has to register for the corresponding online course available on the NPTEL platform as an Audit course.
- Once the course is completed the student can appear for the examination as per the guidelines on the NPTEL portal.
- After clearing the examination successfully; student will be awarded with a certificate.

Assessment of an Audit Course

- The assessment of the course will be done at the institute level. The institute has to maintain the record of the various audit courses opted by the students. The audit course opted by the students could be interdisciplinary.
- During the course students will be submitting the online assignments. A copy of the same can be submitted as a part of term work for the corresponding Audit course.
- On the satisfactory submission of assignments, the institute can mark as "Present" and the student will be awarded the grade AP on the marksheet.

207002 - Engineering Mathematics - III

Teaching Scheme	Credits	Examination Scheme
Theory : 03 Hr./Week Tutorial : 01Hr/Week	04 Theory : 03 Practical : 01	In-Semester : 30 Marks End-Semester : 70 Marks Term Work : 25 Marks

Prerequisite Courses

Differential & Integral calculus, Differential equations of first order & first degree, Fourier series, Collection, classification and representation of data and Vector algebra.

Course Objectives

1. To make the students familiarize with concepts and techniques in Ordinary & Partial differential equations, Laplace transform & Fourier transform, Statistical methods, Probability theory and Vector calculus.
2. The aim is to equip them with the techniques to understand advanced level mathematics and its applications that would enhance analytical thinking power, useful in their disciplines.

Course Outcomes

On completion of the course, learner will be able to

- CO1. SOLVE higher order linear differential equations and its applications to model and analyze mass spring systems.
- CO2. APPLY Integral transform techniques such as Laplace transform and Fourier transform to solve differential equations involved in vibration theory, heat transfer and related mechanical engineering applications.
- CO3. APPLY Statistical methods like correlation, regression in analyzing and interpreting experimental data applicable to reliability engineering and probability theory in testing and quality control.
- CO4. PERFORM Vector differentiation & integration, analyze the vector fields and APPLY to fluid flow problems.
- CO5. SOLVE Partial differential equations such as wave equation, one and two dimensional heat flow equations.

Course Contents

Unit I Linear Differential Equations (LDE) and Applications [08 Hr.]

LDE of nth order with constant coefficients, Complementary Function, Particular Integral, General method, Short methods, Method of variation of parameters, Cauchy's and Legendre's DE, Simultaneous and Symmetric simultaneous DE. Modelling of Mass-spring systems, Free & Forced damped and undamped systems.

Unit II Transforms [08 Hr.]

Laplace Transform (LT): LT of standard functions, properties and theorems, Inverse LT, Application of LT to solve LDE.
Fourier Transform (FT): Fourier integral theorem, Fourier transform, Fourier sine & cosine transforms, Inverse Fourier Transforms.

Unit III Statistics [07 Hr.]

Measures of central tendency, Measures of dispersion, Coefficient of variation, Moments, Skewness and Kurtosis, Curve fitting: fitting of straight line, parabola and related curves, Correlation and Regression, Reliability of Regression Estimates.

Unit IV Probability and Probability Distributions [07 Hr.]

Probability, Theorems on Probability, Bayes Theorem, Random variables, Mathematical Expectation, Probability distributions: Binomial, Poisson, Normal, Test of Hypothesis: Chi-Square test, t-test.

Unit V Vector Calculus [08 Hr.]

Vector differentiation, Gradient, Divergence and Curl, Directional derivative, Solenoidal & Irrotational fields, Vector identities. Line, Surface and Volume integrals, Green's Lemma, Gauss's Divergence theorem and Stoke's theorem.

Unit VI	Applications of Partial Differential Equations (PDE)	[08 Hr.]
Basic concepts, modelling of Vibrating String, Solution of Wave equation, One and two dimensional Heat flow equations, Method of separation of variables, use of Fourier series. Solution of Heat equation by Fourier transforms.		
Books & Other Resources		
Text Books		
1. B.V. Ramana, "Higher Engineering Mathematics", Tata McGraw-Hill		
2. B. S. Grewal, "Higher Engineering Mathematics", Khanna Publication, Delhi		
Reference Books		
1. Erwin Kreyszig, "Advanced Engineering Mathematics", 10e, by Wiley India.		
2. M. D. Greenberg, "Advanced Engineering Mathematics", 2e, by Pearson Education.		
3. Peter V. O'Neil, "Advanced Engineering Mathematics", 7e, by Cengage Learning		
4. S. L. Ross, "Differential Equations", 3e by Wiley India.		
5. Sheldon M. Ross, "Introduction to Probability and Statistics for Engineers and Scientists", 5e, by Elsevier Academic Press		
Guidelines for Tutorial and term Work		
1. Tutorial shall be engaged in four batches (batch size of 20 students maximum) per division.		
2. Term work shall be based on continuous assessment of six assignments (one per each unit) and performance in internal tests. The student shall complete the following activity as a Term Work Journal.		

202047 - Kinematics of Machinery

Teaching Scheme	Credits	Examination Scheme
Theory : 03 Hr./Week Practical : 02 Hr./Week	04 Theory : 03 Practical : 01	In-Semester : 30 Marks End-Semester : 70 Marks Oral : 25 Marks

Prerequisite Courses

Systems in Mechanical Engineering, Engineering Mathematics - I and II, Engineering Physics, Engineering Mechanics, Geometric Modeling & Drafting

Course Objectives

1. To make the students conversant with kinematic analysis of mechanisms applied to real life and industrial applications.
2. To develop the competency to analyze the velocity and acceleration in mechanisms using analytical and graphical approach.
3. To develop the skill to propose and synthesize the mechanisms using graphical and analytical technique.
4. To develop the competency to understand & apply the principles of gear theory to design various applications.
5. To develop the competency to design a cam profile for various follower motions.

Course Outcomes

On completion of the course, learner will be able to

- CO1. APPLY kinematic analysis to simple mechanisms
 CO2. ANALYZE velocity and acceleration in mechanisms by vector and graphical method
 CO3. SYNTHESIZE a four bar mechanism with analytical and graphical methods
 CO4. APPLY fundamentals of gear theory as a prerequisite for gear design
 CO5. CONSTRUCT cam profile for given follower motion

Course Contents

Unit I Fundamentals of Mechanism [07 Hr.]

Kinematic link, Types of links, Kinematic pair, Types of constrained motions, Types of Kinematic pairs, Kinematic chain, Types of joints, Mechanism, Machine, Degree of freedom, Mobility of Mechanism, Inversion, Grashoff's law, Four-Bar Chain and its Inversions, Slider crank Chain and its Inversions, Double slider crank Chain and its Conversions, Mechanisms with Higher pairs, Equivalent Linkages and its Cases - Sliding Pairs in Place of Turning Pairs, Spring in Place of Turning Pairs, Cam Pair in Place of Turning Pairs

Unit II Kinematic Analysis of Mechanisms: Analytical Method [07 Hr.]

Analytical methods for displacement, velocity and acceleration analysis of slider crank Mechanism, Velocity and acceleration analysis of Four-Bar and Slider crank mechanisms using Vector and Complex Algebra Methods. Computer-aided Kinematic Analysis of Mechanism like Slider crank and Four-Bar mechanism, Analysis of Single and Double Hook's joint

Unit III Kinematic Analysis of Mechanisms: Graphical Method [08 Hr.]

Displacement, velocity and acceleration analysis mechanisms by Relative Velocity Method (Mechanisms up to 6 Links), Instantaneous Centre of Velocity, Kennedy's Theorem, Angular Velocity ratio Theorem, Analysis of mechanism by ICR method (Mechanisms up to 6 Links), Coriolis component of Acceleration (Theoretical treatment only)

Unit IV Synthesis of Mechanisms [07 Hr.]

Steps in Synthesis: Type synthesis, Number Synthesis, Dimensional synthesis, Tasks of Kinematic synthesis - Path, function and motion generation (Body guidance), Precision Positions, Chebychev spacing, Mechanical and structural errors

Graphical Synthesis: Inversion and relative pole method for three position synthesis of Four-Bar and Single Slider Crank Mechanisms

Analytical Synthesis: Three position synthesis of Four-Bar mechanism using Freudenstein's equation, Blotch synthesis

Unit V	Kinematics of Gears	[08 Hr.]
<p>Gear: Classification</p> <p>Spur Gear: Terminology, law of gearing, Involute and cycloidal tooth profile, path of contact, arc of contact, sliding velocity, Interference and undercutting, Minimum number of teeth to avoid interference, Force Analysis (theoretical treatment only)</p> <p>Helical and Spiral Gears: Terminology, Geometrical Relationships, virtual number of teeth for helical gears</p> <p>Bevel Gear & Worm and Worm Wheel: Terminology, Geometrical Relationships</p> <p>Gear Train: Types, Analysis of Epicyclic gear Trains, Holding torque - simple, compound and Epicyclic gear Trains, Torque on Sun and Planetary gear Train, compound Epicyclic gear Train</p>		
Unit VI	Mechanisms in Automation Systems	[08 Hr.]
<p>Cams & Followers: Introduction, Classification of Followers and Cams, Terminology of Cam Displacement diagram for the Motion of follower as Uniform velocity, Simple Harmonic Motion (SHM), Uniform Acceleration and Retardation Motion (UARM), Cycloid motion, Cam Profile construction for Knife-edge Follower and Roller Follower, Cam jump Phenomenon</p> <p>Automation: Introductions, Types of Automation</p> <p>Method of Work Part Transport: Continuous transfer, Intermittent or Synchronous Transfer, Asynchronous transfer, Different type of transfer mechanisms - Linear transfer mechanisms and Rotary transfer mechanisms</p> <p>Automated Assembly-Line: Types, Assembly line balancing Buffer Storages, Automated assembly line for car manufacturing, Artificial intelligence in automation</p>		
Books & Other Resources		
Text Books		
<ol style="list-style-type: none"> 1. S. S. Rattan, "Theory of Machines", Third Edition, McGraw Hill Education (India) Pvt. Ltd., New Delhi. 2. Bevan T, "Theory of Machines", Third Edition, Longman Publication 3. G. Ambekar, "Mechanism and Machine Theory", PHI 4. J. J. Uicker, G. R. Pennock, J. E. Shigley, "Theory of Machines and Mechanisms", Fifth Edition, International Student Edition, Oxford 		
Reference Books		
<ol style="list-style-type: none"> 1. Paul E. Sandin, "Robot Mechanisms and Mechanical Devices Illustrated", Tata McGraw Hill Publication 2. Stephen J. Derby, "Design of Automatic Machinery", 2005, Marcel Dekker, New York 3. Neil Sclater, "Mechanisms and Mechanical Devices Sourcebook", Fifth Edition, Tata McGraw Hill Publication 4. Ghosh Malik, "Theory of Mechanism and Machines", East-West Pvt. Ltd. 5. Hannah and Stephans, "Mechanics of Machines", Edward Arnold Publication 6. R. L. Norton, "Kinematics and Dynamics of Machinery", First Edition, McGraw Hill Education (India) P Ltd. New Delhi 7. Sadhu Singh, "Theory of Machines", Pearson 8. Dr. V. P. Singh, "Theory of Machine", Dhanpatrai and Sons 9. C. S. Sharma & Kamlesh Purohit, "Theory of Machine and Mechanism", PHI 10. M.P. Groover, "Automation, production systems and computer-integrated manufacturing", Prentice-Hall of India Pvt. Ltd, New Delhi 		
Web References		
<ol style="list-style-type: none"> 1. https://nptel.ac.in/courses/112104121/ (NPTEL1, Kinematics of Machines, Prof. Ashok K Mallik, IIT Kanpur) 2. https://nptel.ac.in/courses/112/106/112106270/ (NPTEL2, Theory of Mechanism, Prof. Sujatha Srinivasan, IIT Madras) 3. https://nptel.ac.in/courses/112/105/112105268/ (NPTEL3, Kinematics of Mechanisms and Machines, Prof. Anirvan DasGupta, IIT Kharagpur) 		

4. <https://nptel.ac.in/courses/112/105/112105236/> (NPTEL4, Mechanism and Robot Kinematics, Prof. Anirvan DasGupta, IIT Kharagpur)
5. http://www.cdeep.iitb.ac.in/webpage_data/nptel/Mechanical/Robotics/Course/Course_home_lect1.html (NPTEL5, Introduction to Robotics and Automation, IIT Bombay)

Guidelines for Laboratory Conduction

The student shall complete the following activity as a Term Work

Total 10 experiments from the following list must be performed. Term Work of the Student is evaluated based on the completion of Practical, Assignments using Drawing Aids, Assignments using Software & Programming Languages, Assignments using Virtual Laboratory and Detailed Industrial Visit Report.

Practical (*Experiment # 1 is compulsory and Select any Two from Experiment # 2 to 4*)

1. To make a model of any mechanism by using waste material by the group of 4 to 6 students and to give a presentation using PPTs.
2. Speed and torque analysis of epicyclic gear train to determine holding torque.
3. To study and verify cam jump phenomenon.
4. To study manufacturing of gear using gear generation with rack as a cutter and to generate an involute profile.

Assignments using Drawing Aids (*Experiment #1 to 3 and 6 are compulsory and Select any One from Experiment #4-5*)

Do following graphical assignments on Half Imperial drawing sheet:

1. Identify mechanisms in real life and Analyze for types and number of links, pairs, obtain degrees of freedom. Submit the sheet and working video of the mechanism.
2. To solve two problems on velocity and acceleration analysis using relative velocity and acceleration method.
3. To solve two problems on velocity analysis using the ICR method.
4. To draw conjugate profile for any general type of gear tooth.
5. To study various types of gearboxes.
6. To draw cam profile for any two problems with combination of various follower motion with radial and off-set cam.

Assignments using Software (*Any Three Assignments - Minimum one computer programming based and Minimum one based on use of software*)

Do following assignments by using Software or by using Coding/Programming Languages:

1. To design a simple Planer Mechanism by using any software (Geogebra, SAM, Working Model, any 3D Modelling Software, etc.)
2. To do computer programming (using software/programming languages like C, Python, Scilab, Matlab etc.) for Kinematic Analysis of Slider Crank Mechanism using Analytical Method
3. To do computer programming (using software/programming languages like C, Python, Scilab, Matlab etc.) for Kinematic Analysis of Hooke's joint Mechanism using Analytical Method
4. To generate a Cam Profile using any Modelling Software (Mech Analyser, any 3D Modelling Software)
5. To synthesize the Four-Bar and Slider Crank Mechanism (Geogebra, SAM, any 2D/3D Modelling Software)
6. To do computer programming (using software/programming languages like C, Python, Scilab, Matlab etc.) for the Synthesis of Mechanism using Chebychevs spacing, Freudensteins equation and function generation

Assignments using Virtual Laboratory (*minimum Two experiments*)

Please visit the links given below for exploring experiments on Kinematics of Machinery using Virtual Laboratory. Write a Brief Reports of using Virtual Laboratory to perform following assignment:

1. Mechanics-of-Machines Lab (All Experiments), <http://mm-nitk.vlabs.ac.in/index.html>
2. Mechanisms and Robotics - Oldham Coupling Mechanism, <http://vlabs.iitkgp.ernet.in/mr/index.html>
3. Mechanisms and Robotics - Quick Return Mechanism, <http://vlabs.iitkgp.ernet.in/mr/index.html>

4. Mechanisms and Robotics - CAM Follower Mechanism,
<http://vlabs.iitkgp.ernet.in/mr/index.html>

Industrial Visits

A Compulsory industrial visit must be arranged to industries/ establishments consisting automation and mechanization during semester to provide awareness and understanding of the course.

The Industrial Visit must be preferably to

- Manufacturing industries with Assembly-line Automation
- Sugar factory
- Bottle filling plants

Student must submit properly documented Detailed Industrial Visit Report in his/her own words.

Assignments on Content beyond syllabus

Following assignments can be attempted:

1. Forward and Inverse Kinematics of 2R/2P/RP/PR Manipulators using Software (Geogebra, RoboAnalyser, Vlab, etc.)
2. Kinematic Analysis of 6 DOF Industrial Robot using Software (RoboAnalyzer, Vlab, etc.)

202048 - Applied Thermodynamics

Teaching Scheme	Credits	Examination Scheme
Theory : 03 Hr./Week Practical : 02 Hr./Week	04 Theory : 03 Practical : 01	In-Semester : 30 Marks End-Semester : 70 Marks Oral : 25 Marks

Prerequisite Courses

Engineering Thermodynamics, Systems in Mechanical Engineering, Engineering Mathematics - I, Engineering Mathematics - II

Course Objectives

1. To determine COP of refrigeration cycle and study Psychrometric properties and processes.
2. To study working of engine, Actual, Fuel-Air and Air standard cycle and its Performance.
3. To understand Combustion in SI and CI engines and factors affecting performance parameters
4. To study emission from IC Engines and its controlling method, various emission norms.
5. To estimate performance parameters by conducting a test on I. C. Engines.
6. To determine performance parameters of Positive displacement compressor.

Course Outcomes

On completion of the course, learner will be able to

- CO1. DETERMINE COP of refrigeration system and ANALYZE psychrometric processes.
 CO2. DISCUSS basics of engine terminology, air standard, fuel air and actual cycles.
 CO3. IDENTIFY factors affecting the combustion performance of SI and CI engines.
 CO4. DETERMINE performance parameters of IC Engines and emission control.
 CO5. EXPLAIN working of various IC Engine systems and use of alternative fuels.
 CO6. CALCULATE performance of single and multi stage reciprocating compressors and DISCUSS rotary positive displacement compressors

Course Contents

Unit I Basics of Refrigeration and Psychrometry [07 Hr.]

Refrigeration: Reversed Carnot Cycle, unit of refrigeration, Simple Vapour Compression Cycle (VCC), Refrigerating Effect, Compressor Power & COP. Simple Vapor Absorption Cycle (VAC), Comparison between VCC & VAC.

Psychrometry: Introduction, Psychrometry and Psychrometric Properties, Basic Terminologies & Psychrometric Relations, Psychrometric Processes, Psychrometric Chart.

Unit II Introduction to Internal Combustion (IC) Engine [06 Hr.]

IC Engine: Components and Construction details, Terminology, Classification, Applications, Intake and exhaust system, Valves actuating mechanisms, Valve timing diagram.

Fuel, Air and Actual Cycle: Air-standard cycles, fuel air cycles, and actual cycles, Effects of variables on performance, various losses, and Comparison of Air standard with Fuel and Actual cycle.

Unit III SI and CI Engines [09 Hr.]

SI Engines: Theory of Carburetion and Types of Carburetor, Working of Simple Carburetor, Electronic Fuel Injection System, Combustion stages in SI engines, Abnormal Combustion, Theory of Detonation and Parameters affecting detonations, Rating of fuels in SI engines, Combustion Chambers used in SI Engine.

CI Engines: Fuel Injection system, Construction and Working of Fuel Pump, Fuel Injector and Various types of Nozzle, Combustion stages in CI engines, Theory of knocking and Parameters affecting knocking, Rating of fuels in CI engines, Combustion Chambers used in CI Engines.

Unit IV IC Engine Testing and Emission [09 Hr.]

Engine Testing: Engine Testing Procedure, Measurement of indicated power, Brake power, fuel consumption, Air Consumption, Measurement of friction power by Willan's Line Method and Morse Test, calculation of mean effective pressure, various efficiencies, specific fuel consumption, heat balance sheet of IC Engines and performance Characteristic curves.

Emission & Control: Introduction to Indian Driving Cycle (IDC), European Driving Cycle (EDC), SI and CI Engines Emission and controlling methods, Methods to measure emission such as (Non Dispersive Infrared Red (NDIR), Flame Ionization Detector (FID), Chemiluminescent Analyzer, Smoke meter), Euro Norms and Bharat Stage Norms.

Unit V Engine Systems and Alternative Fuels [07 Hr.]

Cooling system: Air Cooling, Liquid cooling, **Lubrication system:** Objectives of lubrication system, properties of lubricant, Methods of lubrication system, **Ignition system:** battery coil ignition system, magneto ignition system, Electronics Ignition (CDI, TCI), Maximum Brake Torque (MBT) & spark advance. Supercharging and Turbo-charging.

Alternative Fuels: Bio-diesel, Ethanol, LPG, CNG and Hydrogen.

Unit VI Compressor [07 Hr.]

Reciprocating Compressor: Applications of compressed air, single stage compressor (without clearance and with clearance volume), volumetric efficiency, isothermal efficiency, effect of clearance volume, free air delivery (FAD), actual indicator diagram for air compressor, Multi staging of compressor, optimum intermediate pressure, intercooler, after cooler, Capacity control of compressors.

Rotary Compressors: Roots blower, Vane type, Screw compressor and Scroll compressor.

Books & Other Resources

Text Books

1. Arora C. P., "Refrigeration and Air Conditioning", Tata McGraw-Hill
2. V. Ganesan, "Internal Combustion Engines", Tata McGraw-Hill
3. M. L. Mathur and R.P. Sharma, "A course in Internal combustion engines", Dhanpat Rai & Co.
4. H.N. Gupta, "Fundamentals of Internal Combustion Engines", PHI Learning Pvt. Ltd.

Reference Books

1. Dossat Ray J, "Principles of refrigeration, S.I. version", Willey Eastern Ltd, 2000
2. Heywood, "Internal Combustion Engine Fundamentals", Tata McGraw-Hill
3. Domkundwar & Domkundwar, "Internal Combustion Engine", Dhanpat Rai & Co.
4. R. Yadav, "Internal Combustion Engine", Central Book Depot, Ahmedabad.
5. S.Domkundwar,C.P. Kothandaraman,A.Domkundwar,"Thermal Engineering",DhanpatRai & Co.

Guidelines for Laboratory Conduction

The student shall complete the following activity as a Term Work

Total 10 of the following list must be performed. During Oral, the Student shall be evaluated based on the completion of Practical, Assignments, Presentations and Detailed Industrial Visit Report.

Practical (Minimum 6 Practical must be performed)

1. Trial on Vapour Compression System
2. Trial on Vapour Absorption System
3. Trial on Air-Conditioning Test Rig.
4. Morse Test on Petrol engine.
5. Trial on Diesel engine.
6. Trial on Petrol engine.
7. Trial on variable compression ratio engine.
8. Trial on Positive Displacement Air Compressor.
9. Demonstration on Exhaust Gas Analyser and Smoke meter.

Survey (Minimum one)

1. Practical Survey of various fuel supply systems.
2. Practical Survey of supercharged and turbocharged engines.

Activity: Presentation based

Compulsory study of following topics must be done by students during semester to gain awareness and further understanding of the course and a presentation of the same should be included in the TW:

1. **Engines:**(any one) Homogeneous charge compression ignition (HCCI)/ Stratified charge

engine/Variable valve timing (VVT)/Variable geometry turbocharger (VGT), etc.

2. **Automotive Field:** (any one) Hydrogen CNG vehicles/Adaptive cruise control system/On-board diagnostic system (OBD) / Electric Battery classification/Fuel Cell vehicle/Rear driving emission (RDE) system

Industrial Visit

A Compulsory industrial visit must be arranged to automobile manufacturing or servicing.

Students must submit properly documented Detailed Industrial Visit Report in his/her own words.

202049 - Fluid Mechanics		
Teaching Scheme	Credits	Examination Scheme
Theory : 03 Hr./Week Practical : 02 Hr./Week	04 Theory : 03 Practical : 01	In-Semester : 30 Marks End-Semester : 70 Marks Oral : 25 Marks
Prerequisite Courses Engineering Mathematics - I, Engineering Mathematics - II, Engineering Mechanics, Engineering Physics		
Course Objectives 1. To understand basic properties of fluids. 2. To learn fluid statics and dynamics 3. To study basics of flow visualization 4. To understand Bernoulli's theorem and its applications. 5. To understand losses in flow, drag and lift forces 6. To learn to establish relation between flow parameters.		
Course Outcomes On completion of the course, learner will be able to CO1. DETERMINE various properties of fluid CO2. APPLY the laws of fluid statics and concepts of buoyancy CO3. IDENTIFY types of fluid flow and terms associated in fluid kinematics CO4. APPLY principles of fluid dynamics to laminar flow CO5. ESTIMATE friction and minor losses in internal flows and DETERMINE boundary layer formation over an external surface CO6. CONSTRUCT mathematical correlation considering dimensionless parameters, also ABLE to predict the performance of prototype using model laws		
Course Contents		
Unit I	Properties of Fluid	[06 Hr.]
Definition of fluid, concept of continuum, density, specific weight, specific gravity, viscosity, viscosity laws, types of fluid and rheology, measurement of viscosity, application based numerical on viscosity-flow through pipe, lubrication, bearing, brake fluids, parallel plates, rotating shafts etc., vapor pressure surface tension, capillarity, compressibility		
Unit II	Fluid Statics	[07 Hr.]
Laws of fluid statics: forces acting on fluid element, pascal's law, hydrostatics law, hydraulic ram Pressure measurement: pressure scale, piezometer, barometer, manometer - simple, inclined, differential, micro manometer, inverted Forces acting on surfaces immersed in fluid: total pressure and center of pressure on submerged plane surfaces, curved surface submerged in liquid including numerical on dam gate Buoyancy: flotation, stability of bodies		
Unit III	Fluid Kinematics	[08 Hr.]
Flow description methods, types of flows, velocity and acceleration fields, continuity equation in 1D & 3D flow, flow visualization (path line, stream line and streak line), stream tube, angularity, vorticity, stream function and velocity potential function, flow net		
Unit IV	Fluid Dynamics	[10 Hr.]
Euler's equation of motion differential form and Navier Stokes equation, Euler's equation of motion along streamline, Bernoulli's theorem and modified Bernoulli's theorem, stagnation pressure, HGL, TEL Flow measurement: venturimeter, orifice meter, pitot tubes, static pitot tube, introduction to coriolis flow meter, introduction to orifices, notches & weirs Laminar flow: Entrance region theory, velocity and shear Stress distribution for laminar flow through pipe, fixed parallel plates and Couette flow, velocity profile of turbulent flow		

Unit V	Internal & External Flow	[09 Hr.]
<p>Internal Flow: Losses - major & minor losses, hydro dynamically smooth and rough boundaries, Moody's chart, compounding of pipes & equivalent pipe, siphons, transmission of power</p> <p>External Flow: Boundary layer formation over a flat plate, boundary layer thickness, displacement thickness, momentum thickness and energy thickness, boundary layer separation and methods to control separation, drag and lift concepts, types of drag, drag & lift coefficient, aerofoil, bluff body, streamline body</p>		
Unit VI	Dimensional Analysis & Similitude	[08 Hr.]
<p>Dimensional Analysis: Introduction, system of dimensions, Dimensional homogeneity, Buckingham-Pi Theorem, repeating variables, dimensionless numbers and their physical significance</p> <p>Similitude & Model Testing: Model & prototype, similarity, scaling parameters, model laws, objectives, importance and application of model studies.</p>		
Books & Other Resources		
Text Books		
<ol style="list-style-type: none"> 1. Sukumar Pati, "Fluid Mechanics and Hydraulics Machines", TATA McGraw Hill. 2. Munson, Young and Okiishi, "Fundamentals of Fluid Mechanics", Wiley India 3. Potter Wiggert, "Fluid Mechanics", Cengage Learning 4. Fox, Pichard, "Introduction to Fluid Mechanics", McDonald- Wiley 5. Modi P. N. and Seth S. M, "Hydraulics and Fluid Mechanics", Standard Book House. 6. Cengel & Cimbala, "Fluid Mechanics", TATA McGraw-Hill 7. F. M. White, "Fluid Mechanics", TATA McGraw-Hill 8. R. K. Bansal, "Fluid Mechanics & Hydraulic Machines", Laxmi Publication 		
Reference Books		
<ol style="list-style-type: none"> 1. Kundu, Cohen, Dowling, "Fluid Mechanics", Elsevier India 2. Chaim Gutfinger David Pnueli, "Fluid Mechanics" Cambridge University press. 3. Edward Shaughnessy, Ira Katz James Schaffer, "Introduction to Fluid Mechanics", Oxford University Press 		
Web References		
<ol style="list-style-type: none"> 1. https://nptel.ac.in/courses/112/105/112105171/ 2. https://nptel.ac.in/courses/112/104/112104118/ 3. https://nptel.ac.in/courses/112/105/112105269/ 4. http://www.efluids.com/efluids/books/efluids_books.htm 5. http://web.mit.edu/hml/ncfmf.html 6. http://www.efluids.com/efluids/pages/edu_tools.htm 7. https://spoken-tutorial.org/tutorial-search/?search_foss=OpenFOAM&search_language= 		
Guidelines for Laboratory Conduction		
The student shall complete the following activity as a Term Work		
<p><i>Total 10 experiments from the following list must be performed. During Oral, the Student is evaluated based on the completion of Practical, Assignments using Virtual Lab and Detailed Mini project / Industrial Visit Report/ Simulation of fluid flow / Programming using any suitable software.</i></p> <p>Practical (Experiment # 3 & 9 are compulsory; Select any One Simulation of Experiments from Experiment # 4 & 6; Perform any Eight experiments)</p> <ol style="list-style-type: none"> 1. Determination of pressure using manometers (minimum two) 2. Determination of fluid viscosity and its variation with temperature. 3. Determination of Metacentric height of floating object. 4. Determination of Reynolds number and flow visualization of laminar and turbulent flow using Reynolds apparatus. 5. Draw flow net using electrical analogy apparatus to calculate discharge for rectangular / enlargement / contraction channel. 6. Verification of modified Bernoulli's equation. 7. Calibration of Orifice meter/ Venturimeter/Notch. 8. Determination of minor/major losses through metal/non-metal pipes. 		

9. Mini project/Industrial visit/Simulation of fluid flow/Programming using any suitable software

Assignments using Virtual Laboratory (*Any Two Virtual Lab experiments from experiment # 1,2,5,7,8 mentioned above*)

Please visit the links given below for exploring and performing experiments on Fluid Mechanics using Virtual Laboratory. Write brief Reports using Virtual Laboratories:

1. <https://eerc03-iiith.vlabs.ac.in/>
2. <http://fm-nitk.vlabs.ac.in/>

202050 - Manufacturing Processes

Teaching Scheme	Credits	Examination Scheme
Theory : 03 Hr./Week	03 Theory : 03	In-Semester : 30 Marks End-Semester : 70 Marks

Prerequisite Courses

Material Science and Metallurgy, Engineering Physics, Systems in Mechanical Engineering

Course Objectives

1. Describe various sand and permanent mould casting methods, procedure and mould design aspects.
2. Understand basics of metal forming processes, equipment and tooling.
3. Understand sheet metal forming operations and die design procedure.
4. Classify, describe and configure the principles of various welding techniques.
5. Understand plastic processing techniques.
6. To know about composites, its fabrication processes.

Course Outcomes

On completion of the course, learner will be able to

- CO1. SELECT appropriate moulding, core making and melting practice and estimate pouring time, solidification rate and DESIGN riser size and location for sand casting process
- CO2. UNDERSTAND mechanism of metal forming techniques and CALCULATE load required for flat rolling
- CO3. DEMONSTRATE press working operations and APPLY the basic principles to DESIGN dies and tools for forming and shearing operations
- CO4. CLASSIFY and EXPLAIN different welding processes and EVALUATE welding characteristics
- CO5. DIFFERENTIATE thermoplastics and thermosetting and EXPLAIN polymer processing techniques
- CO6. UNDERSTAND the principle of manufacturing of fibre-reinforce composites and metal matrix composites

Course Contents

Unit I **Casting Processes** **[07 Hr.]**

Introduction to casting processes, Patterns: Pattern materials, types of pattern, allowances pattern design, Moulding sand, Properties of moulding sands, Core making, Melting practices and furnaces, Pouring and Gating system design, Numerical estimation to find mold filling time, Riser design and placement, Principles of cooling and solidification of casting, Directional and Progressive solidification Estimation of solidification rate, Cleaning and Finishing of casting, Defects and remedies, Principle and equipments of Permanent mould casting, Investment casting, Centrifugal casting, Continuous casting

Unit II **Metal Forming Processes** **[08 Hr.]**

Plastic deformation. Stress-strain diagram for different types of material, Hot and Cold working, Factors affecting plastic deformation, Yield criteria, Concept of flow stress, Forming Limit diagram

Rolling Process: Rolling terminology, Friction in rolling, Calculation of rolling load

Forging: Open and closed die forging, Forging operations

Extrusion: Types, Process parameter

Wire and Tube Drawing: Wire and tube drawing process, Die profile

Friction and lubrication in metal forming, Forming defects, causes and remedies for all forming processes

Unit III **Sheet Metal Forming** **[07 Hr.]**

Types of sheet metal operations, Press working equipment and terminology, Types of dies, Clearance analysis, Estimation of cutting forces, Centre of pressure and blank size determination, Design of strip lay-out, Blanking die design, Introduction to Drawing, Bending dies, Methods of reducing

forces, Formability and forming limit diagrams

Unit IV **Welding Processes** **[08 Hr.]**

Classification of joining processes, Welding terminology and types of joints

Arc Welding Processes: Principles and equipments of Single carbon arc welding, FCAW, TIG, MIG, SAW

Resistance Welding: Spot, Seam and Projection weld process, Heat balance in resistance welding

Gas Welding and Cutting, Soldering, brazing and braze welding

Welding Metallurgy and Heat Affected Zone, Weld inspection, Defects in various joints and their remedies

Unit V **Processing of polymers** **[07 Hr.]**

Thermoplastics and Thermosetting, Processing of polymers, Thermoforming, Extrusion

Moulding: Compression moulding, Transfer moulding, Blow moulding, Rotation moulding, Injection moulding - Process and equipment

Extrusion of Plastic: Type of extruder, extrusion of film, pipe, Cable and Sheet – Principle

Pressure forming and Vacuum forming

Unit VI **Manufacturing of Composites** **[08 Hr.]**

Introduction to composites, Composite properties, Matrices, Fiber reinforcement

Composite Manufacturing Processes: Hand lay-up Process, Spray lay-up, Filament winding process, Resin transfer moulding, Pultrusion, and Compression moulding process, Vacuum impregnation process, Processing of metal matrix composites, Fabrication of ceramic matrix composites, Carbon-carbon composites, Polymer matrix and nano-composites

Books & Other Resources

Text Books

1. P. N. Rao, "Manufacturing Technology Vol. I & II" , Tata McGraw Hill Publishers
2. P. C. Sharma, "Production Engineering", Khanna Publishers

Reference Books

1. R. K. Jain, "Production Technology", Khanna Publishers
2. K. C. Chawala, "Composite Materials", Springer, ISBN 978-0387743646, ISBN 978-0387743653
3. Brent Strong, "Fundamentals of Composites Manufacturing: Materials, Methods", SME Book series

202051 - Machine Shop		
Teaching Scheme	Credits	Examination Scheme
Practical : 02 Hr./Week	01 Practical : 01	In-Semester : 30 Marks End-Semester : 70 Marks Term Work : 50 Marks
Prerequisite Courses Workshop Practice		
Course Objectives		
<ol style="list-style-type: none"> To understand the basic procedures, types of equipment, tooling used for sand casting and metal forming processes through demonstrations and/(or) Industry visits.. To understand TIG/ MIG/ Resistance/Gas welding techniques. To acquire skills to handle grinding and milling machine and to produce gear by milling. To acquire skills to produce a composite part by manual process. 		
Course Outcomes		
On completion of the course, learner will be able to		
CO1. PERFORM welding using TIG/ MIG/ Resistance/Gas welding technique		
CO2. MAKE Fibre-reinforced Composites by hand lay-up process or spray lay-up techniques		
CO3. PERFORM cylindrical/surface grinding operation and CALCULATE its machining time		
CO4. DETERMINE number of indexing movements required and acquire skills to PRODUCE a spur gear on a horizontal milling machine		
CO5. PREPARE industry visit report		
CO6. UNDERSTAND procedure of plastic processing		
Guidelines for Laboratory Conduction		
The student shall complete the following activity as a Term Work		
Practical (<i>Select any One Practical from Practical # 1 & 2; Select any Five Practical from Practical # 3 to 8; Perform Total Six Practicals</i>)		
<ol style="list-style-type: none"> To study and observe various stages of casting through demonstration of sand casting process from pattern making, sand mould preparation and melting and pouring of metal. Visit to any foundry/ permanent mould casting industry to demonstrate various stages of casting and make a report on it. A compulsory visit to any one metal forming industry out of: Rolling mill, Forging plant, Wire/Tube drawing unit and prepare a report on it. A demonstration of any one welding technique out of TIG/ MIG/Resistance/Gas welding. A job drawing to be prepared by an individual institute with details of welding process parameters with weld joint design such as edge preparation, type and size of electrode used, welding current, voltage etc. Manufacturing of Fibre-reinforced Composites by hand lay-up process or spray lay-up techniques. Demonstration on any one plastic component like bottle, bottle caps, machine handles etc. by injection moulding process/ by additive manufacturing process. Demonstration on cylindrical grinding/surface grinding operations, measurement of surface roughness produced and estimation of machining time. Demonstration on indexing mechanism. Calculation of index crank and index plate movement by simple/compound/differential indexing and manufacture of spur gear on a milling machine using indexing head. 		
Instructions for Laboratory Conduction		
Please note following instructions regarding Laboratory Conduction:		
<ol style="list-style-type: none"> Industrial Visits to be conducted by the Teaching Faculty (subject Teacher). Demonstration of Welding machines, Surface/Cylindrical Grinding, Milling machine, Indexing head and calculation of indexing to be taught by a subject Teacher in Practical slot. 		

202052 - Project Based Learning - II

Teaching Scheme	Credits	Examination Scheme
Practical : 04 Hr./Week	02 Practical : 02	Term Work : 50 Marks

Preamble

Currently, engineering education is undergoing significant structural changes worldwide. The rapidly evolving technological landscape forces educators to constantly reassess the content of engineering curricula in the context of emerging fields and with a multidisciplinary focus. In this process, it is necessary to devise, implement and evaluate innovative pedagogical approaches for the incorporation of these novel subjects into the educational programs without compromising the cultivation of the traditional skills. In this context, the educational community is showing rapidly rising interest in project-based learning approaches.

The mainstream engineering education follows traditional classroom teaching, in which the major focus is mainly on the lecture and the student has very little (if any) choice on the learning process. However rapid development in engineering and technology requires adopting a teaching approach that would assist students not only in developing a core set of industry relevant skills, but also enable them to adapt to changes in their professional career.

Course Objectives

1. To emphasize project based learning activities that are long-term, interdisciplinary and student-centric.
2. To inculcate independent and group learning by solving real world problems with the help of available resources.
3. To be able to develop applications based on the fundamentals of mechanical engineering by possibly applying previously acquired knowledge.
4. To get practical experience in all steps in the life cycle of the development of mechanical systems: specification, design, implementation, and testing.
5. To be able to select and utilize appropriate concepts of mechanical engineering to design and analyze selected mechanical system.

Course Outcomes

On completion of the course, learner will be able to

- CO1. IDENTIFY the real-world problem (possibly of interdisciplinary nature) through a rigorous literature survey and formulate / set relevant aims and objectives.
- CO2. ANALYZE the results and arrive at valid conclusions.
- CO3. PROPOSE a suitable solution based on the fundamentals of mechanical engineering by possibly integration of previously acquired knowledge.
- CO4. CONTRIBUTE to society through proposed solutions by strictly following professional ethics and safety measures.
- CO5. USE of technology in proposed work and demonstrate learning in oral and written form.
- CO6. DEVELOP ability to work as an individual and as a team member.

Group Structure

Working in supervisor/mentor –monitored groups. The students plan, manage and complete a task/project/activity which addresses the stated problem.

1. Create groups of 5 (five) to 6 (six) students in each class
2. A supervisor/mentor teacher is assigned to 3-4 groups or one batch

Project Selection

The project can be selected by undertaking a survey of journal papers, patents or field visit (A problem can be theoretical, practical, social, technical, symbolic, cultural and/or scientific). The problem shall consist of following facets: feasibility of arriving at a solution, analyzing the problem, design and development of the system (hardware or virtual).

There are no commonly shared criteria/ guidelines for what constitutes an acceptable project. Projects vary greatly in the depth of the questions explored, the clarity of the learning goals, the

content and structure of the activity undertaken.

Solution to problem-based projects through “*learning by doing*” is recommended. The model begins with the identifying of a problem, often growing out of a question or “wondering”. This formulated problem then stands as the starting point for learning. A problem can be theoretical, practical, social, technical, symbolic, cultural and/or scientific and grows out of students’ wandering within different disciplines and professional environments. As stated in the preamble as the world has adapted and propagated multidisciplinary approach, hence the proposed project activity preferably should not be restricted to only mechanical domain specific projects rather should be Interdisciplinary in nature. However the chosen problem should be integration of other streams of engineering with Mechanical engineering.

Although in a genuine case 100% software/ virtual project topic may be allowed.

Ethical Practices, teamwork and project management:

Use Indian standards or any relevant standards for project manufacturing, respect the time of others, attend the reviews, poster presentation and model exhibitions, strictly follow the deadline of project completion, comply with all legislation requirements that govern workplace health and safety practices.

Effective Documentation

In order to make our engineering graduates capable of preparing effective documentation, it is required for the students to learn the effective writing skills. The PBL final report is expected to consist of the Literature Survey, Problem Statement, Aim and Objectives, System Block Diagram, System Implementation Details, Discussion and Analysis of Results, Conclusion, System Limitations and Future Scope. Many freely available software tools (for instance Mendley (Elsevier), Grammarly) are expected to be used during the preparation of PBL synopsis and final report. It is expected that the PBL guides/mentors shall teach students about utilizing valid sources of information (such as reference papers, books, magazines, etc) related to their PBL topic.

Evaluation & Continuous Assessment

The institution/head shall be committed to ensuring the effective and rigorous implementation of the idea of project based learning. Progress of PBL shall be monitored regularly on a weekly basis. Weekly review of the work shall be necessary. During the process of monitoring and continuous assessment and evaluation the individual and team performance is to be measured. PBL is monitored and continuous assessment is done by supervisor /mentor and authorities. Students must maintain an institutional culture of authentic collaboration, self-motivation, peer-learning and personal responsibility. The institution/department should support students in this regard through guidance/orientation programs and the provision of appropriate resources and services. Supervisor/mentor and Students must actively participate in assessment and evaluation processes.

The effectiveness of the concept PBL lies in rigorous and continuous assessment and evaluation of the student performance. It is recommended that all activities are required to be recorded regularly. A regular assessment of PBL work is required to be maintained at the department in PBL log book by students. It is expected that the PBL log book must include following:

1. Information of students and guide
2. Weekly monitoring by the PBL guide,
3. Assessment sheet for PBL work review by PBL guide and PBL Evaluation Committee (PEC).

The PEC structure shall consist of Head of the department, 1/2 senior faculties of the department and one industry expert (optional). Continuous Assessment Sheet (CAS) is to be maintained by the department.

Recommended parameters for assessment, evaluation and weightage

1. Idea Inception (kind of survey). (10%)
2. Documentation (Gathering requirements, design & modeling, implementation/execution, use of technology and final report, other documents). (15%)
3. Attended reviews, poster presentation and model exhibition. (10%)

4. Demonstration (Poster Presentation, Model Exhibition etc). (10%).
5. Awareness /Consideration of - Environment/ Social /Ethics/ Safety measures/Legal aspects. (5%)
6. Outcome (physical model/prototype/ virtual model/ product development/ assembly & disassembly and analysis of standard mechanism or system, design and development of small applications using Arduino, design of control systems, development of various systems/ subsystems of BAJA/SUPRA/Robots/GoKart/ Sunrisers/Hackathon/ application development and similar activities/ System performance and analysis) (40%)
7. Participation in various competitions/ publication/ copyright/ patent) (10%)

Learning Resources

Reference Books / Research Articles

1. John Larmer, John R. Mergendoller, and Suzie Boss, “Setting the Standard for Project Based Learning”
2. John Larmer and Suzie Boss, “Project Based Teaching: How to Create Rigorous and Engaging Learning Experiences”
3. Erin M. Murphy and Ross Cooper, “Hacking Project Based Learning: 10 Easy Steps to PBL and Inquiry”

Web resources

1. <https://www.edutopia.org/project-based-learning>
2. www.howstuffworks.com
3. <https://www.pblworks.org/>
4. www.wikipedia.org

202053 - Audit Course - IV

Teaching Scheme	Credits	Examination Scheme
-	-	-

GUIDELINES FOR CONDUCTION OF AUDIT COURSE

Faculty mentor shall be allotted for individual courses and he/she shall monitor the progress for successful accomplishment of the course. Such monitoring is necessary for ensuring that the concept of self learning is being pursued by the students 'in true letter and spirit'.

- If any course through Swayam/ NPTEL/ virtual platform is selected the minimum duration shall be of 8 weeks.
- However if any of the course duration is less than the desired (8 weeks) the mentor shall ensure that other activities in form of assignments, quizzes, group discussion etc. (allied with the course) for the balance duration should be undertaken.

In addition to credits courses, it is mandatory that there should be an audit course (non-credit course) from second year of Engineering. The student will be awarded grade as AP on successful completion of the audit course. The student may opt for any one of the audit courses in each semester. Such audit courses can help the student to get awareness of different issues which make an impact on human lives and enhance their skill sets to improve their employability. List of audit courses offered in the semester is provided in the curriculum. Students can choose one of the audit courses from the list of courses mentioned. Evaluation of the audit course will be done at institute level.

The student registered for audit course shall be awarded the grade AP and shall be included such grade in the Semester grade report for that course, provided student has the minimum attendance as prescribed by the Savitribai Phule Pune University and satisfactory in-semester performance and secured a passing grade in that audit course. No grade points are associated with this 'AP' grade and performance in these courses is not considered in the calculation of the performance indices SGPA and CGPA. Evaluation of the audit course will be done at institute level itself.

Selecting an Audit Course

List of Courses to be opted (Any one) under Audit Course IV

- Language & Mind Emotional Intelligence
- Advanced Foreign Language (preferably German/ Japanese)
- Human Behaviour
- Speaking Effectively
- Business Ethics
- Technical writing/ Research writing

The titles indicated above are subject to change in time to come and such an alteration (if any) should be brought to the notice of the BoS.

Using NPTEL Platform: (preferable)

NPTEL is an initiative by MHRD to enhance learning effectiveness in the field of technical education by developing curriculum based video courses and web based e-courses. The details of NPTEL courses are available on its official website www.nptel.ac.in

- Students can select any one of the courses mentioned above and has to register for the corresponding online course available on the NPTEL platform as an Audit course.
- Once the course is completed the student can appear for the examination as per the guidelines on the NPTEL portal.
- After clearing the examination successfully; student will be awarded with a certificate.

Assessment of an Audit Course

- The assessment of the course will be done at the institute level. The institute has to maintain the record of the various audit courses opted by the students. The audit course opted by the students could be interdisciplinary.
- During the course students will be submitting the online assignments. A copy of the same can be submitted as a part of term work for the corresponding Audit course.
- On the satisfactory submission of assignments, the institute can mark as "Present" and the student will be awarded the grade AP on the mark sheet.

Savitribai Phule Pune University

Faculty of Science & Technology



Curriculum/Syllabus

For

Third Year

**Bachelor of Engineering
(Choice Based Credit System)**

**Mechanical Engineering
(2019 Course)**

**Board of Studies – Mechanical and Automobile Engineering
(With Effect from Academic Year 2021-22)**

Savitribai Phule Pune University
Board of Studies - Automobile and Mechanical Engineering
Undergraduate Program - Mechanical Engineering (2019 pattern)

Course Code	Course Name	Teaching Scheme (Hrs./week)			Examination Scheme and Marks						Credit			
		TH	PR	TUT	ISE	ESE	TW	PR	OR	Total	TH	PR	TUT	Total
Semester-V														
302041	Numerical & Statistical Methods	3	-	1	30	70	25	-	-	125	3	-	1	4
302042	Heat & Mass Transfer	3	2	-	30	70	-	50	-	150	3	1	-	4
302043	Design of Machine Elements	3	2	-	30	70	-	-	25	125	3	1	-	4
302044	Mechatronics	3	2	-	30	70	-	-	25	125	3	1	-	4
302045	Elective I	3	-	-	30	70	-	-	-	100	3	-	-	3
302046	Digital Manufacturing Laboratory	-	2	-	-	-	50	-	-	50	-	1	-	1
302047	Skill Development	-	2	-	-	-	25	-	-	25	-	1	-	1
302048	Audit course - V ^s	-	-	-	-	-	-	-	-	-	-	-	-	-
Total		15	10	1	150	350	100	50	50	700	15	5	1	21
Semester-VI														
302049	Artificial Intelligence & Machine Learning	3	2	-	30	70	-	-	25	125	3	1	-	4
302050	Computer Aided Engineering	3	2	-	30	70	-	50	-	150	3	1	-	4
302051	Design of Transmission Systems	3	2	-	30	70	-	-	25	125	3	1	-	4
302052	Elective II	3	-	-	30	70	-	-	-	100	3	-	-	3
302053	Measurement Laboratory	-	2	-	-	-	50	-	-	50	-	1	-	1
302054	Fluid Power & Control Laboratory	-	2	-	-	-	50	-	-	50	-	1	-	1
302055	Internship/Mini project *	-	4	-	-	-	100	-	-	100	-	4	-	4
302056	Audit course - VI ^s	-	-	-	-	-	-	-	-	-	-	-	-	-
Total		12	14	-	120	280	200	50	50	700	12	9	-	21
Elective-I						Elective-II								
302045-A	Advanced Forming & Joining Processes				302052-A	Composite Materials								
302045-B	Machining Science & Technology				302052-B	Surface Engineering								
Abbreviations: TH: Theory, PR: Practical, TUT: Tutorial, ISE: In-Semester Exam, ESE: End-Semester Exam, TW: Term Work, OR: Oral														
Note: Interested students of TE (Automobile Engineering and Mechanical Engineering) can opt for any one of the audit course from the list of audit courses prescribed by BOS (Automobile and Mechanical Engineering)														
Instructions:														
<ul style="list-style-type: none"> Practical/Tutorial must be conducted in FOUR batches per division only. Minimum number of Experiments/Assignments in PR/Tutorial shall be carried out as mentioned in the syllabi of respective courses. Assessment of tutorial work has to be carried out similar to term-work. The Grade cum marks for Tutorial and Term-work shall be awarded on the basis of continuous evaluation. ^sAudit course is mandatory but non-credit course. Examination has to be conducted at the end of Semesters for award of grade at institute level. Grade awarded for audit course shall not be calculated for grade point & CGPA. 														

302041: Numerical and Statistical Methods					
Teaching Scheme		Credits		Examination Scheme	
Theory	3Hrs./Week	Theory	3	In-Semester	30 Marks
Tutorial	1Hr./Week	Tutorial	1	End-Semester	70 Marks
				Term Work	25 Marks
<p>Prerequisites: System of linear equations, Partial differentiation, Statistics, Probability, Problem solving and programming.</p> <p>Course Objectives:</p> <ol style="list-style-type: none"> 1. UNDERSTAND applications of systems of equations and solve mechanical engineering applications. 2. APPLY differential equations to solve the applications in the domain of fluid mechanics, structural, etc. 3. LEARN numerical integration techniques for engineering applications. 4. COMPARE the system's behavior for the experimental data. 5. INTERPRET Statistical measures for quantitative data. 6. ANALYZE datasets using probability theory and linear algebra. <p>Course Outcomes:</p> <p>On completion of the course the learner will be able to;</p> <p>CO1: SOLVE system of equations using direct and iterative numerical methods. CO2: ESTIMATE solutions for differential equations using numerical techniques. CO3: DEVELOP solution for engineering applications with numerical integration. CO4: DESIGN and CREATE a model using a curve fitting and regression analysis. CO5: APPLY statistical Technique for quantitative data analysis. CO6: DEMONSTRATE the data, using the concepts of probability and linear algebra.</p>					
Course Contents					
Unit 1	Roots of Equation and Simultaneous Equations				07 Hrs.
<p>Roots of Equation: Bracketing method and Newton-Raphson method Solution of simultaneous equations: Gauss Elimination Method with Partial pivoting, Gauss-Seidel method, Thomas algorithm for Tri-diagonal Matrix.</p>					
Unit 2	Numerical Solution of Differential Equations				08 Hrs.
<p>Ordinary Differential Equations [ODE]: Taylor series method, Euler Method, Runge-Kutta 4th order. Simultaneous equations using Runge-Kutta 2nd order method. Partial Differential Equations [PDE]: Finite difference method, Simple Laplace method, PDE's Parabolic explicit solution, Elliptic explicit solution.</p>					
Unit3	Numerical Integration				06 Hrs.
<p>Numerical Integration (1D): Trapezoidal rule, Simpson's 1/3rdRule, Simpson's 3/8thRule, Gauss Quadrature 2-point and 3-point method. Double Integration: Trapezoidal rule, Simpson's 1/3rdRule.</p>					

Unit 4	Curve Fitting and Regression Analysis	08 Hrs.
<p>Curve Fitting: Least square technique- first order, power equation, exponential equation and quadratic equation.</p> <p>Regression Analysis: Linear regression, Nonlinear regression, Multiple regressions, Polynomial regression. Lagrange's interpolation, Numerical interpolation and differentiation using Newton's forward method, inverse interpolation (Lagrange's method only).</p>		
Unit 5	Statistics	08 Hrs.
<p>Measures of central tendency: mean, median, mode. Measurement of variability and dispersion: Standard deviation, standard error, variance, range. Measure of shape: skewness, kurtosis</p> <p>Statistical diagram: scattered diagram, histogram, pie charts, and measure of association between two variables. Correlation: Karl Pearson's Coefficient of correlation and its mathematical properties, Spearman's Rank correlation and its interpretations.</p>		
Unit 6	Probability and Linear Algebra	08 Hrs.
<p>Probability: Joint, conditional and marginal probability, Bayes' theorem, independence, theorem of total probability, expectation and variance, random variables. Probability distributions: Binomial, Poisson, Geometric, Uniform, Exponential, Gamma, Normal and Chi square.</p> <p>Linear algebra: Review of matrix operations, vector and vector spaces, linear mapping.</p>		
Books and other resources		
Text Books:		
<ol style="list-style-type: none"> 1. Steven C. Chapra, 'Applied Numerical Methods with MATLAB for Engineers and Scientist', Tata Mc-Graw Hill Publishing Co. Ltd. 2. B. S. Grewal, 'Numerical Methods in Engineering and Science', Khanna Publication. 3. B. S. Grewal, 'Higher Engineering Mathematics', Khanna Publication. 		
References Books:		
<ol style="list-style-type: none"> 1. Erwin Kreyszig, 'Advanced Engineering Mathematics', Wiley India 2. Joe D. Hoffman, 'Numerical Methods for Engineers and Scientists', CRC Press 3. Sheldon M. Ross, 'Introduction to Probability and Statistics for Engineers and Scientists', 5e, by Elsevier Academic Press 4. Deisenth, Faisal, Ong, 'Mathematics for machine learning', Cambridge University Press. 5. Kandasamy, 'Numerical methods', S Chand. 6. Jason Brownlee, 'Statistical Methods for Machine Learning', Machine learning Mastery. 		
Web References:		
<ol style="list-style-type: none"> 1. http://nptel.ac.in/courses/111101003/ 2. http://nptel.ac.in/courses/111105038/ 3. http://nptel.ac.in/courses/111107063/ 4. http://nptel.ac.in/courses/111105041/ 5. http://nptel.ac.in/courses/111104079/ 6. https://www.analyticsvidhya.com/ 		

List of Tutorials

Term Work shall consist of:

Group A – (Any three programs using suitable programming language)

1. Roots of equation
2. Simultaneous equations
3. Ordinary differential equation
4. Partial differential equation
5. Numerical Integration

Group B (Any three programs for simple dataset using suitable programming)

6. Curve fitting using least square technique
7. Regression analysis
8. Determine statistical measures
9. Probability distribution

Group C (Mandatory)

10. One program based mini project using mechanical engineering application dataset

Note: Tutorials shall be mandatorily conducted in the computer laboratory.

302042: Heat and Mass Transfer					
Teaching Scheme		Credits		Examination Scheme	
Theory	3 Hrs./Week	Theory	3	In-Semester	30 Marks
Practical	2 Hrs./Week	Practical	1	End-Semester	70 Marks
				Practical	50 Marks
<p>Prerequisites: First and Second Law of Thermodynamics, Fluid properties, Continuity equation, Differential and Integral Calculus, Ordinary differential and Partial Differential Equations, Numerical solution for Differential Equations.</p>					
<p>Course Objectives:</p> <ol style="list-style-type: none"> 1. IDENTIFY the laws for different modes of heat transfer. 2. UNDERSTAND the properties and economics of thermal insulation and ANALYZE heat transfer through fins and thermal systems with lumped heat capacitance. 3. ANALYZE the natural and forced convective mode of heat transfer in various geometric configurations. 4. UNDERSTAND AND REALIZE various laws with their interrelations and analyze Radiation heat transfer in black and grey bodies/surfaces with or without radiation shields. 5. UNDERSTAND the fundamentals and laws of mass transfer and its applications. 6. ANALYZE various performance parameters for existing heat exchanger and DEVELOP methodologies for designing a heat exchanger under prescribed conditions and for a particular application, with references TEMA standards 					
<p>Course Outcomes: On completion of the course, learner will be able to</p> <p>CO1. ANALYZE & APPLY the modes of heat transfer equations for one dimensional thermal system.</p> <p>CO2. DESIGN a thermal system considering fins, thermal insulation and & Transient heat conduction.</p> <p>CO3. EVALUATE the heat transfer rate in natural and forced convection & validate with experimentation results.</p> <p>CO4. INTERPRET heat transfer by radiation between objects with simple geometries, for black and grey surfaces.</p> <p>CO5. ABILITY to analyze the rate of mass transfer using Fick's Law of Diffusion and understands mass diffusion in different coordinate systems.</p> <p>CO6. DESIGN & ANALYSIS of heat transfer equipments and investigation of its performance.</p>					
Course Contents					
Unit 1	Fundamentals of Heat Transfer				08 Hrs.
<p>Basic Concepts: Different Modes and Laws of heat transfer, 3-D heat conduction equation in Cartesian coordinates (with derivation), and its simplified equations, simplified equations in cylindrical and spherical coordinates (simplified equations, no derivation) thermal conductivity,</p>					

<p>thermal diffusivity, electrical analogy, Thermal contact Resistance.</p> <p>Boundary and initial conditions: Temperature boundary condition, heat flux boundary condition, convection boundary condition, radiation boundary condition.</p> <p>1-D steady state heat conduction without and with heat generation: Heat conduction without heat generation in plane wall, composite wall, composite cylinder, composite sphere. Heat conduction with heat generation in Plane wall, Cylinder and Sphere with different boundary conditions.</p>		
Unit 2	Heat Transfer through Extended Surfaces & Transient Heat Conduction	08 Hrs.
<p>Thermal Insulation – Critical thickness of insulation, Types and properties of insulating materials, Safety considerations in thermal insulation, Economic and cost considerations, Payback period, Numerical on payback period.</p> <p>Heat transfer through extended surfaces: Types of fins and its applications, Governing Equation for constant cross sectional area fins, Solution for infinitely long fin (with derivation), adequately long fin with insulated end tip and short fins (no derivation), Fin Efficiency & Effectiveness of fins, estimation of error in Temperature measurement by thermometer.</p> <p>Transient heat conduction: Validity and criteria of lumped system analysis, Biot Number, Fourier Number, Time Constant and Response of thermocouple, Use of Heisler Charts for plane wall, cylinder and sphere</p>		
Unit 3	Convection	08 Hrs.
<p>Principles of Convection: Local and average heat transfer coefficient, Hydrodynamic and Thermal boundary layer for a flat plate and pipe flow.</p> <p>Forced Convection: Physical significance of non-dimensional numbers, Empirical correlations for flat plate, pipe flow, and flow across cylinders, spheres, tube banks.</p> <p>Free Convection: Physical significance of non-dimensional numbers, Free convection from a vertical, horizontal surface, cylinder and sphere. Mixed Convection</p> <p>Boiling and Condensation: Types of boiling, Regimes of pool boiling, Film wise condensation, Drop wise condensation (No Numerical treatment), Critical heat flux.</p>		
Unit 4	Radiation	07 Hrs.
<p>Thermal Radiation; definition of various terms used in radiation mode; Stefan-Boltzmann law, Kirchhoff's law, Planck's law and Wein's displacement law. Intensity of radiation and solid angle; Lambert's law; Radiation heat exchange between two black surfaces, configuration or view factor. Radiation heat exchange between grey surfaces, Electrical analogy for radiation, Radiation shields, Numerical.</p>		
Unit 5	Mass Transfer	07 Hrs.
<p>Physical origins, applications of mass transfer, Mixture Composition, Phase diagram, Fick's Law of Diffusion with numerical treatment, Restrictive Conditions, Mass diffusion coefficient, Conservation of Species,</p> <p>The Mass Diffusion equation – Cartesian coordinates deviation, cylindrical coordinates and Spherical coordinates (no derivation), Boundary and initial conditions.</p>		

Unit 6:	Heat Exchangers and Equipment Design	07 Hrs.
<p>Heat Exchangers: Classification and applications of heat exchangers, Heat exchanger analysis – LMTD for parallel and counter flow heat exchangers, Effectiveness– NTU method for parallel and counter flow heat exchangers, cross flow heat exchangers, LMTD correction factor, Heat Pipe, Introduction to electronic cooling - Active and passive methods of augmented heat transfer.</p> <p>Process Equipment Design: Condenser Design, Introduction to TEMA standards, Design considerations for heat exchangers, Materials of construction and corrosion, Temperature effects, Radiation effects, Economic consideration, Condenser and Heat exchanger design and performance calculations, Design of shell and tube type Heat Exchanger</p>		
<p>Books & Other Resources</p>		
<p>Text Books:</p> <ol style="list-style-type: none"> 1. Franck P. Incropera, David P. DeWitt – Fundamentals of Heat and Mass Transfer, 2. Y. A. Cengel and A.J. Ghajar, Heat and Mass Transfer – Fundamentals and Applications, Tata McGraw Hill Education Private Limited. 3. S.P. Sukhatme, A Textbook on Heat Transfer, Universities Press. 4. R.C. Sachdeva, Fundamentals of Engineering Heat and Mass Transfer, New Age Science. 5. Joshi's Process Equipment Design, by V.V. Mahajani , S.B. Umarji ,Trinity Press 		
<p>Reference Books:</p> <ol style="list-style-type: none"> 1. P.K. Nag, Heat & Mass Transfer, McGraw Hill Education Private Limited. 2. M.M. Rathod, Engineering Heat and Mass Transfer, Third Edition, Laxmi Publications, New Delhi 3. V. M. Domkundwar, Heat Transfer, Dhanpat Rai & Co Ltd. 4. A.F. Mills, Basic Heat and Mass Transfer, Pearson. 5. S. P. Venkatesan, Heat Transfer, Ane Books Pvt. Ltd. 6. Holman, Fundamentals of Heat and Mass Transfer, McGraw – Hill publication. 7. M. Thirumaleshwar, Fundamentals of Heat and Mass Transfer, Pearson Education India. 8. B.K. Dutta, Heat Transfer-Principles and Applications, PHI. 9. C.P. Kothandaraman, S. V. Subramanyam, Heat and Mass Transfer Data Book, New Academic Science. 10. Process heat Transfer, D. Q. Kern, Wiley Publication 		
<p>NPTEL Links:</p> <p>E books: Links to be provided</p> <ol style="list-style-type: none"> 1. https://libgen.is 2. http://libgen.li/item/index.php?md5=314BFA11A24C3C1ACFDED2B5AB88E5E9 <p>Links of NPTEL / related videos</p> <ol style="list-style-type: none"> 1. https://www.youtube.com/watch?v=qa-PQOjS3zA&list=PL5F4F46C1983C6785 2. https://www.youtube.com/watch?v=qa-PQOjS3zA&list=PL5F4F46C1983C6785 3. https://www.youtube.com/watch?v=J_zqQcncAu4&index=3&list=PLpCr5N2IS7Nmu22MOgDWOOr0sSIlpUNUz3 4. https://www.youtube.com/watch?v=SNnd0f3xXlG&list=PLpCr5N2IS7Nmu22MOgDWOOr0s 		

[SIIpUNUz3&index=11](#)

5. <https://www.youtube.com/watch?v=SNnd0f3xXlg&list=PLpCr5N2IS7Nmu22MOgDWOOr0sSIIpUNUz3&index=11>
6. <https://www.youtube.com/watch?v=lnFjt30goiY&index=18&list=PLpCr5N2IS7Nmu22MOgDWOOr0sSIIpUNUz3>

Guidelines for Laboratory Conduction

The student shall complete the following activity as a Term Work

Complete **eight** experiments and **two** assignments (Sr. no.10 to 13).

1. Determination of Thermal Conductivity of insulating powder.
2. Determination of Thermal Conductivity of metal rod.
3. Determination of local and average heat transfer coefficient in Natural Convection.
4. Determination of local and average heat transfer coefficient in Forced Convection.
5. Determination of temperature distribution, fin efficiency in Natural / Forced Convection.
6. Determination of Emissivity of a Test surface.
7. Determination of Stefan Boltzmann Constant.
8. Determination of heat transfer, overall heat transfer coefficient and effectiveness of Plate Heat Exchanger.
9. Study of Pool boiling phenomenon and determination of Critical Heat Flux (CHF).
10. Assignment to solve transient heat transfer problem using Heisler and Grober Charts.
11. Design of heat exchanger for any simple application.
12. Industrial visit to heat treatment industry/ heat exchanger manufacturing industry.
13. Demonstration of dropwise and filmwise condensation.
14. Virtual laboratory: study of the performance of heat exchanger /study of variation of Thermal Conductivity.

Link for Virtual Lab: - <https://www.vlab.co.in/>

302043: Design of Machine Elements					
Teaching Scheme		Credits		Examination Scheme	
Theory	3Hrs./Week	Theory	3	In-Semester	30 Marks
Practical	2 Hrs./Week	Practical	1	End-Semester	70 Marks
				Oral	25 Marks
<p>Prerequisites: The basics of material elastic behavior, stress, strain, its relationship, failure modes, different theories of failure and its applications. The design cycle, basis of design considerations like strength, rigidity, manufacture, assembly and cost, standards and codes. The preferred sizes and series, tolerances and types of fits. Construction of SMD and BMD. Roots of equations, Interpolation rule.</p>					
<p>Course Objectives:</p> <ol style="list-style-type: none"> 1. UNDERSTAND the various design considerations, design procedure and select materials for a specific application 2. CALCULATE the stresses in machine components due to various types of loads and failure 3. ANALYZE machine components subjected to variable loading for finite and infinite life 4. DESIGN various machine components such as shafts, couplings, keys, screws, joints, springs 					
<p>Course Outcomes:</p> <p>On completion of the course, learner will be able to</p> <p>CO1. DESIGN AND ANALYZE the cotter and knuckle Joints, levers and components subjected to eccentric loading.</p> <p>CO2. DESIGN shafts, keys and couplings under static loading conditions.</p> <p>CO3. ANALYZE different stresses in power screws and APPLY those in the procedure to design screw jack.</p> <p>CO4. EVALUATE dimensions of machine components under fluctuating loads.</p> <p>CO5. EVALUATE & INTERPRET the stress developed on the different type of welded and threaded joints.</p> <p>CO6. APPLY the design and development procedure for different types of springs.</p>					
Course Contents					
Unit 1	Design of Simple Machine Elements				08 Hrs.
Factor of safety, Selection of Factor of Safety, Service factor, Design of Cotter joint, Knuckle joint, Design of hand / foot lever, lever for safety valve, bell crank lever, Design of components subjected to eccentric loading.					
Unit 2	Design of Shafts, Keys and Couplings				08 Hrs.
Shaft design on the Strength basis, torsional rigidity basis and lateral rigidity basis, Design of shaft as per A.S.M.E. code. Design of square and rectangular keys, Kennedy key and splines. Design of Flange Coupling and Bushed-Pin Flexible Coupling.					

Unit 3	Design of Power Screws	07 Hrs.
Terminology of Power Screw, Torque analysis and Design of power screws with square and trapezoidal threads, Collar friction torque, Self-locking screw, Efficiency of square threaded screw, Efficiency of self-locking screw, Design of screw, nuts and C-Clamp. Design of screw jack, Differential and Compound Screw and Re-circulating Ball Screw (Theoretical treatment only).		
Unit 4	Design against Fluctuating loads	07 Hrs.
Stress concentration and its factors, Reduction of stress concentration factors, fluctuating stresses, fatigue failures, endurance limit, S-N curve, Notch sensitivity, Endurance limit, Endurance strength modifying factors, Reversed stresses – Design for Finite and Infinite life, Cumulative damage in fatigue failure, Soderberg, Gerber, Goodman Lines, Modified Goodman diagrams, Fatigue design under combined stresses:- (Theoretical treatment only.)		
Unit 5	Threaded and Welded joints	08 Hrs.
Introduction to threaded joints, Bolts of uniform strength, locking devices, eccentrically loaded bolted joint in shear, Eccentric load perpendicular and parallel to axis of bolt, Eccentric load on circular base. Introduction to welded joints, Strength of butt, parallel and transverse fillet welds, Axially loaded unsymmetrical welded joints, Eccentric load in plane of welds, Welded joints subjected to bending and torsional moments.		
Unit 6	Design of Springs	07 Hrs.
Types and applications of springs, Stress and deflection equations for helical compression Springs, Springs in series and parallel, Design of helical springs, concentric helical springs, surge in spring, Design of Multi-leaf springs, Nipping of Leaf springs, Shot Peening.		
Books and other resources		
Text Books:		
<ol style="list-style-type: none"> 1. Bhandari V.B., Design of Machine Elements, Tata McGraw Hill Publication Co. Ltd. 2. Shigley J.E. and Mischke C.R., Mechanical Engineering Design, McGraw Hill Publication Co. Ltd. 		
References Books:		
<ol style="list-style-type: none"> 1. Spotts M.F. and Shoup T.E., Design of Machine Elements, Prentice Hall International. 2. Juvinal R.C., Fundamentals of Machine Components Design, John Wiley and Sons. 3. Black P.H. and O. Eugene Adams, Machine Design, McGraw Hill Book Co. Inc. 4. Willium C. Orthwein, Machine Components Design, West Publishing Co. and Jaico Publications House. 5. Hall A.S., Holowenko A.R. and Laughlin H.G, Theory and Problems of Machine Design, Schaum's Outline Series. 6. C. S. Sharma and Kamlesh Purohit, Design of Machine Elements, PHI Learning Pvt. Ltd. 7. D. K. Aggarwal & P. C. Sharma, Machine Design, S.K Kataria and Sons. 8. P. C. Gope, Machine Design: Fundamentals and Applications, PHI Learning Pvt. Ltd. 9. Design Data - P.S.G. College of Technology, Coimbatore. 10. K. Mahadevan, K. Balveera Reddy, Design Data Handbook for Mechanical Engineers, CBS Publishers. 		

Term Work

The student shall complete the following activity as a Term Work;

The term work shall consist of three design projects. The design project shall consist of assembly drawing, with a bill of material and overall dimensions and drawings of individual components. The Project should be assigned to a group of maximum four students. Manufacturing tolerances, surface finish symbols and geometric tolerances should be specified for important surfaces. A design report giving all necessary calculations of the design of components should be submitted in a separate file. Design data book shall be referred for selection of materials and standard components for given loading conditions. All three design projects should be carried out using suitable software.

Project 1: - Cotter joint/ knuckle joint/turn buckle for a specified application.

Project 2: - Bush Pin Flexible Coupling for specified application.

Project 3: - Bottle type/toggle jack for vehicles.

OR

Project 3: - A Design Project to develop and apply the knowledge of Machine Design and drafting software for any mechanical system on the basis of: (1) Idea generation, (2) Creativity, Reliability and safety, (3) Design parts of the system (4) Ergonomic Considerations (5) Use of International standards.

Web References:

UNIT 1: Design of Simple Machine Elements

Sr. No	Topic Title	NPTEL video Link
1	Factor of safety, Selection of Factor of Safety, Service factor	https://www.youtube.com/watch?v=ofmbhbVCUqI&list=PL3D4EECEFAA99D9BE&index=3
2	Design of components subjected to eccentric loading.	https://www.youtube.com/watch?v=__py5xbKHGA

UNIT 2: Design of Shafts, Keys and Couplings

3	Design of shaft as per A.S.M.E. code	https://www.youtube.com/watch?v=SL21aDqgs8Q
4	Design of a C-Clamp. Design of screw jack,	https://youtu.be/PEKfS2Q1WqM https://www.youtube.com/watch?v=PEKfS2Q1WqM&list=PL3D4EECEFAA99D9BE&index=19
5	Differential and Compound Screw and Re-circulating Ball Screw	https://www.youtube.com/watch?v=TPURJnlekeo

UNIT 4: Design against Fluctuating Loads

6	Cumulative damage in fatigue failure,	https://www.youtube.com/watch?v=WRoPQGE0WdI
7	Soderberg, Gerber, Goodman Lines, Modified Goodman Diagrams	https://www.youtube.com/watch?v=WRoPQGE0WdI
8	Fatigue design under combined stresses	https://www.youtube.com/watch?v=WRoPQGE0WdI

UNIT 5: Threaded and Welded joints		
9	Eccentrically loaded bolted joint in shear, Eccentric load perpendicular and parallel to axis of bolt	https://www.youtube.com/watch?v=_py5xbKHGA https://www.youtube.com/watch?v=YZYcMtkZiDY
10	Eccentric load on circular base	https://www.youtube.com/watch?v=_py5xbKHGA
11	Eccentric load in plane of welds, Welded joints subjected to bending and torsional moments	https://www.youtube.com/watch?v=_py5xbKHGA https://www.youtube.com/watch?v=YZYcMtkZiDY
UNIT 6: Design of Springs		
12	Surge in spring	https://www.youtube.com/watch?v=tTBnW5gAieM
13	Shot Peening.	https://www.youtube.com/watch?v=46quOD7V-cQ
14	Design of Multi-leaf	https://youtu.be/T4IgtIkBnOo

302044: Mechatronics					
Teaching Scheme		Credits		Examination Scheme	
Theory	3Hrs./Week	Theory	3	In-Semester	30 Marks
Practical	2 Hrs./Week	Practical	1	End-Semester	70 Marks
				Oral	25 Marks
<p>Prerequisites: Basics of Electrical components, Binary to Decimal Conversion, Data communication Module, Op amp Circuits, Linear Algebra, Laplace Transformation method, Logic gates.</p>					
<p>Course Objectives:</p> <ol style="list-style-type: none"> 1. UNDERSTAND the key elements of mechatronics, principle of sensor and its characteristics. 2. UNDERSTAND the concept of signal processing and use of interfacing systems such as ADC, DAC, Digital I/O. 3. UNDERSTAND the block diagram representation and concept of transfer function. 4. UNDERSTAND the system modeling and analysis in frequency domain. 5. UNDERSTAND the system modeling and analysis in time domain, controller modes and its industrial applications.. 6. UTILIZE the concepts of PLC system and its ladder programming and significance of PLC system in industrial application. 					
<p>Course Outcomes:</p> <p>On completion of the course, learner will be able to</p> <p>CO1. DEFINE key elements of mechatronics, principle of sensor and its characteristics.</p> <p>CO2. UTILIZE concept of signal processing and MAKE use of interfacing systems such as ADC, DAC, Digital I/O.</p> <p>CO3. DETERMINE the transfer function by using block diagram reduction technique.</p> <p>CO4. EVALUATE Poles and Zero, frequency domain parameter for mathematical modeling for mechanical system.</p> <p>CO5. APPLY the concept of different controller modes to an industrial application.</p> <p>CO6. DEVELOP the ladder programming for industrial application.</p>					
Course Contents					
Unit 1	Introduction to Mechatronics, Sensors & Actuators				07 Hrs.
<p>Introduction to Mechatronics and its Applications Measurement Characteristics (Static/Dynamic), Sensors: Types of sensors; Motion Sensors – Encoder (Absolute & incremental), Lidar, Eddy Current, Proximity (Optical, Inductive, Capacitive), MEMS Accelerometer; Temperature sensor –Pyrometer, Infrared Thermometer; Force / Pressure Sensors – Strain gauges, Piezoelectric sensor; Flow sensors – Electromagnetic, Ultrasonic, Hot-wire anemometer; Color sensor – RGB type; Biosensors – Enzyme, ECG, EMG Actuators: Servo motor; Hydraulic and Pneumatic (must be restricted to classification and working of one type of linear and rotary actuator); linear electrical actuators Selection of Sensor & Actuator</p>					

Unit 2	Data Acquisition and Signal Communication	08 Hrs.
<p>Signal Communication: Serial, Parallel; Synchronous, Asynchronous Introduction to DAQ, Types, Components of a Data Acquisition System (Sensor, Signal conditioning, processing, controlling and storage/display/action) Data Acquisition: Signal collection, Signal conditioning – Isolation & Filtering, Amplification, Sampling, Aliasing, Sample and hold circuit, Quantization, Analog-to-digital converters (4 bit Successive Approximation type ADC), Digital-to-Analog converters (4 bit R2R type DAC), Data storage Applications: DAQ in Household, Digital Pressure Gauge, Digital Flow measurement, DVB Digital Video Broadcast, AM/FM</p>		
Unit 3	Control systems & transfer function based modelling	07 Hrs.
<p>Introduction to control systems, need, Types- Open and Closed loop, Concept of Transfer Function, Block Diagram & Reduction principles and problems; Applications (Household, Automotive, Industrial shop floor) Transfer Function based modeling of Mechanical, Thermal and Fluid system; Concept of Poles & Zeros; Pole zero plot, Stability Analysis using Routh Hurwitz Criterion (Numerical Approach)</p>		
Unit 4	Time and Frequency Domain Analysis	08 Hrs.
<p>Time Domain Analysis – Unit step Response analysis via Transient response specifications (Percentage overshoot, Rise time, Delay time, Steady state error etc.) Frequency Domain Analysis – Frequency Domain Parameters - Natural Frequency, Damping Frequency and Damping Factor; Mapping of Pole Zero plot with damping factor, natural frequency and unit step response ; Introduction to Bode Plot, Gain Margin, Phase Margin</p>		
Unit 5	Controllers	07 Hrs.
<p>Introduction to controllers, Need for Control, Proportional (P), Integral (I) and Derivative (D) control actions; PI, PD and PID control systems in parallel form; (Numerical approach), Feed forward anticipatory control Manual tuning of PID control, Ziegler–Nichols method Applications: Electro–Hydraulic/Pneumatic Control, Automotive Control</p>		
Unit 6	Programmable Logic Controller (PLC)	08 Hrs.
<p>Introduction to PLC; Architecture of PLC; Selection of PLC; Ladder Logic programming for different types of logic gates; Latching; Timers, Counters; PLC control of Hydraulics / Pneumatics / Mechatronics systems involving timing and counting operations.</p>		
Books and other resources		
Text Books:		
<ol style="list-style-type: none"> 1. William Bolton, Mechatronics: Electronics Control Systems in Mechanical and Electrical Engineering, 6th Ed, 2019 2. K.P. Ramchandran, G.K. Vijayaraghavan, M.S. Balasundaram, Mechatronics: Integrated Mechanical Electronic Systems, Willey Publication, 2008 		
References Books:		
<ol style="list-style-type: none"> 1. Alciatore and Histan, Introduction to Mechatronics and Measurement Systems, 5th Ed, 2019 2. Bishop (Editor), Mechatronics – An Introduction CRC 2006 3. Mahalik, Mechatronics – Principles, concepts and applications, Tata Mc-Graw Hill publication, New Delhi 4. C.D.Johnson, Process Control Instrumentation Technology, Prentice Hall, New Delhi 5. Bolton, Programmable Logic Controller, 4th Ed, Newnes, 2006 		

Web References:

1. <https://www.elprocus.com/what-is-a-biosensor-types-of-biosensors-and-applications/>
2. <https://www.elprocus.com/color-sensor-working-and-applications/>
3. https://www.youtube.com/watch?v=kbjCGGTxqUo&ab_channel=Controlengineering
4. <https://youtu.be/clTA0pONnMs?list=PLHMDN3JFtE5wEz95H2XuzRaafK3fUsaki>
5. [https://nptel.ac.in/content/storage2/courses/108105063/pdf/L-12\(SS\)%20\(IA&C\)%20\(\(EE\)NPTEL\).pdf](https://nptel.ac.in/content/storage2/courses/108105063/pdf/L-12(SS)%20(IA&C)%20((EE)NPTEL).pdf)
6. <https://nptel.ac.in/content/storage2/courses/112104158/lecture5.pdf>

Term Work

The Term work shall consist of completion of Practical, Self-learning Study Assignments and Presentations. Oral examination shall be based on the Term work undertaken during the semester.

Practical (Any one experiments out of experiment no 1 to 3 from the following list whereas experiment no. 4 to 10 are mandatory).

1. Experiment on measurement of temperature using suitable sensor.
2. Experiment on measurement of load using suitable sensor.
3. Experiment on measurement of displacement using suitable sensor.
4. Development of a data acquisition / mechatronics system using low cost open source hardware and software.
5. Experiment on interfacing of suitable sensor and actuator with DAQ.
6. Modeling and analysis of mechanical system and its verification using suitable simulation software.
7. PID control of Mechanical System using suitable simulation software and experimental verification (verification only if experimental setup is available).
8. Ladder Logic Simulation of suitable application.
9. Demonstration of PLC controlled electro hydraulic / electro pneumatic circuit.
10. Industrial visit to understand integration and application of Mechatronics.

Assignments:

1. Application of Sensors and Actuators in Health Science and Selection of Suitable Sensor and Actuator.
2. Block Diagram Representation of Feedback Control System and determination of Closed Loop Transfer Function.

302045-A: Advanced Forming & Joining Processes					
Teaching Scheme		Credits		Examination Scheme	
Theory	3Hrs./Week	Theory	3	In-Semester	30 Marks
				End-Semester	70 Marks
Prerequisite Courses: Manufacturing Processes, Engineering Materials and Metallurgy, Machine shop					
Course Objectives:					
<ol style="list-style-type: none"> 1. UNDERSTAND advances in sheet metal forming operations 2. UNDERSTAND the advanced special metal forming processes. 3. UNDERSTAND weld metallurgy and weld characterization techniques. 4. UNDERSTAND and describe various advanced solid state welding processes. 5. CLASSIFY AND DESCRIBE various advanced welding processes. 6. KNOW about sustainable manufacturing and its role in manufacturing industry 					
Course Outcomes:					
On completion of the course, learner will be able to					
CO1. ANALYSE the effect of friction in metal forming deep drawing and IDENTIFICATION of surface defects and their remedies in deep drawing operations					
CO2. ASSESS the parameters for special forming operation and SELECT appropriate special forming operation for particular applications					
CO3. ANALYSE the effect of HAZ on microstructure and mechanical properties of materials					
CO4. CLASSIFY various solid state welding process and SELECT suitable welding processes for particular applications					
CO5. CLASSIFY various advanced welding process and SELECT suitable welding processes for particular applications.					
CO6. INTERPRET the principles of sustainable manufacturing and its role in manufacturing industry.					
Course Contents					
Unit 1	Mechanics of Sheet Metal Forming				08 Hrs.
Theory of plasticity – yield criteria-work of plastic deformation- Sheet Metal Forming-Formability studies-conventional processes, Effect of friction in forming operation, Experimental techniques of evaluation of friction in metal forming, deep drawing, analysis (Numerical), surface defects identification and remedies, introduction to Forming simulation, Challenges in Forming.					
Unit 2	Special Forming Processes				08 Hrs.
Special Forming Processes: HVF, HERF (Explosive Forming) techniques- super plastic forming techniques-Hydro forming-Stretch forming, Laser beam forming-principles and process parameters-Advantages, limitations and applications of different forming processes. Orbital forging-Isothermal-Hot and cold isostatic pressing-High speed extrusion, Water hammer forming, Incremental Sheet forming, Magnetic Pulse forming, Metal Spinning, Electro Hydraulic Forming, Micro forming.					

Unit 3	Weld Metallurgy	07 Hrs.
Weld Metallurgy: Weld thermal cycles and their effects, effects of pre and post weld heat treatments, concept of HAZ, concept of weldability and its assessment. Welding of dissimilar materials, Weld characterization, Weld decay and weld sensitization, Introduction to ASME, ASWE, IS Welding Standards, (welding skill levels).		
Unit 4	Solid State Welding Processes	07 Hrs.
Solid State Welding Processes: Cold pressure welding, Diffusion bonding, Explosive welding, Ultrasonic welding, Friction stir welding, Forge welding, Roll welding and Hot pressure welding processes - features, advantages, limitations and applications, Advances in adhesive bonding, cladding.		
Unit 5	Advanced Welding Processes	08 Hrs.
Advanced Welding Processes: Electro gas, electroslag welding, Atomic hydrogen welding, Electron beam welding, Laser Beam welding - principle, working and applications, Cold Metal Transfer - concepts, processes and applications, Underwater welding, Welding automation in aerospace, nuclear and surface transport vehicles, Robotic Welding, Plasma Arc Welding, Plasma Transferred Arc Welding.		
Unit 6	Sustainable Manufacturing	07 Hrs.
Sustainable Manufacturing: Introduction to sustainability and drivers for sustainable development and sustainable manufacturing, fundamentals of sustainable manufacturing, various tools, factors of sustainability, Principles of Life Cycle Assessment (Goal, Scope and Life Cycle Inventory), Approaches, Role in Industry 4.0, Green Manufacturing, Environment protection norms, ISO 14000, recycling techniques, safety norms in forming and welding, socio-economic aspects, case study on waste recycling, material recycling, etc.		
Books and other resources		
Text Books:		
<ol style="list-style-type: none"> 1. Sindo Kou, "Welding Metallurgy", Wiley Publications Second Edition 2. Dr. V. D. Kodgire and S. V. Kodgire, "Material Science & Metallurgy For Engineers", Everest Publication 3. William D. Callister, "Materials Science and Engineering an Introduction", Jr, John Wiley & Sons, Inc. 4. O.P. Khanna, " Welding Technology", Dhanpat Rai & Sons Publications Edition 2015 5. Dr. R. S. Parmar, "Welding Processes and Technology", Khanna Publications Edition 2017 6. J. Paulo Davim, " Sustainable Manufacturing", Wiley Publications Edition 2010 		
References Books:		
<ol style="list-style-type: none"> 1. Z. Marciniak, J.L.Duncan, "Mechanics of Sheet Metal Forming", Butterworth Heinemann-2002. 2. Dr. Sadhu Singh, "Theory of Plasticity and Metal Forming Processes", Khanna Publishers Edition 2008 3. O.P. Khanna, " Engineering Metallurgy", Dhanpat Rai & Sons Publications 4. Ali Hasan - Islam Nawaz, "Advanced Welding Technology", SCITECH Publications India Pvt. Ltd. Edition 2018 5. Dr. K. S. Yadav, "Advanced Welding Technology", Rajsons Publications Pvt. Ltd. 6. Tool and Manufacturing Engineers' Handbook: Forming V by Charles Wick Publisher 		

: Society of Manufacturing Engineers; 4th edition (1 Aug. 1996)

7. Dornfeld and David, "Green Manufacturing" - Fundamentals and Applications, DOI 10.1007/978.1.4419.6016.0_2, Springer Science +Business Media, New York 2013.
8. R. Ganesh Narayanan, Jay S Gunasekera, "Sustainable Material Forming and Joining", by CRC Press 2020.

Web References:

1. NPTEL Course on "Forming" by Dr. R. Chandramouli, IIT Madras
2. NPTEL Course on "Welding Engineering" by Dr. D. K. Dwivedi, IIT Roorkee
3. NPTEL Course on "Advances in welding and joining technologies" by Prof. SwarupBag IIT Guwahati.
4. NPTEL Course on "Welding Metallurgy" by Prof. Pradeep K. Jha, IIT Roorkee
5. NPTEL Course on "Sustainability through Green Manufacturing System – An Applied Approach" by Prof. Deepu Philip IIT Kanpur and Dr. Amardeep Singh Oberaioi, NIT Jalandar.

302045-B:Machining Science &Technology					
Teaching Scheme		Credits		Examination Scheme	
Theory	3Hrs./Week	Theory	3	In-Semester	30 Marks
				End-Semester	70 Marks
Prerequisites: Mechanics, Gear terminology, Material properties, Degree of freedom.					
Course Objectives:					
<ol style="list-style-type: none"> 1. KNOW about fundamentals of metal cutting process, tool wear and tool life. 2. IMPART the knowledge of machining phenomenon like milling, gear and thread manufacturing, grinding, super finishing, etc. 3. UNDERSTAND the basic concepts, importance and functions of Jigs, Fixtures. 4. PREPARE list of operations, tools, set of manufacturing instructions and selection of quality assurance method. 5. GENERATE CNC program for appropriate machining processes like turning and milling. 					
Course Outcomes:					
On completion of the course, learner will be able to					
CO1. DEFINE metal cutting principles and mechanics of metal cutting and tool life.					
CO2. DESCRIBE features of gear and thread manufacturing processes.					
CO3. SELECT appropriate grinding wheel and demonstrate the various surface finishing processes.					
CO4. SELECT appropriate jigs/fixtures and to draw the process plan for a given component.					
CO5. SELECT & EVALUATE various parameters of process planning.					
CO6. GENERATE CNC program for Turning / Milling processes and generate tool path using CAM software.					
Course Contents					
Unit 1	Mechanics of Metal Cutting				08 Hrs.
Introduction to metal cutting, Elements of machining process, Geometry of single-point cutting tool, Orthogonal and Oblique cutting processes, Chip formation, Types of chips, Chip thickness ratio, Process parameters and their effect on machining, chip breakers, Merchant's Circle of forces analysis – forces and energy calculations, power consumed – MRR-Effect of Cutting variables on forces, Concepts of Machinability- Factors affecting machinability, Machinability Index, Tool Life, Tool life equation of Taylor, Tool wear and its types, Factors affecting on tool life.					
Unit 2	Gear and Thread Manufacturing				07 Hrs.
Introduction, Materials of gears, Methods of gear manufacturing-casting, forging, forming etc, milling of gears (indexing methods and numerical), Helical gear cutting, Gear Shaping and Gear hobbling, Gear inspection.					
Thread Manufacturing: Various methods of thread manufacturing, thread rolling, die threading & tapping, Thread milling, Thread grinding etc.					

Unit 3	Grinding & Surface finishing	08 Hrs.
Types and Operations of grinding machines, Grinding wheel– Shapes, Designation and selection, Abrasives & classification, Bond & bonding, Grit, Grade & Structure of wheels, Types of grinding wheels, mounting of grinding wheels, Glazing and loading of wheels, Dressing and truing of wheels, Balancing of wheels, Diamond wheels. Super-finishing processes – Introduction to Honing, Lapping, Buffing and Burnishing. (Construction, working and controlling parameters)		
Unit 4	Jigs and Fixtures	08 Hrs.
Significance and purpose of jigs and fixtures and their functions in the manufacturing processes, Concept of degree of freedom, 3-2-1 principle of location. General guidelines to design jigs and fixtures, advantages of jigs and fixtures. Jigs- Definition, Elements of jig with the types, Location guidelines, Principles of clamping, Principles of guiding, Channel jig, Template jig, Plate jig, Angle plate jig, Turn over jig, Box jig, Latch type jig. Fixtures: Definition. Elements of fixtures, Location guidelines, Principles of clamping, Principles of setting element, turning fixture, welding fixture, Milling fixture, Assembly and Inspection fixtures.		
Unit 5	Process Planning	06 Hrs.
Introduction- methods of process planning, drawing interpretation, material evaluation, steps in process selection, production equipment and tooling selection, process parameters calculation for various production processes, Selection of jigs and fixtures, selection of quality assurance methods, documents for process planning, Economics of process planning, case studies.		
Unit 6	CNC Programming	08 Hrs.
CNC Programming-CNC part programming adaptable to suitable controller. Steps in developing CNC part program. CNC part programming for Lathe Machine – Threading & Grooving cycle (Canned cycle). CNC part programming for Milling Machine - Linear & circular interpolation, milling cutter, tool length compensation & cutter radius compensation. Pocketing, contouring & drilling, subroutine and Do loop using canned cycle.		
Books and other resources		
Text Books:		
<ol style="list-style-type: none"> 1. A Text Book of Production Technology, P. C. Sharma, S.Chand Publications 2. A Text Book of Manufacturing Technology, R. K. Rajput, Laxmi Publications (p) LTD 3. A Text book of Manufacturing Technology, Metal Cutting and Machine Tools, P. N. Rao, Vol. 2, 2nd edition, Tata McGraw Hill Publishing Co. Ltd, New Delhi, 2002 4. Elements of Workshop Technology, Vol-II, S. K. HajraChaudhary, Media Promoters &Publications Pvt Ltd. 5. S. K. Sinha, CNC Programming using Fanuc Custom Macro B, McGraw-Hill Professional 		
References Books:		
<ol style="list-style-type: none"> 1. Theory of Metal Cutting, M. C. Shaw, 1st Edition, Oxford and I.B.H. publishing, 1994 2. Jigs & Fixtures, P.H. Joshi, Third edition, McGraw Hill, 2017 3. Production Technology Manufacturing Systems VOL-I & II, R. K. Jain, Khanna Publishers 4. Production Technology –HMT, Tata McGraw Hill publication 5. An Expert Process Planning System, Chang, T. C., Addison Wesley Longman, 1990 		

6. Process Planning- Design/Manufacture Interface, Scallan P, Butterworth-Heinemann, 2003
7. CNC Machines, B. S. Pabla, M. Adithan, New Age International, 2018
8. Manufacturing Science, Amitabh Ghosh and AshokKumar Mallik, Affiliated East-West Press, 2010

Web References:

1. <https://nptel.ac.in/content/storage2/courses/108105063/pdf/L->
2. <https://nptel.ac.in/content/storage2/courses/112105127/pdf/LM-32.pdf>
3. <https://nptel.ac.in/content/storage2/courses/112105127/pdf/LM-34.pdf>
4. <https://nptel.ac.in/courses/112/107/112107143/>

302046: Digital Manufacturing Laboratory					
Teaching Scheme		Credits		Examination Scheme	
Practical	2 Hrs./Week	Practical	1	Term Work	50 Marks
<p>Prerequisites: Construction and operating of conventional machine tools, principles of machining and forming processes, cutting tool and machining parameters, programming languages like C, Python etc., basics of 3D printing.</p>					
<p>Course Objectives:</p> <ol style="list-style-type: none"> 1. ACQUIRE skills to handle conventional machines and CNC machine for manufacturing of a component. 2. PREPARE manual part program for given component as per ISO standards. 3. ACCUSTOM skills of Additive manufacturing technology. 4. APPRECIATE the influence of cutting tool parameters on the performance. 5. APPLY Digital Manufacturing tools for process simulation of manufacturing processes. 6. SELECT appropriate type of jigs and fixtures for a given component 					
<p>Course Outcomes:</p> <p>On completion of the course, learner will be able to</p> <p>CO1.DEVELOP a component using conventional machines, CNC machines and Additive Manufacturing Techniques.</p> <p>CO2.ANALYZE cutting tool parameters for machining given job.</p> <p>CO3.DEMONSTRATE simulation of manufacturing process using Digital Manufacturing Tools.</p> <p>CO4.SELECT and DESIGN jigs and Fixtures for a given component.</p> <p>CO5.DEMONSTRATE different parameters for CNC retrofitting and reconditioning.</p>					
Guidelines for Laboratory Conduction					
<p>The learner shall complete the following activity as a Term Work;</p> <ol style="list-style-type: none"> 1. Demonstration of cutting tool geometry and nomenclature of the tools used in conventional and CNC machines. 2. Machining of a mechanical component using conventional machines such as lathe, drilling, milling, grinding and any additional machine tool or processes as per requirement. Manufacturing drawing with appropriate geometrical and dimensional tolerances, detailed process planning to be included. 3. Preparing manual CNC part program using G Codes and M Codes as per ISO (DIN 66025) and RS274 standards for CNC lathe/mill machine. 4. Machining of mechanical component using CNC machine (Lathe/Mill/HMC/VMC). Manufacturing drawing with appropriate geometrical and dimensional tolerances, detailed process planning to be included. 5. Demonstration of Additive Manufacturing technology (from modelling to printing) (To be performed Batch-wise) 6. Demonstration of the usage of Digital Manufacturing tools for process simulation of manufacturing processes like casting, forging, sheet metal, plastic processing (free / open source software) 					

7. Demonstration of various types of jigs and fixtures, and a case study on design and use of Jigs & Fixture for any given component.
8. Preparing Online Calculator/Catalogue for selection of cutting parameters by using programming languages like C, Python etc.
9. Study on CNC retrofitting and reconditioning
10. Visit to an Industry which uses advanced manufacturing processes

Please note following instructions regarding Laboratory Conduction:

1. Sr. No. 1 to 7 are mandatory and any 2 from Sr. No. 8 to 10.
2. Practical are to be performed under the guidance of concerned faculty member.
3. Journal should consist of Job Drawing, Process Sheet and Program, appropriate write-up and shall be part of term-work submission.

302047: Skill Development					
Teaching Scheme		Credits		Examination Scheme	
Practical	2 Hrs./Week	Practical	1	TW	25 Marks
<p>Prerequisites: Students should have knowledge of Construction and working of IC engine / compressor / gear box / centrifugal pump/tail stock. Working principles of any type of mechanism / power plants. Working of electric and hydraulic systems of 4 wheeler vehicle. Working of machine tools, engine and transmission of different automotive and home appliances. Advanced manufacturing processes. Solid mechanics and design of machine elements.</p>					
<p>Course Objectives:</p> <ol style="list-style-type: none"> 1. INTRODUCE the skills required in an industry such as design, development, assembly & disassembly. 2. DEVELOP the skills required for fault diagnose of engine and transmission of different automotive and various home appliances. 3. ESTABLISH the skills required for maintenance of any machine tool. 4. CREATE awareness about industrial environment. 					
<p>Course Outcomes:</p> <p>On completion of the course, learner will be able to</p> <p>CO1.APPLY & DEMONSTRATE procedure of assembly & disassembly of various machines.</p> <p>CO2.DESIGN & DEVELOP a working/model of machine parts or any new product.</p> <p>CO3.EVALUATE fault with diagnosis on the machines, machine tools and home appliances.</p> <p>CO4.IDENTIFY & DEMONSTRATE the various activities performed in an industry such as maintenance, design of components, material selection.</p>					
Course Contents					
<ol style="list-style-type: none"> 1. Assembly and Disassembly of any of the following mechanical systems/ subsystems: bicycle (geared), e-Bikes, e-Motor Cycles, Drones, Flying devices, gear box, IC engines, centrifugal pump etc. 2. Assembly- Disassembly/ Fault diagnosis of home appliances such as mixer, grinder, washing machine, fan, ovens, gas geyser, chopping machine, kneading machine, exercise machines, etc. 3. Development and demonstration of working/animation model of any mechanism. 4. Design a circuit of electric and hydraulic system of 4 wheelers and its verification. <p style="text-align: center;">OR</p> <p>Circuit design /PCB design using software for control of BLDC electric motors used in e-Vehicles.</p> <ol style="list-style-type: none"> 5. Undertake total preventive maintenance for any machine tool or mechanical system. 6. Visit to an industry for awareness about preventive maintenance. 7. Use of ergonomic principles for the design of hand tools, control in automobile dashboards, human operated mobile devices. 					

8. Use of alternative materials in the construction of daily activity machine and tool components
9. Interpretation of Drawings; Exercises in identifying the type of production, extracting important functional dimensions, checking the number of parts in an assembly. Checking and listing missing dimensions.
10. Exercises in -preparation of detailed production drawings as per BIS standard of simple machine parts having relevant notes and indications (limits/tolerances, surface finish, the process of production, relevant tools, materials, measuring instruments).

The documentation activity as a part of the Term work shall not be restricted to merely generation of 2D/3D CAD Drawings with dimensions (as applicable), Exploded View, Flowchart of Maintenance Work etc. but can be beyond.

Skill Development Documentation Diary must be maintained by every student.

302048: Audit Course V		
Teaching Scheme	Credits	Examination Scheme
	Non-Credit	
GUIDELINES FOR CONDUCTION OF AUDIT COURSE		
<p>Faculty mentor shall be allotted for individual courses and he/she shall monitor the progress for successful accomplishment of the course. Such monitoring is necessary for ensuring that the concept of self-learning is being pursued by the students ‘in true letter and spirit’.</p> <ul style="list-style-type: none"> • If any course through Swayam/ NPTEL/ virtual platform is selected the minimum duration shall be of 8 weeks. • However if any of the course duration is less than the desired (8 weeks) the mentor shall ensure that other activities in form of assignments, quizzes, group discussion etc. (allied with the course) for the balance duration should be undertaken. <p>In addition to credits courses, it is mandatory that there should be an audit course (non-credit course) from third year of Engineering. The student will be awarded grade as AP on successful completion of the audit course. The student may opt for any one of the audit courses in each semester. Such audit courses can help the student to get awareness of different issues which make an impact on human lives and enhance their skill sets to improve their employability. List of audit courses offered in the semester is provided in the curriculum. Students can choose one of the audit courses from the list of courses mentioned. Evaluation of the audit course will be done at institute level.</p> <p>The student registered for audit course shall be awarded the grade AP and shall be included such grade in the Semester grade report for that course, provided student has the minimum attendance as prescribed by the Savitribai Phule Pune University and satisfactory in-semester performance and secured a passing grade in that audit course. No grade points are associated with this 'AP' grade and performance in these courses is not considered in the calculation of the performance indices SGPA and CGPA. Evaluation of the audit course will be done at institute level itself.</p>		
Selecting an Audit Course		
List of Courses to be opted (Any one) under Audit Course V		
<ul style="list-style-type: none"> • Entrepreneurship and IP strategy • Engineering Economics • Mangment of Inventory Systems <p># The titles indicated above are subject to change in time to come and such an alteration (if any) should be brought to the notice of the BOS.</p>		
Using NPTEL Platform: (preferable)		
<p>NPTEL is an initiative by MHRD to enhance learning effectiveness in the field of technical education by developing curriculum based video courses and web based e-courses. The details of NPTEL courses are available on its official website www.nptel.ac.in</p> <ul style="list-style-type: none"> • Students can select any one of the courses mentioned above and has to register for the 		

corresponding online course available on the NPTEL platform as an Audit course.

- Once the course is completed the student can appear for the examination as per the guidelines on the NPTEL portal.
- After clearing the examination successfully; student will be awarded with a certificate.

Assessment of an Audit Course

- The assessment of the course will be done at the institute level. The institute has to maintain the record of the various audit courses opted by the students. The audit course opted by the students could be interdisciplinary.
- During the course students will be submitting the online assignments. A copy of the same can be submitted as a part of term work for the corresponding Audit course.
- On the satisfactory submission of assignments, the institute can mark as “Present” and the student will be awarded the grade AP on the mark-sheet.

302049: Artificial Intelligence & Machine Learning					
Teaching Scheme		Credits		Examination Scheme	
Theory	3Hrs./Week	Theory	3	In-Semester	30 Marks
Practical	2 Hrs./Week	Practical	1	End-Semester	70 Marks
				Oral	25 Marks
Prerequisites: Linear Algebra, Probability, Statistics, Logical Reasoning.					
Course Objectives:					
<ol style="list-style-type: none"> 1. ACQUAINT with fundamentals of artificial intelligence and machine learning. 2. LEARN feature extraction and selection techniques for processing data set. 3. UNDERSTAND basic algorithms used in classification and regression problems. 4. OUTLINE steps involved in development of machine learning model. 5. FAMILIARIZE with concepts of reinforced and deep learning. 6. IMPLEMENT AND ANALYZE machine learning model in mechanical engineering problems. 					
Course Outcomes:					
On completion of the course, learner will be able to					
CO1. DEMONSTRATE fundamentals of artificial intelligence and machine learning.					
CO2. APPLY feature extraction and selection techniques.					
CO3. APPLY machine learning algorithms for classification and regression problems.					
CO4. DEVISE AND DEVELOP a machine learning model using various steps.					
CO5. EXPLAIN concepts of reinforced and deep learning.					
CO6. SIMULATE machine learning model in mechanical engineering problems.					
Course Contents					
Unit 1	Introduction to AI & ML				06 Hrs.
History of AI, Comparison of AI with Data Science, Need of AI in Mechanical Engineering, Introduction to Machine Learning. Basics: Reasoning, problem solving, Knowledge representation, Planning, Learning, Perception, Motion and manipulation. Approaches to AI: Cybernetics and brain simulation, Symbolic, Sub-symbolic, Statistical. Approaches to ML: Supervised learning, Unsupervised learning, Reinforcement learning.					
Unit 2	Feature Extraction and Selection				08 Hrs.
Feature extraction: Statistical features, Principal Component Analysis. Feature selection: Ranking, Decision tree - Entropy reduction and information gain, Exhaustive, best first, Greedy forward & backward, Applications of feature extraction and selection algorithms in Mechanical Engineering.					
Unit 3	Classification & Regression				08 Hrs.
Classification: Decision tree, Random forest, Naive Bayes, Support vector machine. Regression: Logistic Regression, Support Vector Regression. Regression trees: Decision tree, random forest, K-Means, K-Nearest Neighbor (KNN). Applications of classification and regression algorithms in Mechanical Engineering.					

Unit 4	Development of ML Model	07 Hrs.
Problem identification: classification, clustering, regression, ranking. Steps in ML modeling, Data Collection, Data pre-processing, Model Selection, Model training (Training, Testing, K-fold Cross Validation), Model evaluation (understanding and interpretation of confusion matrix, Accuracy, Precision, Recall, True positive, false positive etc.), Hyper parameter Tuning, Predictions.		
Unit 5	Reinforced and Deep Learning	08 Hrs.
Characteristics of reinforced learning; Algorithms: Value Based, Policy Based, Model Based; Positive vs Negative Reinforced Learning; Models: Markov Decision Process, Q Learning. Characteristics of Deep Learning, Artificial Neural Network, Convolution Neural Network. Application of Reinforced and Deep Learning in Mechanical Engineering.		
Unit 6	Applications	08 Hrs.
Human Machine Interaction, Predictive Maintenance and Health Management, Fault Detection, Dynamic System Order Reduction, Image based part classification, Process Optimization, Material Inspection, Tuning of control algorithms.		
Books and other resources		
Text Books:		
<ol style="list-style-type: none"> 1. Deisenroth, Faisal, Ong, Mathematics for Machine Learning, Cambridge University Press, 2020. 2. B Joshi, Machine Learning and Artificial Intelligence, Springer, 2020. 3. Parag Kulkarni and Prachi Joshi, “Artificial Intelligence – Building Intelligent Systems”, PHI learning Pvt. Ltd., ISBN – 978-81-203-5046-5, 2015 4. Stuart Russell and Peter Norvig (1995), “Artificial Intelligence: A Modern Approach,” Third edition, Pearson, 2003. 		
References Books:		
<ol style="list-style-type: none"> 1. Solanki, Kumar, Nayyar, Emerging Trends and Applications of Machine Learning, IGI Global, 2018. 2. Mohri, Rostamizdeh, Talwalkar, Foundations of Machine Learning, MIT Press, 2018. 3. Kumar, Zindani, Davim, Artificial Intelligence in Mechanical and Industrial Engineering, CRC Press, 2021. 4. Zsolt Nagy - Artificial Intelligence and Machine Learning Fundamentals-Apress (2018) 5. Artificial Intelligence by Elaine Rich, Kevin Knight and Nair, TMH 		
Web References:		
<ol style="list-style-type: none"> 1. http://nptel.ac.in/courses/111101003/ 2. https://nptel.ac.in/courses/106/106/106106202/ 3. https://nptel.ac.in/courses/112/103/112103280/ 4. https://www.analyticsvidhya.com/ 		

Term Work

List of Experiments:

1. To study supervised/unsupervised/Reinforcement learning approach.
2. To acquire, visualize and analyze the data set (from time-domain/ frequency-domain/ etc.) .
3. To extract features from given data set and establish training data.
4. To select relevant features using suitable technique.
OR
5. To use PCA for dimensionality reduction.
6. To classify features/To develop classification model and evaluate its performance (any one classifier).
7. To develop regression model and evaluate its performance (any one algorithm).
8. Markov process for modelling manufacturing processes.
OR
9. Reinforced Learning for optimizing engineering designs / Robot Guidance and Navigation.
10. GA for optimization of multi-dimensional function / path planning in robotics.
OR
11. NN for parameter and model identification / tuning of Control Algorithms.

Note:

- Students need to apply the computational algorithms using suitable software / programming language.
- Experiment 1, 2, 3, 6 & 7 are compulsory. Experiment 2 to 7 to be taken on same data set

302050: Computer Aided Engineering					
Teaching Scheme		Credits		Examination Scheme	
Theory	3Hrs./Week	Theory	3	In-Semester	30 Marks
Practical	2 Hrs./Week	Practical	1	End-Semester	70 Marks
				Practical	50 Marks
<p>Prerequisite Courses: Solid Mechanics, Numerical and Statistical Methods, Engineering Mathematics, Manufacturing Processes, Fluid Mechanics, Heat and Mass Transfer.</p>					
<p>Course Objectives:</p> <ol style="list-style-type: none"> 1. UNDERSTAND the basic concepts of Computer Aided Engineering (CAE) and CHARACTERISTICS of various elements required for analysis. 2. NURTURE students about the discretization process and criteria for quality mesh. 3. UNDERSTAND the approaches of Finite Element Method (FEM) and to find displacement and stresses over the body. 4. DEVELOP the knowledge and skills needed to effectively evaluate the results using Finite Element Analysis (FEA). 5. APPLY computational technique to solve complex solid mechanics problems and its loading states. 6. STUDY the applications of CAE in the various domains of the Mechanical Engineering. 					
<p>Course Outcomes:</p> <p>On completion of the course, learner will be able to</p> <p>CO1: DEFINE the use of CAE tools and DESCRIBE the significance of shape functions in finite element formulations.</p> <p>CO2: APPLY the various meshing techniques for better evaluation of approximate results.</p> <p>CO3: APPLY material properties and boundary condition to SOLVE 1-D and 2-D element stiffness matrices to obtain nodal or elemental solution.</p> <p>CO4: ANALYZE and APPLY various numerical methods for different types of analysis.</p> <p>CO5: EVALUATE and SOLVE non-linear and dynamic analysis problems by analyzing the results obtained from analytical and computational method.</p> <p>CO6: GENERATE the results in the form of contour plot by the USE of CAE tools.</p>					
Course Contents					
Unit 1	Elemental Properties				07 Hrs.
<p>Introduction to Computer Aided Engineering (CAE), Use of CAE in Product development, Discretization methods – Finite Element Method (FEM), Finite Difference Method (FDM) and Finite Volume Method (FVM), CAE Tools- Pre-processor, Solver and Post-Processor.</p> <p>Element Shapes – 1D, 2D and 3D elements, Nodal Unknowns and field variables, Coordinate Systems, Shape Functions- linear, quadratic and cubic, Convergence Requirements of Shape Functions, Derivation of Polynomial Shape Functions using coordinate systems for Bar, Beam, Triangular, and rectangular elements.</p>					

Unit 2	Meshing Techniques	06 Hrs.
<p>Discretization of a Structure, 1D, 2D and 3D element Meshing, Element selection criteria, Refining Mesh, Effect of mesh density in critical region, Use of Symmetry.</p> <p>Element Quality Criterion:-Jacobian, Aspect ratio, Warpage, Minimum and Maximum angles, Average element size, Minimum Length, skewness, Tetra Collapse etc., Higher Order Element vs Mesh Refinement, Geometry Associate Mesh, Mesh quality, Bolted and welded joints representation, Mesh independent test.</p>		
Unit 3	1D Finite Element Analysis	08 Hrs.
<p>Consistent Unit System, Introduction to approaches used in Finite Element Analysis (FEA) such as direct approach and energy approach</p> <p>Bar and Truss Element - Element stiffness matrix, Assembling stiffness Equation, Load vector, stress and reaction forces calculations.</p> <p>Temperature effect on Bar Element- Calculation due to uniform temperature change, Stress and reaction forces calculations.</p>		
Unit 4	2D Finite Element Analysis	08 Hrs.
<p>Plane Stress-Strain, axi-symmetric problems in 2D elasticity.</p> <p>Constant Strain Triangle (CST) - Element Stiffness matrix, Assembling stiffness equation, Load vector, Stress and reaction forces calculations.</p> <p>Post Processing Techniques – Check and validate accuracy of results, Average and Un-average stresses, and special tricks for Post Processing. Interpretation of results and design modifications, CAE reports.</p>		
Unit 5	Non-Linear and Dynamic Analysis	08 Hrs.
<p>Non-Linear Analysis: Introduction to Nonlinear Problems, Comparison of Linear and Nonlinear analysis, Types of Nonlinearities, Stress-strain measures for Nonlinear analysis, Analysis of Geometric, Material Nonlinearity, Solution Techniques for Nonlinear analysis, Newton Raphson Method, Essential steps in Nonlinear analysis.</p> <p>Dynamic Analysis: Introduction to Dynamic Analysis, Comparison of Static and Dynamic analysis, Time domain and frequency domain, Types of loading, Simple Harmonic motion, Free vibration, Boundary conditions of free vibration, Solution.</p>		
Unit 6	Applications of Computer Aided Engineering	08 Hrs.
<p>Computational Fluid Dynamics (CFD): Introduction, Three dimensions of Fluid Dynamics, Equilibrium Equation for a fluid, Conservation form of Fluid flow equation, Integral form of the Conservation Laws.</p> <p>Injection moulding of Plastics: Simplification of Mould Geometry for FEA, Material Model for Mould FEA, Boundary Conditions for Mould FEA, Loading of Mould in FEA, Results Analysis.</p> <p>Simulation for Manufacturing Processes like Casting and Sheet Metal Applications: Introduction and workflow of Casting Simulation Software and Sheet Metal Applications.</p> <p>Durability Analysis: Durability, Reliability and Fatigue, FEA bases fatigue analysis viz: Stress-Life approach (S-N method) and Strain-Life approach (E-N method).</p> <p>Crash Analysis: Introduction, Explicit time integration schemes, implicit integration schemes.</p> <p>Noise Vibration and Harshness (NVH) Analysis: NVH Concepts, Terminology, FEA for structural Dynamics, FEA for Acoustics.</p>		

Books and other resources

Text Books:

1. Gokhale N. S., Deshpande S. S., Bedekar S. V. and Thite A. N., Practical Finite Element Analysis, Finite to Infinite, Pune, 1st Edition, 2008.
2. S. S. Bhavikatti, Finite Element Analysis, New Age International Publishers, Third Edition, 2015.
3. Chandrupatla T. R. and Belegunda A. D., Introduction to Finite Elements in Engineering, Prentice Hall India, 2002.
4. G Lakshmi Narasaiah, Finite Element Analysis, BS Publications / BSP Books, 2nd edition, 2020.
5. J. N. Reddy, An Introduction to the Finite Element Method, Mcgraw Hill Series in Mechanical, 2005.
6. P. Seshu, Text book of Finite Element Analysis, PHI Learning Private Limited, New Delhi, 10th Printing, 2012.

References Books:

1. K. J. Bathe, Finite Element Procedure, Prentice-Hall of India (P) Ltd., New Delhi, 1996.
2. Cook R. D., Finite Element Modeling for Stress Analysis, John Wiley and Sons Inc, 1995.
3. G.R. Liu S. S. Quek, The Finite Element Method- A Practical Course, Butterworth Heinemann, 2013.
4. Fagan M. J., Finite Element Analysis Theory and Practice, Harlow Pearson/Prentice Hall, 2012.
5. S. Moaveni, Finite element analysis, theory and application with Ansys, Pearson, Third Edition, 2011.
6. David V. Hutton, Fundamental of Finite Element Analysis, Tata McGraw-Hill, 2017.
7. Mukhopadhyay M and Sheikh A. H., Matrix and Finite Element Analyses of Structures, Ane Books Pvt. Ltd., 2009
8. Daryl L. Logan, A First Course in the Finite Element Method, Fourth Edition, Thomson Canada Limited, 2007.
9. O.C. Zienkiewicz, The Finite Element Method: Its Basis and Fundamentals, Sixth Edition, Elsevier Butterworth-Heinemann, 2005.

Web References:

- <https://nptel.ac.in/courses/112/104/112104116/>-for Basics of Finite Element Analysis by Prof.Nachiketa Tiwari, IIT Kanpur
- <https://nptel.ac.in/courses/112/106/112106130/>for Advanced Finite Element Analysis by Dr. R. Krishnakumar, Department of Mechanical Engineering, IIT Madras
- <https://nptel.ac.in/courses/112/103/112103299/>for Finite Element Analysis for Welding Analysis by Prof. Swarup Bag, Department of Mechanical Engineering, IIT Guwahati.
- <https://sites.ualberta.ca/~wmoussa/AnsysTutorial/> for ANSYS Tutorials

Term Work

The student shall complete the following activity as a Practical using any commercial FEA software or open-source software's

1. 1D Bar Element – Structural Linear Analysis
2. Truss Analysis using 1D Element
3. Plate/Shell Element – Structural Linear and Non-Linear Analysis
4. Beam Element – Non-Linear Buckling Analysis
5. Thermal Analysis – Static/Transient Analysis
6. Coupled Analysis- (Structural + Thermal)
7. Analysis of Machine Component using 3D Elements
8. Non-Linear Analysis of Assembly using Contact Elements
9. Modal Analysis – Spring -Mass system, simply supported/Cantilever beam, etc.
10. Presentation on advanced applications of FEA, NVH, CFD, Crash, Fatigue, Manufacturing, etc.

Note:

- The lab report shall consist of completion of Practical's and Presentations.
- Practical examination shall be based on the practical undertaken during the semester.

302051: Design of Transmission Systems					
Teaching Scheme		Credits		Examination Scheme	
Theory	3Hrs./Week	Theory	3	In-Semester	30 Marks
Practical	2 Hrs./Week	Practical	1	End-Semester	70 Marks
				Oral	25 Marks
<p>Prerequisites: Classification of Gears, Gear Terminology, Terminology of Helical gear, Virtual number of teeth. Classification, selection and application of Belt, chain and rope drives.</p>					
<p>Course Objectives:</p> <ol style="list-style-type: none"> 1. APPLY fundamentals for the design and/or selection of elements in transmission systems. 2. UNDERSTAND the philosophy that real engineering design problems are open-ended and challenging. 3. DEMONSTRATE design skills for the problems in real life industrial applications. 4. DEVELOP an attitude of team work, critical thinking, communication, planning and scheduling through design projects. 5. PERCEIVE about safety, ethical, legal, and other societal constraints in execution of their design projects. 6. BUILD a holistic design approach to find out pragmatic solutions to realistic domestic and industrial problems 					
<p>Course Outcomes:</p> <p>On completion of the course, learner will be able to</p> <p>CO1.APPLY the principle of Spur & Helical gear design for industrial application and PREPARE a manufacturing drawing with the concepts of GD&T.</p> <p>CO2.EXPLAIN and DESIGN Bevel & Worm gear considering design parameters as per design standards.</p> <p>CO3.SELECT&DESIGN Rolling and Sliding Contact Bearings from manufacturer's catalogue for a typical application considering suitable design parameters.</p> <p>CO4.DEFINE and DESIGN various types of Clutches, Brakes, used in automobile.</p> <p>CO5.APPLY various concept to DESIGN Machine Tool Gear box, for different applications</p> <p>CO6.ELABORATE various modes of operation, degree of hybridization and allied terms associated with hybrid electric vehicles.</p>					
Course Contents					
Unit 1	Spur and Helical Gears				07 Hrs.
<p>Introduction to gears: Material selection for gears, Modes of gear tooth failure, Gear Lubrication Methods.</p> <p>Spur Gears: Number of teeth and face width, Force analysis, Beam strength (Lewis) equation, Velocity factor, Service factor, Load concentration factor, Effective load on gear, Wear strength (Buckingham's) equation, Estimation of module based on beam and wear strength, Estimation of dynamic tooth load by velocity factor and Buckingham's equation.</p> <p>AGMA (American Gear Manufacturing Association) approach of Gear design (Only mathematical relations, no numerical)</p>					

Helical Gears: Force analysis of Helical Gear, Beam Strength of Helical Gear, Wear strength and estimation of effective load based on Velocity factor (Barth factor) and Buckingham's equation. (No numerical on force analysis of helical)		
Unit 2	Bevel and Worm Gear	08 Hrs.
<p>Bevel Gears: Types of Bevel gears, Terminology, Virtual number of teeth, and force analysis of Straight Bevel Gear. Design of Straight Bevel Gear based on Beam Strength, Wear strength and estimation of effective load based on Velocity factor (Barth factor) and Buckingham's equation. (Simple numerical to be taken no design calculations)</p> <p>Worm Gears: Worm and worm gear terminology and proportions of worm and worm gears, Force analysis of worm gear drives, Friction in Worm gears, efficiency of worm gears, Worm and worm gear material, Strength and wear ratings of worm gears (Bending stress factor, speed factor, surface stress factor, zone factor) IS 1443-1974, Thermal consideration in worm gear drive. (Simple numerical to be taken no design calculations)</p>		
Unit 3	Sliding and Rolling Contact Bearing	07 Hrs.
<p>Sliding contact bearing (Theoretical treatment only): Introduction to sliding contact bearing, classification, Reynolds's equation (2D), Petroff's equations, Sommerfeld number, Parameters of bearing design.</p> <p>Rolling Contact Bearings: Types of rolling contact Bearings and its selection, Static and dynamic load carrying capacities, Stribeck's Equation, Equivalent bearing load, Load-life relationship, Selection of bearing life, Selection of rolling contact bearings from manufacturer's catalogue, Design for cyclic loads, Types of failure in rolling contact bearings - causes and remedies. (Simple Numerical treatment)</p>		
Unit 4	Design of Clutches and Brakes	07 Hrs.
<p>Clutches: Introduction, Types of clutches, Material, Positive clutches, friction clutches, single plate, multiple plate, Cone clutch, and centrifugal clutches, Application of friction clutches automotive and industrial machinery sector. (Only Theoretical Treatment)</p> <p>Brakes: Introduction, Types of brakes, Material, Design of band brake, external and internal shoe breaks internal expanding shoe brakes, design of disc brakes. Application of brakes in automotive and industrial machinery sector. (Only Theoretical Treatment)</p>		
Unit 5	Design of M/C Tool Gear Box	08 Hrs.
<p>Introduction to Machine Tool Gearboxes, classification, basic considerations in design of drives and its Applications, Determination of variable speed range, Graphical representation of speed and structure diagram, Ray diagram, selection of optimum ray diagram, Kinematic /Gearing Diagram, Deviation diagram, Difference between numbers of teeth of successive gears in a change gear box. (Note: Full design problem to be restricted up to 2 Stages only & No design problem on deviation diagram)</p>		
Unit 6	Transmission system in Hybrid Electric Vehicle	08 Hrs.
<p>Introduction, Types of Hybrid Electric Vehicles: Basic Classification, Basic Modes of Operation, Other Derivatives, Degree of Hybridization. Power Split Devices (PSD): Simple and EM compound PSD, HEV Component Characteristics: The IC Engine, Electric Machines, Battery, HEV Performance Analysis: Series HEV, Parallel HEV, HEV Component Sizing: General Considerations, Sizing for Performance, Optimum Sizing, Power Management: Control Potential, Control.</p>		

Books and other resources

Text Books:

1. Shigley J.E. and Mischke C.R., Mechanical Engineering Design, McGraw Hill Publication Co. Ltd.
2. Spotts M.F. and Shoup T.E., Design of Machine Elements, Prentice Hall International.
3. Bhandari V.B, Design of Machine Elements, Tata McGraw Hill Publication Co. Ltd.
4. Juvinal R.C, Fundamentals of Machine Components Design, John Wiley and Sons.

References Books:

1. Design Data - P.S.G. College of Technology, Coimbatore.
2. Vehicle Powertrain Systems by Behrooz Mashadi, David Crolla. A John Wiley & Sons, Ltd
3. Automobiles–Power trains and Automobiles–Dynamics by Crolla, David, A John Wiley & Sons, Ltd
4. Automotive Engineering Powertrain, Chassis System and Vehicle Body by David A Crolla, Elsevier B H New York, London, Oxford.
5. Jack P.H. and O. Eugene Adams, Machine Design, McGraw Hill Book Co. Inc.
6. William C. Orthwein, Machine Components Design, West Publishing Co. and Jaico Publications House.
7. P. Kannaiah, Design of Transmission systems, SCIETCH Publications Pvt Ltd.
8. C.S. Sharma and Kamlesh Purohit, Design of Machine Elements, PHI Learning Pvt. Ltd.
9. D.K. Aggarwal & P.C. Sharma, Machine Design, S.K Kataria and Sons.
10. P. C. Gope, Machine Design: Fundamentals and Applications, PHI Learning Pvt. Ltd.
11. Bhandari, V. B. Machine Design data book, Tata McGraw Hill Publication Co. Ltd.
12. K. Mahadevan, K. Balveera Reddy, Design Data Handbook for Mechanical Engineers, CBS Publishers.

Web References:

1. https://www.youtube.com/watch?v=b42_IO87X4s
2. <https://www.youtube.com/watch?v=vTZ4Gah3wfo>
3. <https://www.youtube.com/watch?v=ER6LC7ONCD8>
4. <https://www.youtube.com/watch?v=nMsB6Soz4Hc>
5. <https://www.youtube.com/watch?v=WOTDbCPukoM>
6. <https://www.youtube.com/watch?v=fMNQglkUfhs>
7. <https://freevideolectures.com/course/2363/design-of-machine-elements>

Term Work

Student shall complete the following activity as a Term Work;

The Submission shall consist of completion of Two Design projects and study Assignments. Oral examination shall be based on the practical undertaken during the semester.

Design Project 1 (Any one)

1. Design of gearbox for wind mill application or sluice gate. (Use AGMA approach)
2. Design of gearbox for building Elevator. (Use AGMA approach)
3. Design of gearbox for Hoist. (Use AGMA approach)
4. Design of gearbox for Worm gear box for Sugar Industry. (Use AGMA approach)
5. Design of clutch system for automobile
6. Design of brake system for automobile

Design Project 2

Projects shall be in the form of design of mechanical systems on multi speed spindle gear box including design of belt and pulley, Prime mover selection etc.

The design project shall consist of two full imperial (A1) size sheets involving assembly drawing with a part list and overall dimensions and drawings of individual components.

Manufacturing tolerances, surface finish symbols and geometric tolerances should be specified for important surfaces. A design report giving all necessary calculations of the design of components and assembly should be submitted in a separate file. Design data book shall be used wherever necessary to achieve selection of standard components.

Assignment: Any Two (PPT Presentation and Report)

1. Application orientated Numerical on HEV
2. Lubricating oils: Properties, additives, selection of lubricating oils
3. Properties & selection of sliding bearing materials
4. Application of belt, rope and chain drives and its selection method for Industry
5. Transmission system of HEV

302052-A: Composite Materials					
Teaching Scheme		Credits		Examination Scheme	
Theory	3Hrs./Week	Theory	3	In-Semester	30 Marks
				End-Semester	70 Marks
Prerequisites: Engineering Materials, Metallurgy, Manufacturing Process, Basic Design aspects.					
Course Objectives:					
<ol style="list-style-type: none"> 1. DESCRIBE what are composite materials and their differences with respect to conventional materials. 2. COMPREHEND the challenges associated with Polymer Matrix composites. 3. UNDERSTAND the requirement of Metal Matrix Composites 4. RECOGNIZE design and properties aspect of composites 5. UNDERSTAND the testing, inspection and standard in Composites 6. ORIENT to the specific Application of Composites 					
Course Outcomes:					
On completion of the course, learner will be able to					
CO1. DEFINE & COMPARE composites with traditional materials.					
CO2. IDENTIFY & ESTIMATE different parameters of the Polymer Matrix Composite					
CO3. CATEGORISE and APPLY Metal Matrix Process from possessions landscape.					
CO4. DETERMINE volume/weight fraction and strength of Composites.					
CO5. SELECT appropriate testing and inspection method for composite materials.					
CO6. SELECT composites materials for various applications.					
Course Contents					
Unit 1	Introduction to Composites				07 Hrs.
Definitions, Need of Composites, Classification of Composites, Reinforcements and matrices, Types of reinforcements, Types of matrices, Types of composites, Natural Composites, Carbon Fiber composites, Properties of composites in comparison with standard materials. Advantages and Disadvantages. Natural Composites, Hybrid materials and their difference with Composite materials, Applications.					
Unit 2	Polymer Matrix Composite				08 Hrs.
Polymer resins – thermosetting resins, thermoplastic resins – reinforcement fibers – roving’s – woven fabrics – non woven random mats – various types of fibers. PMC processes – hand layup processes – spray up processes – compression moulding – reinforced reaction injection moulding – resin transfer moulding – Pultrusion – Filament winding – Injection moulding. Fiber reinforced plastics (FRP), Glass Fiber Reinforced Plastics (GFRP). Laminated Composites.					
Unit 3	Metal Matrix Composite				07 Hrs.
Characteristics and types of MMC, advantages and limitations of MMC, Reinforcements – particles – fibers. Effect of reinforcement – volume fraction – rule of mixtures. Processing of MMC – powder metallurgy process – diffusion bonding – stir casting – squeeze casting, a spray process, Liquid infiltration In-situ reactions-Interface-measurement of interface properties.					

Unit 4	Mechanics of Composite Materials	08 Hrs.
<p>Geometrical aspects – volume and weight fraction (Numerical). Large particle composites and the rule of mixtures for elastic constants, failure, fatigue, and long-term strength, methods of optimum design of materials and structures, Micromechanics of a Lamina, Unidirectional continuous fiber, discontinuous fibers, short fiber systems, woven reinforcements –Mechanical Testing: Determination of stiffness and strengths of unidirectional composites; tension, compression, flexure and shear (Numerical).</p>		
Unit 5	Testing, Inspection & Standards in Composites	07 Hrs.
<p>Test Environments, Mechanical Test (Tensile, compression, shear & Fatigue) Bond Strength / Ply Adhesion ASTM F904, Testing Techniques for Composite Double Cantilever Beam, End Notch Flexure, Inter laminar Share Strength, Materials Nondestructive Inspection (NDI) of Composites, Thermographic testing of composites. ASTM & ISO standards for composites materials.</p>		
Unit 6	Application of Composite Materials	08 Hrs.
<p>Applications of Composites material for Aerospace and Transportation application, viz LCA/LCH, Automobile Industry -lightweight, cost-effective, multi-material technology, compatibility with automation systems and rapid processing.</p> <p>Energy Applications-Ecofriendly Prime movers, Infrastructure and Building Applications, Marine Applications- Boats and Ships, Ecofriendly storage Tanks Sports Industry-Protective Equipment's.</p>		
Books and other resources		
Text Books:		
<ol style="list-style-type: none"> 1. Chawla K.K., Composite materials Science and Engineering, Springer – Springer New York- 2016 2. Daniel Gay- Composite Materials- Design and Applications, CRC Press, 2014 3. Autar Kaw- Mechanics of Composite Materials, Taylor and Francis, Second Edition- 2006 4. Robert M Jones-Mechanics of Composite Material, CRC Press, 2018 5. Madhujit Mukhopadhyay - Mechanics of Composite Materials and Structure, University Pres, 2004 6. S.C. Sharma -Composite Materials, Narosa Publishing House—2000 		
References Books:		
<ol style="list-style-type: none"> 1. A Bent Strong- Fundamentals of Composites Manufacturing-Materials, Methods and Applications, Society of Manufacturing Engineers, 2008 2. Clyne T.W. and Withers P.J-Introduction to Metal Matrix Composites, Cambridge University Press, 1995 3. Agarwal B. D. and Broutmen L. J-Analysis and performance of Fiber Composites, Wiley Publicaions-Fourth Edition, 2017 4. M. W. Hyer, Scott R. White- Stress Analysis of Fiber-reinforced Composite Materials, DEStech Publications, Inc., 2009 5. Carl T. Herakovich- Mechanics of Fibrous Composites, Wiley Publicaions, 1998 6. Erich Fitzer, Lalit M. Manocha - Carbon Reinforcements and Carbon /carbon Composites, Springer-Verlag, 1998 7. Murray Schwartz, Mel M. Schwartz- Composite Materials Handbook, McGraw-Hill, 1992 8. Composite Materials Handbook, SAE International, 2017 		

Web References:

1. Introduction of Composite - <https://nptel.ac.in/courses/112/104/112104229/>
2. Advanced Composite - <https://nptel.ac.in/courses/112/104/112104249/>
3. Polymer Process - <https://nptel.ac.in/courses/113/105/113105077/>
4. Manufacturing of composite - <https://nptel.ac.in/courses/112/104/112104221/>
5. Processing of Polymer composite - <https://nptel.ac.in/courses/112/107/112107221/>
6. Composite materials - <https://nptel.ac.in/courses/101/106/101106038/>
7. Mechanics of laminated of composite - <https://nptel.ac.in/courses/112/104/112104161/>
8. Composite Materials and Structure - <https://nptel.ac.in/courses/101/104/101104010/>

302052-B: Surface Engineering					
Teaching Scheme		Credits		Examination Scheme	
Theory	3Hrs./Week	Theory	3	In-Semester	30 Marks
				End-Semester	70 Marks
Prerequisites: Basic Chemistry, Engineering Materials & Basic Metallurgy concepts					
Course Objectives:					
<ol style="list-style-type: none"> 1. DEVELOP fundamental understanding and role of materials to allow surface selection for mechanical contact surfaces 2. UNDERSTAND surface modification and coating method to enhance surface performance 3. RECOGNIZE method for testing surface properties 					
Course Outcomes:					
On completion of the course, learner will be able to-					
CO1. DEFINE the basic's principle & mechanism of surface degradation.					
CO2. ANALYSE & SELECT correct corrosion prevention techniques for a different service condition.					
CO3. DEMONSTRATE the role of surface engineering of materials to modify/improve the surface properties.					
CO4. SELECT the suitable surface heat treatments to improve the surface properties.					
CO5. APPLY the surface modification technique to modify surface properties.					
CO6. ANALYSE & EVALUTE various surface coating defects using various testing/characterization method.					
Course Contents					
Unit 1	Introduction to Surface Engineering and Surface Degradation				08 Hrs.
Introduction to engineering components, surface dependent properties and failures, importance and scope of surface engineering; surface and surface energy; Structure and type of interfaces, surface and related equations; Surface engineering: classification, definition, scope and general principles. Adhesive wear, Abrasive wear, Erosion wear, Polishing wear; Corrosion: definition; Various Forms of Corrosion; Corrosion Triangle, Pilling and Bedworth rule, Formation and growth of films, Concept of Electrode Potential, Concept of Polarization, Electrochemical and galvanic series of metals.					
Unit 2	Corrosion Testing and Prevention methods				07 Hrs.
Corrosion Testing –Introduction of Corrosion Testing by Physical (only weight loss & salt spray method) and Electrochemical Methods such as ASTM standard methods only G-5&A262-A.					
Corrosion Prevention methods –Metallurgical and Environmental aspects of corrosion, Inhibitors, Internal & External coating, Cathodic & Anodic protection, use of special alloys, Improvement in design/ changes in design to control corrosion.					
Unit 3	Surface Treatment Methods				08 Hrs.
Diffusion: Principles of diffusion, Fick's law, diffusion in solids, Diffusion in liquids; Surface hardening: Carburizing, Carburizing atmosphere and Heat treatment after Case Hardening, Depth of carburization, Case depth measurement, ASTM E1077-01 Depth of carburization, ASTM standard					

G105, G95, Bainite control in case, Drip Feed Carburizing, dimensional changes during case hardening; Nitriding, Carbonitriding, Tufftriding, Nitrocarburising, Plasma Nitriding; Induction Hardening, Flame Hardening, Laser Hardening, Selection of steels for these treatments and their applications.		
Unit 4	Advance Surface Modification Techniques	07 Hrs.
Surface modification processes: ion beam surface treatment; sol-gel coating technology; laser surface alloying. Coating for corrosion resistance: conversion coatings; compound coatings - diamond-like nanocomposites, nitrides, silicides, and carbides. Coating for wear resistance: carbon nitride thin films; sputter deposited nanostructured ceramic coatings; dielectric coatings of Si-C alloy films. Electroless coating.		
Unit 5	Surface Coating Techniques	07 Hrs.
Introduction; importance of coating; types of coating: metal, inorganic, and organic. Processes of metal coatings: electrodeposition; flame spraying; Cold spray coating; cladding; hot dipping; vapor deposition. Processes of inorganic coatings: spraying; diffusion coating; chemical conversion. Processes of organic coatings: surface preparation; priming coat; top coats, Antidust coating, Hardfacing; Coatings for high temperature, Coatings for aerospace and aircrafts.		
Unit 6	Surface Evaluation and Characterizations	08 Hrs.
Coating Defects & remedies: Crawling, cratering & related defects; Flooding, wrinkling, Bubbling and Pin-holing, Overspray and Dry Spray, Blushing, foaming, blistering, checking and cracking, blooming, chalking, embrittlement, orange peel, yellowing etc. Measurement of coating thickness; porosity and adhesion of surface coating; measurement of residual stress and stability; Surface microscopy and topography by scanning probe microscopy; spectroscopic analysis of modified surfaces; Surface roughness, Atomic force microscopy.		
Books and other resources		
Text Books:		
<ol style="list-style-type: none"> 1. K.G. Budinski, Surface Engineering for Wear Resistances, Prentice Hall, Englewood Cliffs, 1988. 2. M. Ohring, The Materials Science of Thin Films, Academic Press Inc, 2005. 3. Peter Martin, " Introduction to Surface Engineering and Functionally Engineered Materials", John Willey 4. M. G. Fontana - Corrosion Engineering, 3rd Edition, TATA Mc Graw Hill, 2008. 5. J. R. Davis-Surface Engineering for Corrosion and Wear Resistance, ASM International, 2001 6. R. W. Revie & H.H. Uhlig - Corrosion and Corrosion Control, An Introduction to Corrosion Science & Engineering, 4th Edition, Wiley Inter science , 2008. 		
References Books:		
<ol style="list-style-type: none"> 1. Mircea K. Bologa, "Surface Engineering and Applied Electrochemistry", Springer. 2. Devis, J.R.," Surface Engineering for Corrosion & Wear Resistance", 2001 Maney Publicising 3. D.R. Jones - Principals and Prevention of Corrosion, 2nd International Edition, Prentice Hall International Singapore, 1995. 4. L. L. Shreir- Corrosion Volume I & II, Butterworths, London, 1994. 5. ASM Handbook Volume 5: Surface Engineering, ASM International, USA, 1994. 		

Web References:

1. [Aqueous Corrosion and Its Control - Course \(nptel.ac.in\)](#): By Dr. V. S. Raja
2. [Corrosion Failures and Analysis - Course \(nptel.ac.in\)](#):By Dr. KallolMandol
3. [Surface Engineering of Nanomaterials - Course \(nptel.ac.in\)](#): By Prof. Kaushik Pal
4. [Fundamentals of Surface Engineering: Mechanisms, Processes and Characterizations - Course \(nptel.ac.in\)](#)by Prof. D.K. Dwivedi

302053: Measurement Laboratory					
Teaching Scheme		Credits		Examination Scheme	
Practical	2 Hrs./Week	Practical	1	Term Work	50 Marks
<p>Prerequisites: Basics of Linear measurements and working principles of Electrical and Electronics devices.</p>					
<p>Course Objectives:</p> <ol style="list-style-type: none"> 1. DEVELOP necessary skills for calibration and testing of instruments 2. APPLY fundamentals of measuring methods by collecting data ,analysis and interpretation 3. APPLY knowledge of Designing limiting gauges 4. APPLY knowledge of Electronic/Electrical measuring instruments 					
<p>Course Outcomes:</p> <p>On completion of the course, learner will be able to-</p> <p>CO1. EVALUATE causes of errors in Vernier calipers, micrometers by performing experiments in standard metrological conditions, noting deviations at actual and by plotting cause and effect diagram, to reduce uncertainty in measurement.</p> <p>CO2. ANALYZE strain measurement parameters by taking modulus of elasticity in consideration to acknowledge its usage in failure detection and force variations.</p> <p>CO3. EXAMINE surface Textures, surface finish using equipment’s like Talysurf and analyze surface finish requirements of metrological equipment’s like gauges, jaws of vernier calipers, micrometers, magnifying glasses of height gauge and more, to optimize surface finish accuracy requirements and cost of measurement.</p> <p>CO4. MEASURE the dimensional accuracy using Comparator and limit gauges and appraise their usage in actual measurement or comparison with standards set to reduce measurement lead time.</p> <p>CO5. PERFORM Testing of Flow rate, speed and temperature measurements and their effect on performance in machines and mechanisms like hydraulic or pneumatic trainers, lathe machine etc. to increase repeatability and reproducibility.</p> <p>CO6. COMPILE the information of opportunities of entrepreneurships/business in various sectors of metrology like calibrations, testing, coordinate and laser metrology etc in an industry visit report.</p>					
Term Work					
<p>The student shall complete the following activity as a Term Work</p> <ol style="list-style-type: none"> 1. Fundamentals of measurements and Calibration process by using Dead weight Tester/Strain Gauges/Pressure Gauge. 2. Linear and angular Measurement: Demonstration and calculations using Vernier Caliper, Screw gauge, Dial gauge, height gauge, Bevel protector etc. and plotting cause and effect diagram for their errors in measurement with the help of OER software’s or software’s like Minitab or in excel sheet. 3. Limit Gauges: Concepts, uses and applications of Go –No Go Gauges, Taylor’s principle and Design of gauges (Numerical and student activity) 4. Surface roughness measurement of a given sample using surface tester. Students should also 					

plot of flow chart of its usage.

5. Determination of geometry and dimensions of given composite object / single point tool, by using Optical Projector / Tool makers' Microscope and differentiate between its usefulness in real life.
6. Verification of dimensions and geometry of given components using Electric/Mechanical/Optical/Pneumatic comparator in context of manufacturing.
7. Determination of modulus of elasticity of a mild steel specimen using strain gauges and its improvement to reduce cost of measurement.
8. Calibration of Thermocouple for temperature measurement / Experimentation by using Gear Tooth Vernier Caliper
9. Speed Measurement and calibration of photo and magnetic speed pickups for the measurement of speed by using Stroboscope.
10. Calibration for Flowrate measurement by using Anemometers, Ultrasonic flow meters and plotting of Risk Priority Number (RPN) of any of the used equipments.
11. Determination of geometry of a given sample by using Coordinate Measuring Machine as per NPL standard and also acknowledge requirements of ISO 10360-5:2020 in CMM measurement.
12. Applications of Open Education Resources like Scilab in measurement / Students should develop any online calculator/app for calculations/numerical analysis relevant to metrology.

Important Note:

1. Relevant theory to be taught during practical hours
2. Sr. No. 1, 2, 3 and 12 are mandatory and any 4 from Sr. No. 4 to 11.
3. Practical's are to be performed under the guidance of concerned faculty member.

Industry Visit to provide exposure to students (Anyone to be covered to fulfil CO6 essentially)

- Demonstration of CMM with the help of software and its futuristic improvements as per Industry 4.0 requirements.
- Design of Go –No Go gauges and Sensor applications with modernization as per IOT and Industry 4.0
- Calibration Process as per NABL accreditation norms
- Laser Metrology and its relevant setup functions to be carried out by engineers along with safety precautions to reduce measurement lead time and uncertainty.
- Temperature Measurements of Furnaces, Boilers etc with its cost analysis
- Flow Measurements of Air, Fluids to reduce measurement lead time

Text Books:

1. Jain R.K., Engineering Metrology, Khanna Publication.
2. D.S.Kumar, Mechanical Measurements and Control Metropolitan Book Co.Pvt.Ltd.
3. I.C.Gupta, Engineering Metrology, Dhanpath Rai.
4. Bewoor A. K. and Kulkarni V. A., Metrology and Measurements, McGraw hill Publication.

Reference Books:

1. Narayana K.L., Engineering Metrology.
2. Galyer J.F & Shotbolt C.R., Metrology for engineers
3. Judge A.W., Engineering Precision Measurements, Chapman and Hall
4. Francis T. Farago, Mark A. Curtis, Handbook of dimensional measurement

5. ASTM, Handbook of Industrial Metrology, Prentice Hall of India Ltd.
6. Connie Dotson, Fundamentals of Dimensional Metrology, ThomsonPubln. 4th Edition.

Online Education resources: viz. NPTEL web site:

1. nptel.ac.in/courses/112106179
2. www.nptelvideos.in/2012/12/mechanical-measurements-and-metrology.html
3. <https://nptel.ac.in/courses/112/107/112107242/>
4. freevideolectures.com › Mechanical › IIT Madras
5. <https://nptel.ac.in/courses/112/106/112106139/>

302054: Fluid Power & Control Laboratory					
Teaching Scheme		Credits		Examination Scheme	
Practical	2 Hrs./Week	Practical	1	Term Work	50 Marks
Prerequisites: Hydraulic fluids, Relay logic and Ladder Logic/PLC programming					
Course Objectives:					
<ol style="list-style-type: none"> 1. UNDERSTAND working principles of control devices and accessories. 2. SELECT different components from manufactures' catalogues. 3. DEMONSTRATE the capabilities to simulate and design fluid power systems. 4. UNDERTAKE digitalization of fluid power system. 					
Course Outcomes:					
On completion of the course, learner will be able to					
CO1. DEFINE working principle of components used in hydraulic and pneumatic systems.					
CO2. IDENTIFY & EXPLAIN various applications of hydraulic and pneumatic systems.					
CO3. SELECT an appropriate component required for hydraulic and pneumatic systems using manufactures' catalogues.					
CO4. SIMULATE & ANALYSE various hydraulic and pneumatic systems for industrial/mobile applications.					
CO5. DESIGN a hydraulic and pneumatic system for the industrial applications.					
CO6. DESIGN & DEMONESTRATE various IoT, PLC based controlling system using hydraulics and pneumatics.					
Practical					
The student shall complete the following Practical in laboratory					
<ol style="list-style-type: none"> 1. Study of fluid power control systems <ol style="list-style-type: none"> a. Fluid Power Engineering Fundamentals <ul style="list-style-type: none"> ▪ Fluid power basics (governing laws used in fluid power systems) ▪ Discuss fluid power transmission and explain basic methods of transmission of power ▪ Advantages and disadvantages of fluid power systems ▪ Explain role of fluid power engineering in today's industrial automation ▪ Clarify the aims of automation b. Components of Fluid Power System <ul style="list-style-type: none"> ▪ Components of hydraulic system ▪ Components of pneumatic systems ▪ Draw symbols of hydraulic and pneumatic components 2. Study and trial on actuators <ol style="list-style-type: none"> a. Study of actuators used in hydraulics and pneumatics <ul style="list-style-type: none"> ▪ Introduction ▪ Types of actuators <ul style="list-style-type: none"> • Linear actuators • Rotary actuators • Limited rotary actuators b. Test on linear /rotary actuator. Calculate force/speed/rpm/torque as per case. 					

3. A) Study and trial on Gear/Vane/Piston pump
 - a. Study of hydraulic pumps.
 - Introduction and classification
 - Advantages of positive displacement pumps
 - Types of pumps
 - External and internal gear pump
 - Vane pumps
 - Piston pumps
 - Axial pumps
 - Radial piston pumps
 - b. Trial Gear/Vane/Piston pump.
- OR
- B) Study and testing of pressure control valve.
 - a. Circuits with pressure control valve i.e. pressure reducing/counterbalance/brake valve/Sequencing circuit
 - b. Test on pressure relief valve
4. Study and design of compressed air generation and distribution system
 - a. Reservoir
 - b. Driers
 - c. Types of Regulators
 - d. Filters
 - e. Lubricators
 - f. FRL
 - g. Loop piping system
 - h. Assignment on calculation (manual/excel sheet/simulation tool) of pressure loss in piping system
5. Study of control valves
 - a. Introduction
 - b. Types of control valves
 - Directional control valves
 - Pressure control valves
 - Flow control valves
 - Cartridge valves
 - Proportional control valves/Electro-hydraulics/proportional valves
 - Demonstration of cut-section/transparent/dismantling of any one valve
 - c. Regenerative circuit
 - d. Speed control circuits
 - e. Transverse and feed circuit.
6. Study of accessory used in hydraulic systems
 - a. Reservoirs
 - b. Accumulators: weight loaded, spring loaded, gas loaded.
 - c. Intensifier
 - d. Fluid conductors/pipes; pipe fittings
 - e. Demonstration of electro hydraulic circuit/accumulator/intensifier
7. Following experiments to be done on pneumatic trainer
 - a. Automatic reciprocating circuit
 - b. Speed control circuit/Flow control valve
 - c. Pneumatic circuit involving Shuttle valve/ Quick exhaust valve / Two pressure valve
 - d. Electro pneumatic circuits

8. a) Simulation of hydraulic and pneumatic circuits: Design of any two industrial hydraulics and two pneumatic circuits using manufacturers' catalogue and analysis using any open source/free/commercial software or application.
OR
b) Design of industrial hydraulic and pneumatic circuits, selection of components using the manufacturer's catalogue and analysis using any open source/free/commercial software or application.
9. A) Industrial visit. (Automotive workshop, small or medium scale /automation industry)
B) Trouble shooting of fluid power system.
10. Study and implementation of IoT based system to operate electro-pneumatic/hydraulic circuit from a remote location.
i.e. Demonstration of one cycle of operation of cylinder extension by actuation of solenoid and then retraction by deactivation of the solenoid through proximity sensor.
OR
Demonstration of counting and stopping a cycle once the number of the cycle's are completed (using PLC)
OR
any other application of relay ladder logic or PLC. (Equipments required for implementation include Smart Phone, Node MCU, Relay 5 volt to 24 volt and account on cloud.)

Assessment of Term Work

The student shall complete the above mentioned activities and prepare a Term Work Journal;

Important Note:

Term Work of the Student shall be evaluated based on the completion of Practical, Industrial Visit Report and Group Assignment. Continuous evaluation by the faculty shall be done for the award of the Credit associated with the course.

No practical examination shall be conducted for the award of the credit

Books and other resources

Text Books:

1. Esposito A, Fluid Power with application, Prentice Hall
2. Majumdar S.R, Oil Hydraulic system- Principle and maintenance ,Tata McGraw Hill
3. Majumdar S.R, Pneumatics Systems Principles and Maintenance ,Tata McGraw Hill
4. Stewart H. L, Hydraulics and Pneumatics , Taraporewala Publication

References Books:

1. Pipenger J.J, Industrial Hydraulics, McGraw Hill
2. Pinches, Industrial Fluid Power, Prentice Hall
3. Andrew A. Parr, Hydraulics and Pneumatics, Elsevier Science and Technology Books
4. ISO - 1219, Fluid Systems and components, Graphic Symbols
5. Standard manufacturing catalogues
6. Fundamentals of Pneumatics, Vol I, II and III. FESTO
7. Fundamentals of fluid power control, John Watton Cambridge University press 2012
8. Introduction to Fluid power, Thomson Prentice Hall 2004
9. Hydraulic Control Systems Herbert E. Merritt John Wiley and Sons, Inc

Web References:**URL links:**

1. <https://nptel.ac.in/courses/112/106/112106175/>
2. <http://ndl.iitkgp.ac.in/document/QXBqK1czOUpyM3FlamVjTmREMWFEUFdEb25sZ01FZVRtZmhWNXlobUZ0MFJ0Zk1kU1dSYmEwK1RSZG1FMUNDNQ>
Fluid Power Control: Web-Course Module-01 Module-02 Module-03 Module-04

Links of Video Lectures:

1. <https://nptel.ac.in/courses/112/106/112106300/>
2. <https://www.digimat.in/nptel/courses/video/112105047/L01.html>

Recommended on line courses: <https://nptel.ac.in/course.html>

302055: Internship/Mini project				
Teaching Scheme**		Credits	Examination Scheme	
		04	TW	100 Marks
Prerequisites: Knowledge of design, manufacturing processes, modeling, and mechanical systems				
Course Objectives:				
<p>Internship provides an excellent opportunity to learner to see understand the conceptual aspects learned in classes and deployed into the practical world. Industry/on project experience provides much more professional experience as value addition to classroom teaching.</p> <ol style="list-style-type: none"> 1. To encourage and provide opportunities for students to get professional/personal experience through internships. 2. To learn and understand real life/industrial situations. 3. To get familiar with various tools and technologies used in industries and their applications. 4. To nurture professional and societal ethics. 5. To create awareness of social, economic and administrative considerations in the working environment of industry organizations. 				
Course Outcomes:				
<p>On completion of the course, learners should be able to</p> <p>CO1. DEMONSTRATE professional competence through industry internship.</p> <p>CO2. APPLY knowledge gained through internships to complete academic activities in a professional manner.</p> <p>CO3. CHOOSE appropriate technology and tools to solve given problem.</p> <p>CO4. DEMONSTRATE abilities of a responsible professional and use ethical practices in day to day life.</p> <p>CO5. DEVELOP network and social circle, and DEVELOPING relationships with industry people.</p> <p>CO6. ANALYZE various career opportunities and DECIDE career goals.</p>				
**Guidelines:				
<p>Internships are educational and career development opportunities, providing practical experience in a field or discipline. Internships are far more important as the employers are looking for employees who are properly skilled and having awareness about industry environment, practices and culture. Internship is structured, short-term, supervised training often focused around particular tasks or projects with defined time scales.</p> <p>Core objective is to expose technical students to the industrial environment, which cannot be simulated/experienced in the classroom and hence creating competent professionals in the industry and to understand the social, economic and administrative considerations that influence the working environment of industrial organizations.</p> <p>Engineering internships are intended to provide students with an opportunity to apply conceptual knowledge from academics to the realities of the field work/training. The following guidelines are proposed to give academic credit for the internship undergone as a part of the Third Year Engineering curriculum.</p>				

Duration:
Internship is to be completed after semester 5 and before commencement of semester 6 of at least 4 to 6 weeks; and it is to be assessed and evaluated in semester 6.
Internship work Identification:
<p>Student may choose to undergo Internship at Industry/Govt. Organizations/NGO/MSME/Rural Internship/ Innovation/IPR/Entrepreneurship. Student may choose either to work on innovation or entrepreneurial activities resulting in start-up or undergo internship with industry/NGO's/Government organizations/Micro/Small/ Medium enterprises to make themselves ready for the industry.</p> <p>Students must get Internship proposals sanctioned from college authority well in advance. Internship work identification process should be initiated in the Vth semester in coordination with training and placement cell/ industry institute cell/ internship cell. This will help students to start their internship work on time. Also, it will allow students to work in vacation period after their Vth semester examination and before academic schedule of semester VI.</p> <p>Student can take internship work in the form of the following but not limited to:</p> <ol style="list-style-type: none"> 1. Working for consultancy/ research project, 2. Contribution in Incubation/ Innovation/ Entrepreneurship Cell/ Institutional Innovation Council/ startups cells of institute / 3. Learning at Departmental Lab/Tinkering Lab/ Institutional workshop, 4. Development of new product/ Business Plan/ registration of start-up, 5. Industry / Government Organization Internship, 6. Internship through Internshala, 7. In-house product development, intercollegiate, inter department research internship under research lab/group, micro/small/medium enterprise/online internship, 8. Research internship under professors, IISC, IIT's, Research organizations, 9. NGOs or Social Internships, rural internship, 10. Participate in open source development.
Internship Diary/ Internship Workbook:
<p>Students must maintain Internship Diary/ Internship Workbook. The main purpose of maintaining diary/workbook is to cultivate the habit of documenting. The students should record in the daily training diary the day-to-day account of the observations, impressions, information gathered and suggestions given, if any. The training diary/workbook should be signed every day by the supervisor.</p> <p>Internship Diary/workbook and Internship Report should be submitted by the students along with attendance record and an evaluation sheet duly signed and stamped by the industry to the Institute immediately after the completion of the training.</p>
Internship Work Evaluation:
<p>Every student is required to prepare and maintain documentary proofs of the activities done by him as internship diary or as workbook. The evaluation of these activities will be done by Program Head/Cell In-charge/ Project Head/ faculty mentor or Industry Supervisor based on- Overall compilation of internship activities, sub-activities, the level of achievement expected, evidence needed to assign the points and the duration for certain activities.</p> <p>Assessment and Evaluation is to be done in consultation with internship supervisor (Internal and External – a supervisor from place of internship).</p>

Recommended evaluation parameters-Post Internship Internal Evaluation -50 Marks + Internship Diary/Workbook and Internship Report - 50 Marks

Evaluation through Seminar Presentation/Viva-Voce at the Institute

The student will give a seminar based on his training report, before an expert committee constituted by the concerned department as per norms of the institute. The evaluation will be based on the following criteria:

- Depth of knowledge and skills
- Communication & Presentation Skills
- Team Work and Creativity
- Planning & Organizational skills
- Adaptability
- Analytical Skills
- Attitude & Behavior at work
- Societal Understanding
- Ethics
- Regularity and punctuality
- Attendance record
- Diary/Workbook
- Student's Feedback from External Internship Supervisor

After completion of Internship, the student should prepare a comprehensive report to indicate what he has observed and learnt in the training period.

Internship Diary/workbook may be evaluated on the basis of the following criteria:

- Proper and timely documented entries
- Adequacy & quality of information recorded
- Data recorded
- Thought process and recording techniques used
- Organization of the information

The report shall be presented covering following recommended fields but limited to,

- Title/Cover Page
- Internship completion certificate
- Internship Place Details- Company background-organization and activities/Scope and object of the study / Supervisor details
- Index/Table of Contents
- Introduction
- Title/Problem statement/objectives
- Motivation/Scope and rationale of the study
- Methodological details
- Results / Analysis /inferences and conclusion
- Suggestions / Recommendations for improvement to industry, if any
- Attendance Record
- Acknowledgement
- List of reference (Library books, magazines and other sources)

Feedback from internship supervisor(External and Internal)

Post internship, faculty coordinator should collect feedback about student with recommended parameters include as- Technical knowledge, Discipline, Punctuality, Commitment, Willingness to do the work, Communication skill, individual work, Team work, Leadership...

Reference:

1. <https://www.aicte-india.org/sites/default/files/AICTE%20Internship%20Policy.pdf>
2. <https://internship.aicte-india.org/>

IMPORTANT NOTE:

The student shall be encouraged to undertake the industrial internships however the Industry may provide opportunity to a limited few amongst the students available. In such scenario it becomes the moral responsibility of the faculty to create opportunity for such group of students (similar to the ones in Industry) by assigning them some real life problem as a part of the mini project and encouraging/mentoring them to attempt viable solutions. Hence the provision of Mini project is being done to accommodate such students and expose them with the Industrial practices in house. The students can be encouraged to consider analysis of the global patents available as a mini project,

Mini project

Teaching Scheme		Credits		Examination Scheme	
Practical	4 Hrs./Week	Practical	4	Term work	100

Course Objectives:

Students shall UNDERTAKE and EXECUTE a Mini Project through a group of students to

1. **UNDERSTAND** the “Product Development Cycle”, through Mini Project.
2. **PLAN** for various activities of the project and distribute the work amongst team members.
3. **LEARN** budget planning for the project.
4. **INCULCATE** mechanical/interdisciplinary implementation skills.
5. **DEVELOP** students’ abilities to transmit technical information clearly and test the same by delivery of Seminar based on the Mini Project.
6. **UNDERSTAND** the importance of document design by compiling Technical Report on the Mini Project work carried out.

Course Outcomes:

On completion of the course, learner will be able to

- CO1. **EXPLAIN** plan and execute a Mini Project with team.
- CO2. **IMPLEMENT** hardware/software/analytical/numerical techniques, etc.
- CO3. **DEVELOP** a technical report based on the Mini project.
- CO4. **DELIVER** technical seminar based on the Mini Project work carried out.

Course Contents

Maximum Group Size: Minimum 2 and maximum 4 students can form a group for the mini project.

Project Type: (The selected mini project must be based on any of the following)

1. Development of a prototype mechanical system/product.
2. Investigate performance of mechanical systems using experimental method

3. Parametric analysis of components/systems/devices using suitable software
4. Investigation of optimum process/material for product development using market survey.
5. Solution for society/industry problems

The Assessment Scheme will be:

- a. **Continuous Assessment 50 marks** (*based on regular interaction, circuit development*)
- b. **End Semester 50 marks** (*based on poster presentation, demonstration / Seminar*)

Project domain may be from the following, but not limited to:

1. Thermal Systems
2. Robotics Mechanisms/design systems
3. Production/advance manufacturing
4. Materials: Composite/Nano
5. Automation and Control Systems
6. Mechatronic Systems
7. Agriculture system.
8. Smart systems using AI-ML

A project report with following contents shall be prepared:

1. Title
2. Objectives
3. Relevance and significance
4. Methodology
5. Analysis-Simulation/experimentation/survey/testing etc.
6. Result and Discussion
7. Conclusion

302056: Audit Course VI		
Teaching Scheme	Credits	Examination Scheme
	Non-Credit	
GUIDELINES FOR CONDUCTION OF AUDIT COURSE		
<p>Faculty mentor shall be allotted for individual courses and he/she shall monitor the progress for successful accomplishment of the course. Such monitoring is necessary for ensuring that the concept of self-learning is being pursued by the students ‘in true letter and spirit’.</p> <ul style="list-style-type: none"> • If any course through Swayam/ NPTEL/ virtual platform is selected the minimum duration shall be of 8 weeks. • However if any of the course duration is less than the desired (8 weeks) the mentor shall ensure that other activities in form of assignments, quizzes, group discussion etc. (allied with the course) for the balance duration should be undertaken. <p>In addition to credits courses, it is mandatory that there should be an audit course (non-credit course) from third year of Engineering. The student will be awarded grade as AP on successful completion of the audit course. The student may opt for any one of the audit courses in each semester. Such audit courses can help the student to get awareness of different issues which make an impact on human lives and enhance their skill sets to improve their employability. List of audit courses offered in the semester is provided in the curriculum. Students can choose one of the audit courses from the list of courses mentioned. Evaluation of the audit course will be done at institute level.</p> <p>The student registered for audit course shall be awarded the grade AP and shall be included such grade in the Semester grade report for that course, provided student has the minimum attendance as prescribed by the Savitribai Phule Pune University and satisfactory in-semester performance and secured a passing grade in that audit course. No grade points are associated with this 'AP' grade and performance in these courses is not considered in the calculation of the performance indices SGPA and CGPA. Evaluation of the audit course will be done at institute level itself.</p>		
Selecting an Audit Course		
List of Courses to be opted (Any one) under Audit Course VI		
<ul style="list-style-type: none"> • Business and Sustainable Development • Management Information System • International Business <p># The titles indicated above are subject to change in time to come and such an alteration (if any) should be brought to the notice of the BOS.</p>		
Using NPTEL Platform: (preferable)		
<p>NPTEL is an initiative by MHRD to enhance learning effectiveness in the field of technical education by developing curriculum based video courses and web based e-courses. The details of NPTEL courses are available on its official website www.nptel.ac.in</p> <ul style="list-style-type: none"> • Students can select any one of the courses mentioned above and has to register for the corresponding online course available on the NPTEL platform as an Audit course. • Once the course is completed the student can appear for the examination as per the guidelines on the NPTEL portal. • After clearing the examination successfully; student will be awarded with a certificate. 		

Assessment of an Audit Course

- The assessment of the course will be done at the institute level. The institute has to maintain the record of the various audit courses opted by the students. The audit course opted by the students could be interdisciplinary.
- During the course students will be submitting the online assignments. A copy of the same can be submitted as a part of term work for the corresponding Audit course.
- On the satisfactory submission of assignments, the institute can mark as “Present” and the student will be awarded the grade AP on the mark-sheet.