# ACADEMIC REGULATIONS
# COURSE STRUCTURE
# AND
# DETAILED SYLLABUS

## MACHINE DESIGN

## Department of Mechanical Engineering

## M.Tech Two Year Degree Course

(Applicable for the batch admitted from 2017-18)


## GUDLAVALLERU ENGINEERING COLLEGE

(An Autonomous Institute with Permanent Affiliation to JNTUK, Kakinada)

Seshadri Rao Knowledge Village

**GUDLAVALLERU - 521 356, Krishna District, Andhra Pradesh**

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## VISION & MISSION OF THE COLLEGE

**Vision**

To be a leading institution of engineering education and research, preparing students for leadership in their fields in a caring and challenging learning environment.

**Mission**

- To produce quality engineers by providing state-of-the-art engineering education.
- To attract and retain knowledgeable, creative, motivated and highly skilled individuals whose leadership and contributions uphold the college tenets of education, creativity, research and responsible public service.
- To develop faculty and resources to impart and disseminate knowledge and information to students and also to society that will enhance educational level, which in turn, will contribute to social and economic betterment of society.
- To provide an environment that values and encourages knowledge acquisition and academic freedom, making this a preferred institution for knowledge seekers.
- To provide quality assurance.
- To partner and collaborate with industry, government, and R and D institutes to develop new knowledge and sustainable technologies and serve as an engine for facilitating the nation's economic development.
- To impart personality development skills to students that will help them to succeed and lead.
- To instil in students the attitude, values and vision that will prepare them to lead lives of personal integrity and civic responsibility.
- To promote a campus environment that welcomes and makes students of all races, cultures and civilizations feel at home.
- Putting students face to face with industrial, governmental and societal challenges.

## VISION & MISSION OF THE DEPARTMENT

**Vision**

To become a competent centre in moulding students as professional mechanical engineers having ethical standards and social consciousness.

**Mission:**

- To impart value based education and to enhance competencies of students through effective design and delivery of the curriculum that fulfils the needs of the industry.
- To instill desire and confidence in the students to cater the needs of the society through their activities of excellence.
- To impart technical skills and nurture values, and mould the students as professionals to offer solutions to the technological challenges.
- To guide and support the students for enhancing nation's wealth through entrepreneurship.

## III. PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

**PEO-I :** Machine design post graduates have will have strong technical knowledge to design mechanical systems.

**PEO-II :** Machine design post graduates will have problem solving and decision making skills contributing to overall personality and career development.

**PEO-III:** Machine design post graduates will have groomed attitude of team work, team building leadership and regard for ethical practices.

**PEO-IV:** Machine design post graduates will engage in lifelong learning to adapt to socio-economic-technological developments.

## IV. PROGRAM OUTCOMES (POs)

**PO-1 :** An ability to independently carry out research /investigation and development work to solve practical problems.

**PO-2 :** An ability to write and present a substantial technical report/document.

**PO-3 :** An ability to demonstrate a degree of mastery at a level higher than the bachelor program.

**PO-4 :** An ability design complex engineering systems in a multi-disciplinary environment.

**PO-5 :** An ability to apply contemporary techniques and computer aided tools to design mechanical systems.

**PO-5 :** An ability to design Mechanical Systems considering public health, safety, cultural, ethical, legal societal and environmental aspects.

## V. ACADEMIC REGULATIONS

Applicable for the students of M.Tech from the Academic Year 2017-18.

**1. Duration of the Program**

The duration of the program is two academic years consisting of four semesters. However, a student is permitted to complete the course work of M.Tech program in the stipulated time frame of four academic years from the date of joining.

**2. Minimum Instruction Days**

Each semester consists of a minimum of ninety instruction days.

**3. Program Credits**

Each specialization of the M.Tech programs is designed to have a total of 70 credits and the student shall have to complete the two year course work and earn all the 70 credits for the award of M.Tech Degree.

**4. Attendance Regulations**

4.1 A student shall be eligible to appear for Semester End Examinations if he acquires a minimum of 75% of attendance in aggregate of all the subjects.

4.2 Condoning of shortage of attendance in aggregate up to 10% (65% and above and below 75%) in each semester will be considered for genuine reasons such as medical grounds and participation in co-curricular and extra-curricular activities and shall be granted only after approval by the College Academic Committee. Student should submit application for medical leave along with medical certificate from a registered medical practitioner within three days from reporting to the class work after the expiry of the medical leave. In case of participation in co-curricular and extra-curricular activities, either in the college or other colleges, students must take prior written permission from HoD concerned and should also submit the certificate of participation from the organizer of the event within three days after the completion of the event. Only such cases will be considered for condoning attendance shortage.

4.3 A student shall be eligible to claim for condonation of attendance shortage only once during the two years (four semesters) course work.

4.4 A student will not be promoted to the next semester unless he satisfies the attendance requirement of the current semester. He may seek re-admission for that semester when offered next.

4.5 Shortage of Attendance below 65% in aggregate shall in *NO* case be condoned.

4.6 Students whose shortage of attendance is not condoned in any semester are not eligible to take their end examination of that semester and their registration shall stand cancelled.

4.7 A fee stipulated by the college shall be payable towards condoning attendance shortage.

## 5. Examinations and Scheme of Evaluation

### 5.1 Theory Courses :

Each theory course shall be evaluated for a total of 100 marks, consisting of 40 marks for internal assessment and 60 marks for semester end examination.

***Internal Assessment:***

i) Of 40 marks for internal assessment, 10 marks are for continuous assessment in the form of two assignments and 30 marks are based on two mid-term examinations.

ii) Each assignment carries 10 marks and the average of two assignments shall be taken as the marks for continuous assessment.

iii) Each mid-term examination is conducted for 40 marks with two hours duration. Each mid-term examination consists of four questions, each for 10 marks. All the questions need to be answered.

iv) Sum of the75% marks of better scored mid-term examination and 25% marks of less scored mid-term examination are scaled down for 30 marks.

v) For the project based theory course, the distribution of 40 marks for internal evaluation shall be 20 marks for theory, based on two mid- term examinations and 20 marks for project. Each mid-term examination is conducted for 40 marks with two hours duration. Each mid-term examination consists of two questions, each for 20 marks, with internal choice. All the questions need to be answered. Sum of the 75% marks of better scored mid-term examination and 25% marks of less scored mid-term examination are scaled down for 20 marks.

***External Assessment:***

i) Semester End Examination will have 8 questions, each for 12 marks, out of which 5 questions are to be answered.

ii) For the project based theory course, semester end examination will have three questions, each for 20 marks, with internal choice. All the questions need to be answered. There will be no external assessment for project component.

**5.2 Laboratory Courses :**

i) For practical subjects the distribution shall be 40 marks for Internal Evaluation and 60 marks for the End-Examinations. There shall be continuous evaluation by the internal subject teacher during the semester for 40 internal marks. Of the 40 marks for internal, 25 marks shall be for day-to-day performance (15 marks for day-to-day evaluation and 10 marks for Record) and 15 marks shall be evaluated by conducting an internal laboratory test towards the end of semester.

ii) Semester end examination shall be conducted by an internal examiner and an external examiner for 60 marks.

**5.3 (a) Seminar:**

i) For seminar, a student under the supervision of a faculty member, shall collect the literature on an advanced topic related to his specialization and critically review the literature and submit it to the department in a report form towards the end of semester and shall make an oral presentation before the Departmental Review Committee consisting of the supervisor and a senior faculty member / Head of the Department. There shall be an internal evaluation for 100 marks in the form of viva-voce examination and assessment of report and its presentation. There will be NO external evaluation.

ii) If a candidate fails to secure the minimum marks prescribed for successful completion, he has to re-register by paying the prescribed fee at the beginning of subsequent semester(s). He has to submit a fresh report towards the end of that semester and appear for evaluation by the committee.

**(b) Term Paper:**

i) For term paper, a student under the supervision of a faculty member, shall collect the literature on an advanced topic related to his specialization and critically review the research papers and submit it to the department in publication form towards the end of semester and shall make an oral presentation before the Departmental Review Committee consisting of the supervisor and a senior faculty member / Head of the Department. There shall be an internal evaluation for 100 marks in the form of viva-voce examination and assessment of paper and its presentation. There will be NO external evaluation.

ii) If a candidate fails to secure the minimum marks prescribed for successful completion, he has to re-register by paying the prescribed fee at the beginning of subsequent semester(s). He has to submit a fresh paper towards the end of that semester and appear for evaluation by the committee.

### 5.4 Project Work:

Every candidate shall be required to submit a dissertation on a topic approved by the Project Review Committee.

i) A Project Review Committee (PRC) shall be constituted for each specialization with Head of the Department / a Senior Faculty as Chairman and two other senior faculty members.

ii) Registration of Project Work: A candidate who has been promoted to 3rd semester shall be eligible to register for the project work.

iii) The eligible candidate can choose his project supervisor and submit the title, objective, abstract and plan of action of the proposed project work to the department for approval by the PRC. The candidate whose proposal is approved by the PRC shall register for the project work. The minimum duration of project work will be 36 weeks from the date of registration.

iv) If a candidate wishes to change his supervisor or topic of the project, he can do so with the approval of the PRC. In case of such changes, the candidate has to register afresh.

v) There shall be three reviews on the progress of the project work by the PRC with an interval of 12 weeks. The candidate needs to submit a report on the progress of his work and present it before the PRC for assessment. The PRC may suggest for an extension of date of submission of dissertation if the progress of work is not satisfactory or absent himself for the review.

vi) A candidate who has passed all the theory, laboratory, seminar and term paper examinations and shown satisfactory progress of project work is permitted to submit the dissertation after 36 weeks from the date of registration.

vii) If a candidate fails to submit the dissertation by the end of the 4th semester, he has to take the permission for an extension by paying the semester(s) tuition fee.

viii) Three copies of the Project Thesis certified by the supervisor shall be submitted to the Department.

ix) Project evaluation and Viva-Voce examination is conducted at the end of 4th semester by a committee consisting of Project Supervisor, senior faculty of the department, HoD and an External Examiner nominated by the Chief Controller of Examinations out of a panel of three examiners suggested by the department.

The following grades are awarded for the project work:

i. Excellent
ii. Very Good
iii. Good
iv. Satisfactory
v. Unsatisfactory

The Grade "unsatisfactory" is treated as Fail. Failed Students should take supplementary examination after making required modifications, if any, in the dissertation with a minimum gap of 8 weeks by paying the required examination fee.

## 6. Criteria for Passing a Course and Award of Grades:

### 6.1 Criteria for Passing a Course:

i) A candidate shall be declared to have passed in individual theory / laboratory course, if he secures a minimum of 50% aggregate marks (internal & semester end examination marks put together), subject to securing a minimum of 40% marks in the semester end examination.

ii) The candidate shall be declared to have passed in seminar / term paper viva-voce if he secures 50% marks.

iii) The candidate shall be declared to have successfully completed the project work if he secures a minimum of 'satisfactory' grade in the project evaluation and viva-voce examination.

iv) On passing a course of a program, the student shall earn assigned credits in that course.

### 6.2 Method of Awarding Letter Grade and Grade Points for a Course:

A letter grade and grade points will be awarded to a student in each course based on his performance, as per the grading system given below.

| Theory /Elective /Laboratory /Seminar / Term Paper /Project Dissertation (%) | Grade Points | Letter Grade |
|---|---|---|
| $\geq 90$ | 10 | O (Outstanding |
| $\geq 80$ & $< 90$ | 9 | A+ (Excellent) |
| $\geq 70$ & $< 80$ | 8 | A (Very Good) |
| $\geq 60$ & $< 70$ | 7 | B+ (Good) |
| $\geq 50$ & $< 60$ | 6 | B (Above Average) |
| $< 50$ | 0 | F (Fail) |

**6.3 Calculation of Semester Grade Point Average (SGPA)* for semester:**

The performance of each student at the end of the each semester is indicated in terms of SGPA. The SGPA is calculated as given below:

$$\textbf{SGPA} = \frac{\sum(CR \times GP)}{\sum CR} \quad \text{for each semester.}$$

where CR = Credits of a course

GP = Grade Points awarded for a course

* SGPA is calculated for a candidate who passed all the courses in that semester.

**6.4 Eligibility for Award of B.Tech Degree:**

A student will be declared eligible for the award of the M. Tech. Degree if he fulfills the following academic regulations.

(a) Pursued a course of study for not less than two academic years and not more than four academic years.

(b) Registered for prescribed **70** credits and secured **70** credits.

(c) Students, who fail to complete their Two years Course of study within Four years or fail to acquire the prescribed **70** Credits for the award of the degree within four academic years from the year of their admission shall forfeit their seat in M. Tech course and their admission shall stand cancelled.

**6.5 Calculation of Cumulative Grade Point Average (CGPA) for Entire Program:**

The CGPA is calculated as given below:

$$\textbf{CGPA} = \frac{\sum(CR \times GP)}{\sum CR} \quad \text{for entire program.}$$

where CR = Credits of a course

GP = Grade points awarded for a course

* CGPA is calculated for a candidate who passed all the prescribed courses excluding project work.

**6.6 Award of Division:**

After satisfying the requirements prescribed for the completion of the program, the student shall be eligible for the award of B.Tech Degree and shall be placed in one of the following grades:

| CGPA | Class |
|---|---|
| ≥ 7.5 | First Class with Distinction |
| ≥ 6.5 & < 7.5 | First Class |
| ≥ 6.0 & < 6.5 | Second Class |

**7. Supplementary Examinations**

i) Supplementary examinations will be conducted once in a year along with regular examinations.

ii) Semester end supplementary examinations shall be conducted till next regulation comes into force for that semester after the conduct of the last set of regular examinations under the present regulation.

iii) Thereafter supplementary examinations will be conducted in the equivalent courses as decided by the Board of Studies concerned.

**8. Re-admission Criteria**

A candidate, who is detained in a semester due to lack of attendance has to obtain written permission from the Principal for readmission into the same semester after duly fulfilling the required norms stipulated by the college and by paying the required tuition fee and special fee in addition to paying an administrative fee of Rs. 1,000/-

**9. Break in Study**

Student, who discontinues the studies for what-so-ever reason, can get readmission into appropriate semester of M.Tech program only with the prior permission of the Principal of the College, provided such candidate shall follow the transitory regulations applicable to the batch he joins. An administrative fee of Rs.2,000/- per each year of break in study in addition to the prescribed tuition and special fees shall be paid by the candidate to condone his break in study.

**10. Transitory Regulations**

A candidate, who is detained or discontinued in a semester, on readmission shall be required to do all the courses in the curriculum prescribed for the batch of students in which the student joins subsequently. However, exemption will be given to those candidates who have already passed such courses in the earlier semester(s) he was originally admitted into and he will be offered substitute subjects in place of them as decided by the Board of Studies. However, the decision of the Board of Studies will be final.

**11. Withholding of Results**

If the student has not paid the dues, if any, to the College or if any case of indiscipline is pending against him, the result of the student will be withheld. His degree will be withheld in such cases.

**12. Malpractices**

i) The Principal shall refer the cases of malpractices in internal assessment tests and semester end examinations to a malpractice enquiry committee constituted by him for the purpose. Such committee shall follow the approved levels of punishment. The Principal shall take necessary action against the erring students based on the recommendations of the committee.

ii) Any action by the candidate trying to get undue advantage in the performance or trying to help another, or derive the same through unfair means is punishable according to the provisions contained hereunder.

## DISCIPLINARY ACTION FOR MALPRACTICES/IMPROPER CONDUCT IN EXAMINATIONS

| | Nature of Malpractices / Improper conduct | Punishment |
|---|---|---|
| **If the candidate** | | |
| 1.a | Possesses or keeps accessible in examination hall, any paper, note book, programmable calculators, Cell phones, pager, palm computers or any other form of material concerned with or related to the subject of the examination (theory or practical) in which he is appearing but has not made use of (material shall include any marks on the body of the candidate which can be used as an aid in the subject of the examination.) | Expulsion from the examination hall and cancellation of the performance in that subject only. |
| b | Gives assistance or guidance or receives it from any other candidate orally or by any other body language methods or communicates through Cell phones with any candidates or persons in or outside the exam hall in respect of any matter. | Expulsion from the examination hall and cancellation of the performance in that subject only of all the candidates involved. In case of an outsider, he will be handed over to the police and a case is registered against him. |
| 2. | Has copied in the examination hall from any paper, book, programmable calculators, palm computers or any other form of material relevant to the subject of the examination (theory or practical) in which the candidate is appearing. | Expulsion from the examination hall and cancellation of the performance in that subject and all other subjects the candidate has already appeared including practical examinations and project work and shall not be permitted to appear for the remaining examinations of the subjects of that semester / year.<br>The hall ticket of the candidate shall be cancelled. |

| | | |
|---|---|---|
| 3. | Impersonates any other candidate in connection with the examination. | The candidate who has impersonated shall be expelled from examination hall. The candidate is also debarred and forfeits the seat. The performance of the original candidate who has been impersonated shall be cancelled in all the subjects of the examination (including practicals and project work) already appeared and shall not be allowed to appear for the examinations of the remaining subjects of that semester / year. The candidate is also debarred for two consecutive semesters from class work and all examinations. The continuation of the course by the candidate is subject to the academic regulations in connection with forfeiture of seat. If the impostor is an outsider, he will be handed over to the police and a case is registered against him. |
| 4. | Smuggles in the Answer book or takes out or arranges to send out the question paper during the examination or answer book during or after the examination. | Expulsion from the examination hall and cancellation of the performance in that subject and all other subjects the candidate has already appeared including practical examinations and project work and shall not be permitted to appear for the remaining examinations of the subjects of that semester / year. The candidate is also debarred for two consecutive semesters from class work and all examinations. The continuation of the course by the candidate is subject to the academic regulations in connection with forfeiture of seat. |
| 5. | Uses objectionable, abusive or offensive language in the answer paper or in letters to the examiners or writes to the examiner requesting him to award pass marks. | Cancellation of performance in that subject. |

| | | |
|---|---|---|
| 6. | Refuses to obey the orders of the Chief Superintendent/Assistant Superintendent / any officer on duty or misbehaves or creates disturbance of any kind in or around the examination hall or organises a walkout or instigates others to walkout or threatens the officer-in-charge or any person on duty in or outside the examination hall of any injury to his person or to any of his relations whether by words, either spoken or written or by signs or by visible representation, assaults the Officer-in-charge or any person on duty in or outside the examination hall of any of his relations or indulges in any other act of misconduct or mischief which results in damage to or destruction of property in the examination hall or any part of the college campus or engages in any other act which in the opinion of the Officer on duty amounts to use of unfair means or misconduct or has the tendency to disrupt the orderly conduct of the examination. | Expulsion from the examination hall and cancellation of their performance in that subject and all other subjects the candidate(s) has (have) already appeared and shall not be permitted to appear for the remaining examinations of the subjects of that semester / year. The candidates also are debarred and forfeit their seats. In case of outsiders, they will be handed over to the police and a police case is registered against them. |
| 7. | Leaves the exam hall taking away answer script or intentionally tears of the script or any part thereof inside or outside the examination hall. | Expulsion from the examination hall and cancellation of the performance in that subject and all other subjects the candidate has already appeared including practical examinations and project work and shall not be permitted to appear for the remaining examinations of the subjects of that semester. The candidate is also debarred for two consecutive semesters from class work and all university examinations. The continuation of the course by the candidate is subject to the academic regulations in connection with forfeiture of seat. |
| 8. | Possess any lethal weapon or firearm in the examination hall. | Expulsion from the examination hall and cancellation of the performance in that subject and all other subjects the candidate has already appeared including practical examinations and project work and shall not be permitted to appear for the remaining examinations of the subjects of that semester. The candidate is also debarred and forfeits the seat. |

| | | |
|---|---|---|
| 9 | If student of the college who is not a candidate for the particular examination or any person not connected with the college indulges in any malpractice or improper conduct mentioned in clause 6 to 8. | Expulsion from the examination hall and cancellation of the performance in that subject and all other subjects the candidate has already appeared including practical examinations and project work and shall not be permitted to appear for the remaining examinations of the subjects of that semester. The candidate is also debarred and forfeits the seat.<br>Person(s) who do not belong to the college will be handed over to the police and a police case is registered against them. |
| 10. | Comes in a drunken condition to the examination hall. | Expulsion from the examination hall and cancellation of the performance in that subject and all other subjects the candidate has already appeared including practical examinations and project work and shall not be permitted for the remaining examinations of the subjects of that semester / year. |
| 11. | Copying detected on the basis of internal evidence, such as, during valuation or during special scrutiny. | Cancellation of the performance in that subject and all other subjects the candidate has appeared including practical examinations and project work of that semester / year examinations. |
| 12. | If any malpractice is detected which is not covered in the above clauses 1 to 11 shall be referred to the Chief Superintendent of Examinations for future action towards suitable punishment. | |

iii) The involvement of the staff, who are in charge of conducting examinations, valuing examination papers and preparing / keeping records of documents related to the examinations in such acts (inclusive of providing incorrect or misleading information) that infringe upon the course of natural justice to one and all concerned at the examination shall be viewed seriously and appropriate disciplinary action will be taken after thorough enquiry.

**13. Other Matters**

i) Deserving physically challenged candidates will be given additional examination time and a scribe based on the certificate issued by the concerned authority. Students who are suffering from contagious diseases are not allowed to appear either for internal or semester end examinations.

ii) The students who participated in coaching / tournaments held at State / National / International levels through University / Indian Olympic Association during semester end external examination period will be promoted to subsequent semesters as per the guidelines of University Grants Commission Letter No. F.1-5/88 (SPE/PES), dated 18-08-1994.

iii) The Principal shall deal in an appropriate manner with any academic problem which is not covered under these rules and regulations, in consultation with the Heads of the Departments and subsequently such actions shall be placed before the Academic Council for ratification. Any emergency modification of regulation, approved in the meetings of the Heads of the Departments shall be reported to the Academic Council for ratification.

**17. General**

i) The Academic Council may, from time to time, revise, amend or change the regulations, schemes of examination and /or syllabi.

ii) The academic regulations should be read as a whole for the purpose of any interpretation.

iii) In case of any doubt or ambiguity in the interpretation of the above rules, the decision of the Chairman of the Academic Council is final.

v) Wherever the word he, him or his occurs, it will also include she, her and hers.

## VI. CURRICULAR COMPONENTS

| Sl. No. | Course Work - Subject Areas | Total No.of Credits | % of Total Credits |
|---|---|---|---|
| 1 | Baisc Sciences (BS) | 3 | 4.28 |
| 2 | Humanities and Social Sciences (HSS) | 3 | 4.28 |
| 3 | Professional Core (PC) | 25 | 35.72 |
| 4 | Professional Electives (PE) | 9 | 12.86 |
| 7 | Others (Seminar, Term Paper, Dissertation, etc.) | 30 | 42.86 |

# COURSE STRUCTURE

# &

# SYLLABUS

# COURSE STRUCTURE

## I Semester

| Sl. No. | Course Code | Name of the Course / Laboratory | No.of Periods per week | | | No.of Credits |
|---|---|---|---|---|---|---|
| | | | L | T | P | |
| 1 | MA2901 | Computational Methods in Egnineering | 4 | - | - | 3 |
| 2 | ME2901 | Advanced Mechanics of Solids | 4 | - | - | 3 |
| 3 | ME2902 | Analysis and Synthesis of Mechanisms | 4 | - | - | 3 |
| 4 | ME2903 | Mechancial Vibrations ** | 3 | - | 2 | 3 |
| 5 | ME2904 | Gear Engineering | 4 | - | - | 3 |
| 6 | | Professional Elective - I | 4 | - | - | 3 |
| 7 | ME2908 | Machine Dynaics Lab | - | - | 4 | 2 |
| | | **Total** | **23** | **-** | **6** | **20** |

## II Semester

| Sl. No. | Course Code | Name of the Course / Laboratory | No.of Periods per week | | | No.of Credits |
|---|---|---|---|---|---|---|
| | | | L | T | P | |
| 1 | | Research Methodologies | 4 | - | - | 3 |
| 2 | ME2909 | Finite Element Methods ** | 3 | - | 2 | 3 |
| 3 | ME2910 | Design with Advacned Materials | 4 | - | - | 3 |
| 4 | ME2911 | Design for Manufacturing and Assembly | 4 | - | - | 3 |
| 5 | | Professional Elective - II | 4 | - | - | 3 |
| 6 | | Professional Elective - III | 4 | - | - | 3 |
| 7 | ME2918 | Modeling and Analysis Lab | - | - | 4 | 2 |
| 8 | | Seminar | - | - | - | 2 |
| | | **Total** | **23** | **-** | **6** | **22** |

** Project Based Theory Course

**L : Lecture** **T : Tutorial** **P : Practical**

## III Semester

| Sl. No. | Course Code | Name of the Course / Laboratory | No.of Periods per week | | | No.of Credits |
|---|---|---|---|---|---|---|
| | | | L | T | P | |
| 1 | | Term Paper | - | - | 4 | 2 |
| 2 | | Dissertation (Initiated in third semester) | - | - | - | - |
| | | **Total** | **-** | **-** | **4** | **2** |

## IV Semester

| Sl. No. | Course Code | Name of the Course / Laboratory | No.of Periods per week | | | No.of Credits |
|---|---|---|---|---|---|---|
| | | | L | T | P | |
| 1 | | Dissertation (Carried out in third & Fourth Semester | - | - | 52 | 34 |
| | | **Total** | **-** | **-** | **52** | **34** |

## Professional Electives:

### Professional Elective - I

ME2905 Rotor Dynamics

ME2906 Experimental Stress Analysis

ME2907 Product Design

### Professional Elective - II

ME2912 Fracture Mechanics

ME2913 Condition Monitoring

ME2914 Rapid Tooling and Prototyping

### Professional Elective - III

ME2915 Theory of Elasticity

ME2916 Geometric Modeling

ME2917 Tribology

# SYLLABUS

## COMPUTATIONAL METHODS IN ENGINEERING

I Semester

| | | | |
|---|---|---|---|
| Lecture | : 4 | Internal Marks | : 40 |
| Credits | : 3 | External Marks | : 60 |

**Course Objectives**

To make the students

- know how to solve system of equations, ordinary differential equations and partial differential equations numerically.
- understand correlation and regression
- know optimization techniques in solving linear and fractional programming problems

**Learning Outcomes**

Upon successful completion of the course, the students will be able to

- find the solutions of system of linear and non linear equations.
- solve ordinary and partial differential equations numerically.
- determine the correlation coefficient and regression.
- optimize linear and fractional programming problems.

**Course Content**

**UNIT – I: Introduction to Numerical Methods Applied to Engineering Problems**

Solving system of linear equations by Gauss Seidel and Relaxation methods. Solving system of non-linear equations by Newton-Raphson method. Fitting of non-linear curves by the method of least squares.

**UNIT – II: Numerical Solutions of Ordinary Differential Equations**

Conversion of initial value problem to boundary value problem using shooting method, solution through a set of equations - derivative boundary conditions - Rayleigh Ritz method.

**UNIT – III**Upon successful completion of the course, the students will be able to**: Numerical Solutions of Partial Differential Equations**

Finite-difference approximations to derivatives; Laplace equation : Jacobi Method - ADI method, Parabolic Equation – Crank Nicolson method.

**UNIT – IV: Applied Statistics**

Bivariate Data-simple correlation- Correlation analysis - correlation coefficient – coefficient of correlation for ungrouped and grouped bi-variate data – coefficient of determination – test of significance for correlation coefficient. Regression Analysis - simple linear regression - multiple linear regression.

**UNIT – V: Optimization Techniques**

Linear Programming : Mathematical formulation-graphical solution of two variable – simplex method-artificial variable technique- Big M method- linear fractional programming problems.

**Text Books:**


1. S.S.Sastry, Introductory Methods of Numerical Analysis, Prentice Hall India,3rd Edition.(UNITS – I,II,III)
2. Agarrval, B.L., Basic Statistics ,Wiley , 2nd edition.(UNIT - IV)
3. S.D.Sharma, Operations Research, Kedarnath Ram Nadh,1972 ( Unit- V)


**References:**


1. Ward Cheney and David Kincaid M, Numerical Mathematics and Computing, Brooks/Cole Publishing Company1999, Fourth edition.
2. Riley K.F,. M.P.Hobson and Bence S.J, Mathematical Methods for Physics and Engineering, Cambridge University press,1999.
3. Steven C.Chapra, Raymond P.Canale Numerical Methods for Engineers Tata Mc-Graw Hill.
4. Curtis F.Gerald, Partick.O.Wheatly,Applied Numerical analysis, Addison-Wesley,1989.
5. Kanti swarup,Gupta P.K. and Manmohan , Operations Research , S.chand and sons, 2004.


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# ADVANCED MECHANICS OF SOLIDS

I Semester

| | | | | | |
|---|---|---|---|---|---|
| Lecture | : 3 | Practical | : 2 | Internal Marks | : 40 |
| Credits | : 3 | | | External Marks | : 60 |

**Course Objectives**

To make the students

- familiarize with the concepts of stresses and strains in un symmetric bending and torsion using classical methods.

**Learning Outcomes**

Student will be able to

- apply the theory of elasticity including strain/displacement and Hooke's Law relationships.
- solve torsion problems in bars and thin walled methods.
- solve for stresses and deflection beam under unsymmetrical loading.
- assess various failure criteria in engineering problems.

**Course Content**

**UNIT - I:** ***Principal Stresses and Strains***

Plane state of stress- stresses on an inclined plane in a rectangular block under axial loading – compound stresses – normal and tangential stresses – Two perpendicular normal stresses accompanied by a state of simple shear – Mohr's circle of stresses – Principal stresses and strains- Analytical and graphical solutions

**UNIT - II:** ***Shear Center***

Bending axis and shear center-shear center for axi-symmetric and unsymmetrical sections

***Unsymmetrical bending*****:** Bending stresses in Beams subjected to nonsymmetrical bending; deflection of straight beams due to nonsymmetrical bending

**UNIT - III:** ***Curved Beam Theory***

Winkler Bach formula for circumferential stress –limitations – correction factors – radial stress in curved beams – closed ring subjected to concentrated and uniform loads-stresses in chain links.

**UNIT - IV:** ***Axi-Symmetric Problems***

Rotating Discs- flat discs, discs of uniform thickness, discs of uniform strength, rotating cylinders.

***Torsion*****:** Linear elastic solution, Prandtl elastic membrane (Soap-Film) analogy, narrow rectangular cross section, hollow thin wall torsion members, multiple connected cross sections.

**UNIT - V:** ***Introduction to Theory of Elasticity***

Equilibrium and Compatibility conditions for elastic solids, 2D elasticity equations for plane stress, plane strain, Airy's stress function, bending of cantilever loaded at the end.

**Text Books:**


1. Boresi & Sidebottom, "Advanced Mechanics of materials" Wiely International, 6th edition.(UNITS - I,II)
2. Dr Sadhu singh , "Strength of materials" , Khanna Publication, 1st edition (UNITS- III,IV,V)


**Reference Books:**


1. Timoschenko S.P. and Goodier J.N., " Theory of elasticity", McGraw- Hill Publishers, 3rd Edition.
2. L.S Srinath, "Advanced Mechanics of Solids", McGraw Hill Education(India)Pvt. Ltd. 3rd edition.


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# ANALYSIS AND SYNTHESIS OF MECHANISMS

I Semester

| | | | |
|---|---|---|---|
| Lecture | : 4 | Internal Marks | : 40 |
| Credits | : 3 | External Marks | : 60 |

**Course Objectives**

To make the students

- familiarize with the concepts used for kinematic analysis and synthesis of mechanisms.
- familiarize with the concepts of force analysis of mechanisms.

**Learning Outcomes**

Student will be able to

- determine the displacement , velocity and accelerations of links of mechanism.
- determine the forces and torque acting by performing force analysis.
- apply path curvature characteristics in analysis of mechanisms.
- apply analytical and synthesis techniques in design of mechanisms.

**Course Content**

**UNIT - I:** ***Introduction***

Elements of mechanisms ,degrees of freedom , Kutchback equation and Grublers criterion , applications of Grublers criterion, transmission angles- extreme values of transmission angles , toggle positions.

***Displacement , Velocity and Acceleration Analysis (Analytical methods only):*** Analysis for four bar and single slider crank mechanisms.

**Analysis of Complex mechanisms** : Goodman indirect method and Hall Ault auxiliary point method

**UNIT - II:** ***Static Force Analysis***

Static equilibrium , equilibrium of two and three force members , equilibrium of four force members , static force analysis of four bar and slider crank mechanisms.

***Dynamic Force Analysis:***

D Alembert Principle , dynamic analysis of four bar mechanism and single slider crank mechanism – dynamically equivalent system – inertia of Connecting Rod – inertia force and torque in reciprocating Engine.

**UNIT - III:** ***Path Curvature Theory***

Introduction , fixed and moving centrodes , inflection points and inflection circle , Euler Savary Equation , Bobilliers Construction , Collineation axis , Bobillier theorem ,Hartmann construction

**UNIT - IV:** ***Kinematic Synthesis***

Introduction , type, dimensional and number Synthesis , synthesis for function generation, path and motion generation ,Chebyschev Spacing of accuracy points

***Graphical Synthesis Techniques:***

Motion generation for two prescribed positions and three prescribed positions – path generation for three prescribed positions without and with prescribed timing – function generation for three prescribed positions.

**UNIT - V:** ***Analytical Synthesis Techniques***

Four bar and slider crank function generator with three accuracy points – use of complex numbers and dyads – three prescribed positions for motion, path and function generation using dyad.

**Text Books:**


1. S.S. Rattan, " Theory of Machines",Tata Mc Graw Hill, 3rd Edition ( UNITS I,II )
2. Erdman and Sandor ,"Advanced Mechanism Design ",Prentice Hall International ,2nd Edition( UNITS – III,IV,V).


**Reference Books:**


1. Uicker, Pennock and Shigley," Theory of machines and Mechanisms", Oxford Univ Press.
2. Amitabha Ghosh and Ashok Kumar Mallik, " Theory of Mechanism and machines", East West Press pvt Ltd,2nd edition.
3. Robert L.Norton," Design of Machinery", Tata McGraw Hill ,3rd edition.


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# MECHANICAL VIBRATIONS

I Semester

| | | | |
|---|---|---|---|
| Lecture | : 4 | Internal Marks | : 40 |
| Credits | : 3 | External Marks | : 60 |

**Course Objectives**

To make the students

- understand and appreciate the importance of vibrations in mechanical design of machine parts that operate in vibratory conditions,
- write the differential equation of motion of the vibratory systems
- analyze free and forced vibration of single and multi degree of freedom linear systems.
- to develop an ability analyze continuous vibrational systems

**Learning Outcomes**

Student will be able to

- appreciate the need and importance of vibration analysis in mechanical design of machine parts that operate in vibratory conditions.
- model undamped and damped mechanical systems and structures
- analyze the mathematical model of a linear vibratory system to determine its response
- model of SDOF and MDOF vibratory systems and determine their responses
- analyse frequency and time response of vibratory systems
- understand the fundamentals of vibrations of continuous systems such as beams and plates

**Course Content**

**UNIT – I: Fundamentals of Vibration**

Basic concepts of vibration -importance of study of vibration; -elements of vibration; classification of vibration; vibration analysis procedure; spring elements – equivalent stiffness; mass or inertia elements;; definitions and terminology; periodic and simple harmonic motion; the beats phenomenon-representation of harmonic motion in complex form .

**Single Degree Of Freedom System-**

**Undamped Free Vibrations:** Different methods for equation of motion – Newton's second law, D'alembert's principle, energy methods, Rayleigh's method, free vibrations of an undamped torsional vibrations.

**UNIT – II: Damped Free Vibrations**

Components of a vibrating system –different types of dampings - damping elements – equivalent damping; -general differential equation of motion of the system; critical damping coefficient and damping ratio; damped natural frequency; logarithmic decrement; energy dissipated in viscous damping- torsional vibrations-.equation of motion-torsional vibrations with viscous damping

**UNIT – III: Forced Vibration Analysis - Single Degree Of Freedom System**

Response of damped and undamped systems to harmonic excitation; frequency response curve; magnification factor; harmonic excitation of the base, vibration isolation and transmissibility ; response of a damped system under rotating unbalance; forced vibration with coulomb damping.

Vibration measuring instruments –seismic mass, vibrometer, accelerometer– frequency measuring instruments

**UNIT - IV: Two Degree of Freedom Systems**

Principle mode of vibration free and forced vibration analysis of a undamped systems – principal modes – othogonality principle -semi definite systems; torsionally equalent shafts –geared systems.

**UNIT - V: Multidegree and continuous systems**

**Multidegree Freedom Systems** :Introduction-influence coefficients –derive the equation of motion using matrix method , dunkerley's method, and rayleigh's method , eigen values and eigen vectors; torsional vibration of multi rotor systems.

**Continuous Systems** :vibrations of bars and beams- formulation of equation of motion, characteristic equation, eigen values, identification of node and mode shapes

**Text Books:**


1. S. S. Rao , Mechanical Vibrations , 4th Edition, Pearson-Prentice Hall (UNITS-I,II,III,IV,V)
2. G.S. Grover & S.P.Nigam ,Mechanical Vibrations , Nem Chand & Bros, 8th edition, (UNITS-I,II,III,IV)


**Reference Books:**


1. William T. Thomson and Marie Dillon Dahleh , Theory of Vibration with Application, Pearson New International Edition,5th Edition,
2. V.P.Singh ,Mechanical vibration, Dhanpat Rai & Co ,4th Edition
3. Mechanical vibration - Schaum Series, McGraw Hill ,2nd Edition


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# GEAR ENGINEERING

I Semester

| | | | |
|---|---|---|---|
| Lecture | : 4 | Internal Marks | : 40 |
| Credits | : 3 | External Marks | : 60 |

**Course Objectives**

To make the students

- know the design of gears like spur, helical, bevel and worm gears against different types of failures.
- learn the concepts of gear box design and its optimization.

**Learning Outcomes**

Student will be able to

- select and design appropriate gear for the given application and against the failures.
- design the gear box for given specifications.
- optimize the parameters of gear like weight, space etc.

**Course Content**

**UNIT - I:** ***Introduction***

Basic Principles, Nomenclature, types of gear teeth profiles, gear manufacturing processes, gear inspection methods using non-destructive techniques - LPT,MPI and UT.

***Gear Failures*****:** Analysis of gear tooth failures - tooth wear, tooth breakage, pitting, scoring, wear, overloading, gear-casing problems, lubrication failures.

**UNIT - II:** ***Spur& Helical Gears***

Tooth loads, Design considerations, design of spur gear teeth - Lewis beam strength, Buckingham's dynamic load and wear load, design of spur gear - plastic deformation .

**UNIT - III:** ***Bevel & Worm gears***

Tooth loads, design considerations, design of spur gear teeth - Lewis beam strength, Buckingham's dynamic load and wear load, design of spur gear - plastic deformation .

**UNIT - IV:** ***Gear Trains***

Simple, compound, reverted and epicyclic gear trains.

***Gear Box :*** Introduction, types of gear box, construction of ray diagram, design of a gear box - sliding type.

**UNIT - V: *Optimal Gear Design***

Optimization of gear design parameters, weight minimization, constraints in gear train design- space, interference, strength, dynamic considerations, rigidity etc.,

**Text Books:**


1. J.E.Shigley, "Mechanical Engineering Deisgn", TATA Mc.Graw Hill Education Pvt., Ltd.(UNITS – I,II,III,IV)
2. T.V.Sundarajanmurthy, N.Shanmugam", Machine Deisgn", Anuradha Publication, Chennai.(UNITS – IV,V)


**Reference Books:**


1. V.B.Bandari, "Design of Machine Elements " TATA Mc.Graw Hill Education Pvt., Ltd..
2. Norton, "Machine Design - An Integrated Approach", , Pearson Publications, 2nd Edition.
3. S. Jalaluddien," Machine Design" Anuradha Publications, Chennai.


**Note:** Design data book is allowed for examination.

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***Professional Elective - I***

## ROTOR DYNAMICS

I Semester

| | | | |
|---|---|---|---|
| Lecture | : 4 | Internal Marks | : 40 |
| Credits | : 3 | External Marks | : 60 |

**Course Objectives**

To make the students

- develop expertise regarding rotor dynamics and vibration in rotating machinery.
- expose the concepts of rigid rotor dynamics, rotor vibration and critical speeds.

**Learning Outcomes**

Student will be able to

- analyze vibrations in rotating machinery.
- determine the whirling speed of rotor.
- identify the effect of bearings on rotor vibrations.
- monitor the condition of rotors

**Course Content**

**UNIT - I:** ***Introduction to Vibration and the Laval-Jeffcott Rotor Model***

Co-ordinate systems, steady state rotor motion, elliptical motion, single degree of freedom systems, free and forced vibrations. The two degrees of freedom rotor system, translational motion, natural frequencies and natural modes, steady state response to unbalance, the effect of flexible support.

**UNIT - II:** ***Torsional Vibration in Rotating Machinery***

Modeling of rotating machinery shafting - multi degree of freedom systems - determination of natural frequencies and mode shapes - branched systems - Holzer method.

**UNIT - III:** ***Rigid Rotor Dynamics and Critical Speeds***

Rigid disk equation - rigid rotor dynamics- rigid rotor on flexible rotor - the gyroscopic effect on rotor dynamics - whirling of an unbalanced simple elastic rotor, simple shafts with several disks - effect of axial stiffness - determination of bending critical speeds - Campbell diagram.

**UNIT - IV:** ***Influence of Bearing on Rotor Vibration:***

Support stiffness on critical speeds- stiffness and damping coefficients of journal bearings-computation and measurements of journal bearing coefficients -mechanics

of hydro dynamic instability- half frequency whirl and resonance whip- design configurations of stable journal bearings

**UNIT - V: *Balancing and Condition Monitoring of Rotors***

Single plane balancing, multi-plane balancing, balancing of rigid rotors, balancing of flexible rotors noise spectrum, real time analysis, knowledge based expert systems.

**Text Books:**


1. J. S.Rao, "*Rotor Dynamics"*, New Age International Publishers, New Delhi, 2nd Edition.


**Reference Books:**


1. S.Timoshenko, D H.Young and W. Weaver , "Vibration Problems in Engineering", John Wiley, 3nd Edition.
2. Weng Jeng Chen and J Edger Gunter, "Introduction to Dynamics of Rotor – Bearing Systems", Trafford Publishing Ltd., London 3rd Edition.
3. T. Yamamoto and Y.Ishida , "Linear and Nonlinear Rotordynamics: A Modern Treatment with Applications", John Wiley and Sons Inc, New York, 2nd Edition.
4. J. S.Rao, "Vibratory Condition Monitoring of Machines", Narosa Pubulishing House, 2nd Edition.


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***Professional Elective - I***

## EXPERIMENTAL STRESS ANALYSIS

I Semester

| | | | |
|---|---|---|---|
| Lecture | : 4 | Internal Marks | : 40 |
| Credits | : 3 | External Marks | : 60 |

**Course Objectives**

To make the students

- understand the relation between the mechanics theory and experimental stress analysis.
- familiarize with the new experimental methods to determine stresses and strains.

**Learning Outcomes**

Student will be able to

- measure strains using different types of strain gauges
- evaluate stresses using modern techniques of experimental methods

**Course Content**

**UNIT - I: *Introduction***

Stress, strain, plane stress and plane strain conditions, compatibility conditions. problems using plane stress and plane strain conditions, stress functions, Mohrs circle for stress strain, three-dimensional stress strain relations.

**UNIT - II: *Strain Measurement and Recordings***

Various types of strain gauges, electrical resistance strain gauges, semiconductor strain gauges, strain gauge circuits. introduction, static recording and data logging, dynamic recording at very low frequencies, dynamic recording at intermediate frequencies, dynamic recording at high frequencies, dynamic recording at very high frequencies.

**UNIT - III: *Photo Elasticity***

Photo elasticity – polariscope – plane and circularly polarized light, bright and dark field setups, photo elastic materials –isochromatic fringes – isoclinics

***Three Dimensional Photo Elasticity*** **:** Introduction, locking in model deformation, materials for three-dimensional photo elasticity, machining cementing and slicing three-dimensional models, slicing the model and interpretation of the resulting fringe patterns, effective stresses, the shear-difference method in three dimensions, applications of the frozen stress method

**UNIT - IV: *Brittle Coatings***

Introduction, coating stresses, failure theories, brittle coating crack patterns, crack detection, ceramic based brittle coatings, resin based brittle coatings, test procedures for brittle coatings analysis, calibration procedures, analysis of brittle coating data.

***Moire Methods*:** Introduction, mechanism of formation of Moire fringes, the geometrical approach to Moire-fringe analysis, the displacement field approach to Moire-fringe analysis, out of plane displacement measurements, out of plane slope measurements, sharpening and multiplication of Moire-fringes, experimental procedure and techniques.

**UNIT - V: *Birefringent Coatings***

Introduction, coating stresses and strains, coating sensitivity, coating materials, application of coatings, effects of coating thickness, fringeorder determinations in coatings.

**Text Books:**

1. Timoshenke and Goodier Jr ,"Theory of Elasticity" McGraw Hill Education (India) Pvt Ltd, 3rd Edition

**Reference Books:**

1. Love .A.H, "A treatise on Mathematical theory of Elasticity , volume -1" , Nabu Press,
2. Dally and Riley," Experimental stress analysis", Mc Graw-Hill, 2nd Edition

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***Professional Elective - I***

## PRODUCT DESIGN

I Semester

| | | | |
|---|---|---|---|
| Lecture | : 4 | Internal Marks | : 40 |
| Credits | : 3 | External Marks | : 60 |

**Course Objectives**

To make the students

- impart the process of product design;
- expose the various factors influencing product design.

**Learning Outcomes**

Student will be able to

- apply various methods of concept generation to arrive at a fruitful design.
- analyze the factors influencing the design.
- determine the risk and reliability aspects associated with product design.
- select appropriate manufacturing processes to realize the product design
- assess the eco friendly nature of the product.
- communicate design information

**Course Content**

**UNIT - I:** ***Product Design Process***

Design process steps, concept generation, brain storming, synectics. morphological method, TRIZ, behavioral aspects of decision making,

***Modeling and Simulation:*** Role of models in engineering design, mathematical modeling, similitude and scale models, geometric modeling on computer, finite-element analysis.

**UNIT - II:** ***Material Selection***

Material selection for new product design, role of processing in design, design for manufacture and assembly.

**UNIT - III:** ***Design for Reliability***

Causes of unreliability, methods of improving reliability, failure mode and effect analysis, FMEA procedure, fault tree analysis, product liability, intellectual property.

**UNIT - IV:** ***Design for Environment***

Need of design for environment, techniques to reduce environment impact

**UNIT - V: Robust Design and Optimization**

Detail design-activities and decisions in detail design-communicating design and manufacturing information.

**Text Books:**


1. George E. Dieter," Engineering Design", Mc GRAW-HILL LTD.,2nd Edition (UNITS – I,II,III )
2. Kevin Otto," Product Design", Pearson Education, 3rd Edition (UNITS – IV ,V )


**Reference Books:**


1. Richard S. Handscombe," The Product Management Handbook", McGRAW-HILL
2. Ulrich Eppinger," New Product Design and development", TMH
3. KEN HURST," Engineering Design Principles", 1st Edition, ELSEVIER
4. John W. Evans and Jillian Y. Evans," Product Integrity and Reliability in Design", 1st Edition,Springer .


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## MACHINE DYNAMICS LAB

I Semester

| | | | |
|---|---|---|---|
| Practical | : 4 | Internal Marks | : 40 |
| Credits | : 2 | External Marks | : 60 |

**Course Objectives**

To make the students

- study the behavior of machine elements experimentally when subjected to dynamic forces.
- observe and analyse vibration behavior of mechanical systems.

**Learning Outcomes**

Student will be able to

- estimate gyroscopic couple on given rotor system
- estimate the moment of inertia of given component
- estimate the natural frequency of free and forced and torsional vibration systems.
- perform dynamic balancing of rotating and reciprocating masses.
- assess the whirling speed of shaft.

**List of Experiments:**

1. Gyroscopic Couple Apparatus
2. Moment of inertia of bifilar.
3. Moment of inertia of Trifilar.
4. Natural frequency of single rotor system.
5. Natural frequency of two rotor system.
6. Natural frequency of Flywheel with and without damping.
7. Natural frequency of spring mass system.
8. Natural frequency of free vibrations of beam without damping.
9. Frequency of undamped forced vibrations of beam.
10. Frequency of damped force vibrations of beam.
11. Journal Bearing Apparatus.
12. Balancing of Reciprocating Masses.
13. Balancing of Rotating Masses.
14. Friction and Wear Apparatus.
15. Whriling Speed of rotating shaft.

**Open Ended Experiment:**

- Identification of crack in beam and validation using simulation.

**Reference Books:**

1. S.S. Rattan, " Theory of Machines",Tata Mc Graw Hill, 3rd Edition
S. S. Rao , Mechanical Vibrations , 4th Edition, Pearson-Prentice Hall

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# RESEARCH METHODOLOGIES

II Semester

| | | | |
|---|---|---|---|
| Lecture | : 4 | Internal Marks | : 40 |
| Credits | : 3 | External Marks | : 60 |

**Course Objectives**

To make the students

- understand the objectives, motivation and significance of research.
- know research methodologies.
- define research problem and perform data analysis.
- write a research paper and report.

**Learning Outcomes**

Students will be able to

- Understand research approaches
- Understand various research methodologies
- Define a research problem
- Perform data analysis
- Write research papers and reports

**Course Content**

**UNIT – I: Introduction**

Introduction, Objectives and motivation of research, Types of research, Research approaches, Significance of research methods.

**UNIT – II: Research Methodology**

Research methods versus methodology, Research and scientific method, Importance of knowing how research is done, Research process. Criteria for good research.

**UNIT – III: Defining Research Problem**

The research problems, Necessity of defining the problem, Technique involved in defining a problem, Review of related literature, Purpose of literature survey, Identifying the current status, Presentation of literature survey findings. Critique, Survey and peer review process.

**UNIT – IV: Research Design and Data Analysis**

Meaning of research design, Features of good design, important concepts relating to research design, Different research designs, Basic principles of experimental designs.

Methods of Data Collection - Collection of primary data, Observation method, Interview method, Collection of data through questionnaires, Collection of data through schedules, Difference between questionnaires and schedules, Some other methods of data collection, Collection of secondary data, Selection of appropriate method for data collection, Case study method.

Processing and Analysis of Data **-** Processing operations, Some problems in processing, Elements, Types of analysis, Statistics in research.

**UNIT – V: Research Paper and Report Writing**

Final paper presentation. Significance of report writing, Different steps in writing report, Layout of the research report, Types of report, Precautions for writing research reports.

**Text Books:**

1. Research Methodology Methods and Techniques, C.R.Kothari, Wishwa Prakashan Publishers – Second Edition.

**Reference Books:**

1. Template of ASCE/ASME/IEEE for paper writing.

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# FINITE ELEMENT METHODS

II Semester

| | | | |
|---|---|---|---|
| Lecture | : 4 | Internal Marks | : 40 |
| Credits | : 3 | External Marks | : 60 |

**Course Objectives**

To make the students

- Familiarize with the concepts of finite element method to solve engineering problems.

**Learning Outcomes**

Student will be able to

- apply variational and weighted residual methods to solve differential equations.
- apply finite element formulation in structural problems such as 1-D bar, truss and beam problems and determine displacements, stresses and strains
- develop finite element formulations and solve 2-D structural problems using triangular and rectangular elements.
- apply finite element formulation in dynamic problems in structures and determine frequencies and mode shapes.

**Course Content**

**UNIT - I:**

**Formulation Techniques**: Methodology, engineering problems and governing differential equations, variational methods-potential energy method, Raleigh Ritz method, strong and weak forms, weighted residual methods.

**Finite Element Method*:*** Concepts of discretization, types of elements, interpolation function, node numbering scheme, assembly and boundary conditions.

**UNIT - II: Analysis of One Dimensional Problems**

Bar, simple truss and beam elements - shape functions, stiffness matrix, and load vectors, determination of displacements, strains and stresses.

**UNIT - III: Analysis of Two Dimensional problems**

Analysis of 2-D problems using constant strain triangle element, axi symmetric formulations and problems.

**UNIT - IV: Isoparametric Formulations**

Sub, iso and super parametric elements, four noded quadrilateral element, numerical integration – Gaussian quadrature approach.

**UNIT - V: Dynamic Analysis**:

Finite element formulation in dynamic problems in structures using Lagragian Method, consistent and lumped mass models, free vibration analysis, longitudinal and transverse vibrations , mode superposition methods and reduction techniques.

**Text Books:**


1. SS Rao , "The Finite Element Methods in Engineering", Butterworth-Heinemann,5th Edition (UNIT – I )
2. Chandraputla, Ashok and Belegundu , "Introduction to Finite Elements in Engineering ", Prentice – Hall,2011 (UNITS – II,III,IV,V)


**Reference Books:**


1. Daryl L Logan, "A first course in finite element method", Cengage Learning. 5th Edition
2. JN Reddy, "An introduction to Finite Element Method", McGrawHill, 4th Edition.
3. Chandraputla, Ashok and Belegundu , "Introduction to Finite Elements in Engineering ", Prentice – Hall,2011
4. C. S. Krishnamurthy, "Finite Element Analysis -Theory and Programming", Tata Mc Graw Hill,2nd Edition


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# DESIGN WITH ADVANCED MATERIALS

II Semester

| | | | |
|---|---|---|---|
| Lecture | : 4 | Internal Marks | : 40 |
| Credits | : 3 | External Marks | : 60 |

**Course Objectives**

To make the students

- understand the importance of selection of materials used in manufacturing with their behaviour under service.

**Learning Outcomes**

Students will be able to

- analyze the elastic, yield and fracture behaviour of metals.
- select the material for the given applications.
- suggest the modern metallic and Non Metallic materials for the applications.
- choose the suitable smart material for manufacturing.

**Course Content**

**UNIT – I: Fundamentals of Material Science**

Elasticity in metals, mechanism of plastic deformation, slip twinning, role of dislocations, yield stress, shear strength of perfect and real crystals, strengthening mechanism, work hardening, solid solution, grain boundary strengthening, Poly phase mixture, precipitation, particle, fiber and dispersion strengthening, effect of temperature, strain and strain rate on plastic behavior, super plasticity.

Yield criteria: Von mises and Tresca criteria.

**Unit – II: Manufacturing Considerations**

Motivation of selection, cost basis and service requirements, selection for mechanical properties, strength, toughness, fatigue, impact and creep, use of material property charts for material selection.

**Unit – III: Modern Metallic Materials**

Dual phase steels, micro alloyed steels, high strength low alloy (HSLA) Steel, maraging steel, intermetalics, Ni and Ti aluminides, super alloys.

**Unit – IV: Non Metallic Materials**

Polymeric materials and their molecular structures, production techniques for fibers, foams, adhesives and coatings, structure, properties and applications of engineering polymers. composites; Introduction, reinforcement, types of composite materials, - properties, processing and application of composite materials.

**Unit – V: Smart Materials**

Properties, structure and applications of Smart materials, shape memory alloys, metallic glass, quasi crystal and nano crystalline materials, ceramic materials, ceremets, high temperature materials, refractory materials.

**Text Books:**


1. Thomas H.Courtney, "Mechanical behavior of materials" 2nd Edition, McGraw-Hill, 2000 (UNIT-I,II, IV &V)
2. George E.Dieter "Mechanical Metallurgy" McGraw Hill, 1998(UNIT-I, & II)
3. Material Selection in mechanical design by M.F Ashby. Bott(UNIT II & III)


**Reference Books:**


1. Budinski. G.K. and Budinski. K.M., " Engineering Materials: Properties and Selection", 7th Edition, Prentice Hall of India, 2010.
2. Filnn .R.A. and Trojan .P.K., "Engineering Materials and their Applications", (4th Edition), Jai co, 1999.
3. Metals Hand Book, Vol. 10, "Failure Analysis and Prevention", (10th Edition), 1994.


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# DESIGN FOR MANUFACTURING AND ASSEMBLY

II Semester

| | | | |
|---|---|---|---|
| Lecture | : 4 | Internal Marks | : 40 |
| Credits | : 3 | External Marks | : 60 |

**Course Objectives**

To make the students

- Familiarize with the design factors which will ease the manufacturing and assembly.

**Learning Outcomes**

Student will be able to

- incorporate the process constraints & other influencing factors for design.
- design a metal casting product considering trouble shooting elements.
- design a defect free weldment.
- select appropriate material and manufacturing process for product development.
- plan an assembly for ease of manufacture and automation.

**Course Content**

**UNIT - I: Design for Manufacturing**

Overview of the DFM Process, Reduce the cost of manufacturing process, understanding the process and constraints, standard components and process, consider the impact of DFM decisions and other factors.

**UNIT - II: Design Consideration in Metal Casting**

Mold and gating system design, directional solidification, trouble shooting and ease of assembly and automation.

**UNIT - III: Design Considerations for Welding, Forging, Sheet Metal and Powder Metal Process**

By considering joining, defects, minimize the residual stresses and ease of assembly and automation.

**UNIT - IV: Design Considerations in Machining**

By considering machinability, geometric factors, cutting conditions and ease of assembly and automation.

**UNIT - V: Selection of Materials**

Selection of materials for engineering applications using properties, process, shape, charts, ranking and choice.

**Text Books:**

1. George E. Dieter, “Engineering Design” ,McGraw Hill International, 4th Edition

**Reference Books:**

1. Geofrey Boothroyd, Peter Dewhurst, “Product Design for Manufacture and Assembly”, CRC Press, 3rd Edition.
2. O. Molloy , “Design for Manufacturing and Assembly: Concepts, Architectures and Implementation”,Chapman and Hall, 1st Edition

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***Professional Elective - II***

## FRACTURE MECHANCIS

II Semester

| | | | |
|---|---|---|---|
| Lecture | : 4 | Internal Marks | : 40 |
| Credits | : 3 | External Marks | : 60 |

**Course Objectives**

To make the students

- familiarize with the basic concepts of fracture mechanics and its applications..

**Learning Outcomes**

Students will be able to:

- understand different mechanisms of fracture failure.
- determine stress intensity factors by applying Linear Elastic and Elastic Plastic fracture mechanics.
- determine stresses induced at crack tip.
- apply different approaches to determine the plastic zone at the crack tip
- determine different fracture parameters.
- apply the nondestructive test methods to identify the cracks.

**Course Content**

**UNIT – I: Introduction**

History and over view, fracture mechanics approach to design, effect of material properties on fracture.

**Fracture Mechanisms**: Ductile fracture, cleavage, ductile-brittle transition, inter granular fracture, environment assisted cracking.

**Linear Elastic Fracture Mechanics** : Griffith energy balance , energy release rate , crack resistance , R curve , stable and unstable crack growth.

**UNIT – II: Stress Analysis of Cracks**

Modes of fracture - opening , sliding and shearing mode , Airy stress function , crack tip stress field using Westergaard approach, effect of finite size , relation between stress intensity factor and energy release rate.

**UNIT – III: Crack Tip Plastic Zone**

Plastic zone shape , Irwin plastic zone correction, Dugdale approach, shape of the plastic zone, plastic constraint factor, thickness effect.

**UNIT – IV: Elastic-Plastic Fracture Mechanics**

Crack-tip-opening displacement, J contour integral, relationships between J and CTOD, crack-growth resistance curves, J-controlled fracture.

**UNIT – V: Test Methods**

Introduction, $K_{Ic}$-test technique, test methods to determine $J_{Ic}$, test methods to determine $G_{Ic}$ AND $G_{IIc}$, determination of critical CTOD.

**Crack Detection Through Non-Destructive Testing**: Introduction, examination through human senses, liquid penetration inspection, ultrasonic testing, radiographic imaging, magnetic particle inspection.

**Text Books:**


1. T. L. Anderson, Fracture Mechanics: Fundamentals and Applications, 3rd edition, CRC Press.(UNITS – I,II,III,IV)
2. Prashant Kumar, Elements Of Fracture Mechanics, First edition , Mcgraw Hill Education.(UNIT-V)


**Reference Books:**


1. David Broek, Elementary engineering fracture mechanics, 4th edition, Kluwer Academic Publishers
2. J.F. Knott, "Fundamentals of Fracture Mechanics", Butterworths, 1973.
3. J.F. Knott, P Withey, "Worked examples in Fracture Mechanics", Institute of Materials, 2nd Edition


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*Professional Elective - II*

## CONDITION MONITORING

II Semester

| | | | |
|---|---|---|---|
| Lecture | : 4 | Internal Marks | : 40 |
| Credits | : 3 | External Marks | : 60 |

**Course Objectives**

To make the students

- understand the importance of types of maintenance with their limitations and to know the methods of condition monitoring in different industrial sectors.

**Learning Outcomes**

Student will be able to

- apply different maintenance strategies for the need of plant maintenance to reduce the maintenance cost.
- analyze the machine condition with the aid of measuring instruments.
- select appropriate test for fault identification of given application.
- carry out lubrication oil analysis and temperature analysis for given applications.
- analyze the case study including the fault identification and root causes of malfunction.

**Course Content**

**UNIT - I: Maintenance**

Introduction, maintenance strategies, introduction to condition monitoring.

rotating machinery - machine faults and root causes, ISO Standards for vibration analysis.

**UNIT - II: Vibration Monitoring**

Types and benefits of vibration analysis, vibration signature analysis.

**Vibration Measuring Instruments :** Vibration transducers –displacement, velocity and acceleration transducers. vibrometer- introduction, laser vibrometer. accelerometers – piezo resistive, capacitive and inductive type.

**UNIT - III: Non-destructive Testing**

Various techniques for fault detection, introduction to non-destructive testing, types, role of non-destructive testing in condition monitoring.

**Flaw Detection:** Discontinuity – origin and classification, ultrasonic testing and magnetic particle inspection, radiography , liquid penetration test

**UNIT - IV: Wear Debris Analysis**

Wear mechanisms, wear particles, wear process monitoring techniques – Ferrography - Applications, advantages and limitations, spectrometric oil analysis program (SOAP),

**Temperature monitoring:** Need for temperature monitoring, thermography, active and passive thermography, IR thermography, applications, advantages and limitations.

**UNIT - V: Case studies**

Gear box, induction motor, fault detection in roller bearings, reciprocating engine.

**Text Books:**

1. R.A. Collacott ," Mechanical Fault Diagnosis and Condition Monitoring ",John Wiley and Sons .

**Reference Books:**

1. Isermann R., "Fault Diagnosis Applications", Springer-Verlag, Berlin, 2011.
2. Rao, J S., "Vibration Condition Monitoring", Narosa Publishing House, 2nd Edition, 2000.
3. Allan Davies,"Handbook of Condition Monitoring", Chapman and Hall, 2000.

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***Professional Elective - II***

## RAPID TOOLIGN AND PROTOTYPING

II Semester

| | | | |
|---|---|---|---|
| Lecture | : 4 | Internal Marks | : 40 |
| Credits | : 3 | External Marks | : 60 |

**Course Objectives**

To make the students

- familiarize with Rapid Prototype tools and techniques for design and Manufacturing.

**Learning Outcomes**

Student will be able to

- assess the need of RPT in Product development.
- use appropriate RT Software for development of Prototype model.
- judge the correct RP Process for Product/Prototype development.
- predict the technical challenges in 3D printing.
- list the applications of RPT.

**Course Content**

**UNIT - I: Introduction to Rapid Prototyping**

Introduction to prototyping, traditional prototyping Vs. rapid prototyping (RP), need for time compression in product development, usage of RP parts, generic RP process, distinction between RP and CNC, other related technologies, classification of RP.

**UNIT - II: RP Software**

Need for RP software, MIMICS, magics, surgiGuide, 3D-doctor, simplant, velocity2, voxim, solidView, 3Dview, etc., software.

**Software Issues of RP:** Preparation of CAD models, problems with STI, files, STL file manipulation, RP data formats: SLC, CLI, RPI, LEAF, IGES, HP/GL, CT, STEP.

**UNIT - III: Photopolymerization RP Processes**

Sterolighography (SL), SL resin curing process, SL scan patterns, microstereolithography, applications of photopolymerization processes.

**Powder Bed Fusion RP Processes :** Selective laser sintering (SLS), powder fusion mechanism and powder handling, SLS metal and ceramic part creation, electron beam melting (EBM), applications of powder bed fusion processes.

**Extrusion-Based RP Systems:** Fused deposition modelling (FDM), principles, plotting and path control, applications of extrusion-based processes.

**UNIT - IV: Printing RP Processes**

3D printing (3DP), research achievements in printing deposition, technical challenges in printing, printing process modeling, applications of printing processes.

**Sheet Lamination RP Processes:** Laminated Object Manufacturing (LOM), ultrasonic consolidation (UC), gluing, thermal bonding, LOM and UC applications.

**Beam Deposition RP Processes:** Laser Engineered Net Shaping (LENS), Direct Metal Deposition (DMD), processing – structure - properties, relationships, benefits and drawbacks.

**UNIT - V: Rapid Tooling**

Conventional Tooling Vs. Rapid Tooling, classification of rapid tooling, direct and indirect tooling methods, soft and hard tooling methods.

**Errors in RP Processes:** Pre-processing, processing, post-processing errors, part building errors in SLA, SLS, etc.,

**RP Applications:** Design, engineering analysis and planning applications, rapid tooling, reverse engineering, medical applications of RP.

**Text Books:**

1. Chua Chee Kai., Leong KahFai., Chu Sing Lim, “Rapid Prototyping: Principles and Applications in Manufacturing”, World Scientific

**Reference Books:**

1. Ian Gibsn., David W Rosen., Brent Stucker., “Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing”, Springer, 2010
2. Pham, D.T, Dimov, S.S, Rapid Manufacturing, Springer, 2001.

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***Professional Elective - III***

## THEORY OF ELASTICITY

II Semester

| | | | |
|---|---|---|---|
| Lecture | : 4 | Internal Marks | : 40 |
| Credits | : 3 | External Marks | : 60 |

**Course Objectives**

To make the students

- introduce the basic concepts of theory of elasticity

**Learning Outcomes**

Student will be able to

- determine stress distribution and strain components for simple and symmetric problems
- analyze three dimensional problems using equilibrium and compatibility equations
- determine stresses induced in beams of different cross sections
- apply concepts of plasticity to determine the shear stresses and strain energy

**Course Content**

**UNIT - I:**

**Elasticity :** Two dimensional stress analysis - plane stress - plane strain - equations of compatibility - stress function - boundary conditions.

**Problem in Rectangular Coordinates :** Solution by polynomials - Saint Venent's principles - determination of displacement - simple beam problems.

**Problems in polar coordinates :** General equations in polar coordinates - stress distribution symmetrical about axis - strain components in polar coordinates - simple and symmetric problems.

**UNIT - II:**

**Analysis of Stress and Strain in Three Dimensions :** Principle stresses – homogeneous deformations - strain spherical and deviatoric stress - hydrostatic strain.

**General theorems :** Differential equations of equilibrium and compatibility - displacement - uniqueness of solution - reciprocal theorem.

**UNIT - III:**

**Bending of Prismatic Bars :** Stress function - bending of cantilever beam - beam of rectangular cross-section - beams of circular cross-section.

**UNIT - IV:**

**Plasticity :** Plastic deformation of metals - structure of metals - deformation - creep stress relaxation of deformation - strain rate condition of constant maximum shear stress - condition of constant strain energy - approximate equation of plasticity.

**UNIT - V:**

**Methods of Solving Practical Problems :** The characteristic method - engineering method - compression of metal under press - theoretical and experimental data drawing.

**Text Books:**

1. S.P. Timoshenko & J.K Goodier , "Theory of Elasticity", McGraw-Hill,3rd Edition

**Reference Books:**

1. E.P. Unksov ,"An Engineering Theory of Plasticity", Butterworths scientific publications,1961
2. Hoffman and Sacks , "Theory of Plasticity" , McGraw-Hill, New York, 1953.

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***Professional Elective - III***

## GEOMETRIC MODELING

II Semester

| | | | |
|---|---|---|---|
| Lecture | : 4 | Internal Marks | : 40 |
| Credits | : 3 | External Marks | : 60 |

**Course Objectives**

To make the students

- highlight the importance of geometric modeling in design and manufacturing.

**Learning Outcomes**

Student will be able to

- apply various mathematical equations to represent curves.
- select appropriate synthetic curves in modeling process.
- implement the surface modeling for design of various consumer products.
- judge the apt method to create a solid model of desired object

**Course Content**

**UNIT - I: Introduction to Geometric modeling**

Definition, applications. transformations, representation of curves explicit and implicit equations, parametric equations.

**UNIT - II: Cubic Splines-1**

Algebraic and geometric form of cubic spline, tangent vectors, parametric space of a curve, blending functions, four point form, reparametrization, truncating and subdividing of curves. graphic construction and interpretation, composite pc curves.

**UNIT - III:**

**Bezier Curves:** Bernstein basis, equations of Bezier curves, properties, derivatives.

**B-Spline Curves:** B-Spline basis, equations, knot vectors, properties and derivatives.

**UNIT - IV: Surfaces**

Bicubic surfaces, , Bezier surfaces, B-Spline surfaces, surfaces of revolutions, sweep surfaces, ruled surfaces, tabulated cylinder, bilinear surfaces, Gaussian curvature.

**UNIT - V:**

Fundamentals of solid modeling. Sweep representations, constructive solid geometry, boundary representations

**Text Books**

1. Ibrahim Zeid , "CAD/CAM – Theory and Practice", Tata McGraw Hill,2009.(UNITS – I,II,III,IV,V)
2. Roger & Adams , "Mathematical Elements for Computer Graphics" , Tata McGraw Hill,2nd Edition.(UNITS- I,II,III,IV-Mathematical Aspects)

**Reference Books:**

1. Micheal E. Mortenson , "Geometric Modeling", McGraw Hill ,3rd Edition. Computer Aided Design and Manufacturing, K.Lalit Narayan, K.Mallikarjuna Rao, MMM Sarcar, PHI Publishers, 2nd Edition.

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***Professional Elective - III***

## TRIBOLOGY

II Semester

| | | | |
|---|---|---|---|
| Lecture | : 4 | Internal Marks | : 40 |
| Credits | : 3 | External Marks | : 60 |

**Course Objectives**

To make the students

- know the selection of lubricating system for different types of bearings in various environmental conditions;
- understand the genesis of friction, the theories/laws of sliding and rolling friction
- learn about the principles of lubrication, lubrication regimes, theories of Hydrostatic, hydrodynamic, elastohydrodynamic and mixed/ boundary lubrication.
- learn about tribology of different machine components

**Learning Outcomes**

Student will be able to

- select the appropriate bearing materials.
- select the rolling element bearing for the given conditions.
- design hydrostatic, hydrodynamic and air lubrication systems used in bearings.
- Minimize the boundary friction and dry friction.

**Course Content**

**UNIT - I:**

**Introduction:** Nature of surfaces and contact-surface topography, friction and wear mechanisms, effect of lubricants- methods of fluid film formation.

**Lubrication:** Choice of lubricants, types of oil, grease and solid lubricants-additives- lubrication systems and their selection.

**UNIT - II:**

**Selection of Rolling Element Bearings:** Nominal life, static and dynamic capacity-equivalent load, probabilities of survival- cubic mean load -pre loading of bearings, conditioning monitoring using shock pulse method.

**UNIT - III:**

**Hydrostatic Bearings:** Thrust bearings – pad coefficients- restriction optimum film thickness-journal bearings – design procedure –aerostatic bearings; thrust bearings and journal bearings – design procedure.

**UNIT - IV:**

**Hydrodynamic bearings:** Fundamentals of fluid formation – Reynolds's equation; hydrodynamic journal bearings – Sommerfield number- performance parameters – optimum bearing with maximum load capacity – friction – heat generated and heat dissipated. hydrodynamic thrust bearings; Raimondi and Boyd solution for hydrodynamic thrust bearings - fixed tilting pads, single and multiple pad bearings-optimum condition with largest minimum film thickness.

**UNIT - V:**

**Seals:** Different type-mechanical seals, lip seals, packed glands, soft piston seals, mechanical piston rod packing, labyrinth seals and throttling bushes, oil flinger rings and drain grooves – selection of mechanical seals.

**Failure of Tribological Components:** Failure analysis of plain bearings, rolling bearings, gears and seals, wear analysis using soap and ferrography.

**Text Books:**


1. Rowe WW& O' Dionoghue," Hydrostatic and Hybrid bearing design", Butterworths & Co. Publishers Ltd,1983.(UNITS-I,III,IV,V)
2. Collacott R.A, "Mechanical Fault diagnosis and condition monitoring", Chapman and Hall, London ,1977.(UNITS-I,II)
3. Bernard J. Hamrock, "Fundamentals of fluid film lubricant", McGraw-Hill Co., 1994. (UNITS-I,II,III)


**Reference Books:**


1. Neale MJ, (Editor) "Tribology hand Book" ,Neumann Butterworths,1975.
2. Connor and Boyd JJO (Editors) "Standard hand book of lubrication engineers" ASLE, McGraw Hill Book & Co.,1968.
3. Shigley J, E Charles, " Mechanical Engineering Design", McGraw Hill Co.,6th Edition.


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## MODELING AND ANALYSIS LAB

II Semester

| | | | |
|---|---|---|---|
| Lecture | : 4 | Internal Marks | : 40 |
| Credits | : 3 | External Marks | : 60 |

**Course Objectives**

To impart the students

- skills required for modeling and analysis using software package.
- skills required for writing MAT lab code .

**Learning Outcomes**

Student will be able to

- model simple mechanical parts using modeling package
- analyze different engineering problems using analysis package.
- write and execute MAT Lab code for solving engineering problems.

**List of Experiments:**

**a) Using Modeling Package:**

1. Sketching of a drawing with dimensions
2. Modeling of Stuffing Box parts
3. Assembly of parts of Flanged Coupling
4. Modeling of parts of Eccentric and generation of orthographic views
5. Modeling of links of four bar mechanism and simulation of mechanism

**b) Using analysis Package :**

6. 2- D truss analysis.
7. Static Analysis of Beam.
8. Static Analysis of 3-D structure.
9. Steady state Heat Transfer Analysis.
10. Transient thermal analysis
11. Free vibration analysis of Beam.
12. Harmonic Analysis of a Beam
13. Analysis of Axisymmetric Problem.
14. Analysis of Plane Stress problem.
15. Stress analysis of a composite plate.

16. Buckling analysis of column.
17. Optimization of cantilever beam.

**c) Using MATLAB:**

Introduction to MATLAB – Vector and Matrix Manipulations – Matrix functions – Tools for Polynomials – Non linear algebraic equations - Solving Differential equations –writing function subroutines – basic input and output functions – plotting functions.

18. Analysis of Bar structure using Finite Element Method
19. Analysis of Beam Structure using Finite Element Method
20. Analysis of Truss using Finite Element Method
21. Displacement , velocity and acceleration analysis of four bar mechanism.

**Open Ended Experiment:**

- Analysis of connecting rod with composite material

**Reference Books:**


1. Sham Tickoo , SOLIDWORKS 2017 for Designers, CADCIM Technologies,3rd Edition
2. Saeed Moaveni , Finite Element Analysis Theory and Application with ANSYS, Pearson Publishers
3. Rao V Dukkipati , MATLAB for Mechanical Engineers, New Age International Publishers


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