

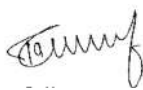
Amrutvahini Sheti and Shikshan Vikas Sanstha's  
**AMRUTVAHINI COLLEGE OF ENGINEERING, SANGAMNER**  
(An Autonomous Institute Approved by AICTE and Affiliated to SPPU, Pune)  
Amrutnagar, Ghulewadi, Sangamner – 422608



**Syllabus**  
Of  
**M. Tech. Mechanical Engineering-Design Engineering**  
w.e.f

**F.Y. M.Tech: 2025 – 2026**



  
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## Abbreviation

AICTE - All India Council for Technical

MOOC - Massive Open Online Course

NEP – National Education Policy

NPTEL - National Program on Technology

PCC - Program Core

PEO - Program Educational Objectives

PSO - Program Specific Outcomes

SWAYAM - Study Webs of Active-learning for Young Aspiring Minds

UGC - University Grants Commission

WK - Knowledge and Attitude Profile

CCE - Comprehensive and Continuous Evaluation

ISO - International Organization for Standardization

EOMS - Educational Organization Management System

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### Institute Vision

To create opportunities for rural students to become able engineers and technocrats through continual excellence in engineering education.

### Institute Mission

Our mission is to create self-disciplined, physically fit, mentally robust and morally strong engineers and technocrats with high degree of integrity and sense of purpose who are capable to meet challenges of ever advancing technology for the benefit of mankind and nature.

We, the management, the faculty and staff, therefore promise to strive hard and commit ourselves to achieve this objective through a continuous process of learning and appreciation of needs of time.

### Department Vision

To transform rural students into competent Mechanical Engineers and technocrats with professional and social values through continual excellence in engineering education.

### Department Mission

**M1:** To impart quality education and training that develop engineers to meet challenges of ever-advancing needs of industry, higher learning and entrepreneurship for the benefit of mankind and nature.

**M2:** To be recognized as a department of academic excellence through resource development, conducive teaching-learning environment, skilled development, innovation and industry-institution interaction.

**M3:** To nurture professional and ethical values and life-long learning for successful career.

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## ISO 21001:2018 - EOMS Policy

We, at AVCOE Sangamner, are committed to:

- Provide quality technical education to the rural students
- Provide conducive environment for all round development of the students.
- Develop as a premier institute for technical education & research as per the needs and expectations of all stake holders.
- Comply all applicable requirements.
- Develop students into technocrats having social responsibility.
- Keep abreast about the advances in technology and innovation.
- Enhance industry-institute interaction.
- Managing intellectual property.
- Maintain hygiene, health and safety for applicable requirements.
- Achieve continual improvement in academic and administrative processes.
- We shall strive to maintain Educational Organizational Management System.

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**Program Outcomes (PO's)**

|             |                                            |                                                                                                                                                                                                                                                                              |
|-------------|--------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>PO1</b>  | Engineering knowledge                      | Engineering Knowledge: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop to the solution of complex engineering problems.                            |
| <b>PO2</b>  | Problem analysis                           | Problem Analysis: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4)                                                                   |
| <b>PO3</b>  | Design / Development of Solutions          | complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required. (WK5)                             |
| <b>PO4</b>  | Conduct Investigations of Complex Problems | Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (WK8).                                                                     |
| <b>PO5</b>  | Engineering Tool Usage                     | Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems. (WK2 and WK6)                                                          |
| <b>PO6</b>  | The Engineer and the World                 | Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. (WK1, WK5, and WK7).                                |
| <b>PO7</b>  | Ethics                                     | Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)                                                                                                                            |
| <b>PO8</b>  | Individual and Collaborative Team work     | Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.                                                                                                                                                                        |
| <b>PO9</b>  | Communication                              | Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences. |
| <b>PO10</b> | Project Management and Finance             | Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.                                       |
| <b>PO11</b> | Life-Long Learning                         | Recognize the need for, and have the preparation and ability for<br>i) Independent and life-long learning<br>ii) Adaptability to new and emerging technologies and<br>iii) Critical thinking in the broadest context of technological change.<br>(WK8)                       |

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## Program Educational Objectives (PEOs)

**PEO1:** Plan, design, manufacture, maintain and improve systems that are technically sound, economically feasible and socially acceptable in the field of Mechanical and allied industries.

**PEO2:** Solve problems of engineering and social relevance by applying knowledge of Mechanical engineering and its advanced tools for sustainable development.

**PEO3:** Work effectively as an individual and as a team member in multidisciplinary projects, and demonstrate managerial and entrepreneurial skills.

**PEO4:** Engage in lifelong learning, career enhancement and adapt to changing professional and societal needs.

## Program Specific Outcomes (PSOs)

**PSO1:** Apply the knowledge, design procedures, mathematical and advance tools for the design and evaluation of mechanical components and systems.

**PSO2:** Demonstrate the ability to evaluate the performance of thermal and fluid systems for effective energy conversions.

**PSO3:** Select and apply appropriate manufacturing technologies and tools; and to develop competencies for working in manufacturing and allied industries.

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## Preamble

The Post-graduate curriculum structure has been designed in accordance with the National Education Policy (NEP) 2020 and the credit framework prescribed through the relevant Government Resolution (GR). The two-year postgraduate program follows a semester-wise credit distribution that provides a balanced combination of Program Core Courses, Program Elective Courses, and experiential learning components. The structure ensures flexibility, skill development, and progressive attainment of program-specific competencies while adhering to the prescribed credit requirements for each semester and the overall two-year postgraduate program.

## Credit Definition

The credit system adopted for the M.Tech. Mechanical Engineering-Design Engineering program is based on the guidelines prescribed under the **NEP 2020 framework for Postgraduate Engineering Programs**. The following definitions are used for determining the credits assigned to theory, tutorial and practical components of a course.

Table 1: Credit Definition and Contact Hours

| Academic Component | Contact Hours per Week | Credits  |
|--------------------|------------------------|----------|
| Lecture (L)        | 1 Hour                 | 1 Credit |
| Practical (P)      | 2 Hours                | 1 Credit |

## Program Credit Requirement

As per the Government of Maharashtra guidelines for implementation of NEP 2020 in undergraduate engineering programs, the two-year M.Tech. Program carries a prescribed credit range of **80 credits (minimum)**. The Institute has adopted a total of **96 credits** for the two-year M.Tech. Mechanical Engineering- Design Engineering program, which falls within the prescribed range.

## Semester-wise Credit Distribution

The following table presents the semester-wise credit distribution adopted for the two-year M.Tech. Mechanical Engineering- Design Engineering program. The credit load is planned within the **23–26 credit range prescribed per semester** under the NEP 2020 framework.

Table 2 -Semester-wise total credits

| Year        | Semester     | Credits |
|-------------|--------------|---------|
| First Year  | Semester I   | 23      |
|             | Semester II  | 23      |
| Second Year | Semester III | 24      |
|             | Semester IV  | 26      |
| Total       |              | 96      |

**Exit Point:** For those who join 2 year PG program, there shall only be one exit point. Students who exit at the end of 1st year shall be awarded a Postgraduate Diploma.

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## Program codes

The institute has assigned a unique program code to each branch

.Table 1 – Program codes

| Sr. No.    | Program code               | Code |
|------------|----------------------------|------|
| PG Program |                            |      |
| 1          | M. Tech Design Engineering | MDE  |

## Subject code Nomenclature

The following nomenclature demonstrates the subject codes:

- **R-Year** (of designing/revising syllabus) – **Program code** (as given in table 1)
- **Course Type** (as per NEP) – **Course Number** (501 – M. Tech Subject 1, 502 – M. Tech Subject, etc.)

## Guidelines for Examination Scheme

The evaluation of students shall be based on continuous academic performance in a course based on Comprehensive Continuous Evaluation (CCE) and End Semester Examination (ESE). Components of the Examination System:

### 1. Comprehensive Continuous Evaluation (CCE):

- CCE of 50 marks based on all the Units of course.
- To design a Comprehensive Continuous Evaluation scheme for a theory subject of 50 marks with the specified parameters, the allocation of marks and the structure can be detailed as follows:

Table 2: Allocation of marks & structure for 3-Credit Subject

| Sr. No.      | Examination                                               | Conduction Marks | Coverage of Units                                                             |
|--------------|-----------------------------------------------------------|------------------|-------------------------------------------------------------------------------|
| 1            | <b>CCE –I</b><br>(Class test – 1) (CT-1)                  | 15               | Units 1-(8 Marks) , Unit 2-(7 Marks)                                          |
| 2            | <b>CCE –II</b><br>(Class test – II.) (CT-II)              | 15               | Units 3-(8 Marks) , Unit 4- (7 Marks)                                         |
| 3            | <b>CCE –III</b><br>(Open Book Test, Seminar, Assignment.) | 20               | Unit 5- 10 Marks- Open Book test<br>Assignments – 5 Marks<br>Seminar- 5 Marks |
| <b>Total</b> |                                                           | <b>50</b>        |                                                                               |

### 2. End Semester Examination (ESE):

The ESE is a compulsory examination for all students. The ESE examination will be conducted at the end of the semester by the institute Department of Examination and Evaluation (DEE). The ESE will be based on 100% syllabus (Unit 1 to Unit 5). The ESE shall be of 50 marks (10 Marks / Unit) conducted for all theory courses as mentioned in the program structure.

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## Curriculum Structure

### First Year M. Tech (Design Engineering) (Semester I)

| Course Code        | Course Type                           | Course Name                                                        | Teaching Scheme (Hrs./week) |          |           | Examination Scheme and Marks |         |           |           |      | Credits |          |           |       |
|--------------------|---------------------------------------|--------------------------------------------------------------------|-----------------------------|----------|-----------|------------------------------|---------|-----------|-----------|------|---------|----------|-----------|-------|
|                    |                                       |                                                                    | Theory                      | Tutorial | Practical | CCE*                         | End-Sem | Term work | Practical | Oral | Theory  | Tutorial | Practical | Total |
| Semester I         |                                       |                                                                    |                             |          |           |                              |         |           |           |      |         |          |           |       |
| R25-MDE-AME-501    | Program Core Course                   | Applied Mathematics for Engineers                                  | 4                           | -        | -         | 50                           | 50      | -         | -         | -    | 4       | -        | -         | 4     |
| R25-MDE-ASA-502    | Program Core Course                   | Advanced Stress Analysis                                           | 4                           | -        | -         | 50                           | 50      | -         | -         | -    | 4       | -        | -         | 4     |
| R25-MDE-AMV-503    | Program Core Course                   | Advanced Mechanical Vibrations                                     | 4                           | -        |           | 50                           | 50      | -         | -         | -    | 4       | -        |           | 4     |
| R25-MDE-OT-504     | Program Core Course                   | Optimization Techniques                                            | 4                           | -        |           | 50                           | 50      | -         | -         | -    | 4       | -        |           | 4     |
| R25-MDE-DELI-505   | Program Core Course                   | Design Engineering Laboratory-I                                    | -                           | -        | 4         | -                            | -       | 25        | -         | 25   | -       | -        | 2         | 2     |
| R25-MDE-MEC-506(A) | Program Elective Course (Elective –I) | <b>Elective-I</b><br>A. Engineering Fatigue and Fracture Mechanics | 3                           | -        | -         | 50                           | 50      | -         | -         | -    | 3       | -        | -         | 3     |
| R25-MDE-MEC-506(B) |                                       | B. Reliability Engineering                                         |                             |          |           |                              |         |           |           |      |         |          |           |       |
| R25-MDE-MEC-506(C) |                                       | C. Acoustics and Noise Control                                     |                             |          |           |                              |         |           |           |      |         |          |           |       |
| R25-MDE-MEC-507    | Program Elective Course (Elective –I) | Elective 1- Fieldwork Assignments                                  | -                           | -        | 2         | -                            | -       | 25        | -         | 25   |         |          | 1         | 1     |
| R25-MDE-CTS-508    | CivicTech Skill Course                | Human Rights I                                                     | -                           | -        | -         | -                            | -       | -         | -         | -    | -       | -        | -         | 1     |
| Total              |                                       |                                                                    | 19                          | -        | 6         | 250                          | 250     | 50        | -         | 50   | 19      | -        | 3         | 23    |

CCE\*: Comprehensive Continuous Evaluation

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**First Year M. Tech (Design Engineering) (Semester II)**

| Course Code        | Course Type                             | Course Name                                              | Teaching Scheme (Hrs./week) |          |           | Examination Scheme and Marks |         |           |           |      | Credits |          |           |       |
|--------------------|-----------------------------------------|----------------------------------------------------------|-----------------------------|----------|-----------|------------------------------|---------|-----------|-----------|------|---------|----------|-----------|-------|
|                    |                                         |                                                          | Theory                      | Tutorial | Practical | CCE*                         | End-Sem | Term work | Practical | Oral | Theory  | Tutorial | Practical | Total |
| Semester II        |                                         |                                                          |                             |          |           |                              |         |           |           |      |         |          |           |       |
| R25-MDE-ASM-509    | Program Core Course                     | Analysis and Synthesis of Mechanisms                     | 4                           | -        | -         | 50                           | 50      | -         | -         | -    | 4       |          | -         | 4     |
| R25-MDE-FEM-510    | Program Core Course                     | Finite Element Method                                    | 4                           | -        | -         | 50                           | 50      | -         | -         | -    | 4       |          | -         | 4     |
| R25-MDE-MMC-511    | Program Core Course                     | Mechanical Measurements and Controls                     | 4                           | -        | -         | 50                           | 50      | -         | -         | -    | 4       | -        | -         | 4     |
| R25-MCO-DELI-512   | Program Core Course                     | Design Engg. Laboratory-II                               | -                           | -        | 4         | -                            | -       | 25        | -         | 25   | -       | -        | 2         | 2     |
| R25-MDE-MEC-513(A) | Program Elective Course (Elective –II)  | Elective-II<br>A. Vehicle dynamics                       | 3                           | -        | -         | 50                           | 50      | -         | -         | -    | 3       | -        | -         | 3     |
| R25-MDE-MEC-513(B) |                                         | B. Material Handling Equipment Design                    |                             |          |           |                              |         |           |           |      |         |          |           |       |
| R25-MDE-MEC-513(C) |                                         | C. Computer-Aided Engineering                            |                             |          |           |                              |         |           |           |      |         |          |           |       |
| R25-MDE-MEC-514(A) | Program Elective Course (Elective –III) | Elective-III<br>A. Tribology in Design                   | 3                           | -        | -         | 50                           | 50      | -         | -         | -    | 3       | -        | -         | 3     |
| R25-MDE-MEC-514(B) |                                         | B. Process Equipment and Piping System Design            |                             |          |           |                              |         |           |           |      |         |          |           |       |
| R25-MDE-MEC-514(C) |                                         | C. Material Science and Mechanical Behavior of Materials |                             |          |           |                              |         |           |           |      |         |          |           |       |
| R25-MDE-SEMI-515   | Program Core Course                     | Seminar I                                                | -                           | -        | 4         | -                            | -       | 25        | -         | 25   | -       | -        | 2         | 2     |
| R25-MDE-CTS-516    | CivicTech Skill Course                  | Human Rights II                                          | -                           | -        | -         | -                            | -       | -         | -         | -    | -       | -        | -         | 1     |
| Total              |                                         |                                                          | 18                          |          | 8         | 250                          | 250     | 50        | -         | 50   | 18      | -        | 4         | 23    |

**CCE\*: Comprehensive Continuous Evaluation**

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**Amrutvahini College of Engineering, Sangamner**  
**M.Tech– Mechanical-Design Engineering**  
**F.Y. Syllabus Semester I**

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|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|------------------------------------------|----------------|---------------------------|---------------------|----------------------|------------------------|-----------|---|--|--|
| <b>Program:</b>                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                    |                  | <b>F. Y. M. Tech</b>                     |                | <b>Semester:</b>          |                     | <b>I</b>             |                        |           |   |  |  |
| <b>Course:</b>                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                    |                  | <b>Applied Mathematics for Engineers</b> |                |                           | <b>Course Code:</b> |                      | R25-MDE-AME-501        |           |   |  |  |
| <b>Teaching Scheme(Hrs/week)</b>                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                    |                  |                                          | <b>Credits</b> | <b>Examination Scheme</b> |                     |                      |                        |           |   |  |  |
| <b>Lecture</b>                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                    | <b>Practical</b> | <b>Tutorial</b>                          |                | <b>CCE</b>                |                     | <b>ESE</b>           | <b>TW</b>              | <b>PR</b> |   |  |  |
| 04 Hrs/Week                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                    | -                | -                                        | 04             | 50                        |                     | 50                   |                        | -         | - |  |  |
| <b>Course Description:</b><br>This course provides advanced mathematical tools for solving engineering problems using complex analysis, transform techniques, differential equations, numerical methods, and calculus of variations. It emphasizes their application to vibration analysis, PDEs, numerical simulation, boundary value problems, and engineering design optimization. |                                                                                                                                                                    |                  |                                          |                |                           |                     |                      |                        |           |   |  |  |
| <b>Course Relevance:</b><br>The course develops advanced mathematical skills required for engineering analysis, modelling, simulation, vibration analysis, and design optimization. It enables students to apply mathematical and numerical techniques to solve complex problems encountered in modern Mechanical and Design Engineering applications.                                |                                                                                                                                                                    |                  |                                          |                |                           |                     |                      |                        |           |   |  |  |
| <b>Prerequisite:</b> Students should have basic knowledge of engineering mathematics, differential equations, matrices, and calculus. Familiarity with ordinary differential equations, partial differential equations, and basic numerical methods is desirable for effective understanding of the course.                                                                           |                                                                                                                                                                    |                  |                                          |                |                           |                     |                      |                        |           |   |  |  |
| <b>Bridge Content:</b> - Review of fundamental calculus, differential equations, matrices, transforms, and numerical methods required for advanced engineering mathematics. The bridge content connects undergraduate mathematical concepts with complex analysis, PDEs, vibration analysis, numerical simulation, and calculus of variations used in M.Tech Design Engineering.      |                                                                                                                                                                    |                  |                                          |                |                           |                     |                      |                        |           |   |  |  |
| <b>Course Objectives:</b><br>To develop advanced mathematical skills for modelling, analysis, and simulation of complex engineering problems. To apply complex analysis, transform techniques, differential equations, numerical methods, and calculus of variations to Mechanical and Design Engineering applications.                                                               |                                                                                                                                                                    |                  |                                          |                |                           |                     |                      |                        |           |   |  |  |
| <b>Course Outcomes:</b> After learning the course, students will be able to                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                    |                  |                                          |                |                           |                     |                      |                        |           |   |  |  |
| <b>CO</b>                                                                                                                                                                                                                                                                                                                                                                             | <b>Course Outcome</b>                                                                                                                                              |                  |                                          |                |                           |                     | <b>Bloom's Level</b> |                        |           |   |  |  |
| CO1                                                                                                                                                                                                                                                                                                                                                                                   | APPLY complex analysis and conformal mapping techniques to solve mathematical problems relevant to engineering applications                                        |                  |                                          |                |                           |                     | 3                    |                        |           |   |  |  |
| CO2                                                                                                                                                                                                                                                                                                                                                                                   | APPLY Fourier and Laplace transform techniques to solve initial value problems and partial differential equations encountered in engineering systems.              |                  |                                          |                |                           |                     | 3                    |                        |           |   |  |  |
| CO3                                                                                                                                                                                                                                                                                                                                                                                   | FORMULATE AND SOLVE differential equations and multi-degree-of-freedom vibration problems using matrix methods, normal modes, and numerical eigenvalue techniques. |                  |                                          |                |                           |                     | 3                    |                        |           |   |  |  |
| CO4                                                                                                                                                                                                                                                                                                                                                                                   | APPLY finite difference methods and calculus of variations to obtain numerical and approximate solutions of engineering boundary value and optimization problems.  |                  |                                          |                |                           |                     | 3                    |                        |           |   |  |  |
| <b>Course Content</b>                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                    |                  |                                          |                |                           |                     |                      |                        |           |   |  |  |
| <b>Unit 1</b>                                                                                                                                                                                                                                                                                                                                                                         | <b>Complex Analysis</b>                                                                                                                                            |                  |                                          |                |                           | <b>8 Hrs.</b>       |                      | <b>CO Mapped: CO 1</b> |           |   |  |  |
| Complex variables, Complex differentiation, Harmonic functions, conformal mapping, Complex integration, Cauchy's integral formulae and Calculus of residues                                                                                                                                                                                                                           |                                                                                                                                                                    |                  |                                          |                |                           |                     |                      |                        |           |   |  |  |

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|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|---------------|------------------------|
| <b>Unit 2</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>Transforms</b>            | <b>8 Hrs.</b> | <b>CO Mapped: CO 2</b> |
| Concept of transforms, Fourier transforms, Applications to partial differential equations, Discrete Fourier transform, Laplace transforms and its inverse, Laplace transform of special functions: Unit step, Unit impulse, Periodic and Error. Applications to initial value problem and wave equation using transform techniques.                                                                                                                                                                                                                                                                                                                                                                                   |                              |               |                        |
| <b>Unit 3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>Differential Equation</b> | <b>8 Hrs.</b> | <b>CO Mapped: CO 3</b> |
| Series Solution of differential equations, Bessel's and Legendre's differential equations, Mass spring systems of multi degree freedom, Matrix formulation for differential equations in vibration theory, Normal mode solution, Numerical computation of Eigen value.                                                                                                                                                                                                                                                                                                                                                                                                                                                |                              |               |                        |
| <b>Unit 4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>Numerical Analysis</b>    | <b>8 Hrs.</b> | <b>CO Mapped: CO 4</b> |
| Finite difference analysis, Explicit and Implicit finite difference scheme, Stability of finite difference method, Applications of finite difference analysis in boundary value problems, one dimensional diffusion equation, Wave equation, Laplace equation.                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                              |               |                        |
| <b>Unit 5</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>Calculus of Variation</b> | <b>8 Hrs.</b> | <b>CO Mapped: CO 4</b> |
| Introduction, Functional, Euler's equation, Isoperimetric Problem, Functional involving higher order derivative, Approximate solution of boundary value problem, Rayleigh –Ritz method , Galerkin's method, Lagrange's principal.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                              |               |                        |
| <b>Textbooks:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                              |               |                        |
| 1. Steven C. Chapra, 'Applied Numerical Methods with MATLAB for Engineers and Scientist', Tata Mc-Graw Hill Publishing Co. Ltd., 5th Edition, 2023<br>2. B. S. Grewal, 'Numerical Methods in Engineering and Science', Khanna Publication, 10th Edition, 2014<br>3. B. S. Grewal, 'Higher Engineering Mathematics', Khanna Publication, 45th Edition, 2023                                                                                                                                                                                                                                                                                                                                                            |                              |               |                        |
| <b>Reference Books:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                              |               |                        |
| 1. Andrews L.C. and Shivamoggi, B. "Integral Transforms for Engineers", Prentice Hall of India Pvt. Ltd., New Delhi, 2003.<br>2. Bronson, R. "Matrix Operations", Schaum's outline series, 2nd Edition, McGraw Hill, 2011.<br>3. James, G., "Advanced Modern Engineering Mathematics ", 3rd Edition, Pearson Education, 2004.<br>4. Johnson, R.A., Miller, I and Freund J., "Miller and Freund's Probability and Statistics for Engineers", Pearson Education, Asia, 8th Edition, 2015.<br>5. O'Neil, P.V., "Advanced Engineering Mathematics ", Thomson Asia Pvt. Ltd., Singapore, 2003.<br>6. Sankara Rao, K., "Introduction to Partial Differential Equations", Prentice Hall of India Pvt. Ltd., New Delhi, 1997. |                              |               |                        |
| <b>MOOCs Links and additional reading material:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                              |               |                        |
| 1. Transform Techniques for Engineers (Indian Institute of Technology Madras / NPTEL) — <a href="https://nptel.ac.in/courses/111106111">https://nptel.ac.in/courses/111106111</a> NPTEL+1<br>2. Introduction to Fourier Analysis (Indian Institute of Technology Kanpur / NPTEL) — <a href="https://onlinecourses.nptel.ac.in/noc24_ma90/preview">https://onlinecourses.nptel.ac.in/noc24_ma90/preview</a> NPTEL Online Courses+1<br>3. Probabilistic Methods in PDE (Indian Institute of Science Education and Research Pune / NPTEL) — <a href="https://nptel.ac.in/courses/111106134">https://nptel.ac.in/courses/111106134</a> NPTEL+1                                                                            |                              |               |                        |

**CO-PO mapping table:**

| CO   | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO 01 | PSO 02 | PSO 03 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|--------|--------|--------|
| CO1  | 3   | 3   | 2   | 2   | 2   | -   | -   | -   | 1   | -    | 2    | 2      | 2      | 2      |
| CO2  | 3   | 3   | 2   | 2   | 2   | -   | -   | -   | 1   | -    | 2    | 2      | 2      | 2      |
| CO3  | 3   | 3   | 3   | 2   | 2   | -   | -   | -   | 2   | -    | 2    | 2      | 2      | 2      |
| CO4  | 3   | 2   | 2   | 2   | 2   | -   | -   | -   | 1   | -    | 2    | 2      | 2      | 2      |
| CO5  | 3   | 3   | 2   | 3   | 3   | -   | -   | -   | 2   | -    | 3    | 2      | 2      | 2      |
| Avg. | 3   | 2.8 | 2.5 | 2.5 | 2.5 | -   | -   | -   | 2   | -    | 2.2  | 2      | 2      | 2      |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

**Assessment Pattern**

| BT Level | CCE |     |                |            |                      |                          | ESE |
|----------|-----|-----|----------------|------------|----------------------|--------------------------|-----|
|          | CT1 | CT2 | Open Book Test | Assignment | Seminar / Case Study | Quiz / presentation etc. |     |
| L1       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L2       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L3       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L4       |     |     |                | ✓          | ✓                    |                          |     |
| L5       |     |     |                |            |                      |                          |     |
| L6       |     |     |                |            |                      |                          |     |

**Unit wise Weightage:**

| Exam           | Unit1 | Unit2 | Unit3 | Unit4 | Unit5 | Total |
|----------------|-------|-------|-------|-------|-------|-------|
| CT1            | 8     | 7     |       |       |       | 15    |
| CT2            |       |       | 8     | 7     |       | 15    |
| Open Book Test |       |       |       |       | 10    | 10    |
| Assignments    | 5     |       |       |       |       | 05    |
| Seminar        | 5     |       |       |       |       | 05    |
| ESE            | 10    | 10    | 10    | 10    | 10    | 50    |
|                |       |       |       |       |       | 100   |

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| <b>Program:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                          |                 | <b>F. Y. M. Tech</b>            | <b>Semester:</b>          |                     | <b>I</b>             |                 |
| <b>Course:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                          |                 | <b>Advanced Stress Analysis</b> |                           | <b>Course Code:</b> |                      | R25-MDE-ASA-502 |
| <b>Teaching Scheme(Hrs/week)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                          |                 | <b>Credits</b>                  | <b>Examination Scheme</b> |                     |                      |                 |
| <b>Lecture</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>Practical</b>                                                                                                                                                         | <b>Tutorial</b> |                                 | <b>CCE</b>                | <b>ESE</b>          | <b>TW</b>            | <b>PR</b>       |
| 04 Hrs/Week                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | -                                                                                                                                                                        | -               | 04                              | 50                        | 50                  | -                    | -               |
| <b>Course Description :</b><br>This course provides advanced analytical and numerical methods for evaluating stress, strain, and deformation in complex engineering components. It covers theories of elasticity, stress transformations, energy methods, and failure criteria applied to 2D and 3D mechanical systems. Emphasis is placed on real-world applications in machine design, aerospace structures, pressure vessels, and automotive components.                                                                                                                                                   |                                                                                                                                                                          |                 |                                 |                           |                     |                      |                 |
| <b>Course Relevance:</b><br>Advanced Stress Analysis is essential for designing safer and more efficient mechanical systems under static, dynamic, and thermal loads. The knowledge supports engineers in predicting material failure, optimizing structural performance, and ensuring compliance with engineering standards. It is highly relevant to industries such as automotive, aerospace, manufacturing, defense, and energy systems where structural integrity is critical.                                                                                                                           |                                                                                                                                                                          |                 |                                 |                           |                     |                      |                 |
| <b>Prerequisite:</b> Engineering Mechanics (Statics & Dynamics), Strength of Materials / Mechanics of Materials, Basic Theory of Elasticity and Stress–Strain Relationships, Calculus and Differential Equations, Fundamental Knowledge of Matrix Algebra and Numerical Methods (preferred)                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                          |                 |                                 |                           |                     |                      |                 |
| <b>Bridge Content:</b> - Foundational concepts required for Advanced Stress Analysis, including stress–strain relations, principal stresses, Mohr’s circle, and basic elasticity. It will also reinforce mathematical tools such as differential equations, tensor notation, and matrix methods essential for solving complex stress problems. Short applications in mechanical components (beams, shafts, and pressure vessels) will help students transition smoothly into advanced analytical and numerical stress evaluation.                                                                             |                                                                                                                                                                          |                 |                                 |                           |                     |                      |                 |
| <b>Course Objectives:</b><br>At the end of this course, students will be able analyze complex stress and strain states in 2D and 3D mechanical components using advanced elasticity principles. Apply energy methods, stress functions, and failure theories to evaluate structural integrity under static, dynamic, and thermal loading. Develop analytical and numerical solutions for structural elements such as beams, plates, shells, and pressure vessels. Use modern computational tools and analytical techniques to optimize designs and ensure reliability in mechanical engineering applications. |                                                                                                                                                                          |                 |                                 |                           |                     |                      |                 |
| <b>Course Outcomes:</b> After learning the course, students will be able to                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                          |                 |                                 |                           |                     |                      |                 |
| <b>CO</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>Course Outcome</b>                                                                                                                                                    |                 |                                 |                           |                     | <b>Bloom’s Level</b> |                 |
| CO1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | APPLY the theory of elasticity to determine stress–strain distributions in 2D and 3D components and formulate governing equations for complex loading conditions.        |                 |                                 |                           |                     | 3                    |                 |
| CO2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | ANALYZE torsional behavior of solid and hollow shafts and evaluate shear stress, angle of twist, and torsional rigidity for engineering applications.                    |                 |                                 |                           |                     | 3                    |                 |
| CO3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | EVALUATE bending stresses, shear stresses, and deflection in beams using advanced analytical and energy-based methods for diverse cross-sections and loading conditions. |                 |                                 |                           |                     | 3                    |                 |
| CO4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | DETERMINE contact stresses in mechanical elements such as gears, bearings, and cam–follower systems using Hertzian contact principles.                                   |                 |                                 |                           |                     | 3                    |                 |

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|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| CO5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <b>PERFORM</b> experimental stress analysis using strain gauges, photoelasticity, and digital image correlation, and interpret measured results to validate analytical and numerical models. | 3             |
| <b>Course Content</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                              |               |
| <b>Unit 1</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>Theory of Elasticity</b>                                                                                                                                                                  | <b>8 Hrs.</b> |
| <b>CO Mapped: CO 1</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                              |               |
| Elasticity problems in two dimensions - stress strain relationship for brittle materials, ductile materials. Compatibility equations in two and three dimensions, free body diagram of complicated structures and stress calculations, stress functions in rectangular and cylindrical coordinate systems, evaluation of stresses in flat rectangular plates with different clamp and load conditions evaluation of the stresses in the flat and circular plate with center hole / holes using stress function.                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                              |               |
| <b>Unit 2</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>Theory of Torsion</b>                                                                                                                                                                     | <b>8 Hrs.</b> |
| <b>CO Mapped: CO 2</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                              |               |
| Torsion of prismatic bars of solid section and thin walled section. Analogies for torsion, membrane analogy, fluid flow analogy and electrical analogy. Torsion of conical shaft, bar of variable diameter, thin walled members of open cross section in which some sections are prevented from warping, Torsion of non-circular shaft.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                              |               |
| <b>Unit 3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>Stresses in Beams</b>                                                                                                                                                                     | <b>8 Hrs.</b> |
| <b>CO Mapped: CO 3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                              |               |
| Concept of shear centre in symmetrical and unsymmetrical bending, stress and deflections in beams subjected to unsymmetrical bending, shear centre for thin wall beam cross section, open section with one axis of symmetry, general open section, and closed section. Curved Beams (Winkler-Bach formula), Combined Bending and torsion, Equivalent Bending Moment, Equivalent Torque, combined bending, torque and internal pressure. Moving loads on Beams.                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                              |               |
| <b>Unit 4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>Contact stresses</b>                                                                                                                                                                      | <b>8 Hrs.</b> |
| <b>CO Mapped: CO 4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                              |               |
| Geometry of contact surfaces, method of computing contact stresses and deflection of bodies in point contact, Stress for two bodies inline contact with load normal to contact area and load normal and tangent to contact area, gear contacts, contacts between cam and follower, ball bearing contacts.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                              |               |
| <b>Unit 5</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>Experimental stress analysis</b>                                                                                                                                                          | <b>8 Hrs.</b> |
| <b>CO Mapped: CO 5</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                              |               |
| Dimensional analysis, analysis techniques, strain gauges, types of strain gauges, materials, configuration, instrumentation, characteristics of strain gauge measurement, theory of photo- elasticity, elements of polariscope, simple and circular polariscope, fringes in dark and white field, isoclinic and isochromatic fringe patterns, evaluation of stresses from these fringe patterns.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                              |               |
| <b>Reference Books:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                              |               |
| <ol style="list-style-type: none"> <li>1. Advanced Mechanics of Materials– Cook and Young, Prentice Hall, 2nd Edition, 1985</li> <li>2. Advanced Strength and Applied Stress Analysis–Richard G. Budynas, McGrawHill, 2nd Edition, 1999.</li> <li>3. Advanced Mechanics of Materials–Boresi, Schmidt, Sidebottom, Willey, 6th Edition, 2002</li> <li>4. Advanced Mechanics of Solids, L S Shrinath, Tata McGrawHill, 2nd Edition, 2003</li> <li>5. Theory of Elasticity–Timoshenko and Goodier, McGrawHill, 3rd Edition, 1970</li> <li>6. Advanced Strength of Materials, Vol.1, 2–Timoshenko, CBS, 3rd Edition, 1970</li> <li>7. Advanced Strength of Materials–Den Hartog, 1952</li> <li>8. Experimental Stress Analysis–Dally &amp; Riley, 3rd Edition, 1991</li> <li>9. Mechanics of Materials E J Hern, Butterworth, 3rd Edition, 1991</li> <li>10. Strength of Materials, Singer Andrue Pytel, Pearson, 6th Edition, 2002</li> </ol> |                                                                                                                                                                                              |               |
| <b>MOOCs Links and additional reading material:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                              |               |
| <ol style="list-style-type: none"> <li>1. Theory of Elasticity (NPTEL) — <a href="https://onlinecourses.nptel.ac.in/noc21_ce45/preview">https://onlinecourses.nptel.ac.in/noc21_ce45/preview</a> Introduction to Fourier Analysis (Indian Institute of Technology Kanpur / NPTEL)<br/><a href="https://onlinecourses.nptel.ac.in/noc24_ma90/preview">https://onlinecourses.nptel.ac.in/noc24_ma90/preview</a> NPTEL Online Courses+1</li> <li>2. Applied Elasticity (NPTEL) — <a href="https://onlinecourses.nptel.ac.in/noc25_me169/preview">https://onlinecourses.nptel.ac.in/noc25_me169/preview</a></li> </ol>                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                              |               |

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3. Aerospace Structural Analysis (NPTEL) — [https://onlinecourses.nptel.ac.in/noc25\\_ae13/preview](https://onlinecourses.nptel.ac.in/noc25_ae13/preview)**CO-PO mapping table:**

| CO   | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO 01 | PSO 02 | PSO 03 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|--------|--------|--------|
| CO1  | 3   | 3   | 2   | 2   | 2   | -   | -   | -   | 1   | -    | 2    | 2      | 2      | 2      |
| CO2  | 3   | 3   | 2   | 2   | 2   | -   | -   | -   | 1   | -    | 2    | 2      | 2      | 2      |
| CO3  | 3   | 3   | 3   | 2   | 2   | -   | -   | -   | 2   | -    | 2    | 2      | 2      | 2      |
| CO4  | 3   | 2   | 2   | 2   | 2   | -   | -   | -   | 1   | -    | 2    | 2      | 2      | 2      |
| CO5  | 3   | 3   | 2   | 3   | 3   | -   | -   | -   | 2   | -    | 3    | 2      | 2      | 2      |
| Avg. | 3   | 2.8 | 2.5 | 2.5 | 2.5 | -   | -   | -   | 2   | -    | 2.2  | 2      | 2      | 2      |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

**Assessment Pattern**

| BT Level | CCE |     |                |            |                      |                          | ESE |
|----------|-----|-----|----------------|------------|----------------------|--------------------------|-----|
|          | CT1 | CT2 | Open Book Test | Assignment | Seminar / Case Study | Quiz / presentation etc. |     |
| L1       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L2       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L3       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L4       |     |     |                | ✓          | ✓                    |                          |     |
| L5       |     |     |                |            |                      |                          |     |
| L6       |     |     |                |            |                      |                          |     |

**Unit wise Weightage:**

| Exam           | Unit1 | Unit2 | Unit3 | Unit4 | Unit5 | Total |
|----------------|-------|-------|-------|-------|-------|-------|
| CT1            | 8     | 7     |       |       |       | 15    |
| CT2            |       |       | 8     | 7     |       | 15    |
| Open Book Test |       |       |       |       | 10    | 10    |
| Assignments    | 5     |       |       |       |       | 05    |
| Seminar        | 5     |       |       |       |       | 05    |
| ESE            | 10    | 10    | 10    | 10    | 10    | 50    |
|                |       |       |       |       |       | 100   |

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|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|---------------------------------------|---------------------------|---------------------|----------------------|-----------------|
| <b>Program:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                               |                 | <b>F. Y. M. Tech</b>                  | <b>Semester:</b>          |                     | <b>I</b>             |                 |
| <b>Course:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                               |                 | <b>Advanced Mechanical Vibrations</b> |                           | <b>Course Code:</b> |                      | R25-MDE-AMV-503 |
| <b>Teaching Scheme(Hrs/week)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                               |                 | <b>Credits</b>                        | <b>Examination Scheme</b> |                     |                      |                 |
| <b>Lecture</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>Practical</b>                                                                                                                                                              | <b>Tutorial</b> |                                       | <b>CCE</b>                | <b>ESE</b>          | <b>TW</b>            | <b>PR</b>       |
| 04 Hrs/Week                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | -                                                                                                                                                                             | -               | 04                                    | 50                        | 50                  | -                    | -               |
| <b>Course Description:</b><br>This course provides an in-depth study of free and forced vibrations in single- and multi-degree-of-freedom mechanical systems, including nonlinear and random vibrations. It covers analytical and computational methods, modal analysis, vibration control, and isolation techniques used in rotating machinery, automotive, aerospace, and structural applications. Emphasis is placed on developing the ability to model complex vibrating systems, interpret dynamic responses, and apply modern tools for vibration analysis and design.                                                                                                         |                                                                                                                                                                               |                 |                                       |                           |                     |                      |                 |
| <b>Course Relevance:</b><br>Advanced Mechanical Vibrations is vital for engineers involved in designing machinery, vehicles, aerospace structures, and industrial equipment where dynamic loading and vibration control are critical for safety, performance, and longevity. The course equips learners with analytical and computational skills to diagnose vibration problems, reduce noise, improve reliability, and enhance system efficiency. Its relevance spans industries such as automotive, aerospace, manufacturing, power generation, and defense, where vibration-related failures and fatigue are major design concerns.                                               |                                                                                                                                                                               |                 |                                       |                           |                     |                      |                 |
| <b>Prerequisite:</b><br>Engineering Mathematics (Differential Equations, Linear Algebra), Fundamentals of Mechanical Vibrations, Engineering Mechanics (Dynamics), Strength of Materials / Mechanics of Materials, Basic Numerical Methods and MATLAB/Python (preferred for simulation)                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                               |                 |                                       |                           |                     |                      |                 |
| <b>Bridge Content: -</b><br>Essential fundamentals needed for Advanced Mechanical Vibrations, including single-degree-of-freedom vibration theory, damping models, harmonic excitation, and basic natural frequency calculations. It will reinforce mathematical tools such as differential equations, matrix operations, and numerical solution methods used for multi-degree and continuous vibrating systems.                                                                                                                                                                                                                                                                     |                                                                                                                                                                               |                 |                                       |                           |                     |                      |                 |
| <b>Course Objectives:</b><br>By the end of this course, students will be able to develop mathematical models for vibrating mechanical systems and determine natural frequencies and mode shapes for single and multi-degree-of-freedom systems. Analyze forced, damped, nonlinear, and random vibration responses using analytical and computational methods. Apply vibration control, isolation, and tuning techniques to improve performance, reduce noise, and prevent fatigue failures in mechanical systems. Use modern engineering tools and simulation software to predict, interpret, and optimize the dynamic behavior of real-world mechanical and structural components.. |                                                                                                                                                                               |                 |                                       |                           |                     |                      |                 |
| <b>Course Outcomes:</b> After learning the course, students will be able to                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                               |                 |                                       |                           |                     |                      |                 |
| <b>CO</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <b>Course Outcome</b>                                                                                                                                                         |                 |                                       |                           |                     | <b>Bloom's Level</b> |                 |
| CO1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>ANALYZE</b> multi-degree-of-freedom (MDOF) mechanical systems to determine natural frequencies, mode shapes, and dynamic responses using analytical and numerical methods. |                 |                                       |                           |                     | 3                    |                 |
| CO2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Model and <b>EVALUATE</b> continuous vibrating systems such as beams, shafts, and plates using partial differential equations and modal analysis.                             |                 |                                       |                           |                     | 3                    |                 |
| CO3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>ASSESS</b> transient vibration behavior under shock, impact, and time-varying loads and apply suitable damping or response mitigation techniques.                          |                 |                                       |                           |                     | 3                    |                 |

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|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                     |               |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| CO4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <b>APPLY</b> vibration control and isolation strategies including tuned mass dampers, absorbers, and active/passive control methods to reduce unwanted vibrations in engineering systems.           | 3             |
| CO5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <b>ANALYZE</b> random vibrations and <b>PERFORM</b> vibration measurement and signal analysis using sensors, FFT, and data acquisition tools for diagnosing faults and validating vibration models. | 3             |
| <b>Course Content</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                     |               |
| <b>Unit 1</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>Multi Degree Freedom System</b>                                                                                                                                                                  | <b>8 Hrs.</b> |
| <b>CO Mapped: CO 1</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                     |               |
| Free vibration equation of motion, influence coefficient i) stiffness coefficient (ii) flexibility coefficient generalized coordinates, coordinate couplings, Lagrange's equations matrix method Eigen values Eigen vector problems, modal analysis, forced vibrations of un-damped system and modal analysis.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                     |               |
| Numerical methods - (i) Rayleigh's Method, (ii) Rayleigh-Ritz Method (iii) Holzer's Method (iv) Methods of Matrix iterations (v) Transfer Matrix Method                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                     |               |
| <b>Unit 2</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>Continuous System</b>                                                                                                                                                                            | <b>8 Hrs.</b> |
| <b>CO Mapped: CO 2</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                     |               |
| Transverse vibrations of String, Longitudinal vibration of Rods, Torsional vibrations of Shaft, Lateral vibrations of simply supported and cantilever beams, Forced vibration of beams.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                     |               |
| <b>Unit 3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>Transient vibrations</b>                                                                                                                                                                         | <b>8 Hrs.</b> |
| <b>CO Mapped: CO 3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                     |               |
| Laplace transformation, Response to an impulsive input, Response to step input, Response to a pulse input-rectangular pulse and half sinusoidal pulse.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                     |               |
| <b>Unit 4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>Vibration Control</b>                                                                                                                                                                            | <b>8 Hrs.</b> |
| <b>CO Mapped: CO 4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                     |               |
| Balancing of rotating machine, in-situ balancing of rotors, control of natural frequency, vibration isolation and vibration absorbers, Passive, active and semi-active control, free layer and constrained layer damping..                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                     |               |
| <b>Unit 5</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>Random Vibrations and Vibration Measurement</b>                                                                                                                                                  | <b>8 Hrs.</b> |
| <b>CO Mapped: CO 5</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                     |               |
| Random Vibrations: Auto and cross correlation function, spectral density, response of linear systems, and analysis of narrow band systems.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                     |               |
| Vibration Measurement : FFT analyzer, vibration exciters, signal analysis, time domain and frequency domain analysis of signals, experimental modal analysis, machine conditioning and monitoring, fault diagnosis                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                     |               |
| <b>Reference Books:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                     |               |
| <ol style="list-style-type: none"> <li>1. Theory of Vibrations with Applications, W. T. Thomson, Pearson Education, Delhi, 5th ed, 2008</li> <li>2. Mechanical Vibrations, S. S. Rao, Pearson Education, Delhi, 6th SI Edition, 2018, 8th Edition, 1996</li> <li>3. Mechanical Vibrations, G K Groover, Nem Chand &amp; Bros, Roorkee, India, 8th Edition, 1996</li> <li>4. Fundamentals of Vibration, Leonard Meirovitch, McGraw Hill International Edison, 1st Edition, 2000.</li> <li>5. Principles of Vibration Control: Ashok Kumar Mallik, Affiliated East-West Press, New Delhi. 1st Edition, 2014,</li> <li>6. Mechanical Vibrations, A H Church, John Wiley &amp; Sons Inc, 2nd Edition, 1963</li> <li>7. Mechanical Vibrations &amp; Noise Engineering, A.G.Ambekar, Prentice Hall of India, New-Delhi, 1st Edition, 2006</li> </ol> |                                                                                                                                                                                                     |               |
| <b>MOOCs Links and additional reading material:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                     |               |
| <ol style="list-style-type: none"> <li>1. <a href="https://onlinecourses.nptel.ac.in/noc22_me76/preview">https://onlinecourses.nptel.ac.in/noc22_me76/preview</a> — Introduction to Mechanical Vibration NPTEL Online Courses</li> <li>2. <a href="https://onlinecourses.nptel.ac.in/noc25_ae17/preview">https://onlinecourses.nptel.ac.in/noc25_ae17/preview</a> — Elements of Mechanical Vibration</li> <li>3. <a href="https://nptel.ac.in/courses/112104040">https://nptel.ac.in/courses/112104040</a> — Principles of Vibration Control</li> <li>4. <a href="https://nptel.ac.in/courses/112103112">https://nptel.ac.in/courses/112103112</a> — Mechanical Vibrations (Video Course)</li> </ol>                                                                                                                                           |                                                                                                                                                                                                     |               |

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**CO-PO mapping table:**

| CO   | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO<br>01 | PSO<br>02 | PSO<br>03 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|-----------|-----------|-----------|
| CO1  | 3   | 3   | 2   | 2   | 2   | -   | -   | -   | 1   | -    | 2    | 2         | 2         | 2         |
| CO2  | 3   | 3   | 2   | 2   | 2   | -   | -   | -   | 1   | -    | 2    | 2         | 2         | 2         |
| CO3  | 3   | 3   | 3   | 2   | 2   | -   | -   | -   | 2   | -    | 2    | 2         | 2         | 2         |
| CO4  | 3   | 2   | 2   | 2   | 2   | -   | -   | -   | 1   | -    | 2    | 2         | 2         | 2         |
| CO5  | 3   | 3   | 2   | 3   | 3   | -   | -   | -   | 2   | -    | 3    | 2         | 2         | 2         |
| Avg. | 3   | 2.8 | 2.5 | 2.5 | 2.5 | -   | -   | -   | 2   | -    | 2.2  | 2         | 2         | 2         |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

**Assessment Pattern**

| BT Level | CCE |     |                |            |                      |                          | ESE |
|----------|-----|-----|----------------|------------|----------------------|--------------------------|-----|
|          | CT1 | CT2 | Open Book Test | Assignment | Seminar / Case Study | Quiz / presentation etc. |     |
| L1       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L2       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L3       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L4       |     |     |                | ✓          | ✓                    |                          |     |
| L5       |     |     |                |            |                      |                          |     |
| L6       |     |     |                |            |                      |                          |     |

**Unit wise Weightage:**

| Exam           | Unit1 | Unit2 | Unit3 | Unit4 | Unit5 | Total |
|----------------|-------|-------|-------|-------|-------|-------|
| CT1            | 8     | 7     |       |       |       | 15    |
| CT2            |       |       | 8     | 7     |       | 15    |
| Open Book Test |       |       |       |       | 10    | 10    |
| Assignments    | 5     |       |       |       |       | 05    |
| Seminar        | 5     |       |       |       |       | 05    |
| ESE            | 10    | 10    | 10    | 10    | 10    | 50    |
|                |       |       |       |       |       | 100   |

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|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|-----------------------------|--------------------|-----|---------------|----|
| Program: F. Y. M. Tech                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                             |          | Semester: I                 |                    |     |               |    |
| Course: Optimization Techniques                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                             |          | Course Code: R25-MDE-OT-504 |                    |     |               |    |
| Teaching Scheme(Hrs/week)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                             |          | Credits                     | Examination Scheme |     |               |    |
| Lecture                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Practical                                                                                                                                                   | Tutorial |                             | CCE                | ESE | TW            | PR |
| 04 Hrs/Week                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | -                                                                                                                                                           | -        | 04                          | 50                 | 50  | -             | -  |
| Course Description :                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                             |          |                             |                    |     |               |    |
| This postgraduate course provides a comprehensive framework for solving complex engineering design challenges by translating physical systems into rigorous mathematical models. It bridges traditional calculus-based algorithms with state-of-the-art computational methodologies to help engineers identify optimal solutions under competing design criteria. Students master linear and non-linear programming paradigms alongside modern metaheuristics like genetic algorithms and particle swarm intelligence. Crucially, the syllabus targets structural efficiency by integrating advanced techniques such as Evolutionary Structural Optimization (ESO) and topology mapping. Ultimately, the course empowers postgraduates to design lightweight, high-performance mechanical systems that meet exact stress, displacement, and economic constraints. |                                                                                                                                                             |          |                             |                    |     |               |    |
| Course Relevance:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                             |          |                             |                    |     |               |    |
| In the era of advanced manufacturing and automated engineering, design success depends on balancing maximum performance with minimal material use. This course equips engineers with the exact computational tools required to automate design variations, dramatically reducing human error and prototyping costs. Mastering these methodologies is vital for structural engineering applications, enabling the development of lightweight components essential to the aerospace, automotive, and heavy machinery sectors.                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                             |          |                             |                    |     |               |    |
| Prerequisite: To successfully undertake this course, students should possess a strong foundation in Engineering Mathematics, particularly multi-variable calculus, linear algebra, and matrix operations. Additionally, basic proficiency in computer programming (such as Python or MATLAB) are essential for implementing optimization algorithms and structural topology models.                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                             |          |                             |                    |     |               |    |
| Bridge Content: - To bridge foundational gaps, students can review introductory materials on matrix-based numerical methods, basic gradient descent algorithms, and finite element analysis (FEA) basics. Familiarity with MATLAB Optimization Toolbox or Python's scipy.optimize library will also help ease the transition from theoretical calculus to computational structural engineering.                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                             |          |                             |                    |     |               |    |
| Course Objectives:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                             |          |                             |                    |     |               |    |
| This course aims to teach students how to mathematically model engineering design problems and systematically solve them using classical, linear, and non-linear programming. It also focuses on deploying modern metaheuristic algorithms and Evolutionary Structural Optimization (ESO) to design highly efficient, lightweight engineering components.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                             |          |                             |                    |     |               |    |
| Course Outcomes: After learning the course, students will be able to                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                             |          |                             |                    |     |               |    |
| CO                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Course Outcome                                                                                                                                              |          |                             |                    |     | Bloom's Level |    |
| CO1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | TRANSLATE complex physical engineering problems into mathematically defined objective functions, constraints, and multi-dimensional design surfaces.        |          |                             |                    |     | 3             |    |
| CO2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | EXECUTE classical and linear programming algorithms, including the Simplex method and post-optimality analysis, to determine optimal system configurations. |          |                             |                    |     | 3             |    |
| CO3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | DEPLOY one-dimensional and multi-dimensional non-linear programming methods to locate local and global performance minima.                                  |          |                             |                    |     | 3             |    |

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|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| CO4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>EXECUTE</b> nature-inspired optimization techniques like Genetic Algorithms and Particle Swarm Optimization to navigate discontinuous engineering design spaces.      | 3             |
| CO5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>APPLY</b> Evolutionary Structural Optimization (ESO) parameters based on stress and stiffness criteria to design lightweight, high-performance mechanical components. | 3             |
| <b>Course Content</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                          |               |
| <b>Unit 1</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <b>Introduction to Mathematical Modeling</b>                                                                                                                             | <b>8 Hrs.</b> |
| <b>CO Mapped: CO 1</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                          |               |
| Introduction to Mathematical Modeling, Types of Modeling. Objective function; Constraints and Constraint surface; Mathematical modeling characteristics and limitations, Formulation of design problems                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                          |               |
| <b>Unit 2</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <b>Classical Optimization Techniques</b>                                                                                                                                 | <b>8 Hrs.</b> |
| <b>CO Mapped: CO 2</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                          |               |
| Engineering applications of optimization, classification of optimization problem, single variable optimization, multi variable optimization with no constraint, equality constraint, in-equality constraint                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                          |               |
| <b>Unit 3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <b>Linear Programming and Non-Linear Programming</b>                                                                                                                     | <b>8 Hrs.</b> |
| <b>CO Mapped: CO 3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                          |               |
| Linear Programming: Simplex algorithm, two phases of the simplex method, Primal-dual simplex method, Sensitivity or post optimality analysis, applications in engineering.<br>Non Linear Programming : One-dimensional minimization - exhaustive search, golden section method, quasi-newton method, random search methods, Powell's method                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                          |               |
| <b>Unit 4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <b>Modern Methods of Optimization</b>                                                                                                                                    | <b>8 Hrs.</b> |
| <b>CO Mapped: CO 4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                          |               |
| Genetic algorithms, Simulated Annealing, Particle Swarm Optimization, Ant Colony Optimization, Teaching Learning Based Optimization, Introduction to ANN                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                          |               |
| <b>Unit 5</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <b>Topology and Evolutionary Structural Optimization</b>                                                                                                                 | <b>8 Hrs.</b> |
| <b>CO Mapped: CO 5</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                          |               |
| Problem formulation and parameterization of design, solution methods, topology optimization as a design tool, combining topology and shape design, ESO Based on Stress Level, evolutionary methods, two-bar frame, Michell type structure, ESO for stiffness or displacement optimization                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                          |               |
| <b>Reference Books:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                          |               |
| 1. Structural Optimization, Raphael T. Haftka and Zafer Gurdal, Kluwer Academic Publishers<br>2. Practical Optimization Methods with Mathematical Applications, M. Asghar Bhatti, Springer<br>3. Topology Optimization – Theory, Methods and Applications, M. P. Bendse, Q. Sigmund<br>4. Evolutionary Topology Optimization of Continuum Structures, Methods and Applications, X. Huang, Y.M. Xie, Wiley, 2010<br>5. Engineering Optimization: Theory and Practice, Singiresu S. Rao, John Wiley & Sons<br>6. Mathematical Modelling, J N Kapur, New age international publication<br>7. Optimization for engineering design, K. Deb, PHI<br>8. Optimization concepts and applications in engineering, Belegundu, Chandrupatla, Pearson Education |                                                                                                                                                                          |               |
| <b>MOOCs Links and additional reading material:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                          |               |
| 1. A Primer to Mathematical Optimization - <a href="https://onlinecourses.nptel.ac.in/noc26_ma122/preview">https://onlinecourses.nptel.ac.in/noc26_ma122/preview</a><br>2. Optimization Theory and Algorithms - <a href="https://onlinecourses.nptel.ac.in/noc26_ee148/preview">https://onlinecourses.nptel.ac.in/noc26_ee148/preview</a><br>3. Optimization from Fundamentals - <a href="https://onlinecourses.nptel.ac.in/noc25_me60/preview">https://onlinecourses.nptel.ac.in/noc25_me60/preview</a>                                                                                                                                                                                                                                           |                                                                                                                                                                          |               |

**CO-PO mapping table:**

| CO   | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO 01 | PSO 02 | PSO 03 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|--------|--------|--------|
| CO1  | 3   | 3   | 2   | 2   | 2   | -   | -   | -   | 1   | -    | 2    | 2      | 2      | 2      |
| CO2  | 3   | 3   | 2   | 2   | 2   | -   | -   | -   | 1   | -    | 2    | 2      | 2      | 2      |
| CO3  | 3   | 3   | 3   | 2   | 2   | -   | -   | -   | 2   | -    | 2    | 2      | 2      | 2      |
| CO4  | 3   | 2   | 2   | 2   | 2   | -   | -   | -   | 1   | -    | 2    | 2      | 2      | 2      |
| CO5  | 3   | 3   | 2   | 3   | 3   | -   | -   | -   | 2   | -    | 3    | 2      | 2      | 2      |
| Avg. | 3   | 2.8 | 2.5 | 2.5 | 2.5 | -   | -   | -   | 2   | -    | 2.2  | 2      | 2      | 2      |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

**Assessment Pattern**

| BT Level | CCE |     |                |            |                      |                          | ESE |
|----------|-----|-----|----------------|------------|----------------------|--------------------------|-----|
|          | CT1 | CT2 | Open Book Test | Assignment | Seminar / Case Study | Quiz / presentation etc. |     |
| L1       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L2       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L3       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L4       |     |     |                | ✓          | ✓                    |                          |     |
| L5       |     |     |                |            |                      |                          |     |
| L6       |     |     |                |            |                      |                          |     |

**Unit wise Weightage:**

| Exam           | Unit1 | Unit2 | Unit3 | Unit4 | Unit5 | Total |
|----------------|-------|-------|-------|-------|-------|-------|
| CT1            | 8     | 7     |       |       |       | 15    |
| CT2            |       |       | 8     | 7     |       | 15    |
| Open Book Test |       |       |       |       | 10    | 10    |
| Assignments    | 5     |       |       |       |       | 05    |
| Seminar        | 5     |       |       |       |       | 05    |
| ESE            | 10    | 10    | 10    | 10    | 10    | 50    |
|                |       |       |       |       |       | 100   |

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|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                      |                 |                |                           |                  |           |           |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|-----------------|----------------|---------------------------|------------------|-----------|-----------|
| <b>Program:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <b>F. Y. M. Tech</b>                 |                 |                | <b>Semester:</b>          | <b>I</b>         |           |           |
| <b>Course:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>Design Engineering Laboratory</b> |                 |                | <b>Course Code:</b>       | R25-MDE-DELI-505 |           |           |
| <b>Teaching Scheme(Hrs/week)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                      |                 | <b>Credits</b> | <b>Examination Scheme</b> |                  |           |           |
| <b>Lecture</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>Practical</b>                     | <b>Tutorial</b> |                | <b>CCE</b>                | <b>ESE</b>       | <b>TW</b> | <b>OR</b> |
| -                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 04 Hrs/Week                          | -               | 02             | -                         | -                | 25        | 25        |
| <b>Course Description and Relevance:</b><br>This Design Laboratory course provides hands-on computational and experimental training to bridge the gap between advanced mechanical engineering theory and practical validation. Students combine numerical programming, data acquisition instrumentation, and FEM software (ANSYS/Abaqus) to analyze structural mechanics, material plasticity, and signal transformations. Additionally, the curriculum builds essential professional skills by training postgraduates to follow ASTM standards and author formal research proposals.                                                                                                                                                                                                                                         |                                      |                 |                |                           |                  |           |           |
| <b>Prerequisite:</b> Students should have a strong foundation in Finite Element Methods (FEM), Strength of Materials, and the mechanical properties of engineering materials. Additionally, a basic understanding of numerical analysis and introductory programming concepts (such as MATLAB, Python, or C++) is essential to complete the computational tasks.                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                      |                 |                |                           |                  |           |           |
| <b>Course Objectives:</b> <ul style="list-style-type: none"><li>• Develop Computational Skills: Train students to write computer programs for mathematical transformations, numerical analysis, and eigenvalue extraction.</li><li>• Master Experimental Techniques: Equip postgraduates with practical skills in data acquisition, instrumentation, and testing structural components like cantilever beams following ASTM standards.</li><li>• Advance Simulation Expertise: Enable students to perform complex non-linear finite element analyses, specifically contact stress and elasto-plastic behaviors, using standard engineering software.</li><li>• Cultivate Research Capabilities: Guide students in drafting structured engineering research proposals and managing formal data collection workflows.</li></ul> |                                      |                 |                |                           |                  |           |           |
| <b>Course Outcomes:</b><br>CO1 - <b>WRITE</b> functional computer programs to extract structural eigenvalues and apply mathematical transforms to solve complex engineering system problems.<br>CO2 - <b>APPLY</b> strain gauge instrumentation and data acquisition systems to measure real-world structural deformations and generate standardized material stress-strain profiles following ASTM-E8M.<br>CO3 - <b>EXECUTE</b> advanced Finite Element Method (FEM) software workflows to model multi-body contact stresses and capture elasto-plastic material behaviors in mechanical specimens.<br>CO4 - <b>SYNTHESIZE</b> industrial instrumentation data and research criteria to author structured, peer-review-quality engineering research proposals.                                                               |                                      |                 |                |                           |                  |           |           |
| <b>Course Content</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                      |                 |                |                           |                  |           |           |
| <b>Design Engineering Laboratory file shall consist of the following assignments/experiments</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                      |                 |                |                           |                  |           |           |
| <ol style="list-style-type: none"><li>1. Computer program to find eigenvalues using numerical method</li><li>2. Computer program of Fourier and Laplace transforms for an engineering application</li><li>3. 3D Stress Tensor &amp; Principal Stresses</li><li>4. Experimental Stress Analysis &amp; Strain Gauge Rosette Transformation</li><li>5. Modal Analysis &amp; Forced Excitation</li><li>6. Lateral Vibrations of Continuous Beams</li><li>7. Linear Programming &amp; The Two-Phase Simplex Method</li><li>8. Design a comprehensive flowchart for a Genetic Algorithm (GA) tailored to solve a discrete structural optimization problem. Clearly label selection, crossover, and mutation operators.</li></ol>                                                                                                    |                                      |                 |                |                           |                  |           |           |

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**NOTE:** Lab. work or Assignments have to be carried out at respective labs as mentioned in the syllabus. Lab work it is to be submitted as term work at the end of the semester after continuous assessment of each by respective teacher

**ASSESSMENT PATTERN:**

- Assignments 1 & 2 (Foundational): 5% each (10% total) — Lower stakes to test core fundamentals.
- Assignments 3, 4, 5 & 6 (Core Modules): 12.5% each (50% total) — Standard technical and analytical problem sets.
- Assignments 7 & 8 (Advanced/Comprehensive): 20% each (40% total) — High-stakes capstone assignments with expectation of programming for complex design problem using MATLAB/PYTHON

**CO-PO mapping table:**

| CO   | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO<br>01 | PSO<br>02 | PSO<br>03 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|-----------|-----------|-----------|
| CO1  | 3   | 3   | 2   | 2   | 2   | -   | -   | -   | 1   | -    | 2    | 2         | 2         | 2         |
| CO2  | 3   | 3   | 2   | 2   | 2   | -   | -   | -   | 1   | -    | 2    | 2         | 2         | 2         |
| CO3  | 3   | 3   | 3   | 2   | 2   | -   | -   | -   | 2   | -    | 2    | 2         | 2         | 2         |
| CO4  | 3   | 2   | 2   | 2   | 2   | -   | -   | -   | 1   | -    | 2    | 2         | 2         | 2         |
| CO5  | 3   | 3   | 2   | 3   | 3   | -   | -   | -   | 2   | -    | 3    | 2         | 2         | 2         |
| Avg. | 3   | 2.8 | 2.5 | 2.5 | 2.5 | -   | -   | -   | 2   | -    | 2.2  | 2         | 2         | 2         |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

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|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|----------------|---------------------------|---------------------|------------|----------------------|-----------|-----------|---|
| <b>Program:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |                                                                                                                                                                                                                  | <b>F. Y. M. Tech</b> |                | <b>Semester:</b>          |                     | <b>I</b>   |                      |           |           |   |
| <b>Course:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |  | <b>Elective – I</b><br><b>Engineering Fatigue and Fracture Mechanics</b>                                                                                                                                         |                      |                |                           | <b>Course Code:</b> |            | R25-MDE-MEC-506(A)   |           |           |   |
| <b>Teaching Scheme(Hrs/week)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |  |                                                                                                                                                                                                                  |                      | <b>Credits</b> | <b>Examination Scheme</b> |                     |            |                      |           |           |   |
| <b>Lecture</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |  | <b>Practical</b>                                                                                                                                                                                                 |                      |                | <b>Tutorial</b>           |                     | <b>CCE</b> | <b>ESE</b>           | <b>TW</b> | <b>PR</b> |   |
| 03 Hrs/Week                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |  | -                                                                                                                                                                                                                |                      | -              |                           | 03                  |            | 50                   | 50        | -         | - |
| <b>Course Description and:</b><br>This course provides advanced knowledge of fatigue behaviour, energy principles, fatigue testing, and fracture mechanisms of engineering materials and components. It covers linear elastic and elastic-plastic fracture mechanics, crack initiation and propagation, and advanced techniques for evaluating structural integrity, reliability, and failure prevention in mechanical systems.                                                                                                                           |  |                                                                                                                                                                                                                  |                      |                |                           |                     |            |                      |           |           |   |
| <b>Course Relevance:</b><br>This course is highly relevant for the safe and reliable design of mechanical components and structures subjected to cyclic and fluctuating loads. It enables engineers to predict fatigue life, analyse crack growth and fracture behaviour, and prevent catastrophic failures in engineering applications.                                                                                                                                                                                                                  |  |                                                                                                                                                                                                                  |                      |                |                           |                     |            |                      |           |           |   |
| <b>Prerequisite:</b> Students should have fundamental knowledge of strength of materials, mechanics of solids, and material behaviour under loading. Familiarity with stress analysis, deformation, and basic mechanical design principles is desirable for understanding fatigue and fracture behaviour.                                                                                                                                                                                                                                                 |  |                                                                                                                                                                                                                  |                      |                |                           |                     |            |                      |           |           |   |
| <b>Bridge Content:</b> Review of fundamental concepts of stress, strain, deformation, failure theories, and strength of materials. Basic concepts of material behaviour under static and cyclic loading, stress concentration, and crack formation will be covered to bridge undergraduate knowledge with advanced fatigue and fracture mechanics.                                                                                                                                                                                                        |  |                                                                                                                                                                                                                  |                      |                |                           |                     |            |                      |           |           |   |
| <b>Course Objectives:</b><br>The course aims to develop an understanding of fatigue behaviour and fracture mechanisms in engineering materials subjected to cyclic and fluctuating loads. It enables students to apply fatigue testing, energy principles, linear elastic and elastic-plastic fracture mechanics for analysing crack initiation and propagation. The course also develops the ability to evaluate structural integrity and design mechanical components for improved safety, reliability, and resistance to fatigue and fracture failure. |  |                                                                                                                                                                                                                  |                      |                |                           |                     |            |                      |           |           |   |
| <b>Course Outcomes:</b> After learning the course, students will be able to                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |  |                                                                                                                                                                                                                  |                      |                |                           |                     |            |                      |           |           |   |
| <b>CO</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  | <b>Course Outcome</b>                                                                                                                                                                                            |                      |                |                           |                     |            | <b>Bloom's Level</b> |           |           |   |
| CO1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |  | <b>Analyze</b> structural components subjected to cyclic loading using stress-life (S-N), strain-life ( $\epsilon$ -N), and fracture mechanics approaches to estimate overall fatigue life and failure limits.   |                      |                |                           |                     |            | 3                    |           |           |   |
| CO2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |  | <b>DESIGN AND EXECUTE</b> fatigue testing protocols following industrial standards to gather empirical data and characterize material endurance thresholds under variable amplitude loading.                     |                      |                |                           |                     |            | 3                    |           |           |   |
| CO3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |  | <b>UTILIZE</b> Linear Elastic Fracture Mechanics (LEFM) principles to compute stress intensity factors (K) and predict brittle fracture propagation in components with pre-existing flaws or sharp cracks.       |                      |                |                           |                     |            | 3                    |           |           |   |
| CO4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |  | <b>FORMULATE AND SOLVE</b> non-linear crack propagation problems using Elastic-Plastic Fracture Mechanics (EPFM) parameters, specifically evaluating the (J)-integral and Crack Tip Opening Displacement (CTOD). |                      |                |                           |                     |            | 3                    |           |           |   |
| CO5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |  | <b>APPLY</b> energy balance criteria (such as Griffith's theory and                                                                                                                                              |                      |                |                           |                     |            | 3                    |           |           |   |

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|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | strain energy release rate (G) and advanced fracture concepts to design resilient, fail-safe engineering structures against catastrophic propagation. |                               |
| <b>Course Content</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                       |                               |
| <b>Unit 1</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>Fatigue Mechanics and Energy Principle</b>                                                                                                         | <b>8 Hrs. CO Mapped: CO 1</b> |
| Time varying uniaxial, biaxial and multiaxial loading of components, load spectra, cycle counting, fatigue damage theories of crack initiation<br>Energy release rate, criteria for crack growth, linear compliance, path independent integrals, J – integral, application of J-integral to cracks and notches, J – integral fracture criterion, experimental determination of the J – integral - single specimen, multiple specimen method                                                                                                                                                                                                                |                                                                                                                                                       |                               |
| <b>Unit 2</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>Fatigue Testing</b>                                                                                                                                | <b>8 Hrs. CO Mapped: CO 2</b> |
| Stress based and strain-based approach Fatigue Testing, Data acquisition and instrumentation, classical methods of fatigue testing, ASTM standards - specimen preparation, procedure.                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                       |                               |
| <b>Unit 3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>Linear Elastic Fracture Mechanics</b>                                                                                                              | <b>8 Hrs. CO Mapped: CO 3</b> |
| Mechanisms of fracture, initiation of fracture and crack propagation, stress and energy criteria and fracture - effects of geometry, Inglis theory of stress, energy concept – Griffith theory of fracture, energy balance during crack growth, modes of loading, calculation of stress intensity – center crack, single edge crack, double edge crack, round hole with crack, superposition of stress intensity factors, leak before break criterion, experimental determination of stress intensity factor – strain gauge method, optical method of photo elasticity                                                                                     |                                                                                                                                                       |                               |
| <b>Unit 4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>Elastic – Plastic Fracture Mechanics</b>                                                                                                           | <b>8 Hrs. CO Mapped: CO 4</b> |
| Introduction, crack tip stress state, Irwin's approximation, Dugdale's approximation, crack opening displacement, shape of the plastic zone – von Mises and Tresca yielding criteria, plastic constraint factor                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                       |                               |
| <b>Unit 5</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>Advanced Topics in Fatigue</b>                                                                                                                     | <b>8 Hrs. CO Mapped: CO 5</b> |
| Fatigue analysis in frequency domain, vibration fatigue, fatigue of welded structure, corrosion fatigue, high temperature and low temperature fatigue                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                       |                               |
| <b>Reference Books:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                       |                               |
| 1. Metal Fatigue Analysis Handbook, YUNG-LI LEE, Elsevier<br>2. Design & Analysis of Fatigue Resistant Welded Structure, Dieter Radaj, Woodhead Publishing<br>3. Fatigue of Structures and Materials, Japp Schijve, Kluwer Academic<br>4. Fatigue Testing and Analysis – Theory and Practice, YUNG-LI LEE, Elsevier<br>5. Metal Fatigue in Engineering, Ali Fatemi, Wiley-Interscience<br>6. Fracture Mechanics Anderson T.L., CRC Press<br>7. Fracture Mechanics, Nestor Perez, Kluwer Academic Publishers<br>8. Fracture Mechanics – An Introduction, Gdoutos E. E., Springer<br>9. Nonlinear Fracture Mechanics for Engineers, Ashok Saxena, CRC Press. |                                                                                                                                                       |                               |
| <b>MOOCs Links and additional reading material:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                       |                               |
| 1. <a href="https://onlinecourses.nptel.ac.in/noc24_me113/preview">https://onlinecourses.nptel.ac.in/noc24_me113/preview</a><br>2. <a href="http://digimat.in/nptel/courses/video/112106065/L06.html">http://digimat.in/nptel/courses/video/112106065/L06.html</a><br>3. <a href="https://onlinecourses.nptel.ac.in/noc25_me25/preview">https://onlinecourses.nptel.ac.in/noc25_me25/preview</a>                                                                                                                                                                                                                                                           |                                                                                                                                                       |                               |

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**CO-PO mapping table:**

| CO   | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO 01 | PSO 02 | PSO 03 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|--------|--------|--------|
| CO1  | 3   | 3   | 2   | 2   | 2   | -   | -   | -   | 1   | -    | 2    | 2      | 2      | 2      |
| CO2  | 3   | 3   | 2   | 2   | 2   | -   | -   | -   | 1   | -    | 2    | 2      | 2      | 2      |
| CO3  | 3   | 3   | 3   | 2   | 2   | -   | -   | -   | 2   | -    | 2    | 2      | 2      | 2      |
| CO4  | 3   | 2   | 2   | 2   | 2   | -   | -   | -   | 1   | -    | 2    | 2      | 2      | 2      |
| CO5  | 3   | 3   | 2   | 3   | 3   | -   | -   | -   | 2   | -    | 3    | 2      | 2      | 2      |
| Avg. | 3   | 2.8 | 2.5 | 2.5 | 2.5 | -   | -   | -   | 2   | -    | 2.2  | 2      | 2      | 2      |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

**Assessment Pattern**

| BT Level | CCE |     |                |            |                      |                          | ESE |
|----------|-----|-----|----------------|------------|----------------------|--------------------------|-----|
|          | CT1 | CT2 | Open Book Test | Assignment | Seminar / Case Study | Quiz / presentation etc. |     |
| L1       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L2       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L3       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L4       |     |     |                | ✓          | ✓                    |                          |     |
| L5       |     |     |                |            |                      |                          |     |
| L6       |     |     |                |            |                      |                          |     |

**Unit wise Weightage:**

| Exam           | Unit1 | Unit2 | Unit3 | Unit4 | Unit5 | Total |
|----------------|-------|-------|-------|-------|-------|-------|
| CT1            | 8     | 7     |       |       |       | 15    |
| CT2            |       |       | 8     | 7     |       | 15    |
| Open Book Test |       |       |       |       | 10    | 10    |
| Assignments    | 5     |       |       |       |       | 05    |
| Seminar        | 5     |       |       |       |       | 05    |
| ESE            | 10    | 10    | 10    | 10    | 10    | 50    |
|                |       |       |       |       |       | 100   |

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|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|----------------|---------------------------|------------|----------------------|-----------|
| <b>Program:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                 | <b>F. Y. M. Tech</b>                                  |                | <b>Semester:</b>          |            | <b>I</b>             |           |
| <b>Course:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                 | <b>Elective – I</b><br><b>Reliability Engineering</b> |                | <b>Course Code:</b>       |            | R25-MDE-MEC-506(B)   |           |
| <b>Teaching Scheme(Hrs/week)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                 |                                                       | <b>Credits</b> | <b>Examination Scheme</b> |            |                      |           |
| <b>Lecture</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>Practical</b>                                                                                                                                                                                                                | <b>Tutorial</b>                                       |                | <b>CCE</b>                | <b>ESE</b> | <b>TW</b>            | <b>PR</b> |
| 03 Hrs/Week                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | -                                                                                                                                                                                                                               | -                                                     | 03             | 50                        | 50         | -                    | -         |
| <b>Course Description :</b><br>This Reliability Engineering course provides a comprehensive framework for predicting, evaluating, and enhancing the lifecycle performance of complex systems and components. Students learn to apply probability theory, network modeling, and statistical testing methodologies to analyze system breakdown patterns, establish maintainability protocols, and calculate operational availability. Ultimately, the curriculum equips postgraduates with the structural risk-assessment skills necessary to balance stress-strength parameters and design highly resilient, fail-safe engineering architectures. |                                                                                                                                                                                                                                 |                                                       |                |                           |            |                      |           |
| <b>Course Relevance:</b><br>In modern automated industries and high-stakes sectors like aerospace and automotive, product failure can lead to catastrophic economic and safety risks. This course is highly relevant as it teaches engineers to quantitatively predict failure rates, optimize system availability, and balance stress-strength variations. Mastering these principles allows design engineers to build highly dependable products, extend system lifecycles, and significantly lower warranty costs.                                                                                                                            |                                                                                                                                                                                                                                 |                                                       |                |                           |            |                      |           |
| <b>Prerequisite:</b> Students should possess a strong foundation in Engineering Mathematics, particularly probability distributions, statistics, and calculus. Additionally, a basic understanding of mechanical components and how operational stresses or material wear cause physical failures over time will help ease the transition into system reliability modeling.                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                 |                                                       |                |                           |            |                      |           |
| <b>Bridge Content:</b> To bridge foundational gaps, students can review introductory materials on basic statistics and lifetime data distributions (like Weibull and Exponential models) alongside Boolean algebra basics for logic modeling. Familiarity with computational tools like MATLAB or Python's scipy.stats library will also help ease the transition from theoretical probability to numerical reliability simulation                                                                                                                                                                                                               |                                                                                                                                                                                                                                 |                                                       |                |                           |            |                      |           |
| <b>Course Objectives:</b><br>Objectives of this course are to introduce students to the foundational principles of probability theory and lifecycle data analysis required to model system failures accurately. It aims to teach postgraduates how to construct complex system reliability networks, evaluate maintainability configurations, and optimize operational availability. Additionally, the course focuses on training engineers to implement robust reliability testing methods and perform stress-strength analysis to ensure structural integrity and mitigate real-world operational risks.                                       |                                                                                                                                                                                                                                 |                                                       |                |                           |            |                      |           |
| <b>Course Outcomes:</b> After learning the course, students will be able to                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                 |                                                       |                |                           |            |                      |           |
| <b>CO</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <b>Course Outcome</b>                                                                                                                                                                                                           |                                                       |                |                           |            | <b>Bloom's Level</b> |           |
| CO1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>APPLY</b> core probability distributions—such as Weibull, Exponential, and Lognormal models—to calculate vital component metrics including hazard rates, Mean Time To Failure (MTTF), and Mean Time Between Failures (MTBF). |                                                       |                |                           |            | 3                    |           |
| CO2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>SYNTHESIZE</b> complex architectural setups using Reliability Block Diagrams (RBD) to accurately compute the overall network reliability of series, parallel, mixed, and redundant hardware systems.                         |                                                       |                |                           |            | 3                    |           |
| CO3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>EVALUATE</b> system maintainability thresholds and configure operational availability indicators (inherent, achieved, and                                                                                                    |                                                       |                |                           |            | 3                    |           |

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|     |                                                                                                                                                                                                                         |   |
|-----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
|     | operational) to streamline life-cycle readiness and design preventive maintenance workflows.                                                                                                                            |   |
| CO4 | <b>DEPLOY</b> logical system failure diagnostic tools, specifically Failure Modes, Effects, and Criticality Analysis (FMECA) alongside Fault Tree Analysis (FTA), to isolate and mitigate early design vulnerabilities. | 3 |
| CO5 | <b>COMPUTE</b> quantitative stress-strength interference parameters to ensure component survival under fluctuating structural loads.                                                                                    | 3 |

### Course Content

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                           |               |                        |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------|---------------|------------------------|
| <b>Unit 1</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>Fundamental Concepts and Probability Theory</b>        | <b>8 Hrs.</b> | <b>CO Mapped: CO 1</b> |
| Reliability definitions, failure, Failure density, Failure Rate, Hazard Rate, MTTF, MTBF, maintainability, availability, pdf, cdf, safety and reliability, Life characteristic phases, modes of failure, Areas of reliability, Importance of Reliability, laws of probability, total probability theorem, probability distributions- binomial, normal, Poisson, lognormal, Weibull, exponential, standard deviation, variance, skewness coefficient, Chebyshev inequality                                                                                                                                                                                                                                        |                                                           |               |                        |
| <b>Unit 2</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>System reliability and modeling</b>                    | <b>8 Hrs.</b> | <b>CO Mapped: CO 2</b> |
| Series, parallel, mixed configuration, k- out of n structure, complex systems- enumeration method, conditional probability method, cut set and tie set method, Redundancy, element redundancy, unit redundancy, standby redundancy, Markov analysis.                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                           |               |                        |
| <b>Unit 3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>Maintainability and Availability</b>                   | <b>8 Hrs.</b> | <b>CO Mapped: CO 3</b> |
| Objectives of maintenance, types of maintenance, Maintainability, factors affecting maintainability, system downtime, Availability - Inherent, Achieved and Operational availability, reliability, and maintainability trade-off.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                           |               |                        |
| <b>Unit 4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>System Reliability Analysis</b>                        | <b>8 Hrs.</b> | <b>CO Mapped: CO 4</b> |
| Reliability allocation or apportionment, Reliability apportionment techniques – equal apportionment, AGREE, ARINC, Reliability block diagrams and models, Reliability predictions from predicted unreliability, minimum effort method.                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                           |               |                        |
| <b>Unit 5</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>Reliability Testing and Strength-based reliability</b> | <b>8 Hrs.</b> | <b>CO Mapped: CO 5</b> |
| Reliability testing and reliability growth testing, Safety factor, safety margin, Stress strength interaction, Material strengths and loads<br>Failure mode effects analysis, severity/criticality analysis, FMECA examples, RPN, Ishikawa diagram for failure representation, fault tree construction, basic symbols development of functional reliability block diagram, Fault tree analysis, fault tree evaluation techniques, minimal cut set method, Monte Carlo evaluation                                                                                                                                                                                                                                 |                                                           |               |                        |
| <b>Reference Books:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                           |               |                        |
| 1. L.S. Srinath, Concepts of Reliability Engg., Affiliated East-West Press (P) Ltd., 1985.<br>2. A.K. Govil, Reliability Engineering, Tata McGraw-Hill Publishing Co. Ltd., 1983.<br>3. E. Balagurusamy, Reliability Engineering, Tata McGraw-Hill Publishing Co. Ltd., 1984.<br>4. B.S. Dhillon, C. Singh, Engineering Reliability, John Wiley & Sons, 1980.<br>5. M.L. Shooman, Probabilistic, Reliability, McGraw-Hill Book Co., 1968.<br>6. P.D.T. Connor, Practical Reliability Engg., John Wiley & Sons, 1985.<br>7. K.C. Kapur, L.R. Lamberson, Reliability in Engineering Design, John Wiley & Sons, 1977.<br>8. A.Birolini, Reliability Engineering, Theory and Practice, Third Edition, Springer, 1999 |                                                           |               |                        |
| <b>MOOCs Links and additional reading material:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                           |               |                        |
| 1. <a href="https://onlinecourses.nptel.ac.in/noc24_me113/preview">https://onlinecourses.nptel.ac.in/noc24_me113/preview</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                           |               |                        |

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2. [https://onlinecourses.nptel.ac.in/noc25\\_mg07/preview](https://onlinecourses.nptel.ac.in/noc25_mg07/preview)

**CO-PO mapping table:**

| CO   | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO 01 | PSO 02 | PSO 03 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|--------|--------|--------|
| CO1  | 3   | 3   | 2   | 2   | 2   | -   | -   | -   | 1   | -    | 2    | 2      | 2      | 2      |
| CO2  | 3   | 3   | 2   | 2   | 2   | -   | -   | -   | 1   | -    | 2    | 2      | 2      | 2      |
| CO3  | 3   | 3   | 3   | 2   | 2   | -   | -   | -   | 2   | -    | 2    | 2      | 2      | 2      |
| CO4  | 3   | 2   | 2   | 2   | 2   | -   | -   | -   | 1   | -    | 2    | 2      | 2      | 2      |
| CO5  | 3   | 3   | 2   | 3   | 3   | -   | -   | -   | 2   | -    | 3    | 2      | 2      | 2      |
| Avg. | 3   | 2.8 | 2.5 | 2.5 | 2.5 | -   | -   | -   | 2   | -    | 2.2  | 2      | 2      | 2      |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

**Assessment Pattern**

| BT Level | CCE |     |                |            |                      |                          | ESE |
|----------|-----|-----|----------------|------------|----------------------|--------------------------|-----|
|          | CT1 | CT2 | Open Book Test | Assignment | Seminar / Case Study | Quiz / presentation etc. |     |
| L1       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L2       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L3       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L4       |     |     |                | ✓          | ✓                    |                          |     |
| L5       |     |     |                |            |                      |                          |     |
| L6       |     |     |                |            |                      |                          |     |

**Unit wise Weightage:**

| Exam           | Unit1 | Unit2 | Unit3 | Unit4 | Unit5 | Total |
|----------------|-------|-------|-------|-------|-------|-------|
| CT1            | 8     | 7     |       |       |       | 15    |
| CT2            |       |       | 8     | 7     |       | 15    |
| Open Book Test |       |       |       |       | 10    | 10    |
| Assignments    | 5     |       |       |       |       | 05    |
| Seminar        | 5     |       |       |       |       | 05    |
| ESE            | 10    | 10    | 10    | 10    | 10    | 50    |
|                |       |       |       |       |       | 100   |

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|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------|----------------------|---------------------------|------------|----------------------|-----------|
| <b>Program:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                 |                                                           | <b>F. Y. M. Tech</b> | <b>Semester:</b>          |            | <b>I</b>             |           |
| <b>Course:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                 | <b>Elective – I</b><br><b>Acoustics and Noise Control</b> |                      | <b>Course Code:</b>       |            | R25-MDE-MEC-506(C)   |           |
| <b>Teaching Scheme(Hrs/week)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                 |                                                           | <b>Credits</b>       | <b>Examination Scheme</b> |            |                      |           |
| <b>Lecture</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <b>Practical</b>                                                                                                                                                                                                                                | <b>Tutorial</b>                                           |                      | <b>CCE</b>                | <b>ESE</b> | <b>TW</b>            | <b>PR</b> |
| 03 Hrs/Week                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | -                                                                                                                                                                                                                                               | -                                                         | 03                   | 50                        | 50         | -                    | -         |
| <b>Course Description :</b><br>This Acoustic and Noise Control course provides an analytical and practical framework for analyzing sound wave mechanics, wave equations, and structural sound transmission. Students learn to evaluate how sound interacts with barriers across stiffness, mass, and damping-controlled regions, alongside using advanced instrumentation like sound level meters and anechoic chambers. Ultimately, the curriculum equips postgraduates with the engineering skills necessary to design efficient noise-isolation barriers and manage industrial acoustic environments                                                                                                                               |                                                                                                                                                                                                                                                 |                                                           |                      |                           |            |                      |           |
| <b>Course Relevance:</b><br>As rapid urbanization and industrial automation increase, managing environmental noise and structural vibrations has become critical for safety and product compliance. This course is highly relevant because it teaches engineers to quantify sound field behaviors, calculate transmission loss across multi-layered barriers, and mitigate machinery noise. Mastering these concepts is essential for designing quiet consumer products, optimizing building insulation, and meeting international acoustic regulations.                                                                                                                                                                              |                                                                                                                                                                                                                                                 |                                                           |                      |                           |            |                      |           |
| <b>Prerequisite:</b> Students should possess a strong foundation in Engineering Mathematics, particularly differential equations, complex variables, and vector calculus. Additionally, a basic understanding of Fluid Mechanics and Wave Physics is essential to model pressure variations, acoustic energy propagation, and boundary layer behaviors effectively.                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                 |                                                           |                      |                           |            |                      |           |
| <b>Bridge Content:</b> To bridge foundational gaps, students can review introductory materials on partial differential equations, complex number notations, and basic wave mechanics (such as frequency-wavelength relations). Familiarity with numerical computing platforms like MATLAB or Python's scipy.signal library will also help ease the transition from theoretical sound wave equations to computational acoustic modeling and data analysis.                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                 |                                                           |                      |                           |            |                      |           |
| <b>Course Objectives:</b><br>The main objectives of this course are to introduce students to the fundamental mathematical and physical principles of sound wave propagation, acoustic field variables, and the derivation of the acoustic wave equation. It aims to teach postgraduates how to analytically evaluate sound transmission mechanics through uniform and composite walls while mapping the effects of stiffness, mass, and damping bounds. Additionally, the course focuses on training engineers to operate advanced acoustic instrumentation and execute standardized sound power measurement procedures within specialized environments like anechoic and reverberant chambers to mitigate industrial noise pollution |                                                                                                                                                                                                                                                 |                                                           |                      |                           |            |                      |           |
| <b>Course Outcomes:</b> After learning the course, students will be able to                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                 |                                                           |                      |                           |            |                      |           |
| <b>CO</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>Course Outcome</b>                                                                                                                                                                                                                           |                                                           |                      |                           |            | <b>Bloom's Level</b> |           |
| CO1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>COMPUTE</b> fundamental sound field variables—including sound pressure levels, particle velocity, acoustic intensity, and decibel combinations—across independent octave bands to assess human auditory response and directivity indicators. |                                                           |                      |                           |            | 3                    |           |
| CO2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>APPLY</b> complex number notation to formulate and solve one-dimensional and spherical acoustic wave equations across normal and oblique media interfaces.                                                                                   |                                                           |                      |                           |            | 3                    |           |
| CO3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>CALCULATE</b> the transmission loss of uniform and composite                                                                                                                                                                                 |                                                           |                      |                           |            | 3                    |           |

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|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | wall systems across stiffness, mass, and damping-controlled frequency regions to assign exact Sound Transmission Class (STC) performance metrics.                                      |               |
| CO4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>DETERMINE</b> optimal material thickness and configuration by evaluating sound absorption metrics and attenuation coefficients to maximize spatial acoustic energy decay.           | 3             |
| CO5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>DEPLOY</b> advanced instrumentation like sound level meters, dosimeters, and octave filters to conduct regulatory sound power assessments inside reverberant and anechoic chambers. | 3             |
| <b>Course Content</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                        |               |
| <b>Unit 1</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>Fundamentals and Wave Mechanics</b>                                                                                                                                                 | <b>8 Hrs.</b> |
| <b>CO Mapped: CO 1</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                        |               |
| Basics of Acoustics: Nature of sound, speed of sound, wavelength, frequency, and wave number relationships. Acoustic, Field Variables: Acoustic pressure, particle velocity, acoustic intensity, and acoustic energy density calculations, Wave Formulations: Characterization of the spherical wave, directivity factor (Q), and directivity index (DI), Logarithmic Scaling: Levels and the decibel (dB) scale, mathematical combination of independent sound sources, octave bands, and human hearing response metrics through weighted sound levels (dBA, dBC).                                                                                     |                                                                                                                                                                                        |               |
| <b>Unit 2</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>The Wave Equation and Sound Propagation</b>                                                                                                                                         | <b>8 Hrs.</b> |
| <b>CO Mapped: CO 2</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                        |               |
| Mathematical Modeling: Derivation and physics of the acoustic wave equation, Analytical Solutions: Complex number notation and harmonic time dependence, one-dimensional wave equation solutions, and exact mathematical solutions for spherical waves, Media Interfaces: Sound wave propagation behavior across boundaries, including changes in media with normal incidence and changes in media with oblique incidence.                                                                                                                                                                                                                              |                                                                                                                                                                                        |               |
| <b>Unit 3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>Sound Transmission and Structural Barriers</b>                                                                                                                                      | <b>8 Hrs.</b> |
| <b>CO Mapped: CO 3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                        |               |
| Mechanics of sound transmission through a wall partition, Evaluation of transmission loss (TL) for walls across different operational frequency bounds, Analytical methods for estimating the transmission loss of uniform structures, computing the cumulative transmission loss for composite walls (containing doors or windows), and calculating the Sound Transmission Class (STC) rating.                                                                                                                                                                                                                                                         |                                                                                                                                                                                        |               |
| <b>Unit 4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>Sound Absorption and Dissipation</b>                                                                                                                                                | <b>8 Hrs.</b> |
| <b>CO Mapped: CO 4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                        |               |
| Dissipation Principles: Mechanics governing the physical absorption of sound at boundary layers and porous materials, Quantifying Losses: Definition and applications of the sound absorption coefficient, Atmospheric & Material Factors: Spatial wave decay, calculations involving the attenuation coefficient and boundary layer damping variables                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                        |               |
| <b>Unit 5</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>Acoustic Measurement and Instrumentation Procedures</b>                                                                                                                             | <b>8 Hrs.</b> |
| <b>CO Mapped: CO 5</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                        |               |
| Measurement Tools: Operational principles of standard sound level meters (SLMs), intensity level meters, octave band filters, real-time acoustic analysers, and personal noise dosimeters, Sound Power Characterization: Standard procedures for the measurement of total sound power emitted by machinery, Environmental Environments: Step-by-step methodologies for sound power measurement in a highly reflective reverberant room and an echo-free anechoic chamber, Field Evaluation: Executing rapid sound power survey measurements, practical field measurement of the directivity factor, and formal regulatory noise measurement procedures. |                                                                                                                                                                                        |               |
| <b>Reference Books:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                        |               |
| 1) Vibration and Noise for Engineers, Kewal Pujara, Dhanpat Rai and Co.<br>2) Industrial Noise Control Fundamentals and applications, Lewis H. Bell, Douglas H. Bell, Marcel Dekker, Inc.<br>3) Fundamentals of Noise & Vibration analysis for Engineers: M. P. Norton, D. G. Karczub, Cambridge University Press<br>4) Engineering Noise Control, Bies D. A. and Hansen C. H, Spon 5) Fundamentals of Acoustics, Kinsler                                                                                                                                                                                                                               |                                                                                                                                                                                        |               |

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L. E. et al , Wiley Mechanical Vibrations, S. S. Rao, Addison-Wesley Publishing Co.

**MOOCs Links and additional reading material:**

1. [https://onlinecourses.nptel.ac.in/noc24\\_me53/preview](https://onlinecourses.nptel.ac.in/noc24_me53/preview)
2. <https://www.coursera.org/learn/intro-to-acoustics>

**CO-PO mapping table:**

| CO   | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO 01 | PSO 02 | PSO 03 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|--------|--------|--------|
| CO1  | 3   | 3   | 2   | 2   | 2   | -   | -   | -   | 1   | -    | 2    | 2      | 2      | 2      |
| CO2  | 3   | 3   | 2   | 2   | 2   | -   | -   | -   | 1   | -    | 2    | 2      | 2      | 2      |
| CO3  | 3   | 3   | 3   | 2   | 2   | -   | -   | -   | 2   | -    | 2    | 2      | 2      | 2      |
| CO4  | 3   | 2   | 2   | 2   | 2   | -   | -   | -   | 1   | -    | 2    | 2      | 2      | 2      |
| CO5  | 3   | 3   | 2   | 3   | 3   | -   | -   | -   | 2   | -    | 3    | 2      | 2      | 2      |
| Avg. | 3   | 2.8 | 2.5 | 2.5 | 2.5 | -   | -   | -   | 2   | -    | 2.2  | 2      | 2      | 2      |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

**Assessment Pattern**

| BT Level | CCE |     |                |            |                      |                          | ESE |
|----------|-----|-----|----------------|------------|----------------------|--------------------------|-----|
|          | CT1 | CT2 | Open Book Test | Assignment | Seminar / Case Study | Quiz / presentation etc. |     |
| L1       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L2       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L3       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L4       |     |     |                | ✓          | ✓                    |                          |     |
| L5       |     |     |                |            |                      |                          |     |
| L6       |     |     |                |            |                      |                          |     |

**Unit wise Weightage:**

| Exam           | Unit1 | Unit2 | Unit3 | Unit4 | Unit5 | Total |
|----------------|-------|-------|-------|-------|-------|-------|
| CT1            | 8     | 7     |       |       |       | 15    |
| CT2            |       |       | 8     | 7     |       | 15    |
| Open Book Test |       |       |       |       | 10    | 10    |
| Assignments    | 5     |       |       |       |       | 05    |
| Seminar        | 5     |       |       |       |       | 05    |
| ESE            | 10    | 10    | 10    | 10    | 10    | 50    |
|                |       |       |       |       |       | 100   |

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|---------------------------|----------------------------------|----------|---------|--------------------|-----------------|----|----|
| Program:                  | F. Y. M. Tech                    |          |         | Semester:          | I               |    |    |
| Course:                   | Elective I Fieldwork Assignments |          |         | Course Code:       | R25-MDE-MEC-507 |    |    |
| Teaching Scheme(Hrs/week) |                                  |          | Credits | Examination Scheme |                 |    |    |
| Lecture                   | Practical                        | Tutorial |         | CCE                | ESE             | TW | OR |
| -                         | 02 Hrs/Week                      | -        | 01      | -                  | -               | 25 | 25 |

**Course Description :**

This Fieldwork Assignments module provides hands-on, field-based experiential learning designed to bridge advanced theoretical principles with real-world engineering and industrial operations. Students step outside the traditional classroom or lab setting to conduct on-site investigations, structural inspections, noise surveys, and data collection workflows directly tied to their elective specializations. Ultimately, the curriculum trains postgraduates to analyze active engineering environments, document operational irregularities, and deliver data-driven solutions compliant with current industrial and environmental safety standards.

**Course Objectives:**

The primary objectives of this module are to engage students in real-world engineering environments where they can gather, process, and evaluate empirical field data directly related to their elective specializations. It aims to train postgraduates to operate specialized monitoring equipment and execute standardized industrial diagnostic workflows under live operational conditions. Additionally, the course focuses on developing the professional capabilities required to cross-reference field observations with regulatory frameworks, troubleshoot complex physical system anomalies, and compile high-quality technical engineering reports suitable for industrial stakeholders.

**Course Outcomes:**

**CO1** - Plan and execute on-site engineering measurement protocols using specialized field equipment to collect accurate, real-world data under live operational conditions.

**CO2** - Analyze field observations and empirical datasets to identify structural, environmental, or system performance flaws specific to their chosen elective domain.

**CO3** - Cross-reference on-site measurements and operational findings with national and international engineering codes, safety mandates, and environmental standards.

**CO4** - Synthesize complex technical field findings, data visualizations, and engineering recommendations into structured, professional-grade diagnostic reports for industrial stakeholders.

**Course Content****ELECTIVE 1: Engineering Fatigue and Fracture Mechanics (R25-MDE-MEC-506(A)) Field Work Assignments**

The Engineering Fatigue and Fracture Mechanics field work file shall consist of the following assignments

**1. Title: Analysis of Fatigue Loading and Damage Accumulation in Engineering Components****Objectives:**

- To understand time-varying uniaxial, biaxial, and multiaxial loading.
- To apply fatigue damage theories to estimate the life until crack initiation.

**2. Title: Fatigue Testing and Standards Compliance****Objectives:**

- To perform fatigue testing following ASTM standards. To compare stress-based and strain-based approaches.
- To familiarize with instrumentation and data acquisition techniques.

**3. Title: Advanced Fatigue Behavior under Special Conditions****Objectives:**

- To analyze fatigue in the frequency domain and under vibration loading.
- To study the fatigue performance of welded structures and corrosion fatigue.

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**4. Title:** Experimental Determination of Stress Intensity Factor in LEFM**Objectives:**

- To understand the principles of Linear Elastic Fracture Mechanics (LEFM).
- To experimentally determine the Stress Intensity Factor (K) for a cracked specimen.

**5. Title:** Elastic–Plastic Fracture Mechanics and J-Integral Application**Objectives:**

- To study plastic zone formation and measure crack tip parameters in EPFM.
- To determine the J-integral experimentally for a notched specimen.

**ELECTIVE 1: Reliability Engineering (R25-MDE-MEC-506(B)) Field Work Assignments**

The Reliability Engineering field work file shall consist of the following assignments

**1. Title:** Reliability Fundamentals and Probability Analysis in Engineering Systems**Objectives:**

- To understand and apply the basic concepts of reliability engineering.
- To model failure behavior using probability theory.
- To compute measures such as MTTF, MTBF, failure density, and hazard rate from real or simulated.

**2. Title:** System Reliability Modeling for Industrial Equipment**Objectives:**

- To model and evaluate system reliability for various configurations.

**3. Title:** Maintainability and Availability Assessment in Real Systems**Objectives:**

- To analyze maintainability and availability characteristics of an operational system..

**4. Title:** Reliability Apportionment and Block Diagram Analysis**Objectives:**

- To allocate reliability requirements to subsystems based on system-level targets.
- To use apportionment techniques and reliability block diagrams for design.

**5. Title:** Reliability Testing and Failure Analysis using FMECA**Objectives:**

- To conduct reliability testing or use test data for evaluating system safety.
- To perform FMECA and develop fault tree for critical failures.

**NOTE:** The field work is to be submitted as term work at the end of semester after continuous assessment by respective teacher

**ELECTIVE 1: Acoustics and Noise Control (R25-MDE-MEC-506(C)) Field Work Assignments**

he Reliability Engineering field work file shall consist of the following assignments

**1. Title:** Environmental Noise Mapping and Decibel Verification**Objective:**

- To measure and calculate fluctuating ambient noise levels across diverse urban and campus environments, execute mathematical decibel combinations of multiple overlapping sound sources, and verify localized compliance with regional pollution limits.

**2. Title:** Far-Field Sound Propagation and Directivity Index Mapping**Objective:**

- To map the spatial attenuation of sound waves emitted from an isolated industrial source over linear distance, solve the inverse-square law for hemispherical propagation, and empirically calculate the source's directivity factor (Q) and directivity index (DI).

**3. Title:** In-Situ Transmission Loss Evaluation of Structural Partitions**Objective:**

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- To conduct a field transmission loss (TL) test across an existing building partition (such as a classroom wall or laboratory composite window) and evaluate its performance against the theoretical Mass Law.

4. **Title:** Evaluation of Room Absorption Coefficients and Reverberation Decay

**Objectives:**

- To measure the sound decay profile of an enclosed space (like an auditorium, empty workshop, or conference hall) to estimate its spatial sound absorption coefficient ( $\alpha$ ) and calculate its target acoustic dampening requirements

5. **Title:** Industrial Machinery Sound Power Survey and Dosimetry Audit

**Objectives:**

- To perform a formal workplace noise survey in an active engineering shop floor or generator room using sound level meters and personal dosimeters to quantify machine sound power levels and evaluate occupational exposure safety..

**NOTE:** The field work is to be submitted as term work at the end of semester after continuous assessment by respective teacher

**CO-PO mapping table:**

| CO   | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO 01 | PSO 02 | PSO 03 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|--------|--------|--------|
| CO1  | 3   | 3   | 2   | 2   | 2   | -   | -   | -   | 1   | -    | 2    | 2      | 2      | 2      |
| CO2  | 3   | 3   | 2   | 2   | 2   | -   | -   | -   | 1   | -    | 2    | 2      | 2      | 2      |
| CO3  | 3   | 3   | 3   | 2   | 2   | -   | -   | -   | 2   | -    | 2    | 2      | 2      | 2      |
| CO4  | 3   | 2   | 2   | 2   | 2   | -   | -   | -   | 1   | -    | 2    | 2      | 2      | 2      |
| Avg. | 3   | 2.8 | 2.5 | 2.5 | 2.5 | -   | -   | -   | 2   | -    | 2.2  | 2      | 2      | 2      |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

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|                           |                |          |         |                    |                 |    |    |
|---------------------------|----------------|----------|---------|--------------------|-----------------|----|----|
| Program:                  | F. Y. M. Tech  |          |         | Semester:          | I               |    |    |
| Course:                   | Human Rights I |          |         | Course Code:       | R25-MDE-CTS-508 |    |    |
| Teaching Scheme(Hrs/week) |                |          | Credits | Examination Scheme |                 |    |    |
| Lecture                   | Practical      | Tutorial |         | CCE                | ESE             | TW | PR |
| =                         | -              | -        | 01      | -                  | -               | -  | -  |

**Course Description and:**

The Human Rights – I course is designed as a foundational credit program for postgraduate students. It introduces the structural framework of human dignity, liberty, and universal freedoms as recognized both globally and nationally. The course unpacks the historical evolution of rights—transitioning from philosophical concepts to enforceable international treaties—and bridges them directly with the Fundamental Rights outlined in Part III of the Constitution of India. Through analyzing the Universal Declaration of Human Rights (UDHR) and key covenants, the curriculum trains students to evaluate how civil, political, and socio-economic rights impact everyday governance and citizenship..

**Course Relevance:**

- **Promotes Constitutional Literacy:** Connects abstract international principles to real-world protections under Indian law, making students aware of their constitutional remedies.
- **Fosters Social Empathy:** Deepens the understanding of systemic inequalities, discrimination, and the struggles of marginalized groups to ensure a more inclusive worldview.
- **Enhances Professional Value:** Equips students entering fields like law, corporate governance, human resources, journalism, civil services, or NGOs with crucial compliance and ethical knowledge.
- **Develops Critical Thinking:** Empowers students to critically evaluate contemporary social justice issues, state policies, and the complex balance between individual liberties and state security.
- **Encourages Global Citizenship:** Aligns local socio-political issues with global benchmarks set by the United Nations, helping students look at humanitarian challenges through a global lens.

**Course Objectives:**

The primary objectives of the Human Rights – I postgraduate course at SPPU are to:

- **Introduce Foundational Concepts:** Familiarize students with the basic philosophy, historical evolution, and core definitions of human rights and duties.
- **Examine Legal Frameworks:** Provide a thorough understanding of global instruments like the Universal Declaration of Human Rights (UDHR) and how they align with the Constitution of India.
- **Analyze the Rights-Duties Balance:** Explore the critical relationship between individual rights and social/civic responsibilities.
- **Cultivate Social Awareness:** Sensitize students to modern humanitarian challenges, systemic discrimination, and the issues faced by vulnerable populations.

**Course Outcomes:** Upon successful completion of this course, students will be able to:

- **CO1 -Explain Core Principles:** Define and discuss the concept of human dignity, liberty, equality, and justice from both national and global perspectives.
- **CO 2 - Interpret Legal Instruments:** Identify and analyze key provisions of the UN Charter, the UDHR, and relevant international covenants.
- **CO3 - Correlate International Standards:** Connect international human rights standards to the Fundamental Rights guaranteed under the Indian Constitution.
- **CO 4- Apply Ethical Decision-Making:** Use human rights principles as an ethical lens to evaluate policies, workplace practices, and real-world social issues in their respective professional fields.

**NOTE:** This is self-paced Course, Students should study as per course content and submit one summary Assignment for the Course for the evaluation of 1 Credit.

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| Course Content                                                                                                                                                                                                                                                                                                                                               |                                                      |          |                                 |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|----------|---------------------------------|
| <b>Unit 1</b>                                                                                                                                                                                                                                                                                                                                                | <b>Introduction &amp; Basic Concepts</b>             | <b>-</b> | <b>CO Mapped: CO 1 and CO 4</b> |
| Historical Origins: Development of human rights in international and national scenarios, .Core Components: Values, human dignity, equality, justice, morals, and ethics., Rights and Duties: The conceptual relationship and balance between individual rights and duties.                                                                                   |                                                      |          |                                 |
| <b>Unit 2</b>                                                                                                                                                                                                                                                                                                                                                | <b>International Framework &amp; UN Charters</b>     | <b>-</b> | <b>CO Mapped: CO 2 and CO 4</b> |
| UN Charter Provisions: Relevance of Preamble and key articles (Articles 1(3), 13(1) (b), 55, and 56), International Bill of Human Rights: Overview and significance of the Universal Declaration of Human Rights (UDHR), Generations of Human Rights: Introduction to first, second, and third-generation rights.                                            |                                                      |          |                                 |
| <b>Unit 3</b>                                                                                                                                                                                                                                                                                                                                                | <b>Civil and Political Rights (First Generation)</b> | <b>-</b> | <b>CO Mapped: CO 3 and CO 4</b> |
| ICCPR Focus: Civil and political provisions under international covenants, Constitutional Linkages: Corresponding guarantees under Part III (Fundamental Rights) of the Constitution of India and landmark judicial cases, Specific Freedoms: Freedom of expression, right to life, personal liberty, and privacy                                            |                                                      |          |                                 |
| <b>Reference Books:</b>                                                                                                                                                                                                                                                                                                                                      |                                                      |          |                                 |
| 1. International Law & Human Rights by <i>Dr. H.O. Agarwal</i><br>2. Introduction to the Constitution of India by Dr. D.D. Basu (or M. Laxmikanth)<br>3. Human Rights in India: Problems and Perspectives by B.P. Singh Sehgal                                                                                                                               |                                                      |          |                                 |
| <b>MOOCs Links and additional reading material:</b>                                                                                                                                                                                                                                                                                                          |                                                      |          |                                 |
| 1. <a href="https://onlinecourses.swayam2.ac.in/cec21_lw07/preview">https://onlinecourses.swayam2.ac.in/cec21_lw07/preview</a><br>2. <a href="https://onlinecourses.swayam2.ac.in/cec21_lw07/preview">https://onlinecourses.swayam2.ac.in/cec21_lw07/preview</a><br>3. <a href="https://www.humanrights.com/course/">https://www.humanrights.com/course/</a> |                                                      |          |                                 |

**CO-PO mapping table:**

| CO  | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO | PSO | PSO |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|-----|-----|-----|
| CO1 | 3   | -   | 2   | 2   | 2   | -   | -   | 2   | 2   | -    | -    | 2   | 2   | 2   |
| CO2 | 3   | -   | 3   | 2   | 2   | -   | -   | 2   | 2   | -    | -    | 2   | 2   | 2   |
| CO3 | 2   | -   | 3   | 2   | 2   | -   | -   | 2   | 2   | -    | -    | 2   | 2   | 2   |
| CO4 | 3   | -   | 2   | 2   | 2   | -   | -   | 2   | 2   | -    | -    | 2   | 2   | 2   |
| Avg | 3   | -   | 2.6 | 2   | 2.2 | -   | -   | 2   | 2   | -    | -    | 2   | 2   | 2   |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

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**MTech– Mechanical-Design Engineering**  
**F.Y. Syllabus Semester II**

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|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|---------------------------------------------|---------------------------|---------------------|----------------------|-----------------|
| <b>Program:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                     |                 | <b>F. Y. M. Tech</b>                        | <b>Semester:</b>          |                     | <b>II</b>            |                 |
| <b>Course:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                     |                 | <b>Analysis and Synthesis of Mechanisms</b> |                           | <b>Course Code:</b> |                      | R25-MDE-ASM-509 |
| <b>Teaching Scheme(Hrs/week)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                     |                 | <b>Credits</b>                              | <b>Examination Scheme</b> |                     |                      |                 |
| <b>Lecture</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>Practical</b>                                                                                                                                                                                                    | <b>Tutorial</b> |                                             | <b>CCE</b>                | <b>ESE</b>          | <b>TW</b>            | <b>PR</b>       |
| 04 Hrs/Week                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | -                                                                                                                                                                                                                   | -               | 04                                          | 50                        | 50                  | -                    | -               |
| <b>Course Description :</b><br>This Analysis and Synthesis of Mechanisms course provides an advanced analytical and computational framework for evaluating the motion profiles of complex multi-body linkages and robotic systems. Students master positional, velocity, and acceleration analyses while using rigorous mathematical synthesis methods to generate exact linkage dimensions for specific paths, motion steps, or geometric functions. Ultimately, the curriculum equips engineers to design structurally balanced, high-speed mechanisms required for modern precision automation and robotic equipment.                                                                                                                          |                                                                                                                                                                                                                     |                 |                                             |                           |                     |                      |                 |
| <b>Course Relevance:</b><br>In modern high-speed automation and robotics, precise motion control is critical for operational efficiency and structural durability. This course is highly relevant because it teaches engineers to eliminate structural design defects, prevent dynamic imbalances, and synthesize custom linkage configurations for complex industrial pathways. Mastering these techniques is essential for developing next-generation automation machinery, automotive suspensions, and high-performance robotic actuators                                                                                                                                                                                                      |                                                                                                                                                                                                                     |                 |                                             |                           |                     |                      |                 |
| <b>Prerequisite:</b> Students should possess a strong foundation in Engineering Mechanics and Theory of Machines, particularly regarding displacement, velocity, and basic acceleration vectors in fundamental linkages. Additionally, a solid grasp of Engineering Mathematics—specifically differential calculus, matrix transformations, and numerical methods—is essential for solving the structural equations of complex mechanisms.                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                     |                 |                                             |                           |                     |                      |                 |
| <b>Bridge Content:</b> To bridge foundational gaps, students can review introductory concepts in vector algebra, complex numbers for planar kinematics, and degrees of freedom in planar mechanisms. Familiarity with computational tools like MATLAB or Python (using numpy and scipy) will also help ease the transition from manual graphical methods to computer-aided kinematic synthesis and link simulation.                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                     |                 |                                             |                           |                     |                      |                 |
| <b>Course Objectives:</b><br>The main objectives of this course are to introduce students to advanced mathematical and vector calculus techniques for analyzing the position, velocity, and acceleration profiles of complex planar and spatial mechanisms. It aims to teach postgraduates how to apply graphical and analytical concepts, such as curvature theory and inflection circles, to evaluate the instantaneous motion characteristics of rigid-body systems. Additionally, the course focuses on training engineers to mathematically synthesize four-bar and multi-link mechanisms for function generation, path generation, and rigid-body guidance to meet exact precision design specifications in modern automated manufacturing. |                                                                                                                                                                                                                     |                 |                                             |                           |                     |                      |                 |
| <b>Course Outcomes:</b> After learning the course, students will be able to                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                     |                 |                                             |                           |                     |                      |                 |
| <b>CO</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>Course Outcome</b>                                                                                                                                                                                               |                 |                                             |                           |                     | <b>Bloom's Level</b> |                 |
| CO1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | ANALYZE the geometric properties, degrees of freedom, and constraints of both standard and complex multi-link planar mechanisms using normal acceleration and auxiliary-point methods.                              |                 |                                             |                           |                     | 3                    |                 |
| CO2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | APPLY graphical and analytical concepts—such as fixed/moving centrodes, the inflection circle, and the Euler-Savary equation—to map the instantaneous velocity and acceleration profiles of higher-pair mechanisms. |                 |                                             |                           |                     | 3                    |                 |

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|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|------------------------|
| CO3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>SYNTHESIZE</b> four-bar and multi-link mechanisms using graphical methods to achieve exact path generation, function generation, and rigid-body guidance through distinct precision points.       | 3             |                        |
| CO4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>CONSTRUCT AND SOLVE</b> mathematical loop-closure equations using computational software to automate the dimensional synthesis of planar linkages based on coordinate targets.                    | 3             |                        |
| CO5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>FORMULATE</b> spatial kinematic equations using matrix transformations and screw theory to calculate structural displacements and joint rotations in spatial mechanisms and robotic manipulators. | 3             |                        |
| <b>Course Content</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                      |               |                        |
| <b>Unit 1</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>Introduction to Kinematics</b>                                                                                                                                                                    | <b>8 Hrs.</b> | <b>CO Mapped: CO 1</b> |
| Review of concepts related to kinematic analysis of mechanisms, degree of freedom, Grashoff's and Grubler's criteria, Transmission and deviation angles, mechanical advantage                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                      |               |                        |
| <b>Unit 2</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>Complex Mechanisms</b>                                                                                                                                                                            | <b>8 Hrs.</b> | <b>CO Mapped: CO 2</b> |
| Types of complex Mechanisms, velocity-acceleration analysis of complex mechanisms by the Normal Acceleration method and Auxiliary Point Method, Introduction to Goodman's Method.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                      |               |                        |
| <b>Unit 3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>Curvature theory</b>                                                                                                                                                                              | <b>8 Hrs.</b> | <b>CO Mapped: CO 3</b> |
| Fixed and moving centrodes, inflection circle, Euler-Savary equation, Bobillier constructions, cubic of stationary curvature                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                      |               |                        |
| <b>Unit 4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>Synthesis of Planar Mechanisms</b>                                                                                                                                                                | <b>8 Hrs.</b> | <b>CO Mapped: CO 4</b> |
| Types, number and dimensional synthesis, function generation, path generation, and rigid body guidance problems, accuracy(precision)points, Chebychev spacing, types of errors, graphical synthesis for function generation and rigid body guidance with two and three accuracy points using Relative pole method & Inversion method.                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                      |               |                        |
| <b>Unit 5</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>Analytical synthesis of Planar Mechanisms, Kinematics of Spatial Mechanisms</b>                                                                                                                   | <b>8 Hrs.</b> | <b>CO Mapped: CO 4</b> |
| Freudenstein's equation, synthesis for four accuracy points, compatibility condition, Introduction to complex numbers method of synthesis, Robert Chebychev theorem, Cognate linkages.<br>Transformations describing planar finite displacements, planar finite transformations, identity transformation, rigid-body transformations, spatial transformations Denavit-Hartenberg parameters, matrix method of analysis of spatial mechanisms                                                                                                                                                                                                                                              |                                                                                                                                                                                                      |               |                        |
| <b>Reference Books:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                      |               |                        |
| 1. Theory of Machines and Mechanisms, A. Ghosh and A.K. Mallik, Affiliated East-West Press.<br>2. Kinematic Synthesis of Linkages, R.S. Hartenberg and J. Denavit, McGraw-Hill.<br>3. Theory of Machines and Mechanisms, J. E. Shigley and J. J. Uicker, 2nd Ed. McGraw-Hill.<br>4. Design of Machinery: An Introduction to the Synthesis and Analysis of Mechanisms and Machines, Robert L. Norton, Tata McGraw-Hill, 3rd Edition.<br>5. Theory of machines – S. S. Rattan McGraw-Hill Publications.<br>6. Mechanisms and Machine Theory- A.G. Ambekar. PHI Learning Pvt. Ltd.<br>7. Mechanism Design- Analysis and Synthesis (Vol.1 and 2), A.G. Erdman and G.N. Sandor, Prentice Hall. |                                                                                                                                                                                                      |               |                        |
| <b>MOOCs Links and additional reading material:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                      |               |                        |
| 1. <a href="https://onlinecourses.nptel.ac.in/noc20_me53/preview">https://onlinecourses.nptel.ac.in/noc20_me53/preview</a><br>2. <a href="https://onlinecourses.nptel.ac.in/noc20_me53/preview">https://onlinecourses.nptel.ac.in/noc20_me53/preview</a>                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                      |               |                        |

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**CO-PO mapping table:**

| CO   | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO<br>01 | PSO<br>02 | PSO<br>03 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|-----------|-----------|-----------|
| CO1  | 3   | 3   | 2   | 2   | 2   | -   | -   | -   | 1   | -    | 2    | 2         | 2         | 2         |
| CO2  | 3   | 3   | 2   | 2   | 2   | -   | -   | -   | 1   | -    | 2    | 2         | 2         | 2         |
| CO3  | 3   | 3   | 3   | 2   | 2   | -   | -   | -   | 2   | -    | 2    | 2         | 2         | 2         |
| CO4  | 3   | 2   | 2   | 2   | 2   | -   | -   | -   | 1   | -    | 2    | 2         | 2         | 2         |
| CO5  | 3   | 3   | 2   | 3   | 3   | -   | -   | -   | 2   | -    | 3    | 2         | 2         | 2         |
| Avg. | 3   | 2.8 | 2.5 | 2.5 | 2.5 | -   | -   | -   | 2   | -    | 2.2  | 2         | 2         | 2         |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

**Assessment Pattern**

| BT Level | CCE |     |                |            |                      |                          | ESE |
|----------|-----|-----|----------------|------------|----------------------|--------------------------|-----|
|          | CT1 | CT2 | Open Book Test | Assignment | Seminar / Case Study | Quiz / presentation etc. |     |
| L1       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L2       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L3       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L4       |     |     |                | ✓          | ✓                    |                          |     |
| L5       |     |     |                |            |                      |                          |     |
| L6       |     |     |                |            |                      |                          |     |

**Unit wise Weightage:**

| Exam           | Unit1 | Unit2 | Unit3 | Unit4 | Unit5 | Total |
|----------------|-------|-------|-------|-------|-------|-------|
| CT1            | 8     | 7     |       |       |       | 15    |
| CT2            |       |       | 8     | 7     |       | 15    |
| Open Book Test |       |       |       |       | 10    | 10    |
| Assignments    | 5     |       |       |       |       | 05    |
| Seminar        | 5     |       |       |       |       | 05    |
| ESE            | 10    | 10    | 10    | 10    | 10    | 50    |
|                |       |       |       |       |       | 100   |

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|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                    |                 |                           |                      |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|---------------------------|----------------------|
| <b>Program:</b> F. Y. M. Tech                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                    |                 | <b>Semester:</b> II       |                      |
| <b>Course:</b> Finite Element Method                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                    |                 | <b>Course Code:</b>       | R25-MDE-FEM-510      |
| <b>Teaching Scheme(Hrs/week)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                    |                 | <b>Credits</b>            |                      |
| <b>Lecture</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <b>Practical</b>                                                                                                                                                                                                   | <b>Tutorial</b> | <b>Examination Scheme</b> |                      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                    |                 | <b>CCE</b>                | <b>ESE</b>           |
| 04 Hrs/Week                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | -                                                                                                                                                                                                                  | -               | 04                        | 50                   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                    |                 |                           | 50                   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                    |                 |                           | -                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                    |                 |                           | -                    |
| <b>Course Description and:</b><br>This Finite Element Method (FEM) course provides a rigorous mathematical and computational framework for analyzing the structural, thermal, and fluid behaviors of complex engineering systems. Students learn to discretize continuous physical domains into finite elements, formulate governing boundary value equations, and solve them using methods like Galerkin and Rayleigh-Ritz. Ultimately, the curriculum equips postgraduates with the theoretical depth and software proficiency required to simulate structural deformation, heat transfer, and non-linear material mechanics in real-world engineering designs.                                                                                                                                         |                                                                                                                                                                                                                    |                 |                           |                      |
| <b>Course Relevance:</b><br>In modern engineering, physical prototyping is often too costly and time-consuming for evaluating complex product designs. This course is highly relevant because it teaches engineers to accurately simulate structural stresses, thermal gradients, and dynamic responses prior to physical manufacturing. Mastering these computational techniques is essential for developing weight-optimized, safe, and high-performance components across the aerospace, automotive, and heavy machinery industries.                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                    |                 |                           |                      |
| <b>Prerequisite:</b> Students should possess a strong foundation in Engineering Mathematics, particularly differential equations, matrix algebra, and variational calculus. Additionally, a thorough understanding of Strength of Materials and Theory of Elasticity—specifically regarding stress-strain relationships, boundary conditions, and structural deflection—is essential to accurately formulate element matrices.                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                    |                 |                           |                      |
| <b>Bridge Content:</b> To bridge foundational gaps, students can review introductory concepts in weighted residual methods, isoparametric coordinates, and matrix assembly techniques. Familiarity with structural analysis software tools like ANSYS, Abaqus, or Python-based FEA solvers will also help ease the transition from theoretical differential equations to practical engineering simulations.                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                    |                 |                           |                      |
| <b>Course Objectives:</b><br>The primary objectives of this course are to introduce students to the foundational mathematical formulations of the finite element method, focusing on variational principles and weighted residual techniques for boundary value problems. It aims to teach postgraduates how to derive element stiffness matrices and load vectors for a variety of structural components, including one-dimensional bars, beams, two-dimensional planar elements, and three-dimensional solid bodies. Additionally, the course focuses on training engineers to implement isoparametric formulations, conduct structural dynamic and thermal analyses, and effectively deploy commercial finite element analysis software to model and evaluate complex, real-world engineering systems. |                                                                                                                                                                                                                    |                 |                           |                      |
| <b>Course Outcomes:</b> After learning the course, students will be able to                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                    |                 |                           |                      |
| <b>CO</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>Course Outcome</b>                                                                                                                                                                                              |                 |                           | <b>Bloom's Level</b> |
| CO1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>DERIVE</b> element stiffness matrices and load vectors to compute nodal displacements and internal stresses for one-dimensional springs, bars, and truss networks under specified physical boundary conditions. |                 |                           | 3                    |
| CO2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>APPLY</b> coordinate mapping equations and numerical integration schemes to develop isoparametric formulations for complex geometric planes, maintaining continuity across two-dimensional structural elements. |                 |                           | 3                    |
| CO3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>CONSTRUCT</b> comprehensive multi-axial strain-displacement                                                                                                                                                     |                 |                           | 3                    |

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|     |                                                                                                                                                                                                                       |   |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
|     | equations and execute volumetric discretization routines to evaluate structural stress distributions within three-dimensional complex geometries.                                                                     |   |
| CO4 | <b>IMPLEMENT</b> incremental numerical algorithms to resolve structural structural variations stemming from geometric distortions, material plasticity, and contact zone transformations.                             | 3 |
| CO5 | <b>DEVELOP</b> modular computational logic for automatic mesh generation, construct stiffness assembly code, enforce essential boundary conditions, and validate simulation fidelity using h- and p-mesh refinements. | 3 |

### Course Content

| Unit 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Introduction, One dimensional problem                         | 8 Hrs. | CO Mapped: CO 1 |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------|--------|-----------------|
| Finite element method, brief history, basic steps, advantages and disadvantages, weak formulation, variational methods of approximation – Rayleigh-Ritz methods, Galerkin method of Weighted Residuals.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                               |        |                 |
| Variational formulation of 1D bar and beam elements (Euler Bernoulli and Timoshenko beam) – governing equation, domain discretization, elemental equations, assembly and element connectivity, application of boundary condition, solution of equations, post-processing of the results.                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                               |        |                 |
| Unit 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Two-Dimensional Isoperimetric Formulation                     | 8 Hrs. | CO Mapped: CO 2 |
| Introduction, types of 2D elements (CST, LST, QST, Isoparametric), shape functions – linear & quadratic, displacement function – criteria for the choice of the displacement function, polynomial displacement functions, displacement function in terms of nodal parameters, strain-nodal parameter relationship, stress-strain relationship, element stiffness matrix, convergence of isoparametric elements, rate of convergence, plane elasticity problems – plane stress, plane strain and axisymmetric problems                                                                                                                                                                                               |                                                               |        |                 |
| Unit 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 3D Problems in stress analysis                                | 8 Hrs. | CO Mapped: CO 3 |
| Introduction, Finite element formulation, stress calculations, mesh preparation, hexahedral and tetrahedral elements, modeling problems [Only theoretical treatment]                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                               |        |                 |
| Unit 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Nonlinear Problems – Geometric, Material and Contact Problems | 8 Hrs. | CO Mapped: CO 4 |
| Introduction to non-linear analysis, formulation for geometrical, material and contact nonlinear problems, Nonlinear equation solving procedure - direct iteration, Newton-Raphson method, modified Newton-Raphson method, incremental techniques                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                               |        |                 |
| Unit 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Special Topics                                                | 8 Hrs. | CO Mapped: CO 5 |
| Algorithmic approach for Finite element formulation of element characteristics, Assembly and incorporation of boundary conditions, Guidelines for code development, Automatic mesh generation techniques, Mesh quality checks, h & p refinements, symmetry – mirror/plane, axial, cyclic & repetitive, Node Numbering scheme, Computer implementation: Pre-processor, Processor, Post-processor                                                                                                                                                                                                                                                                                                                     |                                                               |        |                 |
| Reference Books:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                               |        |                 |
| <ol style="list-style-type: none"> <li>1. Seshu P., “Text book of Finite Element Analysis”, PHI Learning Private Ltd., New Delhi, 2010.</li> <li>2. Mukhopadhyay M and Sheikh A. H., “Matrix and Finite Element Analyses of Structures”, Ane Books Pvt. Ltd., 2009.</li> <li>3. Bathe K. J., “Finite Element Procedures”, Prentice-Hall of India (P) Ltd., New Delhi.</li> <li>4. Cook R. D., “Finite Element Modeling for Stress Analysis”, John Wiley and Sons Inc, 1995</li> <li>5. Chandrupatla T. R. and Belegunda A. D., “Introduction to Finite Elements in Engineering”, Prentice Hall India.</li> <li>6. Liu G. R. and Quek S. S. “The Finite Element Method – A Practical Course”, Butterworth</li> </ol> |                                                               |        |                 |

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Heinemann, 2003.

7. Reddy, J. N., “An Introduction to The Finite Element Method”, Tata McGraw Hill, 2003.

**MOOCs Links and additional reading material:**

1. <https://www.my-mooc.com/en/mooc/finiteelementmethods-cb0221d8-9fe6-4eb2-8360-db3e0bd5e23e>
2. <https://ocw.mit.edu/courses/mechanical-engineering/2-158j-computational-geometry-spring-2003/>

**CO-PO mapping table:**

| CO   | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO 01 | PSO 02 | PSO 03 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|--------|--------|--------|
| CO1  | 3   | 3   | 2   | 2   | 2   | -   | -   | -   | 1   | -    | 2    | 2      | 2      | 2      |
| CO2  | 3   | 3   | 2   | 2   | 2   | -   | -   | -   | 1   | -    | 2    | 2      | 2      | 2      |
| CO3  | 3   | 3   | 3   | 2   | 2   | -   | -   | -   | 2   | -    | 2    | 2      | 2      | 2      |
| CO4  | 3   | 2   | 2   | 2   | 2   | -   | -   | -   | 1   | -    | 2    | 2      | 2      | 2      |
| CO5  | 3   | 3   | 2   | 3   | 3   | -   | -   | -   | 2   | -    | 3    | 2      | 2      | 2      |
| Avg. | 3   | 2.8 | 2.5 | 2.5 | 2.5 | -   | -   | -   | 2   | -    | 2.2  | 2      | 2      | 2      |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

**Assessment Pattern**

| BT Level | CCE |     |                |            |                      |                          | ESE |
|----------|-----|-----|----------------|------------|----------------------|--------------------------|-----|
|          | CT1 | CT2 | Open Book Test | Assignment | Seminar / Case Study | Quiz / presentation etc. |     |
| L1       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L2       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L3       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L4       |     |     |                | ✓          | ✓                    |                          |     |
| L5       |     |     |                |            |                      |                          |     |
| L6       |     |     |                |            |                      |                          |     |

**Unit wise Weightage:**

| Exam           | Unit1 | Unit2 | Unit3 | Unit4 | Unit5 | Total |
|----------------|-------|-------|-------|-------|-------|-------|
| CT1            | 8     | 7     |       |       |       | 15    |
| CT2            |       |       | 8     | 7     |       | 15    |
| Open Book Test |       |       |       |       | 10    | 10    |
| Assignments    | 5     |       |       |       |       | 05    |
| Seminar        | 5     |       |       |       |       | 05    |
| ESE            | 10    | 10    | 10    | 10    | 10    | 50    |
|                |       |       |       |       |       | 100   |

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|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|----------------|---------------------------|-----------------|----------------------|-----------|
| <b>Program:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>F. Y. M. Tech</b>                                                                                                                                                                                         |                 |                | <b>Semester:</b>          | <b>II</b>       |                      |           |
| <b>Course:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>Mechanical Measurements and Controls</b>                                                                                                                                                                  |                 |                | <b>Course Code:</b>       | R25-MDE-MMC-511 |                      |           |
| <b>Teaching Scheme(Hrs/week)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                              |                 | <b>Credits</b> | <b>Examination Scheme</b> |                 |                      |           |
| <b>Lecture</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>Practical</b>                                                                                                                                                                                             | <b>Tutorial</b> |                | <b>CCE</b>                | <b>ESE</b>      | <b>TW</b>            | <b>PR</b> |
| 04 Hrs/Week                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | -                                                                                                                                                                                                            | -               | 04             | 50                        | 50              | -                    | -         |
| <b>Course Description:</b><br>This Mechanical Measurements and Controls course provides an advanced theoretical and practical framework for industrial instrumentation, sensor technologies, and automatic control systems. Students learn to analyze measurement errors, calibrate dynamic physical transducers, and model open- and closed-loop feedback control architectures. Ultimately, the curriculum equips postgraduates with the engineering skills necessary to design precise data acquisition systems and stable automation loops for complex industrial processes.                                                                                                                                                                                  |                                                                                                                                                                                                              |                 |                |                           |                 |                      |           |
| <b>Course Relevance:</b><br>In modern industrial automation and advanced manufacturing, product quality depends heavily on precise data monitoring and rapid response loops. This course is highly relevant because it teaches engineers to accurately measure physical variables, evaluate transducer dynamics, and design stable feedback control systems. Mastering these principles is essential for developing automated manufacturing lines, robotics, and precise testing instrumentation across the automotive and aerospace sectors..                                                                                                                                                                                                                    |                                                                                                                                                                                                              |                 |                |                           |                 |                      |           |
| <b>Prerequisite:</b> Students should possess a strong foundation in Engineering Mathematics, particularly differential equations, Laplace transforms, and linear algebra. Additionally, a thorough understanding of basic Electrical and Electronics Engineering—specifically circuit laws, signal concepts, and introductory physics—is essential to analyze transducer characteristics and feedback loops                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                              |                 |                |                           |                 |                      |           |
| <b>Bridge Content:</b> To bridge foundational gaps, students can review introductory concepts in operational amplifiers (Op-Amps), Laplace block diagrams, and standard signal flow charts. Familiarity with data acquisition tools like LabVIEW, MATLAB Simulink, or Arduino microcontroller interfaces will also help ease the transition from theoretical system equations to practical measurement and automation applications.                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                              |                 |                |                           |                 |                      |           |
| <b>Course Objectives:</b><br>The primary objectives of this course are to introduce students to the fundamental principles of mechanical measurement systems, focusing on the mathematical analysis of error, calibration, and dynamic transducer response. It aims to teach postgraduates how to select and configure appropriate sensors and data acquisition devices for measuring physical variables like displacement, temperature, pressure, and vibration. Additionally, the course focuses on training engineers to model linear control systems using transfer functions and state-space representations while designing classical feedback loops (such as PID control) to ensure stability and accuracy in modern automated manufacturing environments. |                                                                                                                                                                                                              |                 |                |                           |                 |                      |           |
| <b>Course Outcomes:</b> After learning the course, students will be able to                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                              |                 |                |                           |                 |                      |           |
| <b>CO</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>Course Outcome</b>                                                                                                                                                                                        |                 |                |                           |                 | <b>Bloom's Level</b> |           |
| CO1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <b>CLASSIFY AND CHARACTERIZE</b> the static and dynamic errors of measuring systems to optimize instrument calibration and response parameters under active process variations.                              |                 |                |                           |                 | 3                    |           |
| CO2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <b>IDENTIFY AND SELECT</b> optimal physical transducers to accurately monitor mechanical parameters, specifically displacement, pressure, temperature, fluid flow, and high-frequency structural vibrations. |                 |                |                           |                 | 3                    |           |
| CO3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <b>CONSTRUCT</b> exact mathematical transfer functions and state-space representations for open- and closed-loop continuous                                                                                  |                 |                |                           |                 | 3                    |           |

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|     | automated systems under standard signal inputs.                                                                                                                                                   |   |
| CO4 | <b>APPLY</b> analytical frequency-domain criteria—including root locus, Bode plots, and Routh-Hurwitz methods—to evaluate the absolute stability and performance margins of linear feedback loops | 3 |
| CO5 | <b>CONFIGURE AND OPTIMIZE</b> industrial PID tuning frameworks and signal conditioning interfaces to maintain precision and stability in real-world electromechanical operations.                 | 3 |

### Course Content

| Unit 1                                                                                                                                                                                                                                                                                    | Fundamentals of Measurements                                         | 8 Hrs. | CO Mapped: CO 1 |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------|--------|-----------------|
| Characteristics of Measurement system: Static and Dynamic Sensors and Transducers: Force, Speed Measurement, Strain Stress Measurement, FFT (Fast Fourier Transform): Vibration and Noise Measurement, Laser Doppler Vibrometer, Temperature, pressure, flow rate, velocity, humidity.    |                                                                      |        |                 |
| Unit 2                                                                                                                                                                                                                                                                                    | Fundamentals of interfacing of sensors with Microcontroller/computer | 8 Hrs. | CO Mapped: CO 2 |
| Analog and Digital Signals, ADC, DAC, Bit width, Sampling theorem, Noise Filters: Low Pass, Band Pass and High Pass.                                                                                                                                                                      |                                                                      |        |                 |
| Unit 3                                                                                                                                                                                                                                                                                    | Modeling of Mechatronic Systems                                      | 8 Hrs. | CO Mapped: CO 3 |
| Mathematical Modeling of Mechatronics System. Representation of mechatronics system into transfer function blocks, block reduction fundamentals, State space representation, only second order mechanical, electro-mechanical. System Stability analysis using Poles and Zeros of System. |                                                                      |        |                 |
| Unit 4                                                                                                                                                                                                                                                                                    | Control using time domain                                            | 8 Hrs. | CO Mapped: CO 4 |
| Transient response of electromechanical and mechanical system, Routh Hurwitz criterion to determine Poles and Zeros of system, PID control system design and tuning PID parameters based on transient response.                                                                           |                                                                      |        |                 |
| Unit 5                                                                                                                                                                                                                                                                                    | Control using Frequency Domain                                       | 8 Hrs. | CO Mapped: CO 5 |
| Frequency response of electromechanical and mechanical system, Bode plot to determine Phase margin and gain margin, PID control system design and tuning PID parameters based on frequency response.                                                                                      |                                                                      |        |                 |

### Reference Books:

1. Measurement Systems-Application and Design, Doebelin E.O, McGraw Hill Publication
2. Measurement and Instrumentation – Theory and Application, Alan Morris, Reza Langari, Elsevier
3. Instrumentation for Engineering Measurements, James Dally, William Riley and Kenneth McConnell, Wiley.
4. Engineering Metrology and Measurement, N V Raghavendra and Krishnamurthy, Oxford University Press,
5. Engineering Metrology and Measurements, Bentley, Pearson Education
6. Theory and Design for Mechanical Measurements, 3rd Edition, Richard S Figliola, Donald E Beasley, Wiley India
7. Doebelin's Measurement Systems Ernest Doebelin, Dhanesh Manik McGraw-Hill
8. Instrumentation, Measurement and Analysis, B.C. Nakra, K.K. Chaudhry McGraw- Hill
9. A Text book of Engineering Metrology, I C Gupta, Dhanpat Rai Publications
10. A course in Mechanical Measurements and Instrumentation, A K Sawhney, Dhanpat Rai Publications
11. Mechanical Measurements and Instrumentations, Er. R K Rajput, Kataria Publication (KATSON)

### MOOCs Links and additional reading material:

1. [https://onlinecourses.nptel.ac.in/noc24\\_me12/preview](https://onlinecourses.nptel.ac.in/noc24_me12/preview)
2. [https://onlinecourses.nptel.ac.in/noc25\\_me65/preview](https://onlinecourses.nptel.ac.in/noc25_me65/preview)
3. [https://onlinecourses.nptel.ac.in/noc25\\_me17/preview](https://onlinecourses.nptel.ac.in/noc25_me17/preview)

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**CO-PO mapping table:**

| CO   | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO<br>01 | PSO<br>02 | PSO<br>03 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|-----------|-----------|-----------|
| CO1  | 3   | 3   | 2   | 2   | 2   | -   | -   | -   | 1   | -    | 2    | 2         | 2         | 2         |
| CO2  | 3   | 3   | 2   | 2   | 2   | -   | -   | -   | 1   | -    | 2    | 2         | 2         | 2         |
| CO3  | 3   | 3   | 3   | 2   | 2   | -   | -   | -   | 2   | -    | 2    | 2         | 2         | 2         |
| CO4  | 3   | 2   | 2   | 2   | 2   | -   | -   | -   | 1   | -    | 2    | 2         | 2         | 2         |
| CO5  | 3   | 3   | 2   | 3   | 3   | -   | -   | -   | 2   | -    | 3    | 2         | 2         | 2         |
| Avg. | 3   | 2.8 | 2.5 | 2.5 | 2.5 | -   | -   | -   | 2   | -    | 2.2  | 2         | 2         | 2         |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

**Assessment Pattern**

| BT Level | CCE |     |                |            |                      |                          | ESE |
|----------|-----|-----|----------------|------------|----------------------|--------------------------|-----|
|          | CT1 | CT2 | Open Book Test | Assignment | Seminar / Case Study | Quiz / presentation etc. |     |
| L1       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L2       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L3       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L4       |     |     |                | ✓          | ✓                    |                          |     |
| L5       |     |     |                |            |                      |                          |     |
| L6       |     |     |                |            |                      |                          |     |

**Unit wise Weightage:**

| Exam           | Unit1 | Unit2 | Unit3 | Unit4 | Unit5 | Total |
|----------------|-------|-------|-------|-------|-------|-------|
| CT1            | 8     | 7     |       |       |       | 15    |
| CT2            |       |       | 8     | 7     |       | 15    |
| Open Book Test |       |       |       |       | 10    | 10    |
| Assignments    | 5     |       |       |       |       | 05    |
| Seminar        | 5     |       |       |       |       | 05    |
| ESE            | 10    | 10    | 10    | 10    | 10    | 50    |
|                |       |       |       |       |       | 100   |

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|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-----------------------------------|---------------------------|------------|----------------------|-----------|
| <b>Program:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                 |                 | <b>F. Y. M. Tech</b>              | <b>Semester:</b>          |            | <b>II</b>            |           |
| <b>Course:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                 |                 | <b>Design Engg. Laboratory-II</b> | <b>Course Code:</b>       |            | R25-MCO-DELI-512     |           |
| <b>Teaching Scheme(Hrs/week)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                 |                 | <b>Credits</b>                    | <b>Examination Scheme</b> |            |                      |           |
| <b>Lecture</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>Practical</b>                                                                                                                                                                                | <b>Tutorial</b> |                                   | <b>CCE</b>                | <b>ESE</b> | <b>TW</b>            | <b>PR</b> |
| -                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 04 Hrs/Week                                                                                                                                                                                     | -               | 02                                | -                         | -          | 25                   | 25        |
| <b>Course Description :</b><br>The Design Engine Laboratory II is an advanced course that integrates multi body kinematics, structural finite element analysis (FEA), instrumentation error validation, and closed-loop control system design. Students utilize modern simulation software and analytical techniques to model dynamic forces, map structural stresses, tune feedback controllers, and investigate specialized engineering mechanics via domain-specific electives.                                                                                                                      |                                                                                                                                                                                                 |                 |                                   |                           |            |                      |           |
| <b>Course Relevance:</b><br>This laboratory bridges the gap between theoretical physics and industrial implementation, equipping students with the computational synthesis, structural diagnostic, and automation skills required in R&D environments. Mastering these core modules ensures proficiency in predicting structural failures, managing mechanical vibrations, and designing precise instrumentation layouts for complex machinery.                                                                                                                                                         |                                                                                                                                                                                                 |                 |                                   |                           |            |                      |           |
| <b>Course Objectives:</b><br>The objective of this course is to enable students to simulate and analyze kinematic forces and structural behaviors in complex mechanical assemblies using FEA and multi body dynamics software. It also aims to train students to characterize measurement system errors, model closed-loop control loops, and apply PID tuning to optimize the performance and stability of automated machinery.                                                                                                                                                                        |                                                                                                                                                                                                 |                 |                                   |                           |            |                      |           |
| <b>Course Outcomes:</b> After learning the course, students will be able to                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                 |                 |                                   |                           |            |                      |           |
| <b>CO</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <b>Course Outcome</b>                                                                                                                                                                           |                 |                                   |                           |            | <b>Bloom's Level</b> |           |
| CO1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>MODEL AND EVALUATE</b> inertia forces, structural accelerations, and geometric coupler curves in multi body mechanisms using advanced computer simulation software.                          |                 |                                   |                           |            | 3                    |           |
| CO2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>EXECUTE</b> finite element analysis (FEA) to determine stress, deflection, and modal frequency response behavior in continuous structures under static, cyclic, and base-excitation loading. |                 |                                   |                           |            | 3                    |           |
| CO3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>ANALYZE</b> generalized measurement systems by calculating systematic, random, and total experimental errors to establish rigorous uncertainty bounds at specific confidence levels.         |                 |                                   |                           |            | 3                    |           |
| CO4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>FORMULATE</b> mathematical models of electromechanical systems, analyze closed-loop stability, and design optimized PID controller parameters for targeted transient performance.            |                 |                                   |                           |            | 3                    |           |
| CO5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>INVESTIGATE</b> specialized complex engineering problem via domain-specific electives.                                                                                                       |                 |                                   |                           |            | 3                    |           |
| <b>Course Content</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                 |                 |                                   |                           |            |                      |           |
| <b>Design Engineering Laboratory- II file shall consist of the following assignments/experiments</b><br>1. Analysis of inertia forces in slider crank mechanism using computer software<br>2. Coupler curve synthesis for a mechanism using computer software<br>3. Stress and deflection analysis of short and long beams with different end conditions and cross-sections subjected to different loading conditions (i.e., point load – force & moment, distributed load etc) using FEA software<br>4. Direct/Modal frequency response analysis of a beam/plate under a single-point cyclic load/base |                                                                                                                                                                                                 |                 |                                   |                           |            |                      |           |

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excitation with and without damping using FEA software.

5. Generalized Measurement Systems & Error Analysis.

6. Control System Modeling, Stability, and PID Tuning

7. One assignment on Elective II

8. One assignment on Elective IIL

**NOTE:** Lab. work or Assignments have to be carried out at respective labs as mentioned in the syllabus of respective. It is to be submitted as term work at the end of semester after continuous assessment of each by respective teacher.

#### ASSESSMENT PATTERN:

- Assignments 1 & 2 (Foundational): 5% each (10% total) — Lower stakes to test core fundamentals.
- Assignments 3, 4, 5 & 6 (Core Modules): 12.5% each (50% total) — Standard technical and analytical problem sets.
- Assignments 7 & 8 (Advanced/Comprehensive): 20% each (40% total) — High-stakes capstone assignments with expectation of programming for complex design problem using MATLAB/PYTHON

#### CO-PO mapping table:

| CO   | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO 01 | PSO 02 | PSO 03 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|--------|--------|--------|
| CO1  | 3   | 3   | 2   | 2   | 2   | -   | -   | -   | 1   | -    | 2    | 2      | 2      | 2      |
| CO2  | 3   | 3   | 2   | 2   | 2   | -   | -   | -   | 1   | -    | 2    | 2      | 2      | 2      |
| CO3  | 3   | 3   | 3   | 2   | 2   | -   | -   | -   | 2   | -    | 2    | 2      | 2      | 2      |
| CO4  | 3   | 2   | 2   | 2   | 2   | -   | -   | -   | 1   | -    | 2    | 2      | 2      | 2      |
| CO5  | 3   | 3   | 2   | 3   | 3   | -   | -   | -   | 2   | -    | 3    | 2      | 2      | 2      |
| Avg. | 3   | 2.8 | 2.5 | 2.5 | 2.5 | -   | -   | -   | 2   | -    | 2.2  | 2      | 2      | 2      |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

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|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|----------------------------------------|----------------------|
| <b>Program:</b> F. Y. M. Tech                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                    |                 | <b>Semester:</b> II                    |                      |
| <b>Course:</b> Elective – II<br>Vehicle Dynamics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                    |                 | <b>Course Code:</b> R25-MDE-MEC-513(A) |                      |
| <b>Teaching Scheme(Hrs/week)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                    |                 | <b>Credits</b>                         |                      |
| <b>Lecture</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>Practical</b>                                                                                                                                                                                                                   | <b>Tutorial</b> | <b>Examination Scheme</b>              |                      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                    |                 | <b>CCE</b>                             | <b>ESE</b>           |
| 03 Hrs/Week                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | -                                                                                                                                                                                                                                  | -               | 03                                     | 50                   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                    |                 |                                        | 50                   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                    |                 |                                        | -                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                    |                 |                                        | -                    |
| <b>Course Description :</b><br>Vehicle Dynamics provides a rigorous mathematical and physical analysis of ground vehicle behavior, focusing on tire mechanics, tractive performance limits, suspension geometries, and steering response. Students evaluate how vertical, longitudinal, and lateral forces interact under dynamic conditions to dictate overall handling limits and occupant ride comfort.                                                                                                                                  |                                                                                                                                                                                                                                    |                 |                                        |                      |
| <b>Course Relevance:</b><br>This course is vital for automotive engineers designing modern chassis, suspension, and active safety systems (like ABS and stability control) to meet stringent safety and handling standards. Mastering these vehicle interactions allows engineers to simulate performance computationally, reducing physical prototyping costs and optimizing passenger comfort alongside high-speed handling stability.                                                                                                    |                                                                                                                                                                                                                                    |                 |                                        |                      |
| <b>Prerequisite:</b> Students must have a foundational understanding of Kinematics and Dynamics of Machinery to analyze forces, Mechanics of Materials to evaluate structural stresses, and Control Systems Engineering to manipulate transfer functions. Basic proficiency in Differential Equations and introductory CAD/FEA computational software is also required.                                                                                                                                                                     |                                                                                                                                                                                                                                    |                 |                                        |                      |
| <b>Bridge Content:</b> - The Vehicle Dynamics bridging framework smooth the transition from basic physics to complex automotive modeling across five units: tire slip mechanics, multi-axle dynamic weight transfer, spatial suspension layouts, 2-DOF steady-state bicycle handling, and 2-DOF quarter-car ride comfort. This structured sequence equips students with the exact non-linear mechanics, matrix equations, and ISO comfort standards required to successfully execute advanced computational chassis design and simulations. |                                                                                                                                                                                                                                    |                 |                                        |                      |
| <b>Course Objectives:</b><br>The objective of this course is to enable students to mathematically model and computationally simulate the forces acting on a moving vehicle across tire, suspension, handling, and ride modules. It aims to train students to optimize vehicle performance, transient handling stability, and passenger ride comfort while adhering to international safety and automotive testing standards.                                                                                                                |                                                                                                                                                                                                                                    |                 |                                        |                      |
| <b>Course Outcomes:</b> After learning the course, students will be able to                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                    |                 |                                        |                      |
| <b>CO</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>Course Outcome</b>                                                                                                                                                                                                              |                 |                                        | <b>Bloom's Level</b> |
| CO1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>EVALUATE</b> non-linear tire force generation properties using the Pacejka Magic Formula and analyze a road vehicle's tractive performance, aerodynamic limits, and dynamic weight transfer under extreme longitudinal loading. |                 |                                        | 3                    |
| CO2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>CHARACTERIZE</b> spatial suspension layouts to determine the roll center, instantaneous center of rotation, and track dynamic variations in camber and steering compliance.                                                     |                 |                                        | 3                    |
| CO3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>FORMULATE</b> steady-state directional responses using 2-DOF vehicle models to compute understeer gradients, characteristic/critical speeds, and high-speed cornering stability.                                                |                 |                                        | 3                    |
| CO4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>APPLY</b> Model coupled 2-DOF quarter-car dynamics to simulate body bounce and wheel hop frequencies, ensuring the chassis isolates road disturbances according to ISO 2631 human vibration comfort standards.                  |                 |                                        | 3                    |

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| Course Content                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                     |               |                        |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|---------------|------------------------|
| <b>Unit 1</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <b>Tire Characteristics</b>                         | <b>8 Hrs.</b> | <b>CO Mapped: CO 1</b> |
| Tire – types, axis system, mechanics of pneumatic tires - tire forces and moments, rolling resistance of tires, tractive (braking) effort and longitudinal slip (skid), cornering properties of tires, slip angle and cornering force, slip angle and aligning torque, camber and camber thrust, characterization of cornering behavior of tires, performance of tires on wet surfaces, ride properties of tires                                                                   |                                                     |               |                        |
| <b>Unit 2</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <b>Performance characteristics of road vehicles</b> | <b>8 Hrs.</b> | <b>CO Mapped: CO 2</b> |
| Equation of motion and maximum tractive effort, aerodynamic forces and moments, vehicle power plant and transmission characteristics, acceleration time and distance, gradability, engine and transmission matching, Electronic Stability Control (ESC), Braking characteristics of a two-axle vehicle, braking efficiency and stopping distance, antilock brake systems, traction control systems, Electronic Brakeforce Distribution (EBD), Electronic Brake assist System (EBS) |                                                     |               |                        |
| <b>Unit 3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <b>Suspension Kinematics</b>                        | <b>8 Hrs.</b> | <b>CO Mapped: CO 3</b> |
| Terminology, definitions – reference frame, toe-in, toe-out, wheel camber, caster and kingpin angle, steering offset, types of dependent and independent suspensions, equivalent mechanisms (front view / side view), anti-dive and squat geometry, roll center analysis, steering geometry, error, steering force and moments                                                                                                                                                     |                                                     |               |                        |
| <b>Unit 4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <b>Handling characteristics of vehicle</b>          | <b>8 Hrs.</b> | <b>CO Mapped: CO 4</b> |
| Steady-state handling characteristics of a two-axle vehicle, steady-state response to steering input, testing of handling characteristics, transient response characteristics, directional stability, steering of tracked vehicles                                                                                                                                                                                                                                                 |                                                     |               |                        |
| <b>Unit 5</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <b>Vehicle ride characteristics</b>                 | <b>8 Hrs.</b> | <b>CO Mapped: CO 4</b> |
| Calculation of spectral densities, RMS values, relation to ride comfort, vehicle ride models - two-degree-of-freedom vehicle model for sprung and un-sprung mass, numerical methods for determining the response of a quarter-car model to irregular surface profile excitation, two-degree-of-freedom vehicle model for pitch and bounce, active and semi-active suspension                                                                                                       |                                                     |               |                        |
| <b>Reference Books:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                     |               |                        |
| 1. Road Vehicle Dynamics – Problems & Solutions, Rao & Dukkipati, SAE,<br>2. Theory of Ground Vehicles, J.Y. Wong, John Wiley & Sons,<br>3. Fundamentals of Vehicle Dynamics, T.D. Gillespie, SAE                                                                                                                                                                                                                                                                                  |                                                     |               |                        |
| <b>MOOCs Links and additional reading material:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                     |               |                        |
| 1. Introduction to Vehicle Dynamics - <a href="https://nptel.ac.in/courses/107106080">https://nptel.ac.in/courses/107106080</a><br>2. Introduction to Vehicle Dynamics<br><a href="https://www.youtube.com/playlist?list=PLbMVogVj5nJTW50jj9_gvJmdwFWHaqR5J">https://www.youtube.com/playlist?list=PLbMVogVj5nJTW50jj9_gvJmdwFWHaqR5J</a>                                                                                                                                          |                                                     |               |                        |

**CO-PO mapping table:**

| CO   | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO<br>01 | PSO<br>02 | PSO<br>03 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|-----------|-----------|-----------|
| CO1  | 3   | -   | 2   | 2   | 2   | -   | -   | 2   | 2   | -    | -    | 2         | 2         | 2         |
| CO2  | 3   | -   | 3   | 2   | 2   | -   | -   | 2   | 2   | -    | -    | 2         | 2         | 2         |
| CO3  | 2   | -   | 3   | 2   | 2   | -   | -   | 2   | 2   | -    | -    | 2         | 2         | 2         |
| CO4  | 3   | -   | 2   | 2   | 2   | -   | -   | 2   | 2   | -    | -    | 2         | 2         | 2         |
|      |     |     |     |     |     |     |     |     |     |      |      |           |           |           |
| Avg. | 3   | -   | 2.6 | 2   | 2.2 | -   | -   | 2   | 2   | -    | -    | 2         | 2         | 2         |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

**Assessment Pattern**

| BT Level | CCE |     |                |            |                      |                          | ESE |
|----------|-----|-----|----------------|------------|----------------------|--------------------------|-----|
|          | CT1 | CT2 | Open Book Test | Assignment | Seminar / Case Study | Quiz / presentation etc. |     |
| L1       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L2       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L3       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L4       |     |     |                | ✓          | ✓                    |                          |     |
| L5       |     |     |                |            |                      |                          |     |
| L6       |     |     |                |            |                      |                          |     |

**Unit wise Weightage:**

| Exam           | Unit1 | Unit2 | Unit3 | Unit4 | Unit5 | Total |
|----------------|-------|-------|-------|-------|-------|-------|
| CT1            | 8     | 7     |       |       |       | 15    |
| CT2            |       |       | 8     | 7     |       | 15    |
| Open Book Test |       |       |       |       | 10    | 10    |
| Assignments    | 5     |       |       |       |       | 05    |
| Seminar        | 5     |       |       |       |       | 05    |
| ESE            | 10    | 10    | 10    | 10    | 10    | 50    |
|                |       |       |       |       |       | 100   |

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|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|----------------|---------------------------|---------------|---------------------------|-----------|
| <b>Program:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                    | <b>F. Y. M. Tech</b> |                | <b>Semester:</b>          |               | <b>II</b>                 |           |
| <b>Course:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                    | <b>Elective – II</b> |                | <b>Course Code:</b>       |               | <b>R25-MDE-MEC-513(B)</b> |           |
| <b>Material Handling Equipment Design</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                    |                      |                |                           |               |                           |           |
| <b>Teaching Scheme(Hrs/week)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                    |                      | <b>Credits</b> | <b>Examination Scheme</b> |               |                           |           |
| <b>Lecture</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>Practical</b>                                                                                                                                                                   | <b>Tutorial</b>      |                | <b>CCE</b>                | <b>ESE</b>    | <b>TW</b>                 | <b>PR</b> |
| 03 Hrs/Week                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | -                                                                                                                                                                                  | -                    | 03             | 50                        | 50            | -                         | -         |
| <b>Course Description:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                    |                      |                |                           |               |                           |           |
| Material Handling Equipment Design provides a comprehensive engineering approach to the selection, structural analysis, and mechanical design of industrial transport and storage systems, such as conveyors, cranes, hoists, and elevators. Students learn to apply kinematic principles, machine design codes, and material optimization techniques to safely and efficiently manage bulk and unit loads within manufacturing and warehouse environments.                                                                        |                                                                                                                                                                                    |                      |                |                           |               |                           |           |
| <b>Course Relevance:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                    |                      |                |                           |               |                           |           |
| This course is vital for industrial, manufacturing, and plant engineers tasked with optimizing supply chain logistics and automating factory floors. Mastering these design principles ensures engineering graduates can safely size structural beams, select optimal motor-drive configurations, and prevent mechanical failures in high-capacity lifting and conveying machinery. This directly reduces operational downtime, lowers material transport costs, and ensures compliance with modern occupational safety standards. |                                                                                                                                                                                    |                      |                |                           |               |                           |           |
| <b>Prerequisite:</b> To master material handling equipment design, you need a strong foundation in Engineering Mechanics (Statics & Dynamics) and Strength of Materials to calculate load distributions and stress limits. You also need proficiency in Machine Component Design (gears, bearings, shafts) and 3D CAD modeling software to build and simulate the actual machinery.                                                                                                                                                |                                                                                                                                                                                    |                      |                |                           |               |                           |           |
| <b>Bridge Content:</b> - Transforming theoretical physics into practical machinery. It takes the abstract forces learned in Statics and Dynamics and applies them to selecting real-world components like industrial gearboxes, wire ropes, and pneumatic actuators.                                                                                                                                                                                                                                                               |                                                                                                                                                                                    |                      |                |                           |               |                           |           |
| <b>Course Objectives:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                    |                      |                |                           |               |                           |           |
| This course aims to equip students with the skills to design, analyze, and select standard material handling systems like conveyors, cranes, and automated units based on industrial payload demands. Students will learn to apply mechanical principles to optimize facility throughput, structural safety factors, and energy efficiency.                                                                                                                                                                                        |                                                                                                                                                                                    |                      |                |                           |               |                           |           |
| <b>Course Outcomes:</b> After learning the course, students will be able to                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                    |                      |                |                           |               |                           |           |
| <b>CO</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>Course Outcome</b>                                                                                                                                                              |                      |                |                           |               | <b>Bloom's Level</b>      |           |
| CO1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>EVALUATE</b> industrial layout requirements to scientifically select appropriate material handling equipment based on payload, travel constraints, and bulk material properties |                      |                |                           |               | 3                         |           |
| CO2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>DESIGN</b> structural and mechanical elements for industrial cranes and hoisting units, including wire ropes, drums, gearboxes, and safety braking systems                      |                      |                |                           |               | 3                         |           |
| CO3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>SYNTHESIZE</b> structural load configurations for lifting attachments (hooks, grabs) and continuous bulk material handling systems like conveyor lines and elevators            |                      |                |                           |               | 3                         |           |
| CO4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>INTEGRATE</b> automated components, sensors, and intelligent control logic to design modern, efficient, and autonomous material handling workflows                              |                      |                |                           |               | 3                         |           |
| <b>Course Content</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                    |                      |                |                           |               |                           |           |
| <b>Unit 1</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <b>Material handling system and Selection of material handling equipment</b>                                                                                                       |                      |                |                           | <b>8 Hrs.</b> | <b>CO Mapped: CO 1</b>    |           |

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|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------|---------------|------------------------|
| Principles and features of material handling system, importance, terminology, objectives and benefits of better material handling, classification of material handling equipment, choice of material handling equipment, factors affecting for selection, general analysis procedures, basic analytical techniques, the unit load concept                                                                                                                                                                                                                                                                                              |                                                |               |                        |
| <b>Unit 2</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>Design of cranes</b>                        | <b>8 Hrs.</b> | <b>CO Mapped: CO 2</b> |
| Hand-propelled and traveling mechanisms of cantilever and monorail cranes, design considerations for structures of rotary cranes with fixed radius, fixed post and overhead traveling cranes, stability of stationary rotary and traveling rotary cranes, electric overhead travelling crane - essential parts, design parameters, structural considerations, end carriages, long and cross travel mechanisms, brakes, motor selection, safety arrangements, electrical control system                                                                                                                                                 |                                                |               |                        |
| <b>Unit 3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>Load lifting attachments</b>                | <b>8 Hrs.</b> | <b>CO Mapped: CO 3</b> |
| Load chains and types of ropes used in material handling system, forged, standard and Ramshorn hooks, crane grabs and clamps; grab buckets; electromagnet; design consideration for conveyor belts; drums, sheaves, sprockets                                                                                                                                                                                                                                                                                                                                                                                                          |                                                |               |                        |
| <b>Unit 4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>Study of bulk material handling systems</b> | <b>8 Hrs.</b> | <b>CO Mapped: CO 4</b> |
| Objectives of storage; bulk material handling; gravity flow of solids through slides and chutes; storage in bins and hoppers; screw conveyor, vibratory conveyor, pneumatic & hydraulic conveyor (classification, types, principles of operation)                                                                                                                                                                                                                                                                                                                                                                                      |                                                |               |                        |
| <b>Unit 5</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>Automation in material handling</b>         | <b>8 Hrs.</b> | <b>CO Mapped: CO 5</b> |
| Control of hoisting & conveying machinery, material handling in direct-line production and automated lines, safety and design; safety regulations and discipline                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                |               |                        |
| <b>Reference Books:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                |               |                        |
| 1. N. Rudenko, 'Material Handling Equipment', Peace Publishers<br>2. James M. Apple, 'Material Handling System Design', John-Wiley and Sons<br>3. John R. Immer, 'Material Handling' McGraw Hill<br>4. Colin Hardi, 'Material Handling in Machine Shops'. Machinery Publication Co. Ltd.,<br>5. M .P. Nexandrn, 'Material Handling Equipment', MIR Publication,<br>6. C. R. Cock and J. Mason, 'Bulk Solid Handling', Leonard Hill Publication Co. Ltd.,<br>7. Spivakovsy, A.O. and Dyachkov, V.K., 'Conveying Machines', Volumes I and II, MIR Publishers,<br>8. Kulwiac R. A., 'Material Handling Hand Book', John Wiley Publication |                                                |               |                        |
| <b>MOOCs Links and additional reading material:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                |               |                        |
| 1. <a href="https://onlinecourses.nptel.ac.in/noc25_mm04/preview">https://onlinecourses.nptel.ac.in/noc25_mm04/preview</a><br>2. <a href="https://www.coursera.org/learn/machineries-for-heavy-lifting">https://www.coursera.org/learn/machineries-for-heavy-lifting</a><br>3. <a href="https://nptel.ac.in/courses/112104002">https://nptel.ac.in/courses/112104002</a>                                                                                                                                                                                                                                                               |                                                |               |                        |

**CO-PO mapping table:**

| CO   | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO 01 | PSO 02 | PSO 03 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|--------|--------|--------|
| CO1  | 3   | -   | 2   | 2   | 2   | -   | -   | 2   | 2   | -    | -    | 2      | 2      | 2      |
| CO2  | 3   | -   | 3   | 2   | 2   | -   | -   | 2   | 2   | -    | -    | 2      | 2      | 2      |
| CO3  | 2   | -   | 3   | 2   | 2   | -   | -   | 2   | 2   | -    | -    | 2      | 2      | 2      |
| CO4  | 3   | -   | 2   | 2   | 2   | -   | -   | 2   | 2   | -    | -    | 2      | 2      | 2      |
| Avg. | 3   | -   | 2.6 | 2   | 2.2 | -   | -   | 2   | 2   | -    | -    | 2      | 2      | 2      |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

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**Assessment Pattern**

| BT Level | CCE |     |                |            |                      |                          | ESE |
|----------|-----|-----|----------------|------------|----------------------|--------------------------|-----|
|          | CT1 | CT2 | Open Book Test | Assignment | Seminar / Case Study | Quiz / presentation etc. |     |
| L1       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L2       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L3       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L4       |     |     |                | ✓          | ✓                    |                          |     |
| L5       |     |     |                |            |                      |                          |     |
| L6       |     |     |                |            |                      |                          |     |

**Unit wise Weightage:**

| Exam           | Unit1 | Unit2 | Unit3 | Unit4 | Unit5 | Total |
|----------------|-------|-------|-------|-------|-------|-------|
| CT1            | 8     | 7     |       |       |       | 15    |
| CT2            |       |       | 8     | 7     |       | 15    |
| Open Book Test |       |       |       |       | 10    | 10    |
| Assignments    | 5     |       |       |       |       | 05    |
| Seminar        | 5     |       |       |       |       | 05    |
| ESE            | 10    | 10    | 10    | 10    | 10    | 50    |
|                |       |       |       |       |       | 100   |

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|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|---------------------------|----------------------|
| <b>Program:</b> F. Y. M. Tech                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                 |                 | <b>Semester:</b> II       |                      |
| <b>Course:</b> Elective – II<br>Computer-Aided Engineering                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                 |                 | <b>Course Code:</b>       | R25-MDE-MEC-513(C)   |
| <b>Teaching Scheme(Hrs/week)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                 |                 | <b>Credits</b>            |                      |
| <b>Lecture</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>Practical</b>                                                                                                                                                                                | <b>Tutorial</b> | <b>Examination Scheme</b> |                      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                 |                 | <b>CCE</b>                | <b>ESE</b>           |
| 03 Hrs/Week                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | -                                                                                                                                                                                               | -               | 03                        | 50                   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                 |                 |                           | 50                   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                 |                 |                           | -                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                 |                 |                           | -                    |
| <b>Course Description :</b><br>This course provides a comprehensive introduction to modern engineering simulation tools used to validate and optimize product designs before manufacturing. Students will learn the mathematical foundations and practical software workflows of Finite Element Analysis (FEA) for structural mechanics and Computational Fluid Dynamics (CFD) for fluid-thermal systems. By simulating real-world engineering challenges, participants will gain hands-on experience in geometry cleanup, mesh generation, setting boundary conditions, and interpreting simulation data to predict component failure, fatigue, and optimization pathways. |                                                                                                                                                                                                 |                 |                           |                      |
| <b>Course Relevance:</b><br>Computer-Aided Engineering (CAE) is critical for modern product development because it allows engineers to digitally test, simulate, and optimize designs before creating physical prototypes. This dramatically reduces development costs, shortens time-to-market, and ensures structural safety by predicting mechanical failures under real-world operational stresses.                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                 |                 |                           |                      |
| <b>Prerequisite:</b> Computer-Aided Engineering (CAE) course, require solid foundation in Strength of Materials and Fluid Mechanics to understand the physics behind the simulations. Additionally, proficiency in 3D CAD Modeling is required to build and import geometries, along with basic knowledge of Numerical Methods to comprehend how software solves complex engineering matrices.                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                 |                 |                           |                      |
| <b>Bridge Content:</b> - Transitions from static 3D CAD design to active digital simulation by linking their physical geometric models with governing mathematical laws. It teaches how to transform a rigid CAD assembly into a mesh of finite elements, preparing students to convert theoretical structural stresses into reliable, software-driven engineering predictions.                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                 |                 |                           |                      |
| <b>Course Objectives:</b><br>This course aims to teach students how to convert physical engineering problems into digital simulations using standard FEA and CFD workflows. It focuses on training students to analyze structural stresses, optimize component geometry, and predict material failures under real-world operational loads. By the end of the course, participants will be able to validate product designs virtually, significantly reducing prototyping costs and development timelines.                                                                                                                                                                   |                                                                                                                                                                                                 |                 |                           |                      |
| <b>Course Outcomes:</b> After learning the course, students will be able to                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                 |                 |                           |                      |
| <b>CO</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>Course Outcome</b>                                                                                                                                                                           |                 |                           | <b>Bloom's Level</b> |
| CO1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>APPLY</b> the CAE-driven design process to convert initial CAD geometries into optimized structural concepts through appropriate meshing, boundary condition setup, and convergence testing. |                 |                           | 3                    |
| CO2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>PERFORM</b> linear static analysis to determine stress, strain, and displacement fields under steady-state loads, verifying safety factors against material yield limits.                    |                 |                           | 3                    |
| CO3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>EXECUTE</b> normal modes and buckling analyses to identify structural natural frequencies and critical failure loads, preventing catastrophic structural collapse and resonance.             |                 |                           | 3                    |
| CO4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>CONDUCT</b> transient dynamic and advanced FEA simulations to evaluate structural integrity under time-varying impact loads,                                                                 |                 |                           | 3                    |

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|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|-------------------------------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | high-velocity fatigue, or non-linear material behaviors. |                               |
| <b>Course Content</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                          |                               |
| <b>Unit 1</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>CAE Driven Design Process</b>                         | <b>8 Hrs. CO Mapped: CO 1</b> |
| Analysis types, geometry clean-up, meshing techniques, 1-D, 2-D, and 3-D mesh, element selection, special elements, solution convergence, element quality checks, material information, boundary conditions, and loads.                                                                                                                                                                                                                                                                                                                                                                      |                                                          |                               |
| <b>Unit 2</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>Static Analysis</b>                                   | <b>8 Hrs. CO Mapped: CO 2</b> |
| Externally applied forces and pressures, steady-state inertial forces (such as gravity or rotational velocity), imposed (nonzero) displacements, temperatures (for thermal strain), non-linear structural analysis, model verification                                                                                                                                                                                                                                                                                                                                                       |                                                          |                               |
| <b>Unit 3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>Normal Modes and Buckling analysis</b>                | <b>8 Hrs. CO Mapped: CO 3</b> |
| Real eigenvalue analysis, governing equations, methods of computations, normal modes analysis, Block Lanczos and QR damped methods of modes extraction, linear buckling analysis                                                                                                                                                                                                                                                                                                                                                                                                             |                                                          |                               |
| <b>Unit 4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>Transient dynamic analysis</b>                        | <b>8 Hrs. CO Mapped: CO 4</b> |
| Dynamic modeling input, normal mode analysis, reduction in dynamic analysis, rigid body modes, damping, transient response analysis, frequency response analysis, direct matrix input, dynamic equations of motion, residual vector methods, enforced motion, shock and response spectrum analysis, random response analysis, complex eigenvalue analysis                                                                                                                                                                                                                                    |                                                          |                               |
| <b>Unit 5</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>Advanced topics in FEA</b>                            | <b>8 Hrs. CO Mapped: CO 4</b> |
| Complex eigenvalue analysis, normal mode analysis using parts super-element, transfer functions, normal modes of preloaded structures, dynamic design optimization, test-analysis correlation                                                                                                                                                                                                                                                                                                                                                                                                |                                                          |                               |
| <b>Reference Books:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                          |                               |
| 1. Strukturdynamik, R. Gasch, K. Knothe, Springer<br>2. Dynamics of Structures, W. C. Hurty and M. F. Rubinstein, Prentice-Hall<br>3. Dynamics of Structures, R. W. Clough and J. Penzien, McGraw-Hill<br>4. S. Timoshenko, D. H. Young, and W. Weaver, Jr., Vibration Problems in Engineering, John Wiley & Sons<br>5. K. J. Bathe and E. L. Wilson, Numerical Methods in Finite Element Analysis, Prentice-Hall<br>6. Theory of Matrix Structural Analysis, J.S. Przemieniecki, McGraw-Hill<br>7. Structural Dynamics: An Introduction to Computer Methods, R. R. Craig, John Wiley & Sons |                                                          |                               |
| <b>MOOCs Links and additional reading material:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                          |                               |
| 1. <a href="https://onlinecourses.nptel.ac.in/noc26_me126/preview">https://onlinecourses.nptel.ac.in/noc26_me126/preview</a><br>2. <a href="https://nptel.ac.in/courses/112104031">https://nptel.ac.in/courses/112104031</a><br>3. <a href="https://innovationspace.ansys.com/product/fundamentals-of-finite-element-fe-method/">https://innovationspace.ansys.com/product/fundamentals-of-finite-element-fe-method/</a>                                                                                                                                                                     |                                                          |                               |

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**CO-PO mapping table:**

| CO   | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO<br>01 | PSO<br>02 | PSO<br>03 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|-----------|-----------|-----------|
| CO1  | 3   | -   | 2   | 2   | 2   | -   | -   | 2   | 2   | -    | -    | 2         | 2         | 2         |
| CO2  | 3   | -   | 3   | 2   | 2   | -   | -   | 2   | 2   | -    | -    | 2         | 2         | 2         |
| CO3  | 2   | -   | 3   | 2   | 2   | -   | -   | 2   | 2   | -    | -    | 2         | 2         | 2         |
| CO4  | 3   | -   | 2   | 2   | 2   | -   | -   | 2   | 2   | -    | -    | 2         | 2         | 2         |
|      |     |     |     |     |     |     |     |     |     |      |      |           |           |           |
| Avg. | 3   | -   | 2.6 | 2   | 2.2 | -   | -   | 2   | 2   | -    | -    | 2         | 2         | 2         |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

**Assessment Pattern**

| BT Level | CCE |     |                |            |                      |                          | ESE |
|----------|-----|-----|----------------|------------|----------------------|--------------------------|-----|
|          | CT1 | CT2 | Open Book Test | Assignment | Seminar / Case Study | Quiz / presentation etc. |     |
| L1       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L2       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L3       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L4       |     |     |                | ✓          | ✓                    |                          |     |
| L5       |     |     |                |            |                      |                          |     |
| L6       |     |     |                |            |                      |                          |     |

**Unit wise Weightage:**

| Exam           | Unit1 | Unit2 | Unit3 | Unit4 | Unit5 | Total |
|----------------|-------|-------|-------|-------|-------|-------|
| CT1            | 8     | 7     |       |       |       | 15    |
| CT2            |       |       | 8     | 7     |       | 15    |
| Open Book Test |       |       |       |       | 10    | 10    |
| Assignments    | 5     |       |       |       |       | 05    |
| Seminar        | 5     |       |       |       |       | 05    |
| ESE            | 10    | 10    | 10    | 10    | 10    | 50    |
|                |       |       |       |       |       | 100   |

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|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|----------------|---------------------------|------------|----------------------|-----------|
| <b>Program:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                      | <b>F. Y. M. Tech</b>                                |                | <b>Semester:</b>          |            | <b>II</b>            |           |
| <b>Course:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                      | <b>Elective – III</b><br><b>Tribology in Design</b> |                | <b>Course Code:</b>       |            | R25-MDE-MEC-514(A)   |           |
| <b>Teaching Scheme(Hrs/week)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                      |                                                     | <b>Credits</b> | <b>Examination Scheme</b> |            |                      |           |
| <b>Lecture</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>Practical</b>                                                                                                                                                                                     | <b>Tutorial</b>                                     |                | <b>CCE</b>                | <b>ESE</b> | <b>TW</b>            | <b>PR</b> |
| 03 Hrs/Week                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | -                                                                                                                                                                                                    | -                                                   | 03             | 50                        | 50         | -                    | -         |
| <b>Course Description :</b><br>Tribology in Design explores the critical engineering principles of friction, wear, and lubrication to enhance the lifecycle and efficiency of moving machine components. The course focuses on analyzing surface interactions and fluid-film dynamics to select optimal lubricants and wear-resistant materials. By applying these concepts, students learn to minimize mechanical energy loss, prevent surface fatigue, and design highly reliable bearings, gears, and seals                     |                                                                                                                                                                                                      |                                                     |                |                           |            |                      |           |
| <b>Course Relevance:</b><br>Tribology in Design directly addresses the root causes of mechanical failure and energy loss—friction and wear—which account for massive economic losses globally. Mastering this subject allows engineers to extend machinery lifespans, improve energy efficiency, and design high-performance components like long-lasting bearings, gears, and bio-implants.                                                                                                                                       |                                                                                                                                                                                                      |                                                     |                |                           |            |                      |           |
| <b>Prerequisite:</b> Fundamental knowledge of undergraduate-level engineering mathematics including calculus, linear algebra, differential equations, vector calculus, numerical analysis, and basic probability & statistics. Familiarity with MATLAB or Python is desirable.                                                                                                                                                                                                                                                     |                                                                                                                                                                                                      |                                                     |                |                           |            |                      |           |
| <b>Bridge Content:</b> - Tribology in Design, require a strong foundation in Fluid Mechanics to understand lubrication regimes and viscous flow, alongside Strength of Materials to analyze contact stresses and surface deformation. Additionally, basic knowledge of Engineering Materials is required to understand how different metals, polymers, and coatings behave under friction and wear.                                                                                                                                |                                                                                                                                                                                                      |                                                     |                |                           |            |                      |           |
| <b>Course Objectives:</b><br>This course aims to teach students how to analyze the fundamental mechanisms of friction, wear, and lubrication at moving material interfaces. It focuses on training students to apply hydrodynamic and elastohydrodynamic lubrication theories to optimize power transmission components like bearings and gears. By the end of the course, participants will be able to select ideal lubricants, materials, and surface coatings to minimize energy loss and prevent premature mechanical failure. |                                                                                                                                                                                                      |                                                     |                |                           |            |                      |           |
| <b>Course Outcomes:</b> After learning the course, students will be able to                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                      |                                                     |                |                           |            |                      |           |
| <b>CO</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>Course Outcome</b>                                                                                                                                                                                |                                                     |                |                           |            | <b>Bloom's Level</b> |           |
| CO1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>DIAGNOSE AND QUANTIFY</b> the fundamental mechanisms of friction and wear across varying material interfaces to select wear-resistant materials and surface treatments for industrial components. |                                                     |                |                           |            | 3                    |           |
| CO2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>APPLY</b> fluid-film lubrication theories to design and evaluate the performance of finite journal bearings and air-lubricated bearings under steady-state operating conditions.                  |                                                     |                |                           |            | 3                    |           |
| CO3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>FORMULATE</b> mathematical models for hydrostatic squeeze films and elastohydrodynamic lubrication (EHL) to predict minimum film thickness and pressure distribution in highly loaded contacts.   |                                                     |                |                           |            | 3                    |           |
| CO4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>ANALYZE</b> the tribological aspects of rolling motion to minimize power loss, surface fatigue, and rolling resistance in mechanical assemblies like ball bearings, rollers, and gears.           |                                                     |                |                           |            | 3                    |           |

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| Course Content                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                   |               |                        |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|---------------|------------------------|
| <b>Unit 1</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>Friction and Wear</b>                                                          | <b>8 Hrs.</b> | <b>CO Mapped: CO 1</b> |
| Friction Control and Wear prevention, Boundary Lubrication, Tribological properties of Bearing Materials and Lubricants, Theories of friction and wear, instabilities and stick-slip motion.                                                                                                                                                                                                                                                                                                                                                        |                                                                                   |               |                        |
| <b>Unit 2</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>Lubrication of Bearings</b>                                                    | <b>8 Hrs.</b> | <b>CO Mapped: CO 2</b> |
| Mechanics of Fluid Flow, Reynold's Equation and its limitations, idealized bearings, infinitely long plane pivoted and fixed show sliders, infinitely long and infinitely short (narrow) journal bearings, lightly loaded infinitely long journal bearing (Petroff's solution).                                                                                                                                                                                                                                                                     |                                                                                   |               |                        |
| <b>Unit 3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>Finite Bearings and Air lubricated bearings</b>                                | <b>8 Hrs.</b> | <b>CO Mapped: CO 3</b> |
| Finite Bearings: Hydrostatic, Hydrodynamic, and thrust oil bearings, heat in bearings, Air Lubricated Bearings: Tilting pad bearings, hydrostatic, hydrodynamic, and thrust bearings with air lubrication.                                                                                                                                                                                                                                                                                                                                          |                                                                                   |               |                        |
| <b>Unit 4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>Hydrostatic squeeze film</b>                                                   | <b>8 Hrs.</b> | <b>CO Mapped: CO 4</b> |
| Circular and rectangular flat plates, variable and alternating loads, piston pin lubrications, and application to journal bearings.                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                   |               |                        |
| <b>Unit 5</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>Elasto-hydrodynamic Lubrication and Tribological aspects of rolling motion</b> | <b>8 Hrs.</b> | <b>CO Mapped: CO 4</b> |
| Pressure-viscosity term in Reynold's Equation, Hertz theory, Ertel-Grubin Equation, lubrication of spheres. The mechanics of tyre-road interaction, road grip, and rolling resistance, Tribological aspects of wheel on rail contact, Tribological aspects of metal rolling, drawing, and extrusion.                                                                                                                                                                                                                                                |                                                                                   |               |                        |
| <b>Reference Books:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                   |               |                        |
| 1. Basic Lubrication Theory- A Camaron<br>2. Principles of Lubrication – A Camaron, Longman's Green Co. Ltd.<br>3. Fundamentals of Tribology, S. K. Basu, S. N.Sengupatha and D. B.Ahuja, PHI.<br>4. Theory and Practice for Engineers – D. D. Fuller, John Wiley and sons.<br>5. Fundamental of Friction and Wear of Metals – ASM<br>6. The Design of Aerostatic Bearings – J. W. Powell<br>7. Gas Bearings – Grassam and Powell<br>8. Theory Hydrodynamic Lubrication Pinkush and Sterrolight<br>9. Tribology in Machine Design – T. A. Stolarski |                                                                                   |               |                        |
| <b>MOOCs Links and additional reading material:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                   |               |                        |
| 1. <a href="https://nptel.ac.in/courses/112102014">https://nptel.ac.in/courses/112102014</a><br>2. <a href="https://nptel.ac.in/courses/113108083">https://nptel.ac.in/courses/113108083</a><br>3. <a href="https://nptel.ac.in/courses/112102428">https://nptel.ac.in/courses/112102428</a>                                                                                                                                                                                                                                                        |                                                                                   |               |                        |

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**CO-PO mapping table:**

| CO   | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO<br>01 | PSO<br>02 | PSO<br>03 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|-----------|-----------|-----------|
| CO1  | 3   | -   | 2   | 2   | 2   | -   | -   | 2   | 2   | -    | -    | 2         | 2         | 2         |
| CO2  | 3   | -   | 3   | 2   | 2   | -   | -   | 2   | 2   | -    | -    | 2         | 2         | 2         |
| CO3  | 2   | -   | 3   | 2   | 2   | -   | -   | 2   | 2   | -    | -    | 2         | 2         | 2         |
| CO4  | 3   | -   | 2   | 2   | 2   | -   | -   | 2   | 2   | -    | -    | 2         | 2         | 2         |
|      |     |     |     |     |     |     |     |     |     |      |      |           |           |           |
| Avg. | 3   | -   | 2.6 | 2   | 2.2 | -   | -   | 2   | 2   | -    | -    | 2         | 2         | 2         |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

**Assessment Pattern**

| BT Level | CCE |     |                |            |                      |                          | ESE |
|----------|-----|-----|----------------|------------|----------------------|--------------------------|-----|
|          | CT1 | CT2 | Open Book Test | Assignment | Seminar / Case Study | Quiz / presentation etc. |     |
| L1       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L2       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L3       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L4       |     |     |                | ✓          | ✓                    |                          |     |
| L5       |     |     |                |            |                      |                          |     |
| L6       |     |     |                |            |                      |                          |     |

**Unit wise Weightage:**

| Exam           | Unit1 | Unit2 | Unit3 | Unit4 | Unit5 | Total |
|----------------|-------|-------|-------|-------|-------|-------|
| CT1            | 8     | 7     |       |       |       | 15    |
| CT2            |       |       | 8     | 7     |       | 15    |
| Open Book Test |       |       |       |       | 10    | 10    |
| Assignments    | 5     |       |       |       |       | 05    |
| Seminar        | 5     |       |       |       |       | 05    |
| ESE            | 10    | 10    | 10    | 10    | 10    | 50    |
|                |       |       |       |       |       | 100   |

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|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |                                                                                                                                                                                                                                            |                                                                          |                |                  |                           |           |                    |  |            |  |                      |  |           |  |   |  |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|----------------|------------------|---------------------------|-----------|--------------------|--|------------|--|----------------------|--|-----------|--|---|--|
| <b>Program:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |                                                                                                                                                                                                                                            | <b>F. Y. M. Tech</b>                                                     |                | <b>Semester:</b> |                           | <b>II</b> |                    |  |            |  |                      |  |           |  |   |  |
| <b>Course:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |  |                                                                                                                                                                                                                                            | <b>Elective – III<br/>Process Equipment and Piping System<br/>Design</b> |                |                  | <b>Course<br/>Code:</b>   |           | R25-MDE-MEC-514(B) |  |            |  |                      |  |           |  |   |  |
| <b>Teaching Scheme(Hrs/week)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |  |                                                                                                                                                                                                                                            |                                                                          | <b>Credits</b> |                  | <b>Examination Scheme</b> |           |                    |  |            |  |                      |  |           |  |   |  |
| <b>Lecture</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |  | <b>Practical</b>                                                                                                                                                                                                                           |                                                                          |                |                  | <b>Tutorial</b>           |           | <b>CCE</b>         |  | <b>ESE</b> |  | <b>TW</b>            |  | <b>PR</b> |  |   |  |
| 03 Hrs/Week                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |  |                                                                                                                                                                                                                                            |                                                                          | -              |                  | -                         |           | 03                 |  | 50         |  | 50                   |  | -         |  | - |  |
| <b>Course Description :</b><br>This course emphasize on the mechanical design, sizing, and structural analysis of industrial pressure vessels, heat exchangers, and piping systems in compliance with global standards like ASME Codes. It focuses on material selection, wall-thickness calculations, pipe routing, and flexibility analysis to ensure safe fluid transport. By the end of the course, students will be able to develop safe, code-compliant, and optimized plant processing layouts.                                                          |  |                                                                                                                                                                                                                                            |                                                                          |                |                  |                           |           |                    |  |            |  |                      |  |           |  |   |  |
| <b>Course Relevance:</b><br>Process Equipment and Piping System Design is critical for industries like oil and gas, pharmaceuticals, and chemical processing to ensure the safe containment and transport of hazardous, high-pressure fluids [image 4]. Mastering this subject prevents catastrophic structural failures, minimizes leakages, and optimizes plant layout efficiency. Furthermore, it bridges theoretical engineering with industrial practice by training students directly in global safety compliance codes like ASME Section VIII and B31.3. |  |                                                                                                                                                                                                                                            |                                                                          |                |                  |                           |           |                    |  |            |  |                      |  |           |  |   |  |
| <b>Prerequisite:</b> Process Equipment and Piping System Design, require strong foundation in Fluid Mechanics to calculate pressure drops and flow rates, alongside Strength of Materials to determine wall thickness and structural stress limits. Additionally, basic knowledge of Chemical Process Principles or Thermodynamics is required to understand plant operational conditions like temperature and pressure profiles.                                                                                                                               |  |                                                                                                                                                                                                                                            |                                                                          |                |                  |                           |           |                    |  |            |  |                      |  |           |  |   |  |
| <b>Bridge Content:</b> - Transitions from theoretical engineering formulas to practical industrial design by linking mechanical principles directly to global manufacturing standards. It shows how to transform abstract stress and fluid dynamics equations into concrete engineering solutions, like calculating the wall thickness of an ASME-coded pressure vessel or designing a flexible, stress-free piping layout.                                                                                                                                     |  |                                                                                                                                                                                                                                            |                                                                          |                |                  |                           |           |                    |  |            |  |                      |  |           |  |   |  |
| <b>Course Objectives:</b><br>This course aims how to mechanically size and analyze pressure vessels, storage tanks, and industrial piping networks in accordance with ASME codes. It focuses on training students to perform structural stress analysis, evaluate piping flexibility, and select appropriate materials to prevent structural failures. By the end of the course, participants will be able to design safe, cost-effective, and fully code-compliant processing plant layouts.                                                                   |  |                                                                                                                                                                                                                                            |                                                                          |                |                  |                           |           |                    |  |            |  |                      |  |           |  |   |  |
| <b>Course Outcomes:</b> After learning the course, students will be able to                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |  |                                                                                                                                                                                                                                            |                                                                          |                |                  |                           |           |                    |  |            |  |                      |  |           |  |   |  |
| <b>CO</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |  | <b>Course Outcome</b>                                                                                                                                                                                                                      |                                                                          |                |                  |                           |           |                    |  |            |  | <b>Bloom's Level</b> |  |           |  |   |  |
| CO1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |  | <b>FORMULATE AND EVALUATE</b> critical process design parameters (corrosion allowance, joint efficiency, design pressure, and temperature) to establish the boundary conditions for industrial processing systems.                         |                                                                          |                |                  |                           |           |                    |  |            |  | 3                    |  |           |  |   |  |
| CO2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |  | <b>DESIGN</b> internal components for thin-walled cylindrical and spherical vessels, tall columns, and large storage tanks under internal and external loading in compliance with standard codes (like ASME Section VIII Div 1 & API 650). |                                                                          |                |                  |                           |           |                    |  |            |  | 3                    |  |           |  |   |  |
| CO3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |  | <b>APPLY</b> advanced structural mechanics and stress distribution theories to analyze and design thick-walled high-pressure vessels, ensuring safety against auto-fretage and plastic                                                     |                                                                          |                |                  |                           |           |                    |  |            |  | 3                    |  |           |  |   |  |

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|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | deformation.                                                                                                                                                                                                         |               |
| CO4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <b>ENGINEER</b> industrial process piping layouts by calculating required pipe schedules, selecting fittings/valves, and executing thermal flexibility and pressure drop analyses according to ASME B31.3 standards. | 3             |
| <b>Course Content</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                      |               |
| <b>Unit 1</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>Process Design Parameters</b>                                                                                                                                                                                     | <b>8 Hrs.</b> |
| <b>CO Mapped: CO 1</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                      |               |
| Basic concepts in process design, block diagrams for flow of processes, material flow balance. Design pressures –temperatures, design stresses, factory of safety, minimum shell thickness and corrosion allowance, weld joints efficiency, design loading, stress concentration and thermal stresses, failure criteria, cost and profitability estimation. Introduction to design codes like IS-2825, ASME-SECT, EIGHT-DIV-II TEMA.API-650, BS-1500 & 1515.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                      |               |
| <b>Unit 2</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>Design of Cylindrical and Spherical Vessels</b>                                                                                                                                                                   | <b>8 Hrs.</b> |
| <b>CO Mapped: CO 2</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                      |               |
| Thin and thick-walled cylinder analysis, design of end closers, local stresses due to discontinuity or change of shape of the vessel, vessel opening compensation, design of standard and non-standard flanges, design of vessels and pipes under external pressure, design of supports for process vessels.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                      |               |
| <b>Unit 3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>Design of Tall Vessels and Large Storage Tanks</b>                                                                                                                                                                | <b>8 Hrs.</b> |
| <b>CO Mapped: CO 3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                      |               |
| Determination of equivalent stress under combined loadings including seismic and wind loads application of it to vertical equipment like distillation column.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                      |               |
| <b>Unit 4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>Design of Thick-Walled High-Pressure Vessels</b>                                                                                                                                                                  | <b>8 Hrs.</b> |
| <b>CO Mapped: CO 4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                      |               |
| Design by various theories of failure, construction of these vessels with high strength steel and other special methods.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                      |               |
| <b>Unit 5</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>Process Piping Design</b>                                                                                                                                                                                         | <b>8 Hrs.</b> |
| <b>CO Mapped: CO 4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                      |               |
| Flow diagrams and pipe work symbols, design of layout of water, steam and compressed air pipes work, pipe fitting, linings and flanged connections. Types of valves used on pipe line. Fabrication of pipe lines, expansion joints and pipe support.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                      |               |
| Planning, manufacture, inspection and erection of process equipment like pressure vessels, chimneys, ducting, heat exchangers, pulverizing equipment, etc. protective coatings, lining of vessels..                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                      |               |
| <b>Reference Books:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                      |               |
| 1. Process Equipment Design: By Dr. M.V. Joshi, Mc-Millan.<br>2. Process Equipment Design: By Browell and Young, John Wiley.<br>3. Plant Design and Economics: Max and Timasulaus Kalus – McGraw Hill.<br>4. Industrial Instrumentation servicing Hand Book: Cannel Grady, McGraw Hill.<br>5. Chemical Engineering Handbook: Perry John, McGraw Hill.<br>6. Chemical Equipment Design: B.C. Bhattacharya.<br>7. Industrial Pipe Work: D.N.W. Kentish, McGraw Hill.<br>8. Chemical Engineering: J.M. Coulson, Richardson, Sinnott Vol. VII, Maxwell, McMillan.<br>9. Pressure Vessel Design Hand Book: H. Bedna.<br>10. Dryden's outlines of Chemical Technology for the 2 : By Roa M. Gopala, Sitting M., East West Press Pvt. Ltd., New Delhi.<br>11. Applied Process Design for Chemical and Petrochemical, Vol. I, II and III : By E.E. Ludwig, Gulf Publication Co., Houston.<br>12. Chemical Process Control: An Introduction to Theory and Practice: By Stephanopoulos G., Prentice Hall of India, New Delhi.<br>13. Chemical Process Equipment Selection and Design: By Stanley M. Walas, Butterworth- Heinemann Series in Chemical Engineering.<br>14. Process System Analysis and Control: By D.R. Coughanowr, McGraw Hill, New York. |                                                                                                                                                                                                                      |               |

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15. Optimization of Chemical Processes: By Edgar T.F., Himmelblau D.M., McGraw Hill Book Co., New York.

**MOOCs Links and additional reading material:**

1. [https://onlinecourses.nptel.ac.in/noc23\\_ch69/preview](https://onlinecourses.nptel.ac.in/noc23_ch69/preview)
2. [https://digitalskills.iitpravartak.org.in/course\\_details.php?courseID=62&cart=](https://digitalskills.iitpravartak.org.in/course_details.php?courseID=62&cart=)
3. [https://onlinecourses.nptel.ac.in/noc21\\_ch52/preview](https://onlinecourses.nptel.ac.in/noc21_ch52/preview)

**CO-PO mapping table:**

| CO   | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO 01 | PSO 02 | PSO 03 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|--------|--------|--------|
| CO1  | 3   | -   | 2   | 2   | 2   | -   | -   | 2   | 2   | -    | -    | 2      | 2      | 2      |
| CO2  | 3   | -   | 3   | 2   | 2   | -   | -   | 2   | 2   | -    | -    | 2      | 2      | 2      |
| CO3  | 2   | -   | 3   | 2   | 2   | -   | -   | 2   | 2   | -    | -    | 2      | 2      | 2      |
| CO4  | 3   | -   | 2   | 2   | 2   | -   | -   | 2   | 2   | -    | -    | 2      | 2      | 2      |
| Avg. | 3   | -   | 2.6 | 2   | 2.2 | -   | -   | 2   | 2   | -    | -    | 2      | 2      | 2      |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

**Assessment Pattern**

| BT Level | CCE |     |                |            |                      |                          | ESE |
|----------|-----|-----|----------------|------------|----------------------|--------------------------|-----|
|          | CT1 | CT2 | Open Book Test | Assignment | Seminar / Case Study | Quiz / presentation etc. |     |
| L1       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L2       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L3       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L4       |     |     |                | ✓          | ✓                    |                          |     |
| L5       |     |     |                |            |                      |                          |     |
| L6       |     |     |                |            |                      |                          |     |

**Unit wise Weightage:**

| Exam           | Unit1 | Unit2 | Unit3 | Unit4 | Unit5 | Total |
|----------------|-------|-------|-------|-------|-------|-------|
| CT1            | 8     | 7     |       |       |       | 15    |
| CT2            |       |       | 8     | 7     |       | 15    |
| Open Book Test |       |       |       |       | 10    | 10    |
| Assignments    | 5     |       |       |       |       | 05    |
| Seminar        | 5     |       |       |       |       | 05    |
| ESE            | 10    | 10    | 10    | 10    | 10    | 50    |
|                |       |       |       |       |       | 100   |

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|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-------------------------------------------------------------------------------------|--|---------------------------|-------------------------|----------------------|---------------------|--|
| <b>Program:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                 |                 | <b>F. Y. M. Tech</b>                                                                |  |                           | <b>Semester:</b>        |                      | <b>II</b>           |  |
| <b>Course:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                 |                 | <b>Elective – III<br/>Material Science and Mechanical Behavior<br/>of Materials</b> |  |                           | <b>Course<br/>Code:</b> |                      | R25-MDE-MEC-514(C)) |  |
| <b>Teaching Scheme(Hrs/week)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                 |                 | <b>Credits</b>                                                                      |  | <b>Examination Scheme</b> |                         |                      |                     |  |
| <b>Lecture</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>Practical</b>                                                                                                                                                                                | <b>Tutorial</b> |                                                                                     |  | <b>CCE</b>                | <b>ESE</b>              | <b>TW</b>            | <b>PR</b>           |  |
| 03 Hrs/Week                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                 |                 | 03                                                                                  |  | 50                        | 50                      | -                    | -                   |  |
| <b>Course Description :</b><br>This course explores the fundamental relationships between the internal structure of engineering materials and their macroscopic mechanical properties. Students will study crystal structures, defects, diffusion, and phase transformations alongside mechanical behaviors such as elasticity, plasticity, dislocation mechanics, fracture, fatigue, and creep. By evaluating how microstructural variations and environmental conditions impact material limits, participants will gain the analytical skills necessary to predict mechanical failure and select optimal materials for demanding structural applications. |                                                                                                                                                                                                 |                 |                                                                                     |  |                           |                         |                      |                     |  |
| <b>Course Relevance:</b><br>Material Science and Mechanical Behavior of Materials is highly relevant because it dictates how structures and machines respond to physical forces, directly determining their safety, durability, and cost-effectiveness. In fields ranging from aerospace to material handling, understanding atomic structures and failure modes like fatigue, fracture, and creep allows engineers to prevent catastrophic disasters. This knowledge bridges the gap between pure physics and practical engineering, ensuring that parts are optimized for weight, strength, and longevity under harsh industrial operating conditions.    |                                                                                                                                                                                                 |                 |                                                                                     |  |                           |                         |                      |                     |  |
| <b>Prerequisite:</b> To study Material Science and Mechanical Behavior of Materials, require a solid foundation in Engineering Chemistry to understand atomic bonding and crystal structures, alongside Engineering Mechanics (Statics) to grasp how external forces load a material. Additionally, an introductory understanding of Calculus-based Physics is required to analyze thermodynamics, atomic diffusion, and microstructural phase transformations.                                                                                                                                                                                             |                                                                                                                                                                                                 |                 |                                                                                     |  |                           |                         |                      |                     |  |
| <b>Bridge Content:</b> - Transitions from general chemistry and physics concepts to active structural engineering applications by linking microscopic atomic patterns with real-world material strengths. It demonstrates how atomic bond types, crystalline arrays, and microstructural flaws directly dictate macroscopic mechanical responses—explaining precisely why a metal will deform plastically under a tensile load, while a brittle ceramic will fracture catastrophically.                                                                                                                                                                     |                                                                                                                                                                                                 |                 |                                                                                     |  |                           |                         |                      |                     |  |
| <b>Course Objectives:</b><br>This course aims to teach students how the microscopic structure, defects, and phase transformations of engineering materials dictate their macroscopic mechanical properties. It focuses on training students to analyze and predict structural behaviors under real-world loads, including elasticity, plasticity, fracture, fatigue, and creep. By the end of the course, participants will be able to systematically select and treat materials to prevent mechanical failure in demanding engineering applications.                                                                                                       |                                                                                                                                                                                                 |                 |                                                                                     |  |                           |                         |                      |                     |  |
| <b>Course Outcomes:</b> After learning the course, students will be able to                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                 |                 |                                                                                     |  |                           |                         |                      |                     |  |
| <b>CO</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>Course Outcome</b>                                                                                                                                                                           |                 |                                                                                     |  |                           |                         | <b>Bloom’s Level</b> |                     |  |
| CO1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | ANALYZE the response of metals and alloys to applied load by correlating atomic lattice structures, dislocation mechanisms, and microstructural defects with macroscopic mechanical properties. |                 |                                                                                     |  |                           |                         | 3                    |                     |  |
| CO2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | EVALUATE the structural integrity of mechanical components via material testing under complex loading, interpreting multi-axial stress states and yielding conditions.                          |                 |                                                                                     |  |                           |                         | 3                    |                     |  |

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|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| CO3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>FORMULATE</b> mathematical models for macroscopic plastic behavior and elastic-plastic equilibrium to calculate stress distribution, strain hardening parameters, and residual stresses in deformed components. | 3             |
| CO4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>CHARACTERIZE</b> elasto-visco-plasticity in engineering alloys to predict time-dependent creep strain, rate-dependent plastic flow, and structural failure under long-term high-temperature conditions.         | 3             |
| <b>Course Content</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                    |               |
| <b>Unit 1</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <b>Response of metals and alloys to applied load</b>                                                                                                                                                               | <b>8 Hrs.</b> |
| <b>CO Mapped: CO 1</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                    |               |
| Stress, strain, transformations, Mohr's circle, isotropic elasticity, anisotropic elasticity, anisotropic thermal expansion, octahedral shear stress, yield criteria, yield surface, yield curve.                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                    |               |
| <b>Unit 2</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <b>Material Testing under Complex Loading</b>                                                                                                                                                                      | <b>8 Hrs.</b> |
| <b>CO Mapped: CO 2</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                    |               |
| Tensile testing–uni-axial and biaxial tension test, full range stress-strain curves, true stress-strain curve, Bridgman correction, temperature rise, Bauschinger effect, combined bending and torsion test, three-point bend test, elastic recovery.                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                    |               |
| <b>Unit 3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <b>Plastic Behavior</b>                                                                                                                                                                                            | <b>8 Hrs.</b> |
| <b>CO Mapped: CO 3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                    |               |
| Experimental studies of plastic deformations under simple and complex loading, strain hardening, power law approximations, isotropic, kinematic and combined hardening models, theory of plastic flow, strain-rate and temperature dependence of flow stress, deformation theory of plasticity, thermo-plasticity, behavior of metals with initial deformations..                                                                                                                                                                                                                                    |                                                                                                                                                                                                                    |               |
| <b>Unit 4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <b>Elastic-Plastic Equilibrium</b>                                                                                                                                                                                 | <b>8 Hrs.</b> |
| <b>CO Mapped: CO 4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                    |               |
| Equations of Elastic-Plastic Equilibrium, residual stresses and strains, plastic-rigid body, elastic- plastic bending and torsion, elastic-plastic bodies under variable loading, shake down theorems.                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                    |               |
| <b>Unit 5</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <b>Elasto-Visco-Plasticity</b>                                                                                                                                                                                     | <b>8 Hrs.</b> |
| <b>CO Mapped: CO 5</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                    |               |
| Visco-elasticity, rheological models, Maxwell model, Voigt model, Voigt–Maxwell model, damping, natural decay, dependence of damping and elastic modulus on frequency, thermo-elastic effect, low temperature and high temperature visco-plastic deformation models, rubber elasticity, damping, yielding, effect of strain rate, crazing.                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                    |               |
| <b>Reference Books:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                    |               |
| 1. Fundamentals of Materials Science and Engineering, William D. Callister, Jr., John Wiley & Sons,<br>2. Mechanical Metallurgy, George E. Dieter, McGraw-Hill Book Company, 1988<br>3. Theory of Plasticity, J. Chakrabarty, Elsevier, 2006<br>4. Foundations of Theory of Plasticity, L. M. Kachanov, Dover Publications, 2004<br>5. Theory of Plasticity and Metal Forming Processes, Sadhu Singh, Khanna Publishers<br>6. Mechanical Behavior of Materials, W. F. Hosford, Cambridge University Press, 2005<br>7. Plasticity for Structural Engineers, W.F. Chen, Da-Jian Han, SpringerNew York. |                                                                                                                                                                                                                    |               |
| <b>MOOCs Links and additional reading material:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                    |               |
| 1. <a href="https://nptel.ac.in/courses/113104104">https://nptel.ac.in/courses/113104104</a><br>2. <a href="https://onlinecourses.nptel.ac.in/noc21_mm27/preview">https://onlinecourses.nptel.ac.in/noc21_mm27/preview</a><br>3. <a href="https://nptel.ac.in/courses/112103279">https://nptel.ac.in/courses/112103279</a><br>4. <a href="https://www.youtube.com/watch?v=qOcX76owChA">https://www.youtube.com/watch?v=qOcX76owChA</a>                                                                                                                                                               |                                                                                                                                                                                                                    |               |

**CO-PO mapping table:**

| CO   | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO<br>01 | PSO<br>02 | PSO<br>03 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|-----------|-----------|-----------|
| CO1  | 3   | -   | 2   | 2   | 2   | -   | -   | 2   | 2   | -    | -    | 2         | 2         | 2         |
| CO2  | 3   | -   | 3   | 2   | 2   | -   | -   | 2   | 2   | -    | -    | 2         | 2         | 2         |
| CO3  | 2   | -   | 3   | 2   | 2   | -   | -   | 2   | 2   | -    | -    | 2         | 2         | 2         |
| CO4  | 3   | -   | 2   | 2   | 2   | -   | -   | 2   | 2   | -    | -    | 2         | 2         | 2         |
|      |     |     |     |     |     |     |     |     |     |      |      |           |           |           |
| Avg. | 3   | -   | 2.6 | 2   | 2.2 | -   | -   | 2   | 2   | -    | -    | 2         | 2         | 2         |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

**Assessment Pattern**

| BT Level | CCE |     |                |            |                      |                          | ESE |
|----------|-----|-----|----------------|------------|----------------------|--------------------------|-----|
|          | CT1 | CT2 | Open Book Test | Assignment | Seminar / Case Study | Quiz / presentation etc. |     |
| L1       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L2       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L3       | ✓   | ✓   | ✓              | ✓          | ✓                    |                          | ✓   |
| L4       |     |     |                | ✓          | ✓                    |                          |     |
| L5       |     |     |                |            |                      |                          |     |
| L6       |     |     |                |            |                      |                          |     |

**Unit wise Weightage:**

| Exam           | Unit1 | Unit2 | Unit3 | Unit4 | Unit5 | Total |
|----------------|-------|-------|-------|-------|-------|-------|
| CT1            | 8     | 7     |       |       |       | 15    |
| CT2            |       |       | 8     | 7     |       | 15    |
| Open Book Test |       |       |       |       | 10    | 10    |
| Assignments    | 5     |       |       |       |       | 05    |
| Seminar        | 5     |       |       |       |       | 05    |
| ESE            | 10    | 10    | 10    | 10    | 10    | 50    |
|                |       |       |       |       |       | 100   |

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|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|----------------|---------------------------|------------|----------------------|-----------|
| <b>Program:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                      | <b>F. Y. M. Tech</b> |                | <b>Semester:</b>          |            | <b>II</b>            |           |
| <b>Course:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                      | <b>Seminar I</b>     |                | <b>Course Code:</b>       |            | R25-MDE-SEMI-515     |           |
| <b>Teaching Scheme(Hrs/week)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                      |                      | <b>Credits</b> | <b>Examination Scheme</b> |            |                      |           |
| <b>Lecture</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>Practical</b>                                                                                                                                                                                     | <b>Tutorial</b>      |                | <b>CCE</b>                | <b>ESE</b> | <b>TW</b>            | <b>OR</b> |
| -                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 04                                                                                                                                                                                                   | -                    | 03             | -                         | -          | 25                   | 25        |
| <b>Course Description :</b><br>This course provides a structured platform for postgraduate students to explore, analyze, and present state-of-the-art research and emerging industrial trends in mechanical design engineering. Students will develop advanced research skills, learning how to conduct rigorous literature reviews, critically evaluate high-impact peer-reviewed journal papers (such as ASME, Elsevier, or Springer), and synthesize complex technical data. By framing engineering problem statements, analyzing diverse design methodologies, and delivering formal technical presentations, participants will hone the critical communication and analytical skills required for their subsequent dissertation work and professional engineering careers. |                                                                                                                                                                                                      |                      |                |                           |            |                      |           |
| <b>Course Objectives:</b><br>This seminar course aims to train postgraduate students to systematically investigate, critically review, and synthesize state-of-the-art research papers in mechanical design engineering. It focuses on developing skills to identify active research gaps, frame complex technical problem statements, and compile comprehensive engineering reports. By the end of the course, participants will be equipped to confidently deliver professional technical presentations to an expert academic panel, establishing a solid foundation for their master's dissertation.                                                                                                                                                                         |                                                                                                                                                                                                      |                      |                |                           |            |                      |           |
| <b>Course Outcomes:</b> After learning the course, students will be able to                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                      |                      |                |                           |            |                      |           |
| <b>CO</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>Course Outcome</b>                                                                                                                                                                                |                      |                |                           |            | <b>Bloom's Level</b> |           |
| CO1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>CONDUCT</b> systematic, comprehensive literature reviews across high-impact, peer-reviewed international journals to identify contemporary trends and paradigms in mechanical design engineering. |                      |                |                           |            | 3                    |           |
| CO2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>CRITICALLY ANALYZE</b> diverse design methodologies and experimental data to define clear research gaps and frame rigorous engineering problem statements.                                        |                      |                |                           |            | 3                    |           |
| CO3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>AUTHOR</b> structured, technically sound engineering reports and review papers that adhere to international academic standards, ethical citation guidelines, and professional formatting.         |                      |                |                           |            | 3                    |           |
| CO4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>DEFEND</b> complex technical findings and engineering concepts through organized, visually engaging presentations and articulate oral responses before a reviewing academic panel.                |                      |                |                           |            | 3                    |           |
| <b>Course Content</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                      |                      |                |                           |            |                      |           |
| The student shall have to deliver the seminar I in semester II on a topic approved by guide and authorities. It is recommended to allot guide to the student since the commencement of semester I. The guide allotment preferably needs to be carried out in synchronization with mutual domains of interest. It is recommended that seminar shall be on the topic relevant to latest trends in the field of concerned branch, preferably on the topic of specialization based on the electives selected or domain of interest.                                                                                                                                                                                                                                                 |                                                                                                                                                                                                      |                      |                |                           |            |                      |           |
| It is appreciated and strongly recommended that the student will select the domain of his/her dissertation and identify the literature confined to the domain. Thorough literature study based on the broad identified topic has                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                      |                      |                |                           |            |                      |           |

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to be carried out. This practice will eventually lead to convergence of the efforts for the dissertation in Semester III and IV.

The relevant literature then be explored as state-of-the-art, exotic, recent technological advancement, future trend, application and research & innovation. Multidisciplinary topics are encouraged. The student shall submit the duly approved and certified seminar report in standard format, for satisfactory completion of the work by the concerned Guide and head of the department/institute. The student will be assessed based on his/her presentation and preparations by the panel of examiners out of them one has to be an external examiner.

The students are expected to validate their study undertaken by publishing it at standard platforms.

The student has to exhibit the continuous progress through regular reporting and presentations and proper documentation the frequency of the activities in the sole discretion of the PG coordination.

The continuous assessment of the progress need to be documented unambiguously. For standardization and documentation, follow the guidelines circulated by the Department of Mechanical Engineering.

#### **Seminar I Evaluation Matrix:**

##### **Continuous Internal Assessment (Report & Review Phase): 50%**

- 20% — Literature Depth & Gap Identification: Depth of critical analysis across 15+ high-impact journal papers and clear justification of research gaps.
- 15% — Problem Statement Formulation: Clarity, boundary conditions, and design parameters of the engineering problem statement.
- 15% — Report Writing, Structure & Ethical Citations: Technical report organization, structural data flow, and flawless adherence to IEEE/ASME referencing styles.

##### **Panel Evaluation (Presentation & Defense): 50%**

- 15% — Technical Content & Design Rigour: Depth of mechanical design comprehension, analytical validations, equations, or FEA interpretation shown.
- 15% — Q&A Defense & Expert Panel Interaction: Ability to confidently defend the topic and provide precise technical answers to panel questions.
- 10% — Slide Design & Visual Delivery: Clear layout, high-quality engineering schematics, and clean, uncluttered visual aids.
- 10% — Oral Delivery & Professionalism: Vocal clarity, pace, time management, and poise.

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**CO-PO mapping table:**

| CO   | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO<br>01 | PSO<br>02 | PSO<br>03 |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|-----------|-----------|-----------|
| CO1  | 3   | -   | 2   | 2   | 2   | -   | -   | 2   | 2   | -    | -    | 2         | 2         | 2         |
| CO2  | 3   | -   | 3   | 2   | 2   | -   | -   | 2   | 2   | -    | -    | 2         | 2         | 2         |
| CO3  | 2   | -   | 3   | 2   | 2   | -   | -   | 2   | 2   | -    | -    | 2         | 2         | 2         |
| CO4  | 3   | -   | 2   | 2   | 2   | -   | -   | 2   | 2   | -    | -    | 2         | 2         | 2         |
|      |     |     |     |     |     |     |     |     |     |      |      |           |           |           |
| Avg. | 3   | -   | 2.6 | 2   | 2.2 | -   | -   | 2   | 2   | -    | -    | 2         | 2         | 2         |

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

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|                           |                 |          |         |                    |                 |    |    |
|---------------------------|-----------------|----------|---------|--------------------|-----------------|----|----|
| Program:                  | F. Y. M. Tech   |          |         | Semester:          | II              |    |    |
| Course:                   | Human Rights II |          |         | Course Code:       | R25-MDE-CTS-516 |    |    |
| Teaching Scheme(Hrs/week) |                 |          | Credits | Examination Scheme |                 |    |    |
| Lecture                   | Practical       | Tutorial |         | CCE                | ESE             | TW | PR |
| -                         | -               | -        | 01      | -                  | -               | -  | -  |

**Course Description:**

The Human Rights – II course is designed as a foundational credit program for postgraduate students. It introduces the structural framework of human dignity, liberty, and universal freedoms as recognized both globally and nationally. The course unpacks the historical evolution of rights—transitioning from philosophical concepts to enforceable international treaties—and bridges them directly with the Fundamental Rights outlined in Part III of the Constitution of India. Through analyzing the Universal Declaration of Human Rights (UDHR) and key covenants, the curriculum trains students to evaluate how civil, political, and socio-economic rights impact everyday governance and citizenship..

**Course Relevance:**

- **Promotes Constitutional Literacy:** Connects abstract international principles to real-world protections under Indian law, making students aware of their constitutional remedies.
- **Fosters Social Empathy:** Deepens the understanding of systemic inequalities, discrimination, and the struggles of marginalized groups to ensure a more inclusive worldview.
- **Enhances Professional Value:** Equips students entering fields like law, corporate governance, human resources, journalism, civil services, or NGOs with crucial compliance and ethical knowledge.
- **Develops Critical Thinking:** Empowers students to critically evaluate contemporary social justice issues, state policies, and the complex balance between individual liberties and state security.
- **Encourages Global Citizenship:** Aligns local socio-political issues with global benchmarks set by the United Nations, helping students look at humanitarian challenges through a global lens.

**Course Objectives:**

The primary objectives of the Human Rights – II postgraduate course at SPPU are to:

- **Understand Vulnerability Frameworks:** To define and conceptualize the precise meaning of "vulnerability" and "disadvantage" within modern social, economic, and political contexts.
- **Analyze Structural Problems:** To study and evaluate the deeply rooted customary, cultural, and socio-economic biases that continuously target marginalized populations.
- **Evaluate Legal & International Standards:** To understand major global frameworks (such as UN declarations and conventions) alongside domestic constitutional provisions safeguarding the rights of women and children.
- **Examine Marginalization in India:** To look closely at the socio-economic status, legal safeguards, and real-world struggles of Scheduled Castes (SC), Scheduled Tribes (ST), minorities, the elderly, and disabled citizens specifically in the Indian scenario.
- **Investigate Contemporary Rights Violations:** To address the highly nuanced legal protections, structural gaps, and societal apathy faced by special groups like stateless individuals, migrant workers, and sex workers

**Course Outcomes:** Upon successful completion of this course, students will be able to:

- **CO1 -Conceptual Clarity:** Ability to clearly identify, classify, and critique structural and socio-economic vulnerabilities across different layers of society.
- **CO 2 - Advocacy & Sensitisation:** Development of an empathetic, human-centric approach toward resolving rights violations, enabling students to advocate for women, children, and minority groups.
- **CO3 - Policy Analysis: Competency to critically evaluate government welfare schemes** and legal safeguards for Scheduled Castes (SC), Scheduled Tribes (ST), and the disabled, pointing out

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implementation gaps.

- **CO 4- Problem Solving:** Aptitude to address contemporary human rights challenges faced by highly exposed populations like migrant workers, refugees, and stateless persons

**NOTE:** This is self-paced Course, Students should study as per course content and submit one summary Assignment for the Course for the evaluation of 1 Credit.

#### Course Content

| Unit 1                                                                                                                                                             | Vulnerable and Disadvantaged Groups            | - | CO Mapped: CO 1 and CO 4 |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------|---|--------------------------|
| Meaning and core concepts of vulnerability and disadvantage. Customary, socio-economic, and cultural problems faced by these groups.                               |                                                |   |                          |
| Unit 2                                                                                                                                                             | Social Status of Women and Children            | - | CO Mapped: CO 2 and CO 4 |
| International and national standards on Human Rights and Women's Rights. International and national legal benchmarks for the Human Rights of Children.             |                                                |   |                          |
| Unit 3                                                                                                                                                             | Socially and Economically Disadvantaged People | - | CO Mapped: CO 3 and CO 4 |
| Position of Scheduled Castes (SC), Scheduled Tribes (ST), and other marginalized groups in India. Human rights protections for the aged, disabled, and minorities. |                                                |   |                          |
| Unit 4                                                                                                                                                             | Contemporary Rights of Vulnerable Populations  | - | CO Mapped: CO 3 and CO 4 |
| Rights and legal status of stateless persons.<br>Rights, protections, and social challenges concerning sex workers, migrant workers, and other specific groups     |                                                |   |                          |

#### Reference Books:

1. International Law & Human Rights by Dr. H.O. Agarwal
2. Introduction to the Constitution of India by Dr. D.D. Basu (or M. Laxmikanth)
3. Human Rights in India: Problems and Perspectives by B.P. Singh Sehgal

#### MOOCs Links and additional reading material:

1. <https://www.classcentral.com/course/swayam-human-rights-law-and-criminal-justice-23002>
2. [https://onlinecourses.swayam2.ac.in/cec21\\_lw07/preview](https://onlinecourses.swayam2.ac.in/cec21_lw07/preview)

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