# INSTITUTE OF AERONAUTICAL ENGINEERING

**(Autonomous)**

Dundigal, Hyderabad - 500 043

## MECHANICAL ENGINEERING

## COURSE DESCRIPTION FORM

| Course Title | DYNAMICS OF MACHINERY | | | |
|---|---|---|---|---|
| Course Code | A50317 | | | |
| Regulations | R13-JNTUH | | | |
| Course Structure | **Lectures** | **Tutorials** | **Practicals** | **Credits** |
| | 4 | 1 | - | 4 |
| Course Coordinator | Prof. V.V.S.H. Prasad, Professor | | | |
| Team of Instructors | Prof. V.V.S.H. Prasad, Professor, Ms. D. Krishnaja, Assistant Professor | | | |

## I.    COURSE OVERVIEW

Mechanical devices are designed to have mobility to perform certain functions. The theory behind the study of DOM leads us to design machines by understanding the relationship between the geometry and the movement of various parts of machine through kinematics and then considering the forces and their effects by Dynamics of machinery. This course will provide the knowledge on how to analyze the forces acting on various parts of machines and design machines to give required output. This includes relative force analysis and calculation of gyroscopic couples, analyzing forces acting on brakes and clutches, considering the effect of friction, balancing of reciprocating and rotating parts of machines by simultaneous graphical and analytical analysis and minimizing vibrations in various parts of a machine.

## II.    PREREQUISITE(S)

| Level | Credits | Periods | Prerequisite |
|---|---|---|---|
| UG | 4 | 4 | Mathematics, Physics, Mechanics, Kinematics of Machinery. |

## III.    MARKS DISTRIBUTION

| Sessional Marks | University End Exam Marks | Total Marks |
|---|---|---|
| There shall be 2 midterm examinations. Each midterm examination consists of subjective type and Objective type tests. The subjective test is for 10 marks, with duration of 1 hour. Subjective test of each midterm exam shall contain 4 questions. The student has to answer 2 questions, each carrying 5 marks. The objective type test is for 10 marks with duration of 20minutes. It consists of 10 Multiple choice and 10 objective type questions. The student has to answer all the questions and each carries half mark.<br>First midterm examination shall be conducted for the first 2 ½ units of syllabus and second midterm examination shall be conducted for the remaining 2 ½ units.<br><br>Five marks are earmarked for assignments. There shall be two assignments in every theory course. Marks shall be awarded considering the average of two assignments in each course reason whatsoever, will get zero marks(s). | 75 | 100 |

## IV.    EVALUATION SCHEME

| S.No | Component | Duration | Marks |
|------|-----------|----------|-------|
| 1 | I Mid examination | 90 minutes | 20 |
| 2 | I Assignment | -- | 05 |
| 3 | II Mid examination | 90 minutes | 20 |
| 4 | II Assignment | -- | 05 |
| 5 | External examination | 3 hours | 75 |

## V.    COURSE OBJECTIVES

i.   **Understanding** the basic principles of dynamics and to determine the forces acting on machines.
ii.  **Demonstrating** the concept of synthesis and analysis of different machines.
iii. **Explanation** of the working of various dynamometers, brakes, clutches and governors
iv.  **Understanding** the concepts of force analysis, proper balancing & minimizing vibrations.
v.   **Determine** the fundamental frequency of mechanical systems.

## VI.    COURSE OUTCOMES

**After completing this course the student must demonstrate the knowledge and ability to:**

1.  **Analyze** the different forces acting on machines.

2.  **Illustrate** the schematic drawing of real world machines.

3.  **Understand** the basic machine components.

4.  **Compare** different methods of analysis.

5.  **Classify** various machine components

6.  **State** the principles of virtual work, D'Alembert and superposition of forces.

7.  **Compare** different design concepts

8.  **State** the importance of different forces acting on machines.

9.  **Understand** importance of Graphical methods for design.

10. **Illustrate** various analyzing techniques.

11. **Elaborate** the plan to create a machine that competes with the other manufacturers.

12. **Construct** turning moment diagrams.

13. **Elaborate** the Design of machines considering friction, vibrations and balancing properly.

## VII.    HOW PROGRAM OUTCOMES ARE ASSESSED

| | Program outcomes | Level | Proficiency assessed by |
|---|---|---|---|
| PO1 | Capability to apply the knowledge of mathematics, science and engineering in the field of mechanical engineering. | H | Assignments and Tutorials |
| PO2 | An ability to analyze complex engineering problems to arrive at relevant conclusion using knowledge of mathematics, science and engineering. | H | Tutorials |
| PO3 | Competence to design a system, component or process to meet societal needs within realistic constraints. | S | Exams |
| PO4 | To design and conduct research oriented experiments as well as to analyze and implement data using research methodologies. | S | Mini Projects |
| PO5 | An ability to formulate solve complex engineering problem using modern engineering and information Technology tools. | H | Assignments, Exams |
| PO6 | To utilize the engineering practices, techniques, skills to meet needs of the health, safety, legal, cultural and societal issues. | N | Assigning Mini Projects |
| PO7 | To understand impact of engineering solutions in the societal context and demonstrate the knowledge for sustainable development. | S | Assignments |
| PO8 | An understanding and implementation of professional and ethical responsibilities. | H | ------ |
| PO9 | To function as an effective individual and as a member or leader in multi disciplinary environment and adopt in diverse teams. | S | Assignments, Tutorials and Exams |
| PO10 | An ability to assimilate, comprehend, communicate, give & receive instructions to present effectively with engineering community and society. | S | ----- |
| PO11 | An ability to provide leadership in managing complex engineering projects at multidisciplinary environment and to become a Technocrat. | H | Mini Projects |
| PO12 | Recognition of the need and an ability to engage in lifelong learning to keep abreast with technological changes. | S | ------ |

**N - None**      **S - Supportive**      **H – Highly Related**

## VIII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED

| | Program Specific Outcomes | Level | Proficiency Assessed by |
|---|---|---|---|
| PSO 1 | **Professional Skills:** To produce engineering professional capable of synthesizing and analyzing mechanical systems including allied engineering streams. | H | Lectures, Assignments |
| PSO 2 | **Design/ Analysis:** An ability to adopt and integrate current technologies in the design and manufacturing domain to enhance the employability. | S | Projects |
| PSO 3 | **Successful Career and Entrepreneurship:** To build the nation, by imparting technological inputs and managerial skills to become Technocrats. | H | Guest Lectures |

**N - None**      **S - Supportive**      **H – Highly Related**

## IX. SYLLABUS

### UNIT-I

**Angular motion:** Gyroscopes – effect of precession-motion on the stability of moving vehicles such as motor cycle-motorcar-aero-planes and ships. Static and dynamic force analysis of planar mechanisms.

### UNIT-II

**Friction:** Inclined plane-friction of screw and nuts-pivots and rollers-uniform pressure, uniform wear-friction circle and friction axis, lubricating surfaces- boundary friction - film lubrication.
Clutches: single plate, multi plate, cone clutch and centrifugal clutches.

Brakes and dynamometers: Single block brake- internal expanding brake- band brake of a vehicle.
Dynamometers: Absorption and transmission types, general description and method of operation.

**UNIT-III**

**Turning moment diagrams and flywheels**: Turning moment- Inertia torque-connecting rod angular velocity and angular acceleration- crank effort and torque diagrams- fluctuation of energy-flywheels and their design.
Governors: Watt, Porter and Proell governors- spring loaded governors

## UNIT-IV

**Balancing**: Balancing of rotating masses-Primary, secondary and higher balancing of reciprocating masses. Analytical and graphical methods. Unbalanced forces and couples. Examination of V, multi cylinder, inline and radial engines or primary and secondary balancing- locomotive balancing- Hammer blow- Swaying couple-Variation of tractive effort.

## UNIT-V

**Vibrations**: Free vibration of mass attached to a vertical spring- Oscillation of pendulum- Transverse loads-vibration of beams with concentrated and distributed loads. Dunkerley"s method- Raleigh's method
Whirling of shafts- critical speed- torsional vibrations- one, two and three rotor systems.

## TEXT BOOKS:

1. Theory of Machines / S.S. Rattan/ Tata McGraw-Hill education
2. Theory of Mechanisms and Machines/ Jagadish Lal/ Metropolitan book company

## REFERENCE BOOKS:

1. Theory of Machines and Mechanisms/ JOSEPH E. SHIGLEY/ McGraw-Hill publishers
2. Theory of machines/ Thomas Bevan/ Pearson/ 3$^{rd}$ edition
3. Theory of machines/ R. K. Bansal/ Lakshmi Publications
4. Mechanisms and Machine Theory / JS Rao and RV Duggipati/ Newage
5. Theory of Machines/ Sadhu Singh/ Pearson
6. Mechanism and machine theory/ Ashok G. Ambekar/ PHI/ Eastern economy edition

## XI.     COURSE PLAN:

The course plan is meant as a guideline. There may probably be changes.

| Lecture No. | Course Learning Outcomes | Topics to be covered | Reference |
|---|---|---|---|
| 1 | Define gyroscope | Introduction to Gyroscopes | T1, R3 |
| 2 | Define precession Define spin vector | Introduction to angular motion, Precession angular velocity, vector representation of | T1, R3 |
| 3 | Explain the three perpendicular directions of spin vector, | Determination of Gyroscopic couple, Problems on gyroscopic couples | T1, R3 |
| 4 | Discuss the effect of gyroscope on stability of moving car | Effect of gyroscope on stability of moving car | T1, R3 |
| 5 | Discuss the effect of gyroscope on stability of moving | Effect of gyroscope on stability of moving motorcycle | T1, R3 |
| 6 | Discuss the effect of gyroscope on stability of moving | Effect of gyroscope on stability of moving aeroplane | T1, R3 |
| 7 | Discuss the effect of gyroscope on stability of moving ship | Effect of gyroscope on stability of moving ship | T1, R3 |
| 8 | Discuss static and dynamic force analysis | Static and dynamic force analysis of planar mechanisms | T1, R3 |
| 9 | Explain the effect of friction on an inclined plane | Friction on an inclined plane Free body diagrams | T1, R3 |
| 10 | Construct diagrams to calculate unknown forces | Friction on an inclined plane Free body diagrams, problems | T1, R3 |
| 11 | Define film lubrication | Film lubrication | T1, R3 |
| 12 | Distinguish between the friction circle and friction axis | friction circle, Boundary friction | T1, R3 |
| 13 | Define clutch | Introduction to Clutch | T1, R3 |
| 14 | Classify clutches Calculate the torques in | types of clutches | T1, R3 |

| 15 | Define a brake | Introduction to Brakes | T1, R3 |
|---|---|---|---|
| 16 | Explain block brake, band brake & internal expanding | Classification of Brakes | T1, R3 |
| 17 | Define dynamometer | Introduction to dynamometers | T1, R3 |
| 18 | Classify dynamometers | types of dynamometers | T1, R3 |
| 19 | Calculate the torque required | General description of dynamometers | T1, R3 |
| 20 | Explain the method of operation of dynamometer | Methods of operation of dynamometers | T1, R3 |
| 21 | Calculate the torque required | Calculation of brake torque | T1, R3 |
| 22-24 | Calculate the torque required | problems on brake torque | T1, R3 |
| 25 | Explain turning moment diagrams | Turning moment diagrams explanation | T1, R3 |
| 26 | Discuss the TM diagrams for various engines | Turning moment diagrams for various engines | T1, R3 |
| 27 | Discuss inertia torque Determine the torque required | Inertia torque calculation for connecting rod | T1, R3 |
| 28 | Discuss fluctuation of energy | fluctuation of energy | T1, R3 |
| 29-31 | Explain Crank effort and torque diagrams | Crank effort and torque diagrams | T1, R3 |
| 32 | Define flywheel Explain functions of flywheel | Flywheel and its functions | T1, R3 |
| 33-34 | Discuss fly wheel design | Flywheel design | T1, R3 |
| 35-37 | Design the flywheel | problems on flywheel | T1, R3 |
| 38 | Explain different types of governors | Introduction to governors and their classification | T1, R3 |
| 39 | Explain sensitiveness, isochronisms and hunting | sensitiveness, isochronisms and hunting | T1, R3 |
| 40 | Solve problems for calculating equilibrium speeds | effort and power of governors | T1, R3 |
| 41 | Solve problems for calculating equilibrium speeds | problems on governors | T1, R3 |
| 42-44 | Define balancing Discuss the balancing of rotary | Balancing of rotating masses | T1, R3 |
| 45 | Explain Primary balancing of reciprocating masses | Primary balancing of reciprocating masses | T1, R3 |
| 46 | Explain Secondary balancing of reciprocating masses | Secondary balancing of reciprocating masses | T1, R3 |
| 47 | Explain higher balancing of reciprocating masses | higher balancing of reciprocating masses | T1, R3 |
| 48-49 | Explain locomotive balancing | locomotive balancing | T1, R3 |
| 50-51 | Explain unbalanced forces and couples | Graphical method of calculating forces and couples | T1, R3 |
| 52-53 | Explain balancing of Multi cylinder and V- Engines | balancing of Multi cylinder and V- Engines | T1, R3 |
| 54-55 | Explain balancing of In line and radial engines | balancing of In line and radial engines | T1, R3 |
| 56 | Explain vibrations Classify vibrations | Introduction to vibrations and their classification | T1, R3 |
| 57 | Determine natural frequency of vertical single mass-spring | Free vibrations of mass attached to vertical springs | T1, R3 |
| 58 | Determine natural frequency of simple pendulum | oscillations of simple pendulum, transverse vibrations | T1, R3 |
| 59 | Determine natural frequency of transverse vibrations for | Frequency of transverse vibration for concentrated and distributed loads | T1, R3 |

| 60 | Discuss Dunkerley's method Solve problems on frequency | Dunkerley's method for calculating frequency | T1, R3 |
|----|----|----|----|
| 61 | Discuss Raleigh's method Solve problems on frequency | Raleigh's method for frequency calculations | T1, R3 |
| 62 | Define critical speed and whirling speed of shaft | Critical speeds, Whirling of shafts | T1, R3 |
| 63 | Determine natural frequency of one rotor system | Torsional vibrations- one rotor system | T1, R3 |
| 64 | Determine natural frequency of two rotor system | Torsional vibrations- two rotor system | T1, R3 |
| 65 | Determine natural frequency of three rotor system | Torsional vibrations- three rotor system | T1, R3 |

## XI.  MAPPING COURSE OBJECTIVES LEADING TO THE ACHIEVEMENT OF THE PROGRAM OUTCOMES:

| Course Objectives | Program Outcomes | | | | | | | | | | | | Program Specific Outcomes | | |
|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PSO 3 |
| I | H | | | | S | | | H | | | | | S | | |
| II | | | | | S | | | | | | H | | | | S |
| III | H | | S | | | | S | | | | | H | | H | |
| IV | | S | | | | | | | | | H | | | | S |

**N = None**　　　　　　　**S = Supportive**　　　　　　　**H = Highly related**

## XII.  MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF TSHE PROGRAM OUTCOMES:

| Course Outcomes | Program Outcomes | | | | | | | | | | | | Program Specific Outcomes | | |
|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PSO 3 |
| 1 | H | | | | S | | | | | | | | | | S |
| 2 | | H | | | | | | | | | S | | S | | |
| 3 | | H | | | S | | | | | | | | | | |
| 4 | S | | | | | | | | | | H | | | H | |
| 5 | | | | | | | | | | | H | S | | | S |
| 6 | | | | | S | | | | | | | | | | |
| 7 | | S | | | | | | | | | H | | S | | |
| 8 | | | | | H | | | | | | | S | | | |
| 9 | | | H | | | | | | S | | | | | H | |
| 10 | | H | | | | | | | | | S | | | | S |
| 11 | H | | | | | | | | | | | S | S | | |
| 12 | | | | | H | | S | | | | | | | | |
| 13 | | H | | S | | | | | | | | | | H | |

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**Prepared by:**

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