Shri Shankaracharya Technical Campus,

Shri Shankaracharya Group of Institutions

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SCHEME OF EXAMINATION AND SYLLABUS

M. Tech. (MACHINE DESIGN)

SEMSETER – II

SL. NO .	BOARD OF STUDY	SUBJECT CODE	SUBJECT	PERIODS/WEEK			EXAMINATION SCHEME			TOTAL MARKS	CREDIT L+(T+P) /2
				L	T	P	ESE	CT	TA		
1	Mechanical Engineering	ME224201	Finite Element Methods	3	1	0	100	20	20	140	4
2	Mechanical Engineering	ME224202	Theory of Elasticity and Plasticity	3	1	0	100	20	20	140	4
3	Mechanical Engineering	ME224203	Advanced Theory of Mechanisms	3	1	0	100	20	20	140	4
4	Mechanical Engineering	ME224204	Advanced Dynamics of Machines	3	1	0	100	20	20	140	4
5	Mechanical Engineering		ELECTIVE - II	3	1	0	100	20	20	140	4
6	Mechanical Engineering	ME224291	Finite Element Methods Lab	0	0	4	75	-	75	150	2
7	Mechanical Engineering	ME224292	Dynamics Lab	0	0	4	75	-	75	150	2
TOTAL				15	5	8	650	100	250	1000	24

L – Lecture, T –Tutorial, P – Practical, ESE – End Semester Exam, CT – Class Test, TA – Teacher's Assessment

ELECTIVE - II			
SL. No.	**Board of Study**	**Subject Code**	**Subject**
1.	Mechanical Engineering	ME224221	Robotics
2.	Mechanical Engineering	ME224222	Design against Fatigue and Fracture
3.	Mechanical Engineering	ME224223	Composite Materials
4.	Mechanical Engineering	ME224224	Optimization Techniques
5.	Mechanical Engineering	ME224225	Design for Manufacturing and Assembly

		October 2020	1.00	Applicable for AY 2020-21 Onwards
Chairman (AC)	Chairman (BoS)	Date of Release	Version	

Subject Code ME224201	Finite Element Methods	L = 3	T = 1	P = 0	Credits = 4
Evaluation Scheme	ESE	CT	TA	Total	ESE Duration
	100	20	20	140	3 Hours

COURSE OBJECTIVES	COURSE OUTCOMES
1. To provide the fundamental concepts of the theory of the finite element methods. **2.** To provide exposure to solve complex engineering problems by using numerical methods such as finite element methods.	**At the end of this course, the students are expected to be able to:** **CO1:** Obtain an understanding of the fundamental theory of the Finite element methods. **CO2:** Understand and analyse the use of the basic finite elements for solving engineering problems. **CO3:**Apply the finite element technique to solve problems of structural applications using bar, truss, beam and frame elements**.** **CO4:**Apply the finite element method for solving engineering problems related to solid mechanics. Fluid flow and heat transfer. **CO5:**Solve FEM problems by computer softwares.

Unit – 1 [10 Hrs] **CO1**

Introduction to finite element methods: Direct approach for standard discrete system. Potential Energy approach and virtual work approach, Variational approach and Galerkin's weighted residual approach.

Unit – 2 [10Hrs] **CO2**

Interpolation polynomials – Lagrangian and Hermite polynomials.Global, local and natural co-ordinates, Pascal triangle, concept of continuity, convergence criteria.

Shape functions- for one, two and three dimensional elements, Serendipity elements, Concept of iso-parametricelements.

Unit – 3 [10Hrs] **CO3**

1D Finite Element Analysis **:** Bar, truss, beam and frame elements, Governing equation and boundary conditions for 1D FEA of Bar extension and Beam bending problems, Derivation of Element Matrices and Vectors; Assembly, Imposition of Boundary Conditions and Nodal Solution.

Unit – 4 [10 Hrs] **CO4**

*2D Finite Element Analysis***:** CST and LST elements, Finite element formulation for planestress, plane strain and axisymmetric problems, Application of FEA to scalar field problems viz. inviscid and viscid flows, heat transfer, analogous problems of torsion.

Unit – 5 [8Hrs] **CO5**

Computer implementation solution technique of FEM: ANSYS Software Applications, Introduction; general solid modeling using 2D and 3D primitives available in ANSYS; Basic concepts of finite elements, with applications to problems confronted by mechanical designers.

Text Books:

1. An Introduction to Finite Element Method by J.N. Reddy, TMH, New Delhi
2. The Finite Element Method in Engineering by S.S. Rao, Butterworth Heinemann, Boston
3. Introduction to Finite Elements in Engineering by Chandrupatla, and Belegundu, PHI Pvt. Ltd., New Delhi

Reference Books:

1. Textbook of FiniteElement Analysis by P.Seshu, PHI.
2. Introduction to the finite element method by C.S.Desai and J.F.Abdel.
3. The Finite Element Method its Basis and Fundamental by O. C. zienkiewich, R. L.Taylor, J. Z. Zhu.

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SCHEME OF EXAMINATION AND SYLLABUS

M. Tech. (MACHINE DESIGN)

Subject Code ME224202	Theory of Elasticity and Plasticity	L = 3	T = 1	P = 0	Credits = 4
Evaluation Scheme	ESE	CT	TA	Total	ESE Duration
	100	20	20	140	3 Hours

COURSE OBJECTIVES	COURSE OUTCOMES
1. To make students understand the analysis of linear elastic solids under mechanical and thermal loads. 2. To provide exposure to two dimensional problems in Cartesian and polar coordinates 3. To make students understand the principle of torsion of prismatic bars.	**At the end of this course, the students are expected to be able to:** **CO1**: Understand the basic concepts in mechanics of solids, including of strain, internal force, stress and equilibrium in solids. **CO2:**. Understand the stress and deflection of general cross-section beams. **CO3:**.Identify and estimate stresses in rotating machine components. **CO4:** Understand the behaviour of general cross-section shafts under Torsion. **CO5:** Understand the plastic behaviour of materials.

Unit – 1 **CO1**

Theory of Elasticity**:** Plane stress and plane strain problems, Equations of equilibrium, Equations ofcompatibility, Boundary conditions. Stress functions, Bi-harmonic Equations. **[10 Hrs]**

Unit –2 **CO2**

Two Dimensional Problems in Rectangular Coordinates: Saint Venant's Principle, Solution by polymonials,Bending of Cantilever and simply supported beams. **[10 Hrs]**

Unit – 3 **CO3**

Problems in Polar Coordinates: Stress distribution symmetrical about an axis, Bending of curved beams.

Stresses in thick cylinders, rotating solid and hollow discs, rotating shafts and cylinders.

Discs of uniform strength, Shrunkfit assemblies of cylinder, stress concentration due to circularhole in a plate subjected to tensile load. **[10 Hrs]**

Unit – 4 **CO4**

Bending of Plates: Rectangular Plate, Bending of axis –symmetric plate with different end conditions.

Torsion of non-circular shafts: Saint Venant's theory of rectangular shafts, equilateral triangular shaft, elliptical shaft, Torsion of hollow cross sections, Membrane Analogy. **[10 Hrs]**

Unit – 5 **CO5**

Theory of Plasticity**:** Introduction, Saint Venant's theory of plastic flow, yield criteria, plastic torsion of bars of circular cross-section. **[8 Hrs]**

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Text Books:

1. Theory of Elasticity by S. P. Timoshenko & J. N. Goodier, McGraw-Hill.
2. Advanced Mechanics of Solids by L. S. Srinath, Tata McGraw-Hill.
3. Introduction to Theory of plasticity for Engineers by Hoffman and Sach.

Reference Books:

1. Theory of Elasticity by Dr. Sadhu Singh, Khanna Publishers.
2. Advanced Strength of Materials by Den Hartog.
3. Advanced Mechanism of Materials bySeely and Smith.

Subject Code ME224203	Advanced Theory of Mechanisms	L = 3	T = 1	P = 0	Credits = 4
Evaluation Scheme	ESE	CT	TA	Total	ESE Duration
	100	20	20	140	3 Hours

COURSE OBJECTIVES	COURSE OUTCOMES
1. To impart knowledge of kinematic behavior of different mechanisms. 2. To provide exposure tosynthesize and analyze the multi-body systems involving different types of mechanisms.	**At the end of this course, the students are expected to be able to:** **CO1**: Understand the fundamental concepts of various mechanisms. **CO2:** Understand different methods to synthesize simple mechanisms. **CO3:** Understand and evaluate the path traced by various parts of a mechanism. **CO4:**Understand the graphical methods to design a four bar mechanism. **CO5:** Understand the basic concepts of robotic mechanism..

Unit – 1 **CO1**

Introduction to planar mechanisms, spatialmechanisms, equivalent mechanism, kinematic inversion, mobility, transmission angle,deviation angle etc.

Kinematic analysis of mechanisms: displacement, velocity and acceleration analysis ofplanar mechanisms and spatial mechanisms. **[10 Hrs]**

Unit – 2 **CO2**

Synthesis of Planar mechanisms: Type synthesis, number synthesis, dimensional synthesis,Chebyshev polynomials, Freudenstein's displacement equation.

Dimensional synthesis- Different types of synthesis methods e.g. algebraic methods,complex numbers method, Bloch's method etc. **[10 Hrs]**

Unit – 3 **CO3**

Coupler-curve synthesis and cognate linkages.Roberts Law. Cognate of slider crank mechanism, Double points of a coupler curve. **[8 Hrs]**

Unit – 4 **CO4**

Curvature Theory: EulersSavary equation –graphical solution, Hartmann construction, First and second Bobillier construction, Cusp points, Inflection circle for a four bar mechanism. Design of a four bar mechanism for specified angular velocities and acceleration of cranks. Cubic of stationary curvature.

[10 Hrs]

Unit – 5 **CO5**

Analysis and synthesis of Cams.
Introduction to dimensional synthesis of Robot spatial mechanisms ,Kinematic analysis of industrial robot. **[10 Hrs]**

Text Books:

1. Theory of Machines and Mechanisms byUicker, Pennock, Shigley, Tata McGraw-Hill.
2. Mechanism & Machine Theory byJ.S.Rao&R.Dukkipati, Wiley-Easten

Reference Books:

1. Kinematic Synthesis of Linkages byHartenberg, Denavit.
2. Advanced Mechanism and Design (Analysis & Synthesis) –Gorge N Sandal & Arthur G Erdman-PHI.
3. Kinematic Analysis and Synthesis by Mallik, Ghosh, Dittrich.

SCHEME OF EXAMINATION AND SYLLABUS

M. Tech. (MACHINE DESIGN)

Subject Code ME224204	Advanced Dynamics of Machines	L = 3	T = 1	P = 0	Credits = 4
Evaluation Scheme	ESE	CT	TA	Total	ESE Duration
	100	20	20	140	3 Hours

COURSE OBJECTIVES	COURSE OUTCOMES
1. To impart knowledge of dynamic behaviour of machine components. 2. To make students familiar with the techniques to control the dynamic behaviour of machine components.	**At the end of this course, the students are expected to be able to:** **CO1**:. Identify the forces and formulate the dynamic model of machine components involving motion in a plane. **CO2:** Identify various types of coordinate frames required fordescribing the behavior of different mechanisms. **CO3**:.Identify and analyze the dynamic model of cam mechanism. **CO4:** Derive the equations of motion of rotors in absolute and rotating coordinate systems and calculate the critical speeds of rotors. **CO5:** formulate and evaluate behavior of linear time continuous control systems.

Unit – 1 **CO1**

Dynamic Force Analysis: Plane motion mechanism, D'Alemberts Principle, Analysis of a floating link, InertiaForces, The principle of Superposition, Planar rotation about a fixed center, Shaking force and moments. **[10 Hrs]**

Unit – 2 **CO2**

Dynamic force Analysis: space Mechanism, Introduction, Measuring mass moment of inertia, Transformation of Inertia axes, Euler's equation of motion, Impulse and Momentum, Angular impulse andangular momentum. **[10 Hrs]**

Unit – 3 **CO3**

Cam Dynamics: Forces in rigid systems, Mathematical models, Response of undamped cam mechanism – analyticalmethod, Position error, Follower response by phase plane method, jump and cross over shock,Johnson's numerical analysis, Unbalance, spring surge and Wind up. **[10 Hrs]**

Unit – 4 **CO4**

Rotor Dynamics: Single Rotor and Multi Rotor system, balancing, Rotor dynamic consideration in design ,critical speeds and unbalance response stability of rotors, vibrations of discs and blades. **[10 Hrs]**

Unit – 5 **CO5**

Dynamics of Feed Back Control System: Examples of automatic control system, standard input functions,Analysis of proportional-error feedback system, Harmonic input, Stability, Types of controls, Nonlinearsystem. **[8 Hrs]**

Text Books:

1. Theory of Machines and Mechanisms by Uicker, Pennock, Shigley, Tata McGraw-Hill.
2. Dynamics of Machines by Den Hartog.

Reference Books:

1. Kinematics & Dynamics of Machine by Martin, McGraw Hill.
2. Rotor Dynamics by J. S. Rao.

SCHEME OF EXAMINATION AND SYLLABUS

M. Tech. (MACHINE DESIGN)

Subject Code ME224221	Robotics	L = 3	T = 1	P = 0	Credits = 4
Evaluation Scheme	ESE	CT	TA	Total	ESE Duration
	100	20	20	140	3 Hours

COURSE OBJECTIVES	COURSE OUTCOMES
1. To provide exposure in both the aspects of analyses and applications of robotics.	**At the end of this course, the students are expected to be able to:** **CO1:** Understand concepts and key components of roboticstechnologies. **CO2:**Apply various transformations and develop forward and inverse kinematic models of serial robotic manipulators. **CO3:**Solve basic path and motion planning and control problems related to serial robotic manipulator **CO4:**Understand functions and uses of drives and actuators employed in robotics. **CO5:**Understand use of various sensors and vision systems used in robotic manipulators.

Unit – 1 **CO1**

Introduction to Robotics: Definition, Anatomy, Coordinate Systems, WorkEnvelopes, Basic structure, classification, applications of robots. **[8 Hrs]**

Unit – 2 **CO2**

Kinematic analysis of Robotic manipulators:Frame transformation, Denavit-Hartenberg convention, Forward manipulator kinematics, Inversemanipulator kinematics,Velocity and acceleration analysis of serial manipulators. **[10 Hrs]**

Unit – 3 **CO3**

Dynamics of serial manipulators: Lagrange-Euler formulation, Newton- Eulerformulation.

Planning of Manipulator Trajectories: Joint space scheme, Cartesian spacescheme, Robot end-effectors.

[10 Hrs]

Unit – 4 **CO4**

Fundamentals of Robot Drives and Actuators, Hydraulic system stepper motor, Direct current servomotors, A-C servomotors, adaptive control, interpolars. **[10 Hrs]**

Unit – 5 **CO5**

Robotic Sensors: Contact type, noncontacttype, internal sensor, external sensor, Range sensor, Proximity sensor,touch sensor, Force and torque sensor, Encoders, Robotic Vision etc.

Applications of Robot: Handling, loading unloading, welding, painting, assembly, Machining, Manufacturing, Work – cell, Installation of Robots. **[10 Hrs]**

Text Books:

1. Robotics and Control by R K Mittal and I J Nagrath, TMH, New Delhi.
2. Robotics by K.S.Fu, R.C. Gonzalez and C.S.G. Lee, McGraw Hill.

Reference Books:

1. Introduction of Robotics – Mechanics and control by J.J. Craig, Addision-Wesley.
2. Robot Engineering: An Integrated Approach, R.D. Klafter, T.A. Chmielewski and M. Negin, Prentice Hall India.
3. Introduction to Robotics Analysis, system Application, saeed B. Niku, Pearson Education.
4. Kinematics synthesis of linkages, Hardenberg and Denavit.
5. Introduction to Robotics, S.K. Saha, Mcgraw Hill.

Subject Code ME224222	Design against Fatigue and Fracture	L = 3	T = 1	P = 0	Credits = 4
Evaluation Scheme	ESE	CT	TA	Total	ESE Duration
	100	20	20	140	3 Hours

COURSE OBJECTIVES	COURSE OUTCOMES
1. To impart knowledge of fatigue behaviour of materials. 2. To provide broad understanding of fracture behaviour of materials.	**At the end of this course, the students are expected to be able to:** **CO1:** Understand and analyze the failure of machine components due to fatigue loading. **CO2:**Understand about different types of the fractureand analyze the failure of machine components due to fracture. **CO3:**Understand and analyze the failure of machine components due to creep. **CO4:** Understand various modes of surface failure. **CO5:**Understand the concept of probabilistic design techniques.

Unit – 1 **CO1**

Design against Fatigue: Factors affecting fatigue behaviour, Environmental effects, Influence of superimposed static stress, Gerber parabola, Modified Goodmann diagram, Soderburg line, Stress Concentration, Notch sensitivity, Cumulative fatigue damage, Linear damage rule, Miners Equation, Practical measure to combat fatigue. Loading in finite /life range. **[10 Hrs]**

Unit – 2 **CO2**

Design against Fracture: Stress intensity, factor of a crack in finite bodies, fracture criteria, Fracture toughness, Fatigue crack propagation, Plastic deformation, Plastic deformation around crack tip, Crack opening displacement, Design of steam, turbine rotors, Rotor discs, Design of thin walled pressure vessels and pressure piping. **[10 Hrs]**

Unit – 3 **CO3**

Design against Creep: Creep of solids, Creep phenomenon, Parameter methods, Larson Miller Parameter, herby Dorn parameter, Manson Hafford parameter, Creep under biaxial stress, Materials for application at elevated temperature. **[10 Hrs]**

Unit – 4 **CO4**

Surface Failure: Surface geometry, Mating surfaces, Different types of wears-Adhesive, Abrasive, Corrosion, Pitting, spalling: Contact pressure in spherical contact, Stress distribution in spherical contact, Stresses in ball and thrust bearing Cylinder contact stresses, Stresses in cam and follower, Surface fatigue strength. **[10 Hrs]**

Unit – 5 **CO5**
Design for reliability: Introduction Probabilistic approach to design, Design for reliability, Failure mode and effects analysis, Design for safety. **[8 Hrs]**

Text Books:

1. Mechanical Engineering Design by Joseph E. Shigley& Charles R. Mischke.
2. Engineering Design by George E. Dieter, McGraw-Hill.

Reference Books:

1. Advanced Machine Design by A. Mubeen, Khanna Publisher.
2. Machine Design by Robert L. Norton, Pearson Education.

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SCHEME OF EXAMINATION AND SYLLABUS

M. Tech. (MACHINE DESIGN)

Subject Code ME224223	Composite Materials	L = 3	T = 1	P = 0	Credits = 4
Evaluation Scheme	ESE	CT	TA	Total	ESE Duration
	100	20	20	140	3 Hours

COURSE OBJECTIVES	COURSE OUTCOMES
1. To learn the mechanical performance of laminated composites, including failure behaviour.	**At the end of this course, the students are expected to be able to:** **CO1:**Distinguish and categorize the types of composite materials. **CO2:**Analyse the elastic properties and simulate the mechanical performance of composite laminates. **CO3:**Apply Micromechanics principles in estimating the properties of laminated composites. **CO4:**Estimate the strength of laminated composites.**CO5:**Identify and apply the concepts of plate theory in solving composite structural problems.

Unit – 1 **CO1**

Classification and characterization of composite materials; fibrous, laminated and particulate composites, laminae and laminates, manufacture of laminated fibre reinforced composite materials. **[10 Hrs]**

Unit – 2 **CO2**

Macromechanical behaviour of lamina, stress-strain relations, engineering constraints for orthotropic materials, stress-strain relations for lamina of arbitrary orientation,strength and stiffness of an orthotropic lamina. **[10 Hrs]**

Unit – 3 **CO3**

Bi-axial strength theories, Micromechanical behaviour of laminae, Rule of mixtures,Macromechanical behaviour of laminates. **[10 Hrs]**

Unit – 4 **CO4**

Single layered configurations, symmetric and anti-symmetric laminates, known symmetric laminates, Strength of laminates,Interlaminar stresses. **[10 Hrs]**

Unit – 5 **CO5**

Design of laminates. Buckling and vibration of laminated beams, plates and shells. **[8 Hrs]**

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Text Books:

1. Introduction to composite materials design (Material Science &Engg.Series) by Barbero.
2. Composite materials: Design and application by Daniel Gay.

Reference Books:

1. Mechanics of composite materials By Richard M Christensen.
2. Composite Manufacturing Material, Product and Process Engg. By Sanjay Majumdar.

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SCHEME OF EXAMINATION AND SYLLABUS

M. Tech. (MACHINE DESIGN)

Subject Code ME224224	Optimization Techniques	L = 3	T = 1	P = 0	Credits = 4
Evaluation Scheme	ESE	CT	TA	Total	ESE Duration
	100	20	20	140	3 Hours

COURSE OBJECTIVES	COURSE OUTCOMES
1. To impart knowledge and develop basic understanding of the concepts of optimization and mathematical modelling. 2. To provide exposure to computer programming and heuristic approaches to solve optimization problems.	**At the end of this course, the students are expected to be able to:** **CO1:**Understand theory of different optimization methods to solve various types of engineering problems.**CO2:**Understand and solve non-linear optimization problems by using various search techniques. **CO3:**Use different direct and gradient based optimisation method to solve single and multivariable un-constrained or constrained nonlinear function for minimization or maximization. **CO4:**Solve optimization problems by using non-traditional methods such as geometric and integer programming. **CO5:**Understand the application of software for optimization and develop the computer programs for different optimizationalgorithms.

Unit – 1 **CO1**

Introduction to optimization techniques: Basic Concepts, Constrained & unconstrained optimization problems. Functions of one variable, multivariable optimization with no constraints, Kuhn-tucker conditions, equality& inequality constraints. Applications of linear programming general design applications of optimization conventional Vs optimum design process, optimum design Problem formulation process. **[10 Hrs]**

Unit – 2 **CO2**

Non-Linear Programming: Basic Concepts of Non Linear Programming, unimodal function, elimination methods, search techniques exhaustive & dichotomous search, golden section method. Interpolation methods- Quadratic & cubic. Unconstrained minimization methods, direct search method – random search method- random search method, patterned search method-rosan bricks method, descent methods – steepest descent method. **[10 Hrs]**

Unit – 3 **CO3**

Non linear Programming –constrained optimization techniques,Direct method-cutting plane method, gradient project method, indirect method –penalty finds method (Interior & exterior). **[10 Hrs]**

Unit – 4 **CO4**

Geometrical & integer programming, Introduction unconstrained minimization & constrained minimization problems. Polynomial unconstrained minimization problem Integer linear & non-linear programming. **[10 Hrs]**

Unit – 5 **CO5**

Stochastic Program & other topics in optimization stochastic linear & non-linear programming Introduction to optimum design with MAT LAB. **[8 Hrs]**

Text Books:

1. Engg.Optimization theory & practice by S.S.Rao, New Age Pub.
2. Optimization Concepts & application in Engg. by A.D. Belegundu, Pearson.

Reference Books:

1. Introduction to optimum design by J.S.Arora, McGraw Hill Pub.
2. Optimization Theory & Practice by M.C.Joshi, Narosa Pub.
3. Practical Methods of Optimization by R.Flether, Wiley.

Subject Code ME224291	Finite Element Methods Lab	L = 0	T = 0	P = 4	Credits = 2
Evaluation Scheme	ESE	CT	TA	Total	ESE Duration
	75	_--	75	150	--

List of Experiments to be performed:

1. Use and Application of ANSYS and Pro-E for different types of problem related to theory of elasticity and hydrodynamic lubrication, mechanism, vibration, structure, Hydrostatic
2. Static stress analysis of wall bracket.
3. Steady state thermal analysis of circular tank and pipe assembly.
4. To perform stress analysis of 2D trusses using ANSYS.
5. To generate a C program to calculate stresses in a tapered shaft using FEM.
6. To generate a C program to make analysis of 2D truss using isoparametric elements in FEM.
7. To generate a C program to analyse temperature distribution in a one dimensional heat flow model.
8. To use pre-processor in ANSYS to generate & mesh a model using various elements in FEM.
9. To use postprocessor in ANSYS to generate stress analysis results.
10. To analyse stress in a crane hook using ANSYS.
11. Stress analysis of leaf spring using Von-Mises theory in ANSYS.
12. To perform dynamic stress analysis of connecting rod using ANSYS.

Subject Code ME224292	Dynamics Lab	L = 0	T = 0	P = 4	Credits = 2
Evaluation Scheme	ESE	CT	TA	Total	ESE Duration
	75	_--	75	150	--

List of Experiments to be performed:

1. To perform experiment on rotor balancing arrangement.
2. To perform experiment on cam-follower mechanism arrangement.
3. To perform experiment on Gyroscope.
4. To perform experiment on compound pendulum arrangement.
5. To perform experiment on torsional vibration measuring arrangement.