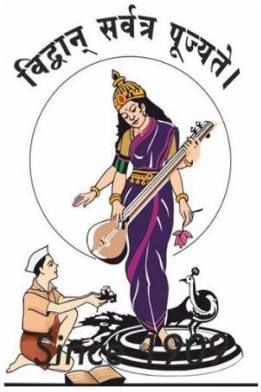


PUNE VIDYARTHI GRIHA'S

COLLEGE OF ENGINEERING AND TECHNOLOGY, PUNE-9

(AFFILIATED TO SAVITRIBAI PHULE PUNE UNIVERSITY, PUNE)

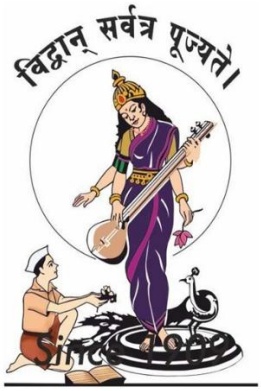
DEPARTMENT OF MECHANICAL ENGINEERING

CURRICULUM BOOK

ACADEMIC YEAR: 2019-20

FOR THE PROGRAMME

MECHANIAL ENGINEERING (UNDER GRADUATE)



PUNE VIDYARTHI GRIHA'S

COLLEGE OF ENGINEERING AND TECHNOLOGY

VISION

TO ACHIEVE EXCELLENCE IN ENGINEERING EDUCATION

MISSION

- **To satisfy all stakeholders**
- **To develop ethical, highly motivated engineering professionals with good human values, requisite skills and competencies**
- **To adopt innovative teaching mechanisms**
- **To promote research culture**
- **To contribute to country's economic development**
- **To be responsive to changes in technology, socio-economic and environmental conditions**

Vision of the Department

"To become premier source of competent Mechanical Engineering professional for providing service to the society"

Mission of the Department

- To provide state of the art facility and to offer opportunities for multifaceted development and enriching learning experience for students, faculty and staff
- To enhance the status as a recognized academic and research Centre in collaboration with other institutions and industry
- To provide interactive and innovative teaching to transform students into competent engineering professionals having good ethical, social and human values
- To deliver ready to employ engineering graduates who are adaptable and practicing lifelong learning to meet the ever changing requirements of the employers

The Program Educational Objectives

- **PEO-I:** To demonstrate the ability to design, develop products, systems and processes in multi-disciplinary engineering environment by application of principles of Science and Engineering
- **PEO-II:** To develop experimental and computational skills necessary to formulate and solve industrial problems related to Mechanical Engineering
- **PEO-III:** To offer sustainable solutions through research, technological competency, leadership skills and team work
- **PEO-IV:** To continue professional development through higher education and lifelong learning
- **PEO-V:** To demonstrate socio-economic, ethical and environmental awareness while making professional decisions

Program Outcomes (POs)

Mechanical Engineering Graduates will be able to:

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to

comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs)

1. **Demonstrate competency in the area of Thermal, Design, Manufacturing and to apply skills in multidisciplinary areas of engineering.**
2. **Face competitive examinations that offer challenging and rewarding careers (pursuing higher studies, general administration or entrepreneurship) in mechanical engineering or other areas.**

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Final Year Curriculum Book

Syllabus Structure of Savitribai Phule Pune University, Pune

B. E. (Mechanical) 2015 course Semester – I

(W.e.f. Academic year 2019-20)

Code	Subject	Teaching Scheme Hrs / week			Examination Scheme					Total Marks	Credits	
		Lecture	Tut	Pract	In Sem	End Sem	TW	PR	OR		Theory	TW/ Pr/OR
402041	Hydraulics and Pneumatics	3	-	2	30	70	25	-	25	150	3	1
402042	CAD CAM Automation	3	-	2	30	70	25	50	-	175	3	1
402043	Dynamics of Machinery	4	-	2	30	70	25	-	25	150	4	1
402044	Elective-I	3	-	2	30	70	25	-	-	125	3	1
402045	Elective-II	3	-	-	30	70	-	-	-	100	3	-
402046	Project-I	-	-	4	-	-	25	-	25	50	-	2
Total		16	-	12	150	350	125	50	75	750	16	6
											22	

Elective – I		Elective – II	
Code	Subject	Code	Subject
402044 A	Finite Element Analysis	402045 A	Automobile Engineering
402044 B	Computational Fluid Dynamics	402045 B	Operation Research
402044 C	Heating Ventilation and Air Conditioning	402045 C	Energy Audit and Management
		402045 D	Open Elective**

B. E. (Mechanical) Semester – II

Code	Subject	Teaching Scheme Hrs / week			Examination Scheme					Total Marks	Credits	
		Lecture	Tut	Pract	In Sem	End Sem	TW	PR	OR		Theory	TW/ Pr/OR
402047	Energy Engineering	3	-	2	30	70	25	-	25	150	3	1
402048	Mechanical System Design	4	-	2	30 (1.5 Hrs)	70 (3 Hrs)	25	-	50	175	4	1
402049	Elective-III	3	-	2	30	70	25	-	-	125	3	1
402050	Elective-IV	3	-	-	30	70	-	-	-	100	3	-
402051	Project-II	-	-	12	-	-	100	-	100	200	-	6
Total		13	-	18	120	280	175	-	175	750	13	9
											22	

Elective – III		Elective – IV	
402049 A	Tribology	402050 A	Advanced Manufacturing Processes
402049 B	Industrial Engineering	402050 B	Solar & Wind Energy
402049 C	Robotics	402050 C	Product Design and Development
		402050 D	Open Elective**

BE (Mechanical)

Semester I

HYDRAULICS & PNEUMATICS

Course Title: HYDRAULICS & PNEUMATICS		**Course Number:** 402041	**Course Code:C401**
Year: FOURTH YEAR (BE)		**Semester: I**	
Designation of Course		Professional Core	
Teaching Scheme: 03Hrs/Week (Theory),02Hrs\Week (Practical)		**Tutorial:** NIL	
Course Assessment Methods	**Direct methods**	In-semester Examination: 30 Marks	End Semester Examination: 70 Marks
		Oral 25 Marks	Term Work 25 Marks
	Indirect Methods	Assignments	Q&A session, Class Test
Prerequisites	Knowledge of Fluid Mechanics, BME, DME-I, DME-II.		
Course Objectives			
1	Application of fluid mechanics and governing laws in hydraulic and pneumatic systems.		
2	Study of working principle of various components used in hydraulic and pneumatic systems.		
3	Selection of different components used in hydraulic and pneumatic systems.		
4	Drawing and design of hydraulic and pneumatic systems.		
5	Industrial applications of hydraulic and pneumatic systems.		
6	Study of low cost automation		
Course Outcomes			
CO1	Working principle of various components used for hydraulic and pneumatic systems.		
CO2	Identify various components of hydraulic and pneumatic systems.		
CO3	Ability to select appropriate components required for hydraulic and pneumatic systems.		
CO4	Ability to design hydraulic and pneumatic systems for Industrial Applications.		
CO5	Ability to understand Industrial applications of hydraulic and pneumatic systems & Troubleshooting of hydraulic &pneumatic systems.		
CO6	Develop and apply knowledge to various applications.		
Course Contents			
Unit-I	**Basics of Fluid Power and Pumps**		
	Fluid power basics, advantages and limitations, fluid power distribution, standard symbols, energy loss in hydraulic systems. Pumps - types, classification, principle of working and constructional details of vane pumps, gear pumps, radial and axial plunger pumps, screw pumps, power and efficiency calculations, and characteristics curves.		
	Assignment		
	ISO symbols for different components of Hydraulic & Pneumatic systems.		

Unit-II	**Actuators and Power Unit**
	Linear and rotary actuators- types, construction and characteristics. Cylinder mountings, cushioning of cylinders. **Power units and accessories** - types of power units, reservoir assembly, constructional details. Accumulators, Intensifiers, Pressure and Temperature switches /sensors, level sensors.
	Practical
	1) Test on Gear \Vane\Piston pump and plotting of performance charactristics.2) Design of accumulators and pressure intensifiers in hydraulic system. 3)Different types of actuators used in hydraulic & pneumatic systems.(Assignment)
Unit-III	**Fluid Power Control**
	Direction control valves - centre positions, methods of actuation, two stage valves, Flow control valves - pressure and temperature compensated. **Pressure control valves -** pressure reducing valve, sequence valve, unloading valve, brake valve, back pressure valve, counter balance valve, check valves, prefill valve, servo valves, cartridge valves, proportional valves.
	Assignment\Practical
	1) Testing of Pressure Relief Valve.
Unit-IV	**Hydraulic Circuits and Contamination Control**
	Hydraulic circuits: Simple reciprocating, regenerative, speed control (meter in, meter out and bleed off), sequencing, synchronization, traverse and feed, automatic reciprocating, fail safe circuit, counter balance circuit, actuator locking, unloading circuit, motor breaking circuit etc. **Contamination control:** Contamination, sources of contamination, suction strainer, filters, filtration, filter ratings.
	Practical
	1) Demonstration of Basic 04 Circuits on Hydraulic Trainer kit.2)Drawing and design of Simple Hydraulic Systems used in practice(05 systems).
Unit- V	**Pneumatics – Components, Control Valves and Circuits**
	Compressors - Types, principle of working and constructional details. Comparison of pneumatic with hydraulic power transmissions. Types of filters, pressure regulators, lubricators, mufflers, dryers, direction control valves, pneumatic actuators, shuttle valve, two pressure valve, quick exhaust valve and time delay valves, electro-pneumatics. Speed regulating methods, pneumatic circuits, reciprocating, cascading time delay etc. Application of pneumatics in low cost automation and in industrial automation.
	Practical
	1)Design of Air distribution system in pneumatic system.2)Demonstration of Basic 04 Circuits on Pneumatic Trainer Kit.

Unit-VI	System Analysis and Design		
	Calculation of piston velocity, thrust under static and dynamic applications, considering friction, inertia loads, design considerations for cylinders, Design of hydraulic/pneumatic circuits for practical application, selection of different components such as reservoir, control elements, actuators, accumulator, intensifier, filters, pumps. (Students are advised to refer manufacturers' catalogues for design and use simulation tool like Automation Studio for analysis).		
	Practical		
	Industrial Visit to study Automation by means of Hydraulic & Pneumatic Systems.		
Text Books	**Author**	**Title of Book**	**Publication**
T1	Anthony Esposito	Fluid Power with applications	Prentice Hall
T2	S.R.Majumdar	Oil Hydraulic Systems	Tata McGraw Hill
T3	Stewart H. L	Hydraulics and Pneumatics	Taraporewala Publication
Reference Books			
R1	J.J.Pipenger	Industrial Hydraulics	Tata McGraw Hill
R2	Pinches	Industrial Fluid Power	Prentice Hall
R3	D.A.Pease	Basic Fluid Power	Prentice Hall
R4	B.Lall	Oil Hydraulics	I.L.A.
R5	A.A.Parr	Hydraulics & Pneumatics	Elsevier Science &Tchnology Books
Self-Learning Facilities, Web Resources, Research papers for reference	Web sites of manufactures of Hydraulic & Pneumatic Systems,System Components		
Contents beyond Syllabus	Applications of H&P Systems for Heavy Duties.		
Additional Experiments	NIL		
Bridging Courses			
Tutorials			
Presentations	CD Presentations, PPT Presentations, Animations.		

CAD - CAM

Course Title: CAD/CAM & AUTOMATION		**Course Number: 402042**	**Course Code: C402**
Year: B.E.		**Semester: VII**	
Designation of Course		Core	
Teaching Scheme: 3 Hrs/Week		**Practical:** 2 Hr/Week	
Course Assessment Methods	**External Tools**	In-semester Examination: 30 Marks	End Semester Examination: 70 Marks
		Class Test: 30 Marks	Oral: 25 Term Work: 25
	Internal Tools	Class Test	Assignments
Prerequisites	Engineering Mechanics, Physics, Strength of Material		
Course Objectives			
1	Basics of Graphic Screen.		
2	Building Transformation Matrices.		
3	Concept of of Finite Element Analysis		
4	Technique of Automation		
5	Concept of of Curves, Surfaces and Solids generation		
6	CAM Technique.		
Course Outcomes			
CO1	Frame and **solve** Transformation Matrices		
CO2	**Apply** the Technique of Finite Element Analysis.		
CO3	**Explain** the concepts in Automation Techniques		
CO4	Define, synthesize and **analyze** engineering curves in CAD interface.		
CO5	Write programs for manufacturing the components using CAD software Students		
CO6	Explain technological aspects of Robotics and **develop** basic programs.		
Course Contents			
Unit-I	**Computer Graphics (8 Hrs)** Transformation-Introduction, Formulation, Translation, Rotation, Scaling, Reflection Homogenous Representation, Concatenated Transformation, Mapping of Geometric Models, Inverse Transformations, Projections: Orthographic, Isometric, and Perspective. Introduction to open GL and commands required for the transformation.		
Unit-II	**Geometrical Modeling (6 Hrs)** Curves:-Introduction, Analytic Curves, Line, Circle, Parabolas, Hyperbolas, Ellipses, Conics, Synthetic Curves, Hermite Cubic Spline, Bezier Curve, B-Spline Curve, Numericals on above topic. Surfaces:-Introduction, Surface Representation, Analytic Surfaces, Synthetic Surfaces, Hermite bicubic Surface, Bezier surfaces, B-spline Surfaces, Coons Surface. No analytical treatment. Solids: Introduction, Geometry and Topology, Solid Representation, Boundary Representation, Euler's equation, Constructive		

	Solid Geometry, Boolean operation for CSG, Hybrid modeling, Feature Based Modeling, Parametric modeling, constraint based modeling, Mass, area, volume calculation.
Unit-III	**Finite Elements Analysis (6 Hrs)** Introduction, Stress and Equilibrium, Boundary Condition, Strain - Displacement Relations, Stress-Strain Relation, Temperature Effects, Potential Energy and Equilibrium: - Rayleigh-Ritz Method, Galerkin‟s Method. One Dimensional Problem: Finite Element Modelling, Coordinate and Shape function, Potential Energy Approach, Galerkin Approach, Assembly of Global Stiffness Matrix and Load Vector, Properties of Stiffness Matrix, Finite Element Equations, Quadratic Shape Function, Temperature Effects . Trusses: Introduction, 2D Trusses, Assembly of Global Stiffness Matrix. Introduction, Constant Strain Triangle Problem, Modeling and Boundary Conditions.
Unit-IV	**Computer Aided Modelling (8 Hrs)** CAD Hierarchy, Integrating CAD, NC and CAM, NC programming using G and M codes adoptable to FANUC controller for lathe and milling, Generative Programming on CNC, DNC, Adaptive control system, CIM,CAPP.
Unit- V	**Introduction to Automation (8 Hrs)** Types of Automation, Transfer line mechanism, Geneva mechanism, Group Technology, Automated guided Vehicles, Automatic Storage and Retrieval System, Flexible Manufacturing System.
Unit-VI	**Robot Technology (8 Hrs)** Classification and Structure of Robotic Systems Point-to-Point Robotic Systems, Continuous Path Robotic System. Configurations of Robotic system, Joints, Drives, Controller, Types of end effectors mechanical, magnetic, pneumatic etc., Industrial Applications of Robots, Robot Programming, Programming Languages
List of Practical's	Eight out of the following (two on CAD based, three on CAE based, three on CAM based and two on robot and R. P.) 1. Developing CAD model of mechanical sub assembly 2. Developing component/ assembly using CAD features. 3. Program on concatenated Transformation involving Three steps.

	4. Stress and Deflection Analysis of 2D truss. 5. Stress and Deflection Analysis of Beam. 6. Stress and deflection analysis of plate 2D/3D.[Mechanical Component] Tool path generation for Turning – Grooving and Threading. Tool path generation for Milling – Facing, Pocketing, Contouring and Drilling. Tool path generation of Turn Mill. Tool path generation for Multi Axis Machining. Robot simulation/Robot Gripper Design. Case study on R.P.		
Text Books	**Author**	**Title of Book**	**Publication**
T1	Ibrahim Zeid and R.	CAD/CAM - Theory and Practice	Tata
T2	Sivasubramanian		Publishing Co. 2009
Reference Books			
R1	Chandrupatla T.R. and	Introduction to Finite Elements in Engineering"	Prentice Hall India
Self-Learning Facilities, Web Resources, Research papers for reference	-		
Contents beyond Syllabus	Case study discussions		
Additional Experiments	-		
Bridging Courses	-		
Presentations	-		

Dynamics of Machinery

Course Title: Dynamics of Machinery		**Course Number: 402043**	**Course Code:C403**
Year: BE		**Semester: I**	
Designation of Course		Core	
Teaching Scheme: TH:4 Hrs/Week PR: 2 Hrs/Week		**Tutorial:** Nil	
Course Assessment Methods	**External Tools**	In-semester Examination: 30 Marks	End Semester Examination: 70 Marks
		Oral	Term Work
	Internal Tools	Class Test	Assignment
Prerequisites	Engineering Mechanics, Theory of Machines, Strength of Material		
Course Objectives			
1	To be conversant with balancing problems of machines		
2	To understand fundamentals of free and forced vibrations		
3	To develop competency in understanding of vibration and noise in Industry		
4	To develop analytical competency in solving vibration problems		
5	To understand the various techniques of measurement and control of vibration and noise		
Course Outcomes			
CO1	**Estimate** natural frequency for single DOF undamped & damped free vibratory systems		
CO2	**Determine** response to forced vibrations due to harmonic excitation, base excitation and excitation due to unbalance forces		
CO3	**Estimate** natural frequencies, mode shapes for 2 DOF undamped free longitudinal and torsional vibratory systems		
CO4	**Apply** balancing technique for static and dynamic balancing of multi cylinder inline and radial engines		
CO5	**Describe** vibration measuring instruments for industrial / real life applications along with suitable method for vibration control		
CO6	**Explain** noise, its measurement & noise reduction techniques for industry and day today life problems		
Course Contents			
Unit-I	***Single Degree of Freedom Systems – Free Vibration*** ***10 Hrs***		
	Fundamentals of Vibration: Elements of a vibratory system, vector representation of S.H.M., degrees of freedom, Introduction to Physical and Mathematical modeling of vibratory systems : Bicycle, Motor bike and Quarter Car. types of vibration, equivalent stiffness and damping, formulation of differential equation of motion (Newton, D'Alembert and energy method) **Undamped free vibrations:** Natural frequency for longitudinal, transverse and torsional vibratory systems. **Damped free vibrations:** Different types of damping, Viscous damping – over damped, critically damped and under damped systems, initial conditions, logarithmic decrement,		

	Dry friction or coulomb damping - frequency and rate of decay of oscillations.
Unit-II	***Single Degree of Freedom Systems - Forced Vibrations*** ***8 Hrs***
	Forced vibrations of longitudinal and torsional systems, Frequency Response to harmonic excitation, excitation due to rotating and reciprocating unbalance, base excitation, Magnification factor, Force and Motion transmissibility, Quality Factor. Half power bandwidth method, Critical speed of shaft having single rotor of undamped systems.
Unit-III	***Two Degree of Freedom Systems – Undamped Vibrations*** ***8 Hrs***
	Free vibration of spring coupled systems – longitudinal and torsional, torsionally equivalent shafts, natural frequency and mode shapes, Eigen value and Eigen vector by Matrix method, Combined rectilinear and angular motion, Vibrations of Geared systems.
Unit-IV	***Balancing*** ***8 Hrs***
	Static and dynamic balancing, balancing of rotating masses in single and several planes, primary and secondary balancing of reciprocating masses, balancing in single cylinder engines, balancing in multicylinder in-line engines, direct and reverse cranks method –radial and V engines
Unit- V	***Measurement and Control of Vibration*** ***8 Hrs***
	A) Measurement : Vibration Measuring Instruments, Accelerometers, Impact hammer, Vibration shakers, Vibration Analyzer, Vibration based condition monitoring, Analysis of Vibration Spectrum, Standards related to measurement of vibration, Human response to vibrations. ***B) Control :*** Vibration control methods, passive, semi active (Introduction to Electro-Rheological & Magneto-Rheological dampers) and active vibration control, control of excitation at the source, control of natural frequency, Vibration isolators, Tuned Dynamic Vibration Absorbers, Introduction to Torsional Damper.
Unit-VI	***Introduction to Noise*** ***6 Hrs***
	Fundamentals of noise, Sound concepts, Decibel Level, white noise, weighted sound pressure level, Logarithmic addition, subtraction and averaging, sound intensity, noise measurement, sound fields, octave band, sound reflection, absorption and transmission, acoustic material & its characteristics, Noise control at the Source, along the path and at the receiver, pass-by-noise, Reverberation chamber, Anechoic Chamber, Human Exposure to Noise and Noise standards.
List of Practical	• To determine natural frequency of transverse vibration of beam using vibration analyzer • To determine the natural frequency of damped vibration of single degree freedom system and to find it's damping coefficient • To obtain frequency response curves of single degree freedom system of vibration for different amount of damping

	• Balancing of wheel / rotor on computerized balancing machine • A case study based on Conditioning Monitoring and Fault Diagnosis. • Noise measurement and analysis using vibration Analyzer • To verify natural frequency of torsional vibration of two rotor system and position of node • To determine critical speed of shaft with single rotor • Assignment: Simulation (using suitable software) of free response of SDOF damped system to demonstrate different damping conditions by solving differential equation numerically		
Text Books	**Author**	**Title of Book**	**Publication**
T1	Rao S. S.	Mechanical Vibration	Pearson Education Kinderley New Delhi
T2	Grover G. K.	Mechanical Vibration	NEM Chand & Bros Roorkee
Reference Books			
R1	Thomson W.T.	Theory of Vibration	CBS Publishers
R2	Singh V. P.	Mechanical Vibration	Dhanpat rai and sons New Delhi
R3	Kelly S.G.	Mechanical Vibration	Tata McGraw Hill Publications
Self-Learning Facilities, Web Resources, Research papers for reference	Research Papers on Vibration Based Condition Monitoring, NPTEL Online Lectures		
Contents beyond Syllabus	Vibration Model for Ball Bearing Vibration in the context of Human Body		
Additional Experiments	Experiment on shock absorbers		
Bridging Courses			
Tutorials			
Presentations			

Finite Element Analysis

Course Title: Finite Element Analysis		**Course Number:402044 A**	**Course Code:**
Year: BE		**Semester: I**	
Designation of Course		Elective-I	
Teaching Scheme:3Hrs/Week		**Practical:**2 Hr/Week	
Course Assessment Methods	**External Tools**	In-semester Examination: 30 Marks	End Semester Examination: 70 Marks
		Class Test: 30 Marks	Oral: Nil Term Work: 25
	Internal Tools	Class Test	Assignments
Prerequisites	Fluid Mechanics, Heat transfer, Numerical methods, Programming Languages.		

Course Objectives

1	To understand the philosophy and general procedure of Finite Element Method as applied to solid mechanics and thermal analysis problems
2	To familiarize students with the displacement-based finite element method for displacement and stress analysis and to introduce related analytical and computer tools
3	To provide a bridge between hand calculations based on mechanics of materials and machine design and numerical solutions for more complex geometries and loading states
4	To study approximate nature of the finite element method and convergence of results are examined
5	To provide some experience with a commercial FEM code and some practical modeling exercises

Course Outcomes

CO1	Student will be able to **understand** the different techniques used to solve mechanical engineering problems.
CO2	Student will be able to **derive** and use 1-D and 2-D element stiffness matrices and load vectors from various methods to solve for displacements and stresses
CO3	Student will be able to **apply** mechanics of materials and machine design topics to provide preliminary results used for testing the reasonableness of finite element results.
CO4	Student will be able to **explain** the inner workings of a finite element code for linear stress, displacement, temperature and modal analysis
CO5	Student will be able to **use** commercial finite element analysis software to solve complex problems in solid mechanics and heat transfer
CO6	Student will be able to **interpret** the results of finite element analyses and make an assessment of the results in terms of modeling (physics assumptions) errors, discretization (mesh density and refinement toward convergence) errors, and numerical (round-off) errors.

Course Contents

Unit-I	**Fundamental Concepts of FEA (6 Hrs)** Introduction: Solution methodologies to solve engineering problems, governing equations, mathematical modelling of field problems in engineering, discrete and continuous models. Brief history of FEM, Finite Element terminology (nodes, elements, domain, continuum, degrees of freedom, loads & constraints), general steps involved in FEM, applications of FEM in various fields, advantages and disadvantages of FEM, consistent units system, essential and natural boundary conditions, symmetric boundary conditions. Introduction to different approaches used in FEA : Direct approach, Variational formulation- Principal of Minimum Potential Energy (PMPE), Galerkin weighted residual method, Principle of Virtual Work, Rayleigh-Ritz method, relation between FEM and Rayleigh-Ritz method Types of Analysis (Introduction) : Linear static analysis, Non-linear analysis, Dynamic analysis, Linear buckling analysis, Thermal analysis, Fatigue analysis, Crash analysis.
Unit-II	**1D Elements (6 Hrs)** Types of 1D elements, displacement function, global and local coordinate systems, polynomial form of interpolation functions- linear, quadratic and cubic, properties of shape function, primary and secondary variables. Formulation of elemental stiffness matrix and load vector for bar, truss and beam using any approach, Formulation of load vector due to uniform temperature change (only for bar). Assembly of global stiffness matrix and load vector, properties of stiffness matrix, half bandwidth, treatment of boundary conditions- elimination approach, stress and reaction forces calculations
Unit-III	**2D Elements (6 Hrs)** Two-Dimensional Stress Analysis: Plane Stress/Strain problems in 2D elasticity, constitutive relations Constant Strain Triangle(CST), Liner Strain Rectangle (LSR), displacement function, Pascal's triangle, compatibility and completeness requirement, geometric isotropy, convergence requirements, strain filed, stress filed, Formulation of element stiffness matrix and load vector for Plane Stress/Strain problems Assembly of global stiffness matrix and load vector, Boundary conditions, solving for primary variables (displacement), stress calculations
Unit-IV	**Isoparametric Elements and Numerical Integration (6 Hrs)** Concept of isoparametric elements, Terms isoparametric, super parametric and subparametric. Coordinate mapping : Natural coordinates, Area coordinates (for triangular elements), higher order triangular and quadrilateral elements (Lagrangean and serendipity elements), geometry associative mesh, quality checks, mesh refinement- p vs h refinements, Uniqueness of mapping - Jacobian matrix. Numerical integration: Gauss Quadrature in one and two dimension, Order of Gauss integration, full and reduced integration, sub-modeling, substructuring.

Unit- V	**1D Steady State Heat Transfer Problems (6 Hrs)** Introduction, One dimensional steady-state heat transfer problem- Governing differential equation, Finite Element formulation using Galerkin's approach for composite wall and thin Fin , essential and natural boundary conditions and solving for temperature distribution
Unit-VI	**Dynamic Analysis (6 Hrs)** Types of dynamic analysis, general dynamic equation of motion, lumped and consistent mass, Mass matrices formulation of bar, truss and beam element. Undamped-free vibration: Eigenvalue problem, evaluation of eigenvalues and eigenvectors (characteristic polynomial technique).
List of Practicals	• Computer program for stress analysis of 1D bar using linear and quadratic elements. Show the variation of stress and strain within the element for linear and quadratic bar element • Computer program for stress analysis of 2-D truss subjected to plane forces • Computer programs for (i) modal analysis and, (ii) stress for 1-D beam (simply supported or cantilever beams) • Static stress concentration factor calculation for a plate with center hole subjected to axial loading in tension using FEA software • Modal analysis of any machine component using FEA software. • Stress and deflection analysis of any machine component consisting of 3-D elements using FEA software • Elasto-plastic stress analysis of plate using FEA software

Text Books	**Author**	**Title of Book**	**Publication**
T1	Daryl L	A First Course in the Finite Element Method	Logan
T2	G Lakshmi Narasaiah,	Finite Element Analysis	B S Publications
T3	Y.M.Desai, T.I.Eldho and A.H.Shah	Finite Element Method with Applications in Engineering	Pearson Education
T4	Chandrupatla T. R. and Belegunda A. D	Introduction to Finite Elements in Engineering	Prentice Hall India
T5	P., Seshu	Text book of Finite Element Analysis	PHI

Reference Books	Author	Title of Book	Publication
R1	Bathe K. J.,	Finite Element Procedures	Prentice Hall of India
R2	R. D. Cook,	Concepts and Applications of Finite Element Analysis	Wiley, India
R3	Kwon Y. W., Bang H	Finite Element Method using MATLAB	CRC Press
R4	Peter Kattan	MATLAB Guides to Finite Elements- An Interactive Approach	Springer
R5	S. Moaveni	Finite element analysis, theory and application with Ansys	Prentice Hall
R6	Erdogan Madenci and Ibrahim Guven	The Finite Element Method and Applications in Engineering Using Ansys	Springer
R7	David V. Hutton	Fundamental of Finite Element Analysis	Tata McGraw-Hill
R8	Gokhale N. S.	Practical Finite Element Analysis	Finite to Infinite, Pune
Self-Learning Facilities, Web Resources, Research papers for reference	Animations, NPTEL Video		
Contents beyond Syllabus			
Additional Experiments			
Bridging Courses			
Presentations			

Automobile Engineering

Course Title: Automobile Engineering		**Course Number: C 305**	**Course Code:402045A**
Year: 2019-20		**Semester: I**	
Designation of Course		Professional Core	
Teaching Scheme: 03 Hrs/Week(Theory)		**Tutorial:** 1 Hr/Week	
Course Assessment Methods	**Direct Method**	In-semester 30 Marks	End Semester Examination 70 Marks
		Oral (25 Marks)	
	Indirect Method	Class Test	Assignments
Prerequisites	Knowledge of PHYSICS, BASIC MATHEMATICS., manufacturing processes, Workshop Practices		
Course Objectives			
1	To make the student conversant with fundamentals of automobile systems.		
2	To develop competencies in performance analysis of vehicles.		
3	To make the student conversant with automobile safety, electrical system and vehicle maintenance.		
4	To understand the emerging trends of electric vehicles, hybrid electric vehicles and solar vehicles.		
Course Outcomes			
CO1	To compare and select the proper automotive system for the vehicle.		
CO2	To analyse the performance of the vehicle.		
CO3	To diagnose the faults of automobile vehicles.		
CO4	To apply the knowledge of EVs, HEVs and solar vehicles		
Course Contents			
Unit-I	**Introduction and Drive Train**		
	Introduction: Current scenario in Indian auto/ancillary industries, vehicle specifications and classification. Chassis and Frames: Types of chassis layout with reference to power plant locations and drive, various types of frames, constructional details. Drive Train: Types of transmission system, necessity and selection of clutch, necessity of gear box and different types, fluid flywheel, torque convertor, continuous variable transmission, , overdrive, propeller shaft, final drive and differential.		
Unit-II	**Axles, Wheels and Tyres, Steering System**		
	Axles: Purpose, requirement and types of front and rear axle, loads acting on rear axles. Wheels and tyres: Wheel construction, alloy wheel, wheel balancing, type of tyres, tyre construction, tyre materials, factors affecting tyre life. Steering system : Steering mechanism, steering geometry, cornering force, slip angle, scrub radius, steering characteristics, steering linkages and gearbox, power steering, collapsible steering, reversibility of steering, four wheel steering, wheel alignment.		
Unit-III	**Suspension and Brake System**		

	Suspension : Types of suspension linkages, types of suspension springs- leaf, coil, air springs, hydro gas, rubber suspension, interconnected suspension, self levelling suspension (active suspension), shock absorbers (hydraulic and air). Brake systems: Drum, disc, mechanical, hydraulic, air brakes, vacuum, power assisted brakes, hand brake, ABS, EBD.
Unit-IV	**Vehicle Performance and Safety**
	Vehicle performance: Parameters, vehicle resistances, traction and tractive effort, power requirement for propulsion, road performance curves (numericals), stability of vehicles, vehicle testing on chassis dynamometer. Vehicle safety: Types of active and passive safety, vehicle interior and ergonomics, NVH in automobiles.
Unit- V	**Electrical System and Vehicle Maintenance**
	Batteries : Principles and construction of lead-acid battery, characteristics of battery, rating capacity and efficiency of batteries, various tests on battery condition, charging methods, introduction to lithium batteries. Electrical system and accessories : Insulated and earth return systems, positive and negative earth systems, electrical fuel pump, speedometer, fuel, oil and temperature gauges, horn, wiper system, automotive sensors and actuators, electronic control unit/module. Maintenance: Types of vehicle maintenance, servicing/overhauling of clutch, gear box, propeller shaft, differential, axles, steering system, suspension system, break system, electrical system.
Unit-VI	**Electric and Hybrid Electric Vehicles**
	Introduction: Concept and environmental importance of EVs, HEVs and solar vehicles. Electric vehicles: Layout, construction and working. Hybrid electric vehicles: Types, layout, hybridization factor, plug in hybrid electric vehicles, fuel efficiency analysis. Challenges and future scope of EVs and HEVs.

Text Books	**Author**	**Title of Book**	**Publication**
T1	K. Newton and W. Seeds, T.K. Garrett	"Motor Vehicle", 13thEdition	Elsevier publications
T2	Hans Hermann Braess, Ulrich Seiffen,	Handbook of Automotive Engineering	SAE Publications
T3	William H. Crouse	Automotive Mechanics	McGraw Hill Publications
T4	Joseph Heitner	Automotive Mechanics	C.B.S Publishers and Distributors
Reference Books			
R1	Dr. Kirpal Singh	Automobile Engineering	Volume 1, Standard Publishers distributors
R2	Crouse/Anglin	Automobile Mechanics	TATA Mcgraw-Hill
R3	R. B. Gupta	Automobile Engineering	Satya Prakashan

R4	Husain, Iqbal	Electric and hybrid vehicles	2 edition, CRC Press
Self-Learning Facilities, Web Resources, Research papers for reference	**Online Education resources: viz. NPTEL web site**: (1) NPTEL (2) freevideolectures.com › Mechanical › IIT Madras		
Contents beyond Syllabus	Industrial Visit.		
Additional Experiments	--		
Bridging Courses	--		
Assignments	--		
Tutorials	--		
Presentations	PPT Presentations.		

Operation Research

Course Title: OPERATION RESEARCH		**Course Number: 402045B**	**Course Code: C045**
Year: FINAL YEAR(B.E.)		**Semester: FIFTH(07)**	
Designation of Course		Professional Core	
Teaching Scheme: 03 Hrs./Week (Theory).		**Tutorial:** NIL	
Course Assessment Methods	**Direct methods**	In-semester Examination: 30 Marks	End Semester Examination: 70 Marks
	Indirect Methods	Assignments	Class Test
Prerequisites	Knowledge of PHYSICS, BASIC MATHEMATICS.		
Course Objectives			
1	Ability to understand the scope of operations research in engineering industry.		
2	Ability to develop analytical competency in solving optimization functions in Transportation methods for the organization		
3	Ability to understand OR technique for better strategic management of various resources		
4	Ability to calculate optimal solution for various industrial problems.		
5	Ability to learn various cost effective strategies in various applications in Industry		
Course Outcomes			
CO1	Illustrate the need to optimally utilize the resources in various types of industries.		
CO2	Apply and analyze mathematical optimization functions to various applications		
CO3	Demonstrate cost effective strategies in various applications in industry.		
CO4	Evaluate various cost effective strategies in various applications in industry.		
CO5	To practice obtaining optimal solution for various industrial project management problems.		
CO6	To compile information together in such a way that yeilds network analysis problem.		

Course Contents	
Unit-I	**Introduction: Operation Research**
	• Introduction: Definition, Evolution and Classification of Quantitative Methods and Operations Research Techniques, Methodology, Advantages and Limitations • Linear Programming: Introduction, Formulation, Simplex Method (Big – M and Two Phase Methods), Dual Simplex Method (Conversion of primal to dual) • Introduction to Sensitivity Analysis. • Decision Theory: Meaning and Steps in Decision Making, Types of Management Decisions, Decision under Certainty, under Risk, under Uncertainty, Decision Trees.
Unit-II	**Transportation Model**
	• Introduction, Formulation, Basic Method of Solving Transportation Problem, Optimization Methods like UV and Stepping Stone Method, Concept of Trans-shipment Methods as an Extension of Transportation.
	Assignment Problem
	Hungarian Method to solve Assignment Problem, Travelling Salesman as an Extension of Assignment Problem
Unit-III	**Theory of Games and Investment Analysis**
	• Theory of Games : Introduction, Minimax and Maximin Principle, Solution of Game with Saddle Point, Solution by Dominance, Solution by Graphical Method, m x n size Game Problem, Iterative method, Introduction to formulation of games using Linear Programming. • Investment Analysis: Break-Even Analysis, Payback Period Method, A (A) R Method, DCF Method, IRR Method, Introduction to Probabilistic Models
Unit-IV	**Inventory Control and Replacement Analysis**
	□ Inventory Control - Deterministic Models- Shortage, without shortage; Probabilistic Inventory Models, Introduction to Concept of Service level. □ Replacement Analysis - Replacement of Items that Deteriorate, Replacement of Items that Fail Suddenly.
Unit- V	**Queuing Theory and Sequencing models**
	• Queuing Theory - Introduction, Basis Structure, Terminology (Kendal's Notations) and Applications. • Queuing Model M/M/1: /FIFO, M/M/c. • Sequencing models: Solution of sequencing Problem - Processing of n jobs through two machines, Processing of n jobs through three machines, Processing of two jobs through m Machines, Processing of n jobs through m Machines
Unit-VI	**Integer and Dynamic Programming**

	• Integer Programming: Introduction to Integer Programming, Cutting plane method and Branch and Bound Method. • Dynamic Programming: Introduction, DP Model, Applications of DP Model to shortest route problems. Solution of LPP by Dynamic Programming		
Text Books	**Author**	**Title of Book**	**Publication**
T1	Prem Kumar Gupta, D. S. Hira	Problems in Operations Research: Principles and Solutions	S. Chand, 1991
T2	J. K. Sharma	Operations Research : Theory And Application	Laxmi pub. India
Reference Books			
R1	Belegundu	Optimization Concepts and Applications in engineering	Cambridge Uni. Press, India
R2	Hillier F.S., and Lieberman G.J	Operations Research, Eight Edition	Mc. Tata McGraw Hill, India
R3	Ravindran	Engineering optimization Methods and Appliations‖, 2nd edition	Wiley, India
R4	Ravindran Phillips and Solberg	Operations Research Principles and Practice, Second Edition	Mc. WSE Willey,
R5	Hamdy A Taha	Operations Research - An introduction	Pearson Education
Self-Learning Facilities, Web Resources, Research papers for reference	https://www.informs.org/About-INFORMS/What-is-**Operations-Research**		
Contents beyond Syllabus	Case study discussions.		
Additional Experiments	N.A.		
Bridging Courses	N.A.		
Tutorials	N.A.		
Presentations	• Unit wise presentation of subtopics to be displayed on projector. • Animated Videos.		