PUNE VIDYARTHI GRIHA'S

COLLEGE OF ENGINEERING AND TECHNOLOGY AND

G K PATE(WANI) INSTITUTE OF MANAGEMENT, PUNE-9

(AFFILIATED TO UNIVERSITY OF PUNE, PUNE)

MECHANICAL ENGINEERING DEPARTMENT

CURRICULUM BOOK

ACADEMIC YEAR: 2023-24

FOR THE PROGRAMME

T. E. (MECHANICAL ENGINEERING)

PUNE VIDYARTHI GRIHA'S

COLLEGE OF ENGINEERING AND TECHNOLOGY AND

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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**

Mechanical Engineering Department

Vision of the Department

"To become premier source of competent Mechanical Engineering professionals 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 teamwork
- **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

Mechanical Engineering Department

Programme Educational Outcomes

PO1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2: 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.

PO3: 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.

PO4: 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.

PO5: 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.

PO6: 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.

PO7: 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.

PO8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10: 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.

PO11: 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.

PO12: 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.

Programme Specific Outcomes

PSO1: Demonstrate competency in the area of Thermal, Design, Manufacturing and to apply skills in multidisciplinary areas of engineering

PSO2: 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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Syllabus Structure for Semester V & VI

Savitribai Phule Pune University

Board of Studies - Automobile and Mechanical Engineering
Undergraduate Program - Mechanical Engineering (2019 pattern)

Course Code	Course Name	Teaching Scheme (Hrs./week)			Examination Scheme and Marks						Credit			
		TH	PR	TUT	ISE	ESE	TW	PR	OR	Total	TH	PR	TUT	Total
Semester-V														
302041	Numerical & Statistical Methods	3	-	1	30	70	25	-	-	125	3	-	1	4
302042	Heat & Mass Transfer	3	2	-	30	70	-	50	-	150	3	1	-	4
302043	Design of Machine Elements	3	2	-	30	70	-	-	25	125	3	1	-	4
302044	Mechatronics	3	2	-	30	70	-	-	25	125	3	1	-	4
302045	Elective I	3	-	-	30	70	-	-	-	100	3	-	-	3
302046	Digital Manufacturing Laboratory	-	2	-	-	-	50	-	-	50	-	1	-	1
302047	Skill Development	-	2	-	-	-	25	-	-	25	-	1	-	1
302048	Audit course - V$	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**15**	**10**	**1**	**150**	**350**	**100**	**50**	**50**	**700**	**15**	**5**	**1**	**21**
Semester-VI														
302049	Artificial Intelligence &Machine Learning	3	2	-	30	70	-	-	25	125	3	1	-	4
302050	Computer Aided Engineering	3	2	-	30	70	-	50	-	150	3	1	-	4
302051	Design of Transmission Systems	3	2	-	30	70	-	-	25	125	3	1	-	4
302052	Elective II	3	-	-	30	70	-	-	-	100	3	-	-	3
302053	Measurement Laboratory	-	2	-	-	-	50	-	-	50	-	1	-	1
302054	Fluid Power &Control Laboratory	-	2	-	-	-	50	-	-	50	-	1	-	1
302055	Internship/Mini project *	-	4	-	-	-	100	-	-	100	-	4	-	4
302056	Audit course - VI$	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**12**	**14**	**-**	**120**	**280**	**200**	**50**	**50**	**700**	**12**	**9**	**-**	**21**

Elective-I		**Elective-II**	
302045-A	Advanced Forming & Joining Processes	302052-A	Composite Materials
302045-B	Machining Science & Technology	302052-B	Surface Engineering

Abbreviations: TH: Theory, **PR**: Practical, **TUT**: Tutorial, **ISE**: In-Semester Exam, **ESE**: End-Semester Exam, **TW**: Term Work, **OR**: Oral

Numerical & Statistical Methods

Course Title: Numerical and Statistical Methods		**Course Number: C301**	**Course Code: 302041**
Year: T.E.		**Semester: V**	
Designation of Course		Professional Core	
Teaching Scheme: 3 Hrs/Week		**Tutorial:** 1Hr./Week	
Course Assessment Methods	**Direct methods**	Insem Examination: 30 Marks	End Semester Examination: 70 Marks
	Indirect Methods	Assignments	Class Test
Prerequisites	System of linear equations, Partial differentiation, Statistics, Probability, Problem solving and programming.		
Course Objectives			
1	UNDERSTAND applications of systems of equations and solve mechanical engineering applications.		
2	APPLY differential equations to solve the applications in the domain of fluid mechanics, structural, etc.		
3	LEARN numerical integration techniques for engineering applications.		
4	COMPARE the system's behavior for the experimental data.		
5	INTERPRET Statistical measures for quantitative data.		
6	ANALYZE datasets using probability theory and linear algebra.		
Course Outcomes			
CO1	SOLVE system of equations using direct and iterative numerical methods.		
CO2	ESTIMATE solutions for differential equations using numerical techniques.		
CO3	DEVELOP solution for engineering applications with numerical integration.		
CO4	DESIGN and CREATE a model using a curve fitting and regression analysis.		
CO5	APPLY statistical Technique for quantitative data analysis.		
CO6	DEMONSTRATE the data, using the concepts of probability and linear algebra.		
Course Contents			
Unit-I	**Roots of Equation and Simultaneous Equations**		
	Roots of Equation: Bracketing method and Newton-Raphson method Solution of simultaneous equations: Gauss Elimination Method with Partial pivoting, Gauss- Seidel method, Thomas algorithm for Tri-diagonal Matrix.		
Unit-II	**Numerical Solution of Differential Equations**		
	Ordinary Differential Equations [ODE]: Taylor series method, Euler Method, Runge-Kutta 4th order. Simultaneous equations using Runge-		

	Kutta 2nd order method. **Partial Differential Equations [PDE]**: Finite difference method, Simple Laplace method, PDE's Parabolic explicit solution, Elliptic explicit solution.
Unit-III	**Numerical Integration**
	Numerical Integration (1D): Trapezoidal rule, Simpson's 1/3 Rule, Simpson's3/8 Rule, Gauss Quadrature2-point and 3-point method. **Double Integration**: Trapezoidal rule, Simpson's 1/3rdRule.
Unit-IV	**Curve Fitting and Regression Analysis**
	Curve Fitting: Least square technique- first order, power equation, exponential equation and quadratic equation. **Regression Analysis**: Linear regression, Nonlinear regression, Multiple regressions, Polynomial regression. Lagrange's interpolation, Numerical interpolation and differentiation using Newton's forward method, inverse interpolation (Lagrange's method only).
Unit- V	**Statistics**
	Measures of central tendency: mean, median, mode. Measurement of variability and dispersion: Standard deviation, standard error, variance, range. Measure of shape: skewness, kurtosis Statistical diagram: scattered diagram, histogram, pie charts, and measure of association between two variables. Correlation: Karl Pearson's Coefficient of correlation and its mathematical properties, Spearman's Rank correlation and its interpretations.
Unit-VI	**Probability and Linear Algebra**
	Probability: Joint, conditional and marginal probability, Bayes' theorem, independence, theorem of total probability, expectation and variance, random variables. Probability distributions: Binomial, Poisson, Geometric, Uniform, Exponential, Gamma, Normal and Chi square. **Linear algebra**: Review of matrix operations, vector and vector spaces, linear mapping.
List of Practicals	

Text Books	**Author**	**Title of Book**	**Publication**
T1	Steven C. Chapra	Applied Numerical Methods with MATLAB for Engineers and Scientist	Tata Mc-Graw Hill Publishing Co. Ltd
T2	B. S. Grewal	Numerical Methods in Engineering and Science	Khanna Publication
T3	B. S. Grewal	Higher Engineering Mathematics	Khanna Publication
Reference Books			
R1	Erwin Kreyszig	Advanced Engineering Mathematics	Wiley India
R2	Joe D. Hoffman	Numerical Methods for Engineers and Scientists	CRC Press

R3	Sheldon M. Ross	Introduction to Probability and Statistics for Engineers and Scientists	Elsevier Academic Press
R4	Deisentoth, Faisal, Ong	Mathematics for machine learning	Cambridge University Press
R5	Kandasamy	Numerical methods	S Chand
R6	Jason Brownlee	Statistical Methods for Machine Learning	Machine learning Mastery
Self-Learning Facilities, Web Resources, Research papers for reference	1. http://nptel.ac.in/courses/111101003/ 2. http://nptel.ac.in/courses/111105038/ 3. http://nptel.ac.in/courses/111107063/ 4. http://nptel.ac.in/courses/111105041/ 5. http://nptel.ac.in/courses/111104079/ 6. https://www.analyticsvidhya.com/		
Contents beyond Syllabus	1. False position method in Roots of Equation. 2. Runge Kutta 2nd Order method for solving ODE 3. Numerical Integration using combination of trapezoidal, simpson's 1/3rd & Simpson's 3/8th Method		
Additional Experiments	N.A.		
Bridging Courses	N.A.		
Tutorials	N.A.		
Presentations	N.A.		

Self Learning Facilities

1. https://www.youtube.com/watch?v=qFJGMBDfFMY&list=PLkZjai-2Jcxn35XnijUtqqEg0Wi5Sn8ab

2. https://www.youtube.com/watch?v=pOtnzAXlXvI&list=PLwdnzlV3ogoUY43XoMwVVCWDSImC9mVQB

3. https://www.youtube.com/watch?v=TWAN_T66Cps&list=PLq-Gm0yRYwTguDcfylj1ZicXxzdZCAr5S

Heat and Mass Transfer

Course Title: Heat & Mass Transfer		**Course Number:**	**Course Code: 302042**
Year: T.E. (2019 Pattern)		**Semester: I**	
Designation of Course		Professional Core	
Teaching Scheme: 3 Hrs/Week		**Practical : 2 Hrs/week**	
Course Assessment Methods	**Direct External methods**	In- Semester Examination: 30 Marks	End Semester Examination: 70Marks
		Practical Exam: 50 Marks	
	Direct Internal Methods	Assignments	Class Test
Prerequisites	1. Engineering Mathematics 2. Engineering Physics 3. Engineering Thermodynamics		
Course Objectives			
1	IDENTIFY the laws for different modes of heat transfer		
2	UNDERSTAND the properties and economics of thermal insulation and ANALYZE heat transfer through fins and thermal systems with lumped heat capacitance		
3	ANALYZE the natural and forced convective mode of heat transfer in various geometric configurations.		
4	UNDERSTAND AND REALIZE various laws with their interrelations and analyze Radiation heat transfer in black and grey bodies/surfaces with or without radiation shields		
5	UNDERSTAND the fundamentals and laws of mass transfer and its applications.		
6	ANALYZE various performance parameters for existing heat exchanger and DEVELOP methodologies for designing a heat exchanger under prescribed		

	conditions and for a particular application, with references TEMA standards
Course Outcomes: On completion of the course, learner will be able to	
CO1	**Identify** the various modes of heat transfer and **implement** the basic heat conduction equations for steady one-dimensional thermal system without and with internal heat generation.
CO2	**Understand** the concept of thermal insulation and transient heat analysis and **analyze** the thermal systems with lumped heat capacitance and the thermal systems with extended surfaces
CO3	**Analyze** and **evaluate** the heat transfer rate in natural and forced convection and **Understand** the boiling and condensation heat transfer
CO4	**Interpret** heat transfer by radiation between objects with simple geometries
CO5	**Understand** the concept of mass transfer and mass diffusion equation
CO6	**Analyze** the different types of heat exchangers and **Execute** the effectiveness and rating of heat exchangers
Course Contents	
Unit-I	**Fundamentals of Heat Transfer**
	Basic Concepts: Different Modes and Laws of heat transfer, 3-D heat conduction equation in Cartesian coordinates (with derivation), and its simplified equations, simplified equations in cylindrical and spherical coordinates (simplified equations, no derivation) thermal conductivity, thermal diffusivity, electrical analogy, Thermal contact Resistance. Boundary and initial conditions: Temperature boundary condition, heat flux boundary condition, convection boundary condition, radiation boundary condition. 1-D steady state heat conduction without and with heat generation: Heat conduction without heat generation in plane wall, composite wall, composite cylinder, composite sphere. Heat conduction with heat generation in Plane wall, Cylinder and Sphere with different boundary conditions
	Practical /Assignment / Tutorial

	● Determination of Thermal Conductivity of insulating powder. ● Determination of Thermal Conductivity of metal rod.
Unit-II	**Heat Transfer through Extended Surfaces & Transient Heat Conduction**
	Thermal Insulation – Critical thickness of insulation, Types and properties of insulating materials, Safety considerations in thermal insulation, Economic and cost considerations, Payback period, Numerical on payback period. Heat transfer through extended surfaces: Types of fins and its applications, Governing Equation for constant cross sectional area fins, Solution for infinitely long fin (with derivation), adequately long fin with insulated end tip and short fins (no derivation), Fin Efficiency & Effectiveness of fins, estimation of error in Temperature measurement by thermometer. Transient heat conduction: Validity and criteria of lumped system analysis, Biot Number, Fourier Number, Time Constant and Response of thermocouple, Use of Heisler Charts for plane wall, cylinder and sphere
	Practical /Assignment / Tutorial
	● Determination of temperature distribution, fin efficiency in Natural / Forced Convection ● Assignment to solve transient heat transfer problem using Heisler and Grober Charts
Unit-III	**Convection**
	Principles of Convection: Local and average heat transfer coefficient, Hydrodynamic and Thermal boundary layer for a flat plate and pipe flow Forced Convection: Physical significance of non-dimensional numbers, Empirical correlations for flat plate, pipe flow, and flow across cylinders, spheres, tube banks. Free Convection: Physical significance of non-dimensional numbers, Free convection from a vertical, horizontal surface, cylinder and sphere. Mixed

	Convection Boiling and Condensation: Types of boiling, Regimes of pool boiling, Film wise condensation, Drop wise condensation (No Numerical treatment), Critical heat flux
	Practical /Assignment / Tutorial
	● Determination of local and average heat transfer coefficient in Natural Convection ● Determination of local and average heat transfer coefficient in Forced Convection. ● Study of Pool boiling phenomenon and determination of Critical Heat Flux (CHF) ● Demonstration of dropwise and filmwise condensation
Unit-IV	**Radiation**
	Thermal Radiation; definition of various terms used in radiation mode; Stefan-Boltzmann law, Kirchhoff's law, Planck's law and Wein's displacement law. Intensity of radiation and solid angle; Lambert's law; Radiation heat exchange between two black surfaces, configuration or view factor. Radiation heat exchange between grey surfaces, Electrical analogy for radiation, Radiation shields, Numerical
	Practical /Assignment / Tutorial
	● Determination of Emissivity of a Test surface ● Determination of Stefan Boltzmann Constant
Unit- V	**Mass Transfer**
	Physical origins, applications of mass transfer, Mixture Composition, Phase diagram, Fick's Law of Diffusion with numerical treatment, Restrictive Conditions, Mass diffusion coefficient, Conservation of Species,

	The Mass Diffusion equation – Cartesian coordinates deviation, cylindrical coordinates and Spherical coordinates (no derivation), Boundary and initial conditions
Unit-VI	**Heat Exchangers and Equipment Design**
	Heat Exchangers: Classification and applications of heat exchangers, Heat exchanger analysis – LMTD for parallel and counter flow heat exchangers, Effectiveness– NTU method for parallel and counter flow heat exchangers, cross flow heat exchangers, LMTD correction factor, Heat Pipe, Introduction to electronic cooling - Active and passive methods of augmented heat transfer Process Equipment Design: Condenser Design, Introduction to TEMA standards, Design considerations for heat exchangers, Materials of construction and corrosion, Temperature effects, Radiation effects, Economic consideration, Condenser and Heat exchanger design and performance calculations, Design of shell and tube type Heat Exchanger
	Practical /Assignment / Tutorial
	● Determination of heat transfer, overall heat transfer coefficient and effectiveness of Plate Heat Exchanger

Text Books	**Author**	**Title of Book**	**Publication**
T1	Franck P. Incropera, David P. DeWitt	Fundamentals of Heat and Mass Transfer	John Wiley & Sons
T2	Y. A. Cengel and A.J. Ghajar	Heat and Mass Transfer – Fundamentals and Applications	Tata McGraw Hill Education Private Limited
T3	S.P. Sukhatme	A Textbook on Heat Transfer	Universities Press
T4	R.C. Sachdeva	Fundamentals of Engineering Heat and Mass Transfer	New Age Science
T5	Joshi's Process Equipment Design	Mahajani , S.B. Umarji	Trinity Press

Reference Books			
R1	P.K. Nag	Heat & Mass Transfer	McGraw Hill Education
R2	M.M. Rathod	Engineering Heat and Mass Transfer	Laxmi Publications
R3	V. M. Domkundwar	Heat Transfer	Dhanpat Rai & Co Ltd
R4	Holman	Fundamentals of Heat and Mass Transfer	McGraw Hill
R5	C.P. Kothandaraman S. V. Subramanyam	Heat and Mass Transfer Data Book	New Academic Science
R6	Process heat Transfer	D. Q. Kern	Wiley Publication
Self-Learning Facilities, **Web Resources,** **Research papers for reference**	NPTEL, Virtual Labs, Other reference material from web		
Contents beyond Syllabus	Virtual Lab		

Curriculum Book

Course Title: Design of Machine Elements		**Course Number: 302043**	**Course Code: C303**
Year: TE (Mech) 2023-24		**Semester: I**	
Designation of Course		Professional Core/~~Elective~~	
Teaching Scheme		**Theory** : 3 Hrs/Week **Practical:** 2 Hrs/Week	
Course Assessment Methods	**External**	In-semester Examination: 30 Marks	End Semester Examination: 70 Marks
		Term Work 25 marks, Oral 25 Marks	
	Internal	Assignments	Class test
Prerequisites	Engineering Mechanics, Strength of Materials		
Course Objectives			
1	To explain the different steps involved in designing various machine components with reference to stresses involved, material selection and manufacturing methods, type of loads- Static and/or fluctuating		
2	To identify various modes of failure of commonly used machine components and to adopt related design procedure thereafter.		
3	To apply codes and standards to machine component design.		
4	To design and analyze suitable joints, fasteners, screws, welds etc.		
Course Outcomes: At the end of course			
CO1	Students will be able to **design** and **analyze** the cotter and knuckle Joints, levers and components subjected to eccentric loading.		
CO2	Students will be able to **design** shafts, keys and couplings under static loading conditions.		
CO3	Students will be able to **analyze** different stresses in power screws and **apply** those in the procedure to design screw jack.		
CO4	Students will be able to **evaluate** dimensions of machine components under fluctuating loads.		
CO5	Students will be able to evaluate and **interpret** the stress developed on the different type of welded and threaded joints.		
CO6	Students will be able to **apply** the design and development procedure for different types of springs.		
Course Contents			
Unit-I	**Design of Simple Machine Elements**		
	Factor of safety, Selection of Factor of Safety, Service factor, Design of Cotter joint, Knuckle joint, Design of hand / foot lever, lever for safety valve, bell crank lever, Design of components subjected to eccentric loading.		
Unit-II	**Design of Shafts, Keys and Couplings**		

	Shaft design on the Strength basis, torsional rigidity basis and lateral rigidity basis, Design of shaft as per A.S.M.E. code. Design of square and rectangular keys, Kennedy key and splines. Design of Flange Coupling and Bushed-Pin Flexible Coupling.
Unit-III	**Design of Power Screws**
	Terminology of Power Screw, Torque analysis and Design of power screws with square and trapezoidal threads, Collar friction torque, Self-locking screw, Efficiency of square threaded screw, Efficiency of self-locking screw, Design of screw, nuts and C-Clamp. Design of screw jack, Differential and Compound Screw and Re-circulating Ball Screw (Theoretical treatment only).
Unit-IV	**Design against Fluctuating loads**
	Stress concentration and its factors, Reduction of stress concentration factors, fluctuating stresses, fatigue failures, endurance limit, S-N curve, Notch sensitivity, Endurance limit, Endurance strength modifying factors, Reversed stresses – Design for Finite and Infinite life, Cumulative damage in fatigue failure, Soderberg, Gerber, Goodman Lines, Modified Goodman diagrams, Fatigue design under combined stresses:- (Theoretical treatment only.)
Unit- V	**Threaded and Welded joints**
	Introduction to threaded joints, Bolts of uniform strength, locking devices, eccentrically loaded bolted joint in shear, Eccentric load perpendicular and parallel to axis of bolt, Eccentric load on circular base. Introduction to welded joints, Strength of butt, parallel and transverse fillet welds, Axially loaded unsymmetrical welded joints, Eccentric load in plane of welds, Welded joints subjected to bending and torsional moments.
Unit-VI	**Design of Springs**
	Types and applications of springs, Stress and deflection equations for helical compression Springs, Springs in series and parallel, Design of helical springs, concentric helical springs, surge in spring, Design of Multi-leaf springs, Nipping of Leaf springs, Shot Peening.
	Practical/Tutorial/TW
	The student shall complete the following activity as a Term Work; The term work shall consist of three design projects. The design project shall consist of assembly drawing, with a bill of material and overall dimensions and drawings of individual components. The Project should be assigned to a group of maximum four students. Manufacturing tolerances, surface finish symbols and geometric tolerances should be specified for important surfaces. A design report giving all necessary calculations of the design of components should be submitted in a separate file. Design data book shall be referred for selection of materials and standard components for given loading conditions. All three design projects should be carried out using suitable software. Project 1: - Cotter joint/ knuckle joint/turn buckle for a specified application. Project 2: - Bush Pin Flexible Coupling for specified application. Project 3: - Bottle type/toggle jack for vehicles. OR

	Project 3: - A Design Project to develop and apply the knowledge of Machine Design and drafting software for any mechanical system on the basis of: (1) Idea generation, (2) Creativity, Reliability and safety, (3) Design parts of the system (4) Ergonomic Considerations (5) Use of International standards.		
Text Books	**Author**	**Title of Book**	**Publication**
T1	Shigley J.E. and Mischke C.R.	Mechanical Engineering Design	McGraw Hill Publication Co. Ltd.
T2	Spotts M.F. and Shoup .E.	Design of Machine Elements	Prentice Hall International.
T3	Bhandari V.B.	Design of Machine Elements,	Tata McGraw Hill Publication Co. Ltd.
T4	Juvinal R.C.	Fundamentals of Machine Components Design	John Wiley and Sons
Reference Books			
R1	Black P.H. and O. Eugene Adams	Machine Design	McGraw Hill
R2	Willium C. Orthwein	Machine Components Design	West Publishing Co. and Jaico Publications
R3	Hall A.S.	Theory and Problems of Machine Design,	Schaum's Outline Series.
R4	C.S.Sharma and Kamlesh Purohit	Design of Machine Elements	PHI Learing Pvt. Ltd
R5	P.S.G. College of Technology, Coimbatore.	Design data book	P.S.G. College of Technology, Coimbatore.
Self-Learning Facilities, **Web Resources,** **Research papers for reference**	NPTEL Video Lectures Castigliano's theorem https://www.youtube.com/watch?v=pbx3e8Rbf7k https://nptel.ac.in/courses/112101095/, Lecture No. 28 Design of Turn Buckle https://www.youtube.com/watch?v=mjgQO3b4xso Factor of Safety https://www.youtube.com/watch?v=ofmbhbVCUqI&list=PL3D4EECEFAA99D9BE&index=3 Design of Shafts https://www.youtube.com/watch?v=SL21aDqgs8Q		

Contents beyond Syllabus	Stress Analysis using ANSYS
Additional Experiments	NIL
Bridging Courses	NIL
Tutorials	NIL
Presentations	NIL

Course Title

Course Title: Mechatronics		**Course Number: 302050**	**Course Code:C310**
Year: THIRD YEAR(T.E.)		**Semester: I**	
Designation of Course		Professional Core	
Teaching Scheme: 03 Hrs./Week (Theory)		**Tutorial:** 01 Hrs/ Week	
Course Assessment Methods	**Direct methods**	In-semester Examination: 30 Marks	End Semester Examination: 70 Marks
			Term Work
	Indirect Methods	Class Test,	Seminars, Q&A session, Assignments, Group Discussion.
Prerequisites	Knowledge of PHYSICS, BASIC MATHEMATICS.		
Course Objectives			
1	Understand key elements of Mechatronics system, representation into block diagram.		
2	Understand concept of transfer function, reduction and analysis		
3	Understand principles of sensors, its characteristics, interfacing with DAQ microcontroller		
4	Understand the concept of PLC system and its ladder programming, and significance of PLC systems in industrial application		
5	Understand control actions such as Proportional, derivative and integral and study its significance in industrial applications		
Course Outcomes			
CO1	Use basic knowledge in electronics and mechanical engineering to solve problems specific to mechatronics and interpret various types of sensors and actuators for typical mechatronics system.		
CO2	Demonstrate the concept of transfer function with the help of block diagram representation by reduction and examine the stability of control system		
CO3	To develop data acquisition system for interfacing various sensors and transducers		
CO4	To understand and analyse and infer PLC techniques for Mechanical applications		
CO5	To understand system modelling and time domain analysis		
CO6	To develop control systems using PID controllers		
Course Contents			
Unit-I	**Introduction to Mechatronics, Sensors & Actuators**		
	Introduction to Mechatronics and its Applications; Measurement Characteristics: Static and Dynamic; Sensors: Position sensors- Potentiometer, LVDT, incremental Encoder; Proximity sensors-Optical, Inductive, Capacitive; Temperature sensor-RTD, Thermocouples; Force / Pressure		

	Sensors-Strain gauges; Flow sensors-Electromagnetic; Actuators: Stepper motor, Servo motor, Solenoids; Selection of Sensor & Actuator.
	Assignment
	• Assignment on measurement system.
	Practical
	1. Measurement of Load / Force using Load Cell*(Estimation of unknown weight using above voltage characteristics). 2. Measurement of Temperature: Thermocouple, Thermistor & RTD and comparative analysis (estimation of sensitivity). 3. Measurement of displacement using LVDT characteristics
Unit-II	**Block Diagram Representation**
	Introduction to Mechatronic System Design; Identification of key elements of Mechatronics systems and represent into Block Diagram; Open and Closed loop Control System; Concept of Transfer Function; Block Diagram & Reduction principles; Applications of Mechatronic systems: Household, Automotive, Industrial shop floor.
	Assignment
	Assignment on Block diagram reduction principle
Unit-III	**Data Acquisition**
	Introduction to Signal Communication & Types-Synchronous, Asynchronous, Serial, Parallel; Bit width, Sampling theorem, Aliasing, Sample and hold circuit, Sampling frequency; Interfacing of Sensors / Actuators to Data Acquisition system; 4 bit Successive Approximation type ADC; 4 bit R-2R type DAC; Current and Voltage Amplifier.
	Assignment
	Assignment on sampling theorem.
Unit-IV	**Programmable Logic Control**
	Introduction to PLC; Architecture of PLC; Selection of PLC; Ladder Logic programming for different types of logic gates; Latching; Timers, Counter; Practical examples of Ladder Programming.
	Assignment
	Assignment on Logic gates and Ladder diagram
	Practical
	• PLC control system: - ladder logic implementation on real time system. • Ladder Diagram development for different types of Logic Gates using suitable Software
Unit- V	**Frequency Domain Modelling and Analysis**
	Transfer Function based modeling of Mechanical, Thermal and Fluid system; concept of Poles & Zeros; Stability Analysis using Routh Hurwitz Criterion; Bode Plots: Introduction to Bode Plot, Gain Margin, Phase Margin, Relative Stability Analysis, Frequency Domain Parameters-Natural Frequency, Damping Frequency and Damping Factor; Mapping of Pole Zero plot with

	damping factor, natural frequency and unit step response.		
	Assignment		
	Assignment on Time domain and Frequency domain analysis.		
Unit-VI	**Control System**		
	Proportional (P), Integral (I) and Derivative (D) control actions; PI, PD and PID control systems in parallel form; Unit step Response analysis via Transient response specifications: Percentage overshoot, Rise time, Delay time, Steady state error; Manual tuning of PID control; Linear Quadratic Control (LQR).		
	Assignment		
	Assignment on PID Control system.		
	Practical		
	• Real Time Temperature / Flow Control using PID Control system. • PID Control Implementation on DC Motor Speed Control System		
Text Books	**Author**	**Title of Book**	**Publication**
T1	K.P. Ramchandran.	Mechatronics: Integrated Mechanical Electronic Systems	Willey Publication
T2	Bolton	Mechatronics - A multidisciplinary approach	Prentice Hall
Reference Books			
R1	Alciatore&Histand	Introduction to Mechatronics and Measurement system	Mc- Graw Hill publication
R2	Bishop	Mechatronics – An Introduction	CRC Press
R3	Mahalik	Mechatronics – Principles, concepts and applications	Tata Mc-Graw Hill publication.
Self-Learning Facilities, Web Resources, Research papers for reference	Web sites of Mechatronics, PLC, PID.		
Contents beyond Syllabus	Guest lecture on PLC and SCADA		
Additional Experiments	NIL		
Bridging Courses	NIL		
Tutorials	NIL		
Presentations	CD Presentations, PPT Presentations.		

Advanced Forming & Joining Processes

Course Title: Advanced Forming & Joining Processes		**Course Number:** 302045-A	**Course Code:** 302045-A
Year: Third Year		**Semester: I**	
Designation of Course		Professional Core	
Teaching Scheme: 3Hrs/Week		**Tutorial:**	
Course Assessment Methods	**Direct methods**	Insem Examination: 30Marks	End Semester Examination: 70 Marks
	Indirect Methods	Assignments	Class Test
Prerequisites	Basic Mechanical Engineering, mathematics		
Course Objectives			
1	UNDERSTAND advances in sheet metal forming operations		
2	UNDERSTAND the advanced special metal forming processes.		
3	UNDERSTAND weld metallurgy and weld characterization techniques.		
4	UNDERSTAND and describe various advanced solid state welding processes.		
5	CLASSIFY AND DESCRIBE various advanced welding processes		
6	KNOW about sustainable manufacturing and its role in manufacturing industry		
Course Outcomes			
CO1	ANALYSE the effect of friction in metal forming deep drawing and IDENTIFICATION of surface defects and their remedies in deep drawing operations.		
CO2	ASSESS the parameters for special forming operation and SELECT appropriate special forming operation for particular applications.		
CO3	ANALYSE the effect of HAZ on microstructure and mechanical properties of materials.		
CO4	CLASSIFY various solid state welding process and SELECT suitable welding processes for particular applications.		
CO5	CLASSIFY various advanced welding process and SELECT suitable welding processes for particular applications.		
CO6	INTERPRET the principles of sustainable manufacturing and its role in manufacturing industry.		

Course Contents	
Unit-I	**Mechanics of Sheet Metal Forming**
	Theory of plasticity – yield criteria-work of plastic deformation- Sheet Metal Forming-Formability studies-conventional processes, Effect of friction in forming operation, Experimental techniques of evaluation of friction in metal forming, deep drawing, analysis (Numerical), surface defects identification and remedies, introduction to Forming simulation, Challenges in Forming.

Unit-II	**Special Forming Processes**
	Special Forming Processes: HVF, HERF (Explosive Forming) techniques-super plastic forming techniques-Hydro forming-Stretch forming, Laser beam forming-principles and process parameters-Advantages, limitations and applications of different forming processes. Orbital forging-Isothermal-Hot and cold isostatic pressing-High speed extrusion, Water hammer forming, Incremental Sheet forming, Magnetic Pulse forming, Metal Spinning, Electro Hydraulic Forming, Micro forming.
Unit-III	**Weld Metallurgy**
	Weld Metallurgy: Weld thermal cycles and their effects, effects of pre and post weld heat treatments, concept of HAZ, concept of weldability and its assessment. Welding of dissimilar materials, Weld characterization, Weld decay and weld sensitization, Introduction to ASME, ASWE, IS Welding Standards, (welding skill levels).
Unit-IV	**Solid State Welding Processes**
	Solid State Welding Processes: Cold pressure welding, Diffusion bonding, Explosive welding, Ultrasonic welding, Friction stir welding, Forge welding, Roll welding and Hot pressure welding processes - features, advantages, limitations and applications, Advances in adhesive bonding, cladding.
Unit- V	**Advanced Welding Processes**
	Advanced Welding Processes: Electrogas, electroslag welding, Atomic hydrogen welding, Electron beam welding, Laser Beam welding - principle, working and applications, Cold Metal Transfer - concepts, processes and applications, Underwater welding, Welding automation in aerospace, nuclear and surface transport vehicles, Robotic Welding, Plasma Arc Welding, Plasma Transferred Arc Welding.
Unit-VI	**Sustainable Manufacturing**
	Sustainable Manufacturing: Introduction to sustainability and drivers for sustainable development and sustainable manufacturing, fundamentals of sustainable manufacturing, various tools, factors of sustainability, Principles of Life Cycle Assessment (Goal, Scope and Life Cycle Inventory), Approaches, Role in Industry 4.0, Green Manufacturing, Environment protection norms, ISO 14000, recycling techniques, safety norms in forming and welding, socio-economic aspects, case study on waste recycling, material recycling, etc.

Text Books	**Author**	**Title of Book**	**Publication**
T1	Sindo Kou	Welding Metallurgy	Wiley Publications
T2	Dr. V. D. Kodgire and S. V. Kodgire	Material Science & Metallurgy For Engineers	Everest Publication
Reference Books			
R1	Z. Marciniak, J.L.Duncan	Mechanics of Sheet Metal Forming	utterworth Heinemann-2002
R2	Dr. Sadhu Singh	Theory of Plasticity and Metal Forming Processes	Khanna Publishers Edition 2008
R3	O.P. Khanna	Engineering Metallurgy	Dhanpat Rai & Sons Publications

Self-Learning Facilities, Web Resources, Research papers for reference	Nil
Contents beyond Syllabus	Nil
Additional Experiments	Nil
Bridging Courses	Nil
Tutorials	Nil
Presentations	Nil

Artificial Intelligence & Machine Learning

Course Title: Artificial Intelligence & Machine Learning		**Course Number: C309**	**Course Code: 302049**
Year: T.E.		**Semester: VI**	
Designation of Course		Professional Core	
Teaching Scheme: 3 Hrs/Week		**Tutorial:** 2Hr./Week	
Course Assessment Methods	**Direct methods**	Insem Examination: 30 Marks	End Semester Examination: 70 Marks
	Indirect Methods	Assignments	Class Test
Prerequisites	Linear Algebra, Probability, Statistics, Logical Reasoning.		
Course Objectives			
1	ACQUAINT with fundamentals of artificial intelligence and machine learning.		
2	LEARN feature extraction and selection techniques for processing data set.		
3	UNDERSTAND basic algorithms used in classification and regression problems.		
4	OUTLINE steps involved in development of machine learning model.		
5	FAMILIARIZE with concepts of reinforced and deep learning.		
6	IMPLEMENT AND ANALYZE machine learning model in mechanical engineering problems.		
Course Outcomes			
CO1	DEMONSTRATE fundamentals of artificial intelligence and machine learning.		
CO2	APPLY feature extraction and selection techniques.		
CO3	APPLY machine learning algorithms for classification and regression problems.		
CO4	DEVISE AND DEVELOP a machine learning model using various steps.		
CO5	EXPLAIN concepts of reinforced and deep learning.		
CO6	SIMULATE machine learning model in mechanical engineering problems.		
Course Contents			
Unit-I	**Introduction to AI & ML**		
	History of AI, Comparison of AI with Data Science, Need of AI in Mechanical Engineering, Introduction to Machine Learning. **Basics**: Reasoning, problem solving, Knowledge representation, Planning, Learning, Perception, Motion and manipulation. **Approaches to AI:** Cybernetics and brain simulation, Symbolic, Sub-symbolic, Statistical. **Approaches to ML:** Supervised learning, Unsupervised learning, Reinforcement learning.		
Unit-II	**Feature Extraction and Selection**		
	Feature extraction: Statistical features, Principal Component Analysis. **Feature selection:** Ranking, Decision tree - Entropy reduction and		

	information gain, Exhaustive, best first, Greedy forward & backward, Applications of feature extraction and selection algorithms in Mechanical Engineering.		
Unit-III	**Classification & Regression**		
	Classification: Decision tree, Random forest, Naive Bayes, Support vector machine. **Regression:** Logistic Regression, Support Vector Regression. Regression trees: Decision tree, random forest, K-Means, K-Nearest Neighbor (KNN). Applications of classification and regression algorithms in Mechanical Engineering.		
Unit-IV	**Development of ML Model**		
	Problem identification: classification, clustering, regression, ranking. Steps in ML modeling, Data Collection, Data pre-processing, Model Selection, Model training (Training, Testing, K-fold Cross Validation), Model evaluation (understanding and interpretation of confusion matrix, Accuracy, Precision, Recall, True positive, false positive etc.), Hyper parameter Tuning, Predictions.		
Unit- V	**Reinforced and Deep Learning**		
	Characteristics of reinforced learning; Algorithms: Value Based, Policy Based, Model Based; Positive vs Negative Reinforced Learning; Models: Markov Decision Process, Q Learning. Characteristics of Deep Learning, Artificial Neural Network, Convolution Neural Network. Application of Reinforced and Deep Learning in Mechanical Engineering.		
Unit-VI	**Applications**		
	Human Machine Interaction, Predictive Maintenance and Health Management, Fault Detection, Dynamic System Order Reduction, Image based part classification, Process Optimization, Material Inspection, Tuning of control algorithms.		
List of Practicals			
Text Books	**Author**	**Title of Book**	**Publication**
T1	Deisenroth, Faisal, Ong,	Mathematics for Machine Learning	Cambridge University Press, 2020
T2	B Joshi	Machine Learning and Artificial Intelligence	Springer, 2020
T3	Parag Kulkarni and Prachi Joshi	Artificial Intelligence – Building Intelligent Systems	PHI learning Pvt. Ltd.
T4	Stuart Russell and Peter Norvig (1995)	Artificial Intelligence: A Modern Approach	Pearson
Reference Books			
R1	Solanki, Kumar, Nayyar	Emerging Trends and Applications of Machine Learning	IGI Global, 2018
R2	Mohri, Rostamizdeh, Talwalkar	Foundations of Machine Learning	MIT Press
R3	Kumar, Zindani,	Artificial Intelligence in	CRC Press, 2021

	Davim	Mechanical and Industrial Engineering	
R4	Zsolt Nagy	Artificial Intelligence and Machine Learning Fundamentals	Apress (2018)
R5	Elaine Rich, Kevin Knight and Nair	Artificial Intelligence	TMH
Self-Learning Facilities, Web Resources, Research papers for reference	1. http://nptel.ac.in/courses/111101003/ 2. https://nptel.ac.in/courses/106/106/106106202/ 3. https://nptel.ac.in/courses/112/103/112103280/ 4. https://www.analyticsvidhya.com/		
Lab Experiments	1. To study supervised/unsupervised/Reinforcement learning approach. 2. To acquire, visualize and analyze the data set (from time-domain/ frequency-domain/ etc.) . 3. To extract features from given data set and establish training data. 4. To select relevant features using suitable technique. OR 5. To use PCA for dimensionality reduction. 6. To classify features/To develop classification model and evaluate its performance (any one classifier). 7. To develop regression model and evaluate its performance (any one algorithm). 8. Markov process for modelling manufacturing processes. OR 9. Reinforced Learning for optimizing engineering designs / Robot Guidance and Navigation. 10. GA for optimization of multi-dimensional function / path planning in robotics. OR 11. NN for parameter and model identification / tuning of Control Algorithms.		
Contents beyond Syllabus	1. Search optimization in Artificial Intelligence. 2. Multivariate regression in Machine Learning.		
Additional Experiments	N.A.		
Bridging Courses	N.A.		
Tutorials	N.A.		
Presentations	N.A.		

Self Learning Facilities

1. https://www.youtube.com/watch?v=TjZBTDzGeGg&list=PLUl4u3cNGP63gFHB6xb-kVBiQHYe_4hSi
2. https://www.youtube.com/watch?v=J8Eh7RqggsU&list=PLoROMvodv4rO1NB9TD4iUZ3qghGEGtqNX
3. https://www.youtube.com/watch?v=ZiwogMtbjr4&list=PLoROMvodv4rOca_Ovz1DvdtWuz8BfSWL2
4. https://www.youtube.com/watch?v=jGwO_UgTS7I&list=PLoROMvodv4rMiGQp3WXShtMGgzqpfVfbU
5. https://www.youtube.com/watch?v=0xaLT4Svzgo&list=PLxC_ffO4q_rW0bqQB80_vcQB09HOA3ClV
6. https://scikit-learn.org/stable/
7. https://machinelearningmastery.com/start-here/

Curriculum Book

Course Title: Computer Aided Engineering		**Course Number: 302050**	**Course Code: C310**
Year: TE (Mech) 2023-24		**Semester: II**	
Designation of Course		Professional Core/~~Elective~~	
Teaching Scheme		**Theory :** 3 Hrs/Week	**Practical:** 2 Hrs/Week
Course Assessment Methods	**External**	In-semester Examination: 30 Marks	End Semester Examination: 70 Marks
		Practical Exam 50 Marks	
	Internal	Assignments	Class test
Prerequisites	Solid Mechanics, Numerical and Statistical Methods, Engineering Mathematics, Manufacturing Processes, Fluid Mechanics, Heat and Mass Transfer		
Course Objectives			
1	To explain the basic concepts of Computer Aided Engineering (CAE) and characteristics of various elements required for analysis.		
2	To explain the discretization process and criteria for quality mesh.		
3	To demonstrate the approaches of Finite Element Method (FEM) and to find displacement and stresses over the body.		
4	To develop the knowledge and skills amongst students needed to effectively evaluate the results using Finite Element Analysis (FEA).		
5	To apply computational technique to solve complex solid mechanics problems and its loading states.		
6	To explain the applications of CAE in the various domains of the Mechanical Engineering		
Course Outcomes: At the end of course			
CO1	Students will be able to **formulate** the shape function for 1D elements.		
CO2	Students will be able to **illustrate** the quality parameters required during meshing.		
CO3	Students will be able to **apply** material properties and boundary condition to **solve** 1-D and 2-D element stiffness matrices to obtain nodal or elemental solution.		
CO4	Students will be able to **Analyze** plane stress and plane strain problem.		
CO5	Students will be able to **interpret** the concept of non-linear and dynamic analysis problems.		
CO6	Students will be able to **summarize** the concepts of CFD, Crash Analysis, and NVH analysis.		
Course Contents			
Unit-I	**Elemental Properties**		
	Introduction to Computer Aided Engineering (CAE), Use of CAE in Product development, Discretization methods – Finite Element Method (FEM), Finite Difference Method (FDM) and Finite Volume Method (FVM), CAE Tools- Pre-processor, Solver and Post-Processor. Element Shapes – 1D, 2D and 3D elements, Nodal Unknowns and field variables, Coordinate Systems, Shape Functions- linear, quadratic and cubic, Convergence Requirements of Shape Functions, Derivation of Polynomial Shape Functions using coordinate systems for Bar, Beam, Triangular, and rectangular elements.		
Unit-II	**Meshing Techniques**		

	Discretization of a Structure, 1D, 2D and 3D element Meshing, Element selection criteria, Refining Mesh, Effect of mesh density in critical region, Use of Symmetry. Element Quality Criterion:-Jacobian, Aspect ratio, Warpage, Minimum and Maximum angles, Average element size, Minimum Length, skewness, Tetra Collapse etc., Higher Order Element vs Mesh Refinement, Geometry Associate Mesh, Mesh quality, Bolted and welded joints representation, Mesh independent test.
Unit-III	**1D Finite Element Analysis**
	Consistent Unit System, Introduction to approaches used in Finite Element Analysis (FEA) such as direct approach and energy approach **Bar and Truss Element** - Element stiffness matrix, Assembling stiffness Equation, Load vector, stress and reaction forces calculations. **Temperature effect on Bar Element-** Calculation due to uniform temperature change, Stress and reaction forces calculations.
Unit-IV	**2D Finite Element Analysis**
	Plane Stress-Strain, axi-symmetric problems in 2D elasticity. **Constant Strain Triangle (CST) -** Element Stiffness matrix, Assembling stiffness equation, Load vector, Stress and reaction forces calculations. **Post Processing Techniques** – Check and validate accuracy of results, Average and Un-average stresses, and special tricks for Post Processing. Interpretation of results and design modifications, CAE reports.
Unit- V	**Non-Linear and Dynamic Analysis**
	Non-Linear Analysis: Introduction to Nonlinear Problems, Comparison of Linear and Nonlinear analysis, Types of Nonlinearities, Stress-strain measures for Nonlinear analysis, Analysis of Geometric, Material Nonlinearity, Solution Techniques for Nonlinear analysis, Newton Raphson Method, Essential steps in Nonlinear analysis. **Dynamic Analysis:** Introduction to Dynamic Analysis, Comparison of Static and Dynamic analysis, Time domain and frequency domain, Types of loading, Simple Harmonic motion, Free vibration, Boundary conditions of free vibration, Solution.
Unit-VI	**Applications of Computer Aided Engineering**
	Computational Fluid Dynamics (CFD): Introduction, Three dimensions of Fluid Dynamics, Equilibrium Equation for a fluid, Conservation form of Fluid flow equation, Integral form of the Conservation Laws. **Injection moulding of Plastics:** Simplification of Mould Geometry for FEA, Material Model for Mould FEA, Boundary Conditions for Mould FEA, Loading of Mould in FEA, Results Analysis. **Simulation for Manufacturing Processes like Casting and Sheet Metal Applications:** Introduction and workflow of Casting Simulation Software and Sheet Metal Applications. **Durability Analysis:** Durability, Reliability and Fatigue**,** FEA bases fatigue analysis viz: Stress-Life approach (S-N method) and Strain-Life approach (E-N method). **Crash Analysis:** Introduction, Explicit time integration schemes, implicit integration schemes. **Noise Vibration and Harshness (NVH) Analysis:** NVH Concepts, Terminology, FEA for structural Dynamics, FEA for Acoustics.
	Practical/Tutorial/TW
	The student shall complete the following activity as a Practical using any commercial FEA software or open-source software's 1. 1D Bar Element – Structural Linear Analysis

	2. Truss Analysis using 1D Element 3. Plate/Shell Element – Structural Linear and Non-Linear Analysis 4. Beam Element – Non-Linear Buckling Analysis 5. Thermal Analysis – Static/Transient Analysis 6. Coupled Analysis- (Structural + Thermal) 7. Analysis of Machine Component using 3D Elements 8. Non-Linear Analysis of Assembly using Contact Elements 9. Modal Analysis – Spring -Mass system, simply supported/Cantilever beam, etc. 10. Presentation on advanced applications of FEA, NVH, CFD, Crash, Fatigue, Manufacturing, etc. **Note:** 1. The lab report shall consist of completion of Practical's and Presentations. 2. Practical examination shall be based on the practical undertaken during the semester.
Text Books	**Details**
T1	Gokhale N. S., Deshpande S. S., Bedekar S. V. and Thite A. N., Practical Finite Element Analysis, Finite to Infinite, Pune, 1st Edition, 2008.
T2	S. S. Bhavikatti, Finite Element Analysis, New Age International Publishers, Third Edition, 2015.
T3	Chandrupatla T. R. and Belegunda A. D., Introduction to Finite Elements in Engineering, Prentice Hall India, 2002.
T4	G Lakshmi Narasaiah, Finite Element Analysis, BS Publications / BSP Books, 2nd edition, 2020.
T5	J. N. Reddy, An Introduction to the Finite Element Method, Mcgraw Hill Series in Mechanical, 2005.
T6	P. Seshu, Text book of Finite Element Analysis, PHI Learning Private Limited, New Delhi, 10th Printing, 2012.
Reference Books	**Details**
R1	K. J. Bathe, Finite Element Procedure, Prentice-Hall of India (P) Ltd., New Delhi, 1996.
R2	Cook R. D., Finite Element Modeling for Stress Analysis, John Wiley and Sons Inc, 1995.
R3	G.R. Liu S. S. Quek, The Finite Element Method- A Practical Course, Butterworth Heinemann, 2013.
R4	Fagan M. J., Finite Element Analysis Theory and Practice, Harlow Pearson/Prentice Hall, 2012.
R5	S. Moaveni, Finite element analysis, theory and application with Ansys, Pearson, Third Edition, 2011.
Self-Learning Facilities,	NPTEL Video Lectures 1. **https://nptel.ac.in/courses/112/104/112104116/-**for Basics of Finite Element Analysis by Prof.Nachiketa Tiwari, IIT Kanpur 2. **https://nptel.ac.in/courses/112/106/112106130/**for Advanced Finite Element Analysis by Dr. R. Krishnakumar, Department of Mechanical Engineering, IIT Madras

Web Resources, **Research papers for reference**	3. https://nptel.ac.in/courses/112/103/112103299/for Finite Element Analysis for Welding Analysis by Prof. Swarup Bag, Department of Mechanical Engineering, IIT Guwahati. 4. https://sites.ualberta.ca/~wmoussa/AnsysTutorial/ for ANSYS Tutorials
Contents beyond Syllabus	Explanation about Experimental Modal Analysis
Additional Experiments	NIL
Bridging Courses	NIL
Tutorials	NIL
Presentations	Presentation on advanced applications of FEA, NVH, CFD, Crash, Fatigue, Manufacturing, etc.

Course Title: Design of Transmission Systems

Course Title: Design of Transmission Systems		**Course Number: 302051**	**Course Code: C**
Year: TE (Mech)		**Semester: II**	
Designation of Course		Professional Core	
Teaching Scheme: 3 Hrs/Week		**Practical:** 2 hrs/week	
Course Assessment Methods	**External Tools**	In-semester Examination:30 Marks	End Semester Examination: 70 Marks
		Oral: 25 Marks	
	Internal Tools	Class Test	Assignments
Prerequisites	Classification of Gears, Gear Terminology, Terminology of Helical gear, Virtual number of teeth. Classification, selection and application of Belt, chain and rope drives.		
Course Objectives			
1	APPLY fundamentals for the design and/or selection of elements in transmission systems.		
2	UNDERSTAND the philosophy that real engineering design problems are open-ended and challenging.		
3	DEMONSTRATE design skills for the problems in real life industrial applications.		
4	DEVELOP an attitude of team work, critical thinking, communication, planning and scheduling through design projects.		
5	PERCEIVE about safety, ethical, legal, and other societal constraints in execution of their design projects.		
6	BUILD a holistic design approach to find out pragmatic solutions to realistic domestic and industrial problems		
Course Outcomes			
CO1	**APPLY** the principle of Spur & Helical gear design for industrial application and PREPARE a manufacturing drawing with the concepts of GD&T.		
CO2	**EXPLAIN** and **DESIGN** Bevel & Worm gear considering design parameters as per design standards.		
CO3	**SELECT & DESIGN** Rolling and Sliding Contact Bearings from manufacturer's catalogue for a typical application considering suitable design parameters.		
CO4	**DEFINE and DESIGN** various types of Clutches, Brakes, used in automobile.		
CO5	**APPLY** various concept to DESIGN Machine Tool Gear box, for different		

	applications
CO6	**ELABORATE** various modes of operation, degree of hybridization and allied terms associated with hybrid electric vehicles.
	Course Contents
Unit 1	***Spur and Helical Gears*** ***07 Hrs***
	Introduction to gears: Material selection for gears, Modes of gear tooth failure, Gear Lubrication Methods. **Spur Gears:** Number of teeth and face width, Force analysis, Beam strength (Lewis) equation, Velocity factor, Service factor, Load concentration factor, Effective load on gear, Wear strength (Buckingham's) equation, Estimation of module based on beam and wear strength, Estimation of dynamic tooth load by velocity factor and Buckingham's equation. AGMA (American Gear Manufacturing Association) approach of Gear design (Only mathematical relations, no numerical) **Helical Gears:** Force analysis of Helical Gear, Beam Strength of Helical Gear, Wear strength and estimation of effective load based on Velocity factor (Barth factor) and Buckingham's equation. (No numerical on force analysis of helical)
Unit 2	***Bevel and Worm Gear*** ***08 Hrs***
	Bevel Gears: Types of Bevel gears, Terminology, Virtual number of teeth, and force analysis of Straight Bevel Gear. Design of Straight Bevel Gear based on Beam Strength, Wear strength and estimation of effective load based on Velocity factor (Barth factor) and Buckingham's equation. (Simple numerical to be taken no design calculations) **Worm Gears:** Worm and worm gear terminology and proportions of worm and worm gears, Force analysis of worm gear drives, Friction in Worm gears, efficiency of worm gears, Worm and worm gear material, Strength and wear ratings of worm gears (Bending stress factor, speed factor, surface stress factor, zone factor) IS 1443-1974, Thermal consideration in worm gear drive. (Simple numerical to be taken no design calculations)
Unit 3	***Sliding and Rolling Contact Bearing*** ***07 Hrs***
	Sliding contact bearing (Theoretical treatment only): Introduction to sliding contact bearing, classification, Reynolds's equation (2D), Petroff's equations, Sommerfeld number, Parameters of bearing design. **Rolling Contact Bearings:** Types of rolling contact Bearings and its selection, Static and dynamic load carrying capacities, Stribeck's Equation, Equivalent bearing load, Load-life relationship, Selection of bearing life, Selection of rolling contact bearings from manufacturer's catalogue, Design for cyclic loads, Types of failure in rolling contact bearings - causes and remedies. (Simple Numerical

	treatment)
Unit 4	***Design of Clutches and Brakes 07 Hrs***
	Clutches: Introduction, Types of clutches, Material, Positive clutches, friction clutches, single plate, multiple plate, Cone clutch, and centrifugal clutches, Application of friction clutches automotive and industrial machinery sector. (Only Theoretical Treatment) **Brakes:** Introduction, Types of brakes, Material, Design of band brake, external and internal shoe breaks internal expanding shoe brakes, design of disc brakes. Application of brakes in automotive and industrial machinery sector. (Only Theoretical Treatment)
Unit 5	**Design of M/C Tool Gear Box 0 *8 Hrs***
	Introduction to Machine Tool Gearboxes, classification, basic considerations in design of drives and its Applications, Determination of variable speed range, Graphical representation of speed and structure diagram, Ray diagram, selection of optimum ray diagram, Kinematic /Gearing Diagram, Deviation diagram, Difference between numbers of teeth of successive gears in a change gear box. *(Note: Full design problem to be restricted up to 2 Stages only & No design problem on deviation diagram)*
Unit 6	**Transmission system in Hybrid Electric Vehicle *08 Hrs***
	Introduction, Types of Hybrid Electric Vehicles: Basic Classification, Basic Modes of Operation, Other Derivatives, Degree of Hybridization. Power Split Devices (PSD): Simple and EM compound PSD, HEV Component Characteristics: The IC Engine, Electric Machines, Battery, HEV Performance Analysis: Series HEV, Parallel HEV, HEV Component Sizing: General Considerations, Sizing for Performance, Optimum Sizing, Power Management: Control Potential, Control.
	TERM WORK
	Student shall complete the following activity as a Term Work; The Submission shall consist of completion of Two Design projects and study Assignments. Oral examination shall be based on the practical undertaken during the semester. **Design Project 1 (Any one) (2)** 1. Design of gearbox for wind mill application or sluice gate. (Use AGMA approach) **2. Design of gearbox for building Elevator. (Use AGMA approach)** 3. Design of gearbox for Hoist. (Use AGMA approach) 4. Design of gearbox for Worm gear box for Sugar Industry. (Use AGMA

	approach) 5. Design of clutch system for automobile 6. Design of brake system for automobile **Design Project 2** **Projects shall be in the form of design of mechanical systems on multi speed spindle gear box** including design of belt and pulley, Prime mover selection etc. The design project shall consist of two full imperial (A1) size sheets involving assembly drawing with a part list and overall dimensions and drawings of individual components. Manufacturing tolerances, surface finish symbols and geometric tolerances should be specified for important surfaces. A design report giving all necessary calculations of the design of components and assembly should be submitted in a separate file. Design data book shall be used wherever necessary to achieve selection of standard components. **Assignment: Any Two (PPT Presentation and Report)** 1. Application orientated Numerical on HEV 2. Lubricating oils: Properties, additives, selection of lubricating oils 3. Properties & selection of sliding bearing materials **4. Application of belt, rope and chain drives and its selection method for Industry** **5. Transmission system of HEV**
Text Books: 1. Shigley J.E. and Mischke C.R., Mechanical Engineering Design, McGraw Hill Publication Co. ltd. 2. Spotts M.F. and Shoup T.E., Design of Machine Elements, Prentice Hall International. 3. Bhandari V.B, Design of Machine Elements, Tata McGraw Hill Publication Co. Ltd. 4. Juvinal R.C, Fundamentals of Machine Components Design, John Wiley and Sons.	
Reference Books: 1. Design Data - P.S.G. College of Technology, Coimbatore. 2. Vehicle Powertrain Systems by Behrooz Mashadi, David Crolla. A John Wiley & Sons, Ltd 3. Automobiles–Power trains and Automobiles–Dynamics by Crolla, David, A John Wiley &Sons, Ltd 4. Automotive Engineering Powertrain, Chassis System and Vehicle Body by David A Crolla, Elsevier B H New York, London, Oxford. 5. lack P.H. and O. Eugene Adams, Machine Design, McGraw Hill Book Co. Inc. 6. Willium C. Orthwein, Machine Components Design, West Publishing Co. and Jaico Publications House. 7. P. Kannaiah, Design of Transmission systems‖, SCIETCH Publications Pvt Ltd. 8. C.S. Sharma and Kamlesh Purohit, Design of Machine Elements, PHI Learning Pvt. Ltd. 9. D.K. Aggarwal& P.C. Sharma, Machine Design, S.K Kataria and Sons. 10. P. C. Gope, Machine Design: Fundamentals and Applications, PHI Learning Pvt. Ltd. 11. Bhandari, V. B. Machine Design data book, Tata McGraw Hill Publication Co. Ltd.	

12. K. Mahadevan, K. Balveera Reddy, Design Data Handbook for Mechanical Engineers, CBS Publishers.	
Self-Learning Facilities, Web Resources, Research papers for reference	Animations of Gears, SKF online catalogue, different types of Gear Box
Contents beyond Syllabus	Failure mode in gears and detection
Additional Experiments	None
Bridging Courses	None
Tutorials	None
Presentations	**Any Two (PPT ON 4,5)** 1. Application orientated Numerical on HEV 2. Lubricating oils: Properties, additives, selection of lubricating oils 3. Properties & selection of sliding bearing materials **4. Application of belt, rope and chain drives and its selection method for Industry** **5. Transmission system of HEV**

Composite Materials (Elective – II)

Course Title : Composite Materials (Elective – II)		**Course Number : C312**	**Course Code : 302052A**
Year : Third Year Mech. Engg. (TE)		**Semester : II**	
Designation of Course		Professional Core	
Teaching Scheme : 3 Hrs/Week		**Practical / Tutorial :** --	
Course Assessment Methods	**Direct methods**	In-semester Examination (**ISE**) 30 Marks	End Semester Examination (**ESE**)70 Marks
			Term Work (**TW**) : --
	Indirect Methods	Class Test : 30 Marks	Assignments 30 Marks
Prerequisites	Engineering Materials, Metallurgy, Manufacturing Processes, Basic Design aspects		
Course Objectives			
1	**DESCRIBE** what are composite materials and their differences with respect to conventional materials.		
2	**COMPREHEND** the challenges associated with Polymer Matrix composites.		
3	**UNDERSTAND** the requirement of Metal Matrix Composites		
4	**RECOGNIZE** design and properties aspect of composites		
5	**UNDERSTAND** the testing, inspection and standard in Composites		
6	**ORIENT** to the specific Application of Composites		
Course Outcomes			
CO1	On completion of the course, learner will be able to **DEFINE & COMPARE** composites with traditional materials.		
CO2	On completion of the course, learner will be able to **IDENTIFY & ESTIMATE** different parameters of Polymer Matrix Composite		
CO3	On completion of the course, learner will be able to **CATEGORISE** & **APPLY** Metal Matrix Process from possessions landscape.		
CO4	On completion of the course, learner will be able to **DETERMINE** volume/weight fraction and strength of Composites.		
CO5	On completion of the course, learner will be able to **SELECT** appropriate testing and inspection method for composite materials.		
CO6	On completion of the course, learner will be able to **SELECT** composites materials for various applications.		
Course Contents			
Unit - 1	**Introduction to Composites**		
	Definitions, Need of Composites, Classification of Composites, Reinforcements and matrices, Types of reinforcements, Types of matrices, Types of composites, Natural Composites, Carbon Fiber composites, Properties of composites in comparison with standard materials. Advantages and Disadvantages. Natural Composites, Hybrid materials and their difference with Composite materials, Applications.		
	Practical / Tutorial		

Unit - 2	**Polymer Matrix Composites**
	Polymer resins – thermosetting resins, thermoplastic resins – reinforcement fibers – roving's – woven fabrics – non woven random mats – various types of fibers. PMC processes – hand layup processes – spray up processes – compression moulding – reinforced reaction injection moulding – resin transfer moulding – Pultrusion – Filament winding – Injection moulding. Fiber reinforced plastics (FRP), Glass Fiber Reinforced Plastics (GFRP). Laminated Composites.
	Practical / Tutorial

Unit - 3	**Metal Matrix Composites**
	Characteristics and types of MMC, advantages and limitations of MMC, Reinforcements – particles – fibers. Effect of reinforcement – volume fraction – rule of mixtures. Processing of MMC – powder metallurgy process – diffusion bonding – stir casting – squeeze casting, a spray process, Liquid infiltration In-situ reactions-Interface-measurement of interface properties.
	Practical / Tutorial

Unit - 4	**Mechanics of Composite Materials**
	Geometrical aspects – volume and weight fraction (Numerical). Large particle composites and the rule of mixtures for elastic constants, failure, fatigue, and long-term strength, methods of optimum design of materials and structures, Micromechanics of a Lamina, Unidirectional continuous fiber, discontinuous fibers, short fiber systems, woven reinforcements –Mechanical Testing: Determination of stiffness and strengths of unidirectional composites; tension, compression, flexure and shear (Numerical).
	Practical / Tutorial

Unit - 5	**Testing, Inspection & Standards in Composites**
	Test Environments, Mechanical Test (Tensile, compression, shear & Fatigue) Bond Strength / Ply Adhesion ASTM F904, Testing Techniques for Composite Double Cantilever Beam, End Notch Flexure, Inter laminar Share Strength, Materials Nondestructive Inspection (NDI) of Composites, Thermographic testing of composites. ASTM & ISO standards for composites materials.
	Practical / Tutorial

Unit - 6	**Application of Composite Materials**
	Applications of Composites material for Aerospace and Transportation application, viz LCA/LCH, Automobile Industry - lightweight, cost - effective, multi - material technology, compatibility with automation systems and rapid processing. Energy Applications - Ecofriendly Prime movers, Infrastructure and Building Applications, Maine Applications - Boats and Ships, Ecofriendly storage Tanks Sports Industry-Protective Equipment's.
	Practical / Tutorial

	Books and Other Resources		
Text Books	**Author**	**Title of Book**	**Publication**
T1	Chawla K.K.	Composite materials Science and Engineering	Springer New York
T2	Daniel Gay	Composite Materials – Design and Applications	CRC Press, 2014
T3	Autar Kaw	Mechanics of Composite Materials	Taylor and Francis
T4	Robert M Jones	Mechanics of Composite Materials	CRC Press, 2018
T5	M. Mukhopadhyay	Mechanics of Composite Materials and Structure	University Press, 2004
T6	S.C. Sharma	Composite Materials	Narosa Pub. House
Reference Books			
R1	A. Bent Strong	Fundamentals of Composites Manufacturing-Materials, Methods and Applications	Society of Manufacturing Engineers, 2008
R2	Clyne T W & Withers	Introduction to Metal Matrix Composites	Cambridge University Press, 1995
R3	Agarwal & Broutmen	Analysis and performance of Fiber Composites	Wiley Publicaions-Fourth Edition, 2017
R4	MW Hyer & SR White	Stress Analysis of Fiber rein-forced Composite Materials	DES Tech Publications, Inc., 2009
R5	C.T. Herakovich	Mechanics of Fibrous Composites	Wiley Publicaions, 1998
R6	E.Fitzer & L.Manocha	Carbon Reinforcements and Carbon /carbon Composites	Springer Verlag, 1998
R7	Murray Schwartz	Composite Materials Handbook	McGraw - Hill, 1992
R8		Composite Materials Handbook	SAE International, 2017

Self-Learning Facilities, Web Resources, Research papers for reference	**Web References:** 1. Introduction of Composite - https://nptel.ac.in/courses/112/104/112104229/ 2. Advanced Composite - https://nptel.ac.in/courses/112/104/112104249/ 3. Polymer Process - https://nptel.ac.in/courses/113/105/113105077/ 4. Manufacturing of composite - https://nptel.ac.in/courses/112/104/112104221/ 5. Processing of Polymer composite - https://nptel.ac.in/courses/112/107/112107221/ 6. Composite materials - https://nptel.ac.in/courses/101/106/101106038/ 7. Mechanics of laminated of composite - https://nptel.ac.in/courses/112/104/112104161/ 8. Composite Materials and Structure - https://nptel.ac.in/courses/101/104/101104010/
Contents beyond Syllabus	Processing of Polymer Matrix Composites https://www.youtube.com/watch?v=RMzGBRL_o3E&list=PLSGws_74K01_G67ptndBraskY3jCW7FLQ
Pract. / Tutorials	None