Savitribai Phule Pune University
Faculty of Science & Technology

Curriculum/Syllabus

For

Third Year

Bachelor of Engineering

(Choice Based Credit System)

Mechanical Engineering

(2019 Course)

Board of Studies – Mechanical and Automobile Engineering

(With Effect from Academic Year 2021-22)

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

Note: Interested students of TE (Automobile Engineering and Mechanical Engineering) can opt for any one of the audit course from the list of audit courses prescribed by BOS (Automobile and Mechanical Engineering)

Instructions:

- Practical/Tutorial must be conducted in FOUR batches per division only.
- Minimum number of Experiments/Assignments in PR/Tutorial shall be carried out **as mentioned in the syllabi** of respective courses.
- Assessment of tutorial work has to be carried out similar to term-work. The Grade cum marks for Tutorial and Term-work shall be awarded on the basis of **continuous evaluation.**
- [$]Audit course is mandatory but non-credit course. Examination has to be conducted at the end of Semesters for award of grade at institute level. Grade awarded for audit course shall not be calculated for grade point & CGPA.

302041: Numerical and Statistical Methods					
Teaching Scheme		**Credits**		**Examination Scheme**	
Theory	**3Hrs./Week**	**Theory**	**3**	**In-Semester**	**30 Marks**
Tutorial	**1Hr./Week**	**Tutorial**	**1**	**End-Semester**	**70 Marks**
				Term Work	**25 Marks**

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:

On completion of the course the learner will be able to;

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 1	**Roots of Equation and Simultaneous Equations**	**07 Hrs.**

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 2	**Numerical Solution of Differential Equations**	**08 Hrs.**

Ordinary Differential Equations [ODE]: Taylor series method, Euler Method, Runge-Kutta 4^{th} order. Simultaneous equations using Runge-Kutta 2^{nd} order method.

Partial Differential Equations [PDE]: Finite difference method, Simple Laplace method, PDE's Parabolic explicit solution, Elliptic explicit solution.

Unit3	**Numerical Integration**	**06 Hrs.**

Numerical Integration (1D): Trapezoidal rule, Simpson's $1/3^{rd}$Rule, Simpson's$3/8^{th}$Rule, Gauss Quadrature2-point and 3-point method.

Double Integration: Trapezoidal rule, Simpson's $1/3^{rd}$Rule.

Unit 4	Curve Fitting and Regression Analysis	08 Hrs.

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 5	Statistics	08 Hrs.

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 6	Probability and Linear Algebra	08 Hrs.

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.

Books and other resources

Text Books:

1. Steven C. Chapra, 'Applied Numerical Methods with MATLAB for Engineers and Scientist', Tata Mc-Graw Hill Publishing Co. Ltd.
2. B. S. Grewal, 'Numerical Methods in Engineering and Science', Khanna Publication.
3. B. S. Grewal, 'Higher Engineering Mathematics', Khanna Publication.

References Books:

1. Erwin Kreyszig, 'Advanced Engineering Mathematics', Wiley India
2. Joe D. Hoffman, 'Numerical Methods for Engineers and Scientists', CRC Press
3. Sheldon M. Ross, 'Introduction to Probability and Statistics for Engineers and Scientists', 5e, by Elsevier Academic Press
4. Deisentoth, Faisal, Ong, 'Mathematics for machine learning', Cambridge University Press.
5. Kandasamy, 'Numerical methods', S Chand.
6. Jason Brownlee, 'Statistical Methods for Machine Learning', Machine learning Mastery.

Web References:

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/

List of Tutorials
Term Work shall consist of: **Group A – (Any three programs using suitable programming language)** 1. Roots of equation 2. Simultaneous equations 3. Ordinary differential equation 4. Partial differential equation 5. Numerical Integration **Group B (Any three programs for simple dataset using suitable programing)** 6. Curve fitting using least square technique 7. Regression analysis 8. Determine statistical measures 9. Probability distribution **Group C (Mandatory)** 10. One program based mini project using mechanical engineering application dataset **Note: Tutorials shall be mandatorily conducted in the computer laboratory.**

302042: Heat and Mass Transfer					
Teaching Scheme		**Credits**		**Examination Scheme**	
Theory	**3 Hrs./Week**	**Theory**	**3**	**In-Semester**	**30 Marks**
Practical	**2 Hrs./Week**	**Practical**	**1**	**End-Semester**	**70 Marks**
				Practical	**50 Marks**

Prerequisites: First and Second Law of Thermodynamics, Fluid properties, Continuity equation, Differential and Integral Calculus, Ordinary differential and Partial Differential Equations, Numerical solution for Differential Equations.

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. **ANALYZE** & **APPLY** the modes of heat transfer equations for one dimensional thermal system.

CO2. **DESIGN a** thermal system considering fins, thermal insulation and & Transient heat conduction.

CO3. **EVALUATE** the heat transfer rate in natural and forced convection & validate with experimentation results.

CO4. **INTERPRET** heat transfer by radiation between objects with simple geometries, for black and grey surfaces.

CO5. **ABILITY** to analyze the rate of mass transfer using Fick's Law of Diffusion and understands mass diffusion in different coordinate systems.

CO6. **DESIGN & ANALYSIS** of heat transfer equipments and investigation of its performance.

Course Contents

Unit 1	**Fundamentals of Heat Transfer**	**08 Hrs.**

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.

Unit 2	**Heat Transfer through Extended Surfaces & Transient Heat Conduction**	**08 Hrs.**

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

Unit 3	**Convection**	**08 Hrs.**

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.

Unit 4	**Radiation**	**07 Hrs.**

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.

Unit 5	**Mass Transfer**	**07 Hrs.**

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 6:	Heat Exchangers and Equipment Design	07 Hrs.

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

Books & Other Resources

Text Books:

1. Franck P. Incropera, David P. DeWitt – Fundamentals of Heat and Mass Transfer,
2. Y. A. Cengel and A.J. Ghajar, Heat and Mass Transfer – Fundamentals and Applications, Tata McGraw Hill Education Private Limited.
3. S.P. Sukhatme, A Textbook on Heat Transfer, Universities Press.
4. R.C. Sachdeva, Fundamentals of Engineering Heat and Mass Transfer, New Age Science.
5. Joshi's Process Equipment Design, by V.V. Mahajani , S.B. Umarji ,Trinity Press

Reference Books:

1. P.K. Nag, Heat & Mass Transfer, McGraw Hill Education Private Limited.
2. M.M. Rathod, Engineering Heat and Mass Transfer, Third Edition, Laxmi Publications, New Delhi
3. V. M. Domkundwar, Heat Transfer, Dhanpat Rai & Co Ltd.
4. A.F. Mills, Basic Heat and Mass Transfer, Pearson.
5. S. P. Venkatesan, Heat Transfer, Ane Books Pvt. Ltd.
6. Holman, Fundamentals of Heat and Mass Transfer, McGraw – Hill publication.
7. M. Thirumaleshwar, Fundamentals of Heat and Mass Transfer, Pearson Education India.
8. B.K. Dutta, Heat Transfer-Principles and Applications, PHI.
9. C.P. Kothandaraman, S. V. Subramanyam, Heat and Mass Transfer Data Book, New Academic Science.
10. Process heat Transfer, D. Q. Kern, Wiley Publication

NPTEL Links:

E books: Links to be provided

1. https://libgen.is
2. http://libgen.li/item/index.php?md5=314BFA11A24C3C1ACFDED2B5AB88E5E9

Links of NPTEL / related videos

1. https://www.youtube.com/watch?v=qa-PQOjS3zA&list=PL5F4F46C1983C6785
2. https://www.youtube.com/watch?v=qa-PQOjS3zA&list=PL5F4F46C1983C6785
3. https://www.youtube.com/watch?v=J_zqQcncAu4&index=3&list=PLpCr5N2IS7Nmu22MOgDWOr0sSlIpUNUz3
4. https://www.youtube.com/watch?v=SNnd0f3xXlg&list=PLpCr5N2IS7Nmu22MOgDWOr0s

SlIpUNUz3&index=11

5. https://www.youtube.com/watch?v=SNnd0f3xXlg&list=PLpCr5N2IS7Nmu22MOgDWOr0sSlIpUNUz3&index=11
6. https://www.youtube.com/watch?v=lnFjt30goiY&index=18&list=PLpCr5N2IS7Nmu22MOgDWOr0sSlIpUNUz3

Guidelines for Laboratory Conduction

The student shall complete the following activity as a Term Work

Complete **eight** experiments and **two** assignments (Sr. no.10 to 13).

1. Determination of Thermal Conductivity of insulating powder.
2. Determination of Thermal Conductivity of metal rod.
3. Determination of local and average heat transfer coefficient in Natural Convection.
4. Determination of local and average heat transfer coefficient in Forced Convection.
5. Determination of temperature distribution, fin efficiency in Natural / Forced Convection.
6. Determination of Emissivity of a Test surface.
7. Determination of Stefan Boltzmann Constant.
8. Determination of heat transfer, overall heat transfer coefficient and effectiveness of Plate Heat Exchanger.
9. Study of Pool boiling phenomenon and determination of Critical Heat Flux (CHF).
10. Assignment to solve transient heat transfer problem using Heisler and Grober Charts.
11. Design of heat exchanger for any simple application.
12. Industrial visit to heat treatment industry/ heat exchanger manufacturing industry.
13. Demonstration of dropwise and filmwise condensation.
14. Virtual laboratory: study of the performance of heat exchanger /study of variation of Thermal Conductivity.

Link for Virtual Lab: - https://www.vlab.co.in/

302043: Design of Machine Elements					
Teaching Scheme		**Credits**		**Examination Scheme**	
Theory	**3Hrs./Week**	**Theory**	**3**	**In-Semester**	**30 Marks**
Practical	**2 Hrs./Week**	**Practical**	**1**	**End-Semester**	**70 Marks**
				Oral	**25 Marks**

Prerequisites: The basics of material elastic behavior, stress, strain, its relationship, failure modes, different theories of failure and its applications. The design cycle, basis of design considerations like strength, rigidity, manufacture, assembly and cost, standards and codes. The preferred sizes and series, tolerances and types of fits. Construction of SMD and BMD. Roots of equations, Interpolation rule.

Course Objectives:

1. **UNDERSTAND** the various design considerations, design procedure and select materials for a specific application
2. **CALCULATE** the stresses in machine components due to various types of loads and failure
3. **ANALYZE** machine components subjected to variable loading for finite and infinite life
4. **DESIGN** various machine components such as shafts, couplings, keys, screws, joints, springs

Course Outcomes:

On completion of the course, learner will be able to

CO1. **DESIGN AND ANALYZE** the cotter and knuckle Joints, levers and components subjected to eccentric loading.

CO2. **DESIGN** shafts, keys and couplings under static loading conditions.

CO3. **ANALYZE** different stresses in power screws and **APPLY** those in the procedure to design screw jack.

CO4. **EVALUATE** dimensions of machine components under fluctuating loads.

CO5. **EVALUATE** & **INTERPRET** the stress developed on the different type of welded and threaded joints.

CO6. **APPLY** the design and development procedure for different types of springs.

Course Contents

Unit 1	**Design of Simple Machine Elements**	**08 Hrs.**

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 2	**Design of Shafts, Keys and Couplings**	**08 Hrs.**

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 3	Design of Power Screws	07 Hrs.
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 4	**Design against Fluctuating loads**	**07 Hrs.**
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 5	**Threaded and Welded joints**	**08 Hrs.**
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 6	**Design of Springs**	**07 Hrs.**
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.		

Books and other resources

Text Books:

1. Bhandari V.B., Design of Machine Elements, Tata McGraw Hill Publication Co. Ltd.
2. Shigley J.E. and Mischke C.R., Mechanical Engineering Design, McGraw Hill Publication Co. Ltd.

References Books:

1. Spotts M.F. and Shoup T.E., Design of Machine Elements, Prentice Hall International.
2. Juvinal R.C., Fundamentals of Machine Components Design, John Wiley and Sons.
3. Black P.H. and O. Eugene Adams, Machine Design, McGraw Hill Book Co. Inc.
4. Willium C. Orthwein, Machine Components Design, West Publishing Co. and Jaico Publications House.
5. Hall A.S., Holowenko A.R. and Laughlin H.G, Theory and Problems of Machine Design, Schaum's Outline Series.
6. C. S. Sharma and Kamlesh Purohit, Design of Machine Elements, PHI Learing Pvt. Ltd.
7. D. K. Aggarwal & P. C. Sharma, Machine Design, S.K Kataria and Sons.
8. P. C. Gope, Machine Design: Fundamentals and Applications, PHI Learing Pvt. Ltd.
9. Design Data - P.S.G. College of Technology, Coimbatore.
10. K. Mahadevan, K. Balveera Reddy, Design Data Handbook for Mechanical Engineers, CBS Publishers.

Term Work		
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.		
Web References:		
UNIT 1: Design of Simple Machine Elements		
Sr. No	**Topic Title**	**NPTEL video Link**
1	Factor of safety, Selection of Factor of Safety, Service factor	https://www.youtube.com/watch?v=ofmbhbVCUqI&list=PL3D4EECEFAA99D9BE&index=3
2	Design of components subjected to eccentric loading.	https://www.youtube.com/watch?v=__py5xbKHGA
UNIT 2: Design of Shafts, Keys and Couplings		
3	Design of shaft as per A.S.M.E. code	https://www.youtube.com/watch?v=SL21aDqgs8Q
4	Design of a C-Clamp. Design of screw jack,	https://youtu.be/PEKfS2Q1WqM https://www.youtube.com/watch?v=PEKfS2Q1WqM&list=PL3D4EECEFAA99D9BE&index=19
5	Differential and Compound Screw and Re-circulating Ball Screw	https://www.youtube.com/watch?v=TPURJnlekeo
UNIT 4: Design against Fluctuating Loads		
6	Cumulative damage in fatigue failure,	https://www.youtube.com/watch?v=WRoPQGE0WdI
7	Soderberg, Gerber, Goodman Lines, Modified Goodman Diagrams	https://www.youtube.com/watch?v=WRoPQGE0WdI
8	Fatigue design under combined stresses	https://www.youtube.com/watch?v=WRoPQGE0WdI

UNIT 5: Threaded and Welded joints		
9	Eccentrically loaded bolted joint in shear, Eccentric load perpendicular and parallel to axis of bolt	https://www.youtube.com/watch?v=__py5xbKHGA https://www.youtube.com/watch?v=YZYcMtkZiDY
10	Eccentric load on circular base	https://www.youtube.com/watch?v=__py5xbKHGA
11	Eccentric load in plane of welds, Welded joints subjected to bending and torsional moments	https://www.youtube.com/watch?v=__py5xbKHGA https://www.youtube.com/watch?v=YZYcMtkZiDY
UNIT 6: Design of Springs		
12	Surge in spring	https://www.youtube.com/watch?v=tTBnW5gAieM
13	Shot Peening.	https://www.youtube.com/watch?v=46quOD7V-cQ
14	Design of Multi-leaf	https://youtu.be/T4IgtIkBnOo

302044: Mechatronics					
Teaching Scheme		**Credits**		**Examination Scheme**	
Theory	**3Hrs./Week**	**Theory**	**3**	**In-Semester**	**30 Marks**
Practical	**2 Hrs./Week**	**Practical**	**1**	**End-Semester**	**70 Marks**
				Oral	**25 Marks**

Prerequisites: Basics of Electrical components, Binary to Decimal Conversion, Data communication Module, Op amp Circuits, Linear Algebra, Laplace Transformation method, Logic gates.

Course Objectives:

1. **UNDERSTAND** the key elements of mechatronics, principle of sensor and its characteristics.
2. **UNDERSTAND** the concept of signal processing and use of interfacing systems such as ADC, DAC, Digital I/O.
3. **UNDERSTAND** the block diagram representation and concept of transfer function.
4. **UNDERSTAND** the system modeling and analysis in frequency domain.
5. **UNDERSTAND** the system modeling and analysis in time domain, controller modes and its industrial applications..
6. **UTILIZE** the concepts of PLC system and its ladder programming and significance of PLC system in industrial application.

Course Outcomes:

On completion of the course, learner will be able to

CO1. **DEFINE** key elements of mechatronics, principle of sensor and its characteristics.
CO2. **UTILIZE** concept of signal processing and **MAKE** use of interfacing systems such as ADC, DAC, Digital I/O.
CO3. **DETERMINE** the transfer function by using block diagram reduction technique.
CO4. **EVALUATE** Poles and Zero, frequency domain parameter for mathematical modeling for mechanical system.
CO5. **APPLY** the concept of different controller modes to an industrial application.
CO6. **DEVELOP** the ladder programming for industrial application.

Course Contents

Unit 1	**Introduction to Mechatronics, Sensors & Actuators**	**07 Hrs.**

Introduction to Mechatronics and its Applications Measurement Characteristics (Static/Dynamic),

Sensors: Types of sensors; Motion Sensors – Encoder (Absolute & incremental), Lidar, Eddy Current, Proximity (Optical, Inductive, Capacitive), MEMS Accelerometer;

Temperature sensor –Pyrometer, Infrared Thermometer; Force / Pressure Sensors – Strain gauges, Piezoelectric sensor; Flow sensors – Electromagnetic, Ultrasonic, Hot-wire anemometer; Color sensor – RGB type; Biosensors – Enzyme, ECG, EMG

Actuators: Servo motor; Hydraulic and Pneumatic (must be restricted to classification and working of one type of linear and rotary actuator); linear electrical actuators Selection of Sensor & Actuator

Unit 2	Data Acquisition and Signal Communication	08 Hrs.
Signal Communication: Serial, Parallel; Synchronous, Asynchronous Introduction to DAQ, Types, Components of a Data Acquisition System (Sensor, Signal conditioning, processing, controlling and storage/display/action) Data Acquisition: Signal collection, Signal conditioning – Isolation& Filtering, Amplification, Sampling, Aliasing, Sample and hold circuit, Quantization, Analog-to-digital converters (4 bit Successive Approximation type ADC), Digital-to-Analog converters (4 bit R2R type DAC), Data storage Applications: DAQ in Household ,Digital Pressure Gauge, Digital Flow measurement, DVB Digital Video Broadcast, AM/FM		
Unit 3	**Control systems & transfer function based modelling**	**07 Hrs.**
Introduction to control systems, need, Types- Open and Closed loop, Concept of Transfer Function, Block Diagram & Reduction principles and problems; Applications (Household, Automotive, Industrial shop floor) Transfer Function based modeling of Mechanical, Thermal and Fluid system; Concept of Poles & Zeros; Pole zero plot, Stability Analysis using Routh Hurwitz Criterion (Numerical Approach)		
Unit 4	**Time and Frequency Domain Analysis**	**08 Hrs.**
Time Domain Analysis – Unit step Response analysis via Transient response specifications (Percentage overshoot, Rise time, Delay time, Steady state error etc.) Frequency Domain 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 ; Introduction to Bode Plot, Gain Margin, Phase Margin		
Unit 5	**Controllers**	**07 Hrs.**
Introduction to controllers, Need for Control, Proportional (P), Integral (I) and Derivative (D) control actions; PI, PD and PID control systems in parallel form; (Numerical approach), Feed forward anticipatory control Manual tuning of PID control, Ziegler–Nichols method Applications: Electro–Hydraulic/Pneumatic Control, Automotive Control		
Unit 6	**Programmable Logic Controller (PLC)**	**08 Hrs.**
Introduction to PLC; Architecture of PLC; Selection of PLC; Ladder Logic programming for different types of logic gates; Latching; Timers, Counters; PLC control of Hydraulics / Pneumatics / Mechatronics systems involving timing and counting operations.		

Books and other resources

Text Books:

1. William Bolton, Mechatronics: Electronics Control Systems in Mechanical and Electrical Engineering, 6th Ed, 2019
2. K.P. Ramchandran, G.K. Vijyaraghavan, M.S. Balasundaram, Mechatronics: Integrated Mechanical Electronic Systems, Willey Publication, 2008

References Books:

1. Alciatore and Histand, Introduction to Mechatronics and Measurement Systems, 5th Ed, 2019
2. Bishop (Editor),Mechatronics – An Introduction CRC 2006
3. Mahalik, Mechatronics – Principles, concepts and applications, Tata Mc-Graw Hill publication, New Delhi
4. C.D.Johnson, Process Control Instrumentation Technology, Prentice Hall,New Delhi
5. Bolton, Programmable Logic Controller, 4th Ed, Newnes, 2006

Web References:

1. https://www.elprocus.com/what-is-a-biosensor-types-of-biosensors-and-applications/
2. https://www.elprocus.com/color-sensor-working-and-applications/
3. https://www.youtube.com/watch?v=kbjCGGTXqUo&ab_channel=Controlengineering
4. https://youtu.be/clTA0pONnMs?list=PLHMDN3JFtE5wEz95H2XuzRaafK3fUsaki
5. https://nptel.ac.in/content/storage2/courses/108105063/pdf/L-12(SS)%20(IA&C)%20((EE)NPTEL).pdf
6. https://nptel.ac.in/content/storage2/courses/112104158/lecture5.pdf

Term Work

The Term work shall consist of completion of Practical, Self-learning Study Assignments and Presentations. Oral examination shall be based on the Term work undertaken during the semester.

Practical (**Any one** experiments out of experiment no **1 to 3** from the following list whereas experiment no. **4 to 10** are mandatory).

1. Experiment on measurement of temperature using suitable sensor.
2. Experiment on measurement of load using suitable sensor.
3. Experiment on measurement of displacement using suitable sensor.
4. Development of a data acquisition / mechatronics system using low cost open source hardware and software.
5. Experiment on interfacing of suitable sensor and actuator with DAQ.
6. Modeling and analysis of mechanical system and its verification using suitable simulation software.
7. PID control of Mechanical System using suitable simulation software and experimental verification (verification only if experimental setup is available).
8. Ladder Logic Simulation of suitable application.
9. Demonstration of PLC controlled electro hydraulic / elector pneumatic circuit.
10. Industrial visit to understand integration and application of Mechatronics.

Assignments:

1. Application of Sensors and Actuators in Health Science and Selection of Suitable Sensor and Actuator.
2. Block Diagram Representation of Feedback Control System and determination of Closed Loop Transfer Function.

302045-A: Advanced Forming & Joining Processes					
Teaching Scheme		**Credits**		**Examination Scheme**	
Theory	**3Hrs./Week**	**Theory**	**3**	**In-Semester**	**30 Marks**
				End-Semester	**70 Marks**

Prerequisite Courses: Manufacturing Processes, Engineering Materials and Metallurgy, Machine shop

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:

On completion of the course, learner will be able to

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 1	**Mechanics of Sheet Metal Forming**	**08 Hrs.**

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 2	**Special Forming Processes**	**08 Hrs.**

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 3	Weld Metallurgy	07 Hrs.
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 4	**Solid State Welding Processes**	**07 Hrs.**
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 5	**Advanced Welding Processes**	**08 Hrs.**
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 6	**Sustainable Manufacturing**	**07 Hrs.**
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.		

Books and other resources

Text Books:

1. Sindo Kou, “Welding Metallurgy”, Wiley Publications Second Edition
2. Dr. V. D. Kodgire and S. V. Kodgire, “Material Science & Metallurgy For Engineers”, Everest Publication
3. William D. Callister, “Materials Science and Engineering an Introduction”, Jr, John Wiley & Sons, Inc**.**
4. O.P. Khanna, " Welding Technology", Dhanpat Rai & Sons Publications Edition 2015
5. Dr. R. S. Parmar,"Welding Processes and Technology", Khanna Publications Edition 2017
6. J. Paulo Davim, " Sustainable Manufacturing", Wiley Publications Edition 2010

References Books:

1. Z. Marciniak, J.L.Duncan, "Mechanics of Sheet Metal Forming", Butterworth Heinemann-2002.
2. Dr. Sadhu Singh, "Theory of Plasticity and Metal Forming Processes", Khanna Publishers Edition 2008
3. O.P. Khanna, " Engineering Metallurgy", Dhanpat Rai & Sons Publications
4. Ali Hasan - Islam Nawaz, "Advanced Welding Technology", SCITECH Publications India Pvt. Ltd. Edition 2018
5. Dr. K. S. Yadav, "Advanced Welding Technology"', Rajsons Publications Pvt. Ltd.
6. Tool and Manufacturing Engineers' Handbook: Forming V by Charles Wick Publisher

: Society of Manufacturing Engineers; 4th edition (1 Aug. 1996)
7. Dornfeld and David, "Green Manufacturing" - Fundamentals and Applications, DOI 10.1007/978.1.4419.6016.0_2, Springer Science +Business Media, New York 2013.
8. R. Ganesh Narayanan, Jay S Gunasekera,"Sustainable Material Forming and Joining", by CRC Press 2020.

Web References:

1. NPTEL Course on "Forming" by Dr. R. Chandramouli, IIT Madras
2. NPTEL Course on "Welding Engineering" by Dr. D. K. Dwivedi, IIT Roorkee
3. NPTEL Course on "Advances in welding and joining technologies" by Prof. SwarupBag IIT Guwahati.
4. NPTEL Course on "Welding Metallurgy" by Prof. Pradeep K. Jha, IIT Roorkee
5. NPTEL Course on "Sustainability through Green Manufacturing System – An Applied Approach" by Prof. Deepu Philip IIT Kanpur and Dr. Amardeep Singh Oberaoi, NIT Jalandar.

302045-B:Machining Science &Technology					
Teaching Scheme		**Credits**		**Examination Scheme**	
Theory	**3Hrs./Week**	**Theory**	**3**	**In-Semester**	**30 Marks**
				End-Semester	**70 Marks**

Prerequisites: Mechanics, Gear terminology, Material properties, Degree of freedom.

Course Objectives:

1. **KNOW** about fundamentals of metal cutting process, tool wear and tool life.
2. **IMPART** the knowledge of machining phenomenon like milling, gear and thread manufacturing, grinding, super finishing, etc.
3. **UNDERSTAND** the basic concepts, importance and functions of Jigs, Fixtures.
4. **PREPARE** list of operations, tools, set of manufacturing instructions and selection of quality assurance method.
5. **GENERATE** CNC program for appropriate machining processes like turning and milling.

Course Outcomes:

On completion of the course, learner will be able to

CO1. **DEFINE** metal cutting principles and mechanics of metal cutting and tool life.
CO2. **DESCRIBE** features of gear and thread manufacturing processes.
CO3. **SELECT** appropriate grinding wheel and demonstrate the various surface finishing processes.
CO4. **SELECT** appropriate jigs/fixtures and to draw the process plan for a given component.
CO5. **SELECT** & **EVALUATE** various parameters of process planning.
CO6. **GENERATE** CNC program for Turning / Milling processes and generate tool path using CAM software.

Course Contents

Unit 1	**Mechanics of Metal Cutting**	**08 Hrs.**

Introduction to metal cutting, Elements of machining process, Geometry of single-point cutting tool, Orthogonal and Oblique cutting processes,

Chip formation, Types of chips, Chip thickness ratio, Process parameters and their effect on machining, chip breakers,

Merchant's Circle of forces analysis – forces and energy calculations, power consumed – MRR- Effect of Cutting variables on forces,

Concepts of Machinability- Factors affecting machinability, Machinability Index, Tool Life, Tool life equation of Taylor, Tool wear and its types, Factors affecting on tool life.

Unit 2	**Gear and Thread Manufacturing**	**07 Hrs.**

Introduction, Materials of gears, Methods of gear manufacturing-casting, forging, forming etc, milling of gears (indexing methods and numerical), Helical gear cutting, Gear Shaping and Gear hobbling, Gear inspection.

Thread Manufacturing: Various methods of thread manufacturing**,** thread rolling, die threading & tapping, Thread milling, Thread grinding etc.

Unit 3	Grinding & Surface finishing	08 Hrs.

Types and Operations of grinding machines, Grinding wheel– Shapes, Designation and selection, Abrasives & classification, Bond & bonding, Grit, Grade & Structure of wheels, Types of grinding wheels, mounting of grinding wheels, Glazing and loading of wheels, Dressing and truing of wheels, Balancing of wheels, Diamond wheels.

Super-finishing processes – Introduction to Honing, Lapping, Buffing and Burnishing. (Construction, working and controlling parameters)

Unit 4	Jigs and Fixtures	08 Hrs.

Significance and purpose of jigs and fixtures and their functions in the manufacturing processes, Concept of degree of freedom, 3-2-1 principle of location. General guidelines to design jigs and fixtures, advantages of jigs and fixtures.

Jigs- Definition, Elements of jig with the types, Location guidelines, Principles of clamping, Principles of guiding, Channel jig, Template jig, Plate jig, Angle plate jig, Turn over jig, Box jig, Latch type jig.

Fixtures: Definition. Elements of fixtures, Location guidelines, Principles of clamping, Principles of setting element, turning fixture, welding fixture, Milling fixture, Assembly and Inspection fixtures.

Unit 5	Process Planning	06 Hrs.

Introduction- methods of process planning, drawing interpretation, material evaluation, steps in process selection, production equipment and tooling selection, process parameters calculation for various production processes, Selection of jigs and fixtures, selection of quality assurance methods, documents for process planning, Economics of process planning, case studies.

Unit 6	CNC Programming	08 Hrs.

CNC Programming-CNC part programming adaptable to suitable controller. Steps in developing CNC part program. CNC part programming for Lathe Machine – Threading & Grooving cycle (Canned cycle). CNC part programming for Milling Machine - Linear & circular interpolation, milling cutter, tool length compensation & cutter radius compensation. Pocketing, contouring & drilling, subroutine and Do loop using canned cycle.

Books and other resources

Text Books:

1. A Text Book of Production Technology, P. C. Sharma, S.Chand Publications
2. A Text Book of Manufacturing Technology, R. K. Rajput, Laxmi Publications (p) LTD
3. A Text book of Manufacturing Technology, Metal Cutting and Machine Tools, P. N. Rao, Vol. 2, 2nd edition, Tata McGraw Hill Publishing Co. Ltd, New Delhi, 2002
4. Elements of Workshop Technology, Vol-II, S. K. HajraChaudhary, Media Promoters &Publications Pvt Ltd.
5. S. K. Sinha, CNC Programming using Fanuc Custom Macro B, McGraw-Hill Professional

References Books:

1. Theory of Metal Cutting, M. C. Shaw, 1st Edition, Oxford and I.B.H. publishing, 1994
2. Jigs & Fixtures, P.H. Joshi, Third edition, McGraw Hill, 2017
3. Production Technology Manufacturing Systems VOL-I & II, R. K. Jain, Khanna Publishers
4. Production Technology –HMT, Tata McGraw Hill publication
5. An Expert Process Planning System, Chang, T. C., Addison Wesley Longman, 1990

6. Process Planning- Design/Manufacture Interface, Scallan P, Butterworth-Heinemann, 2003
7. CNC Machines, B. S. Pabla, M. Adithan, New Age International, 2018
8. Manufacturing Science, Amitabh Ghosh and AshokKumar Mallik, Affiliated East-West Press, 2010

Web References:

1. https://nptel.ac.in/content/storage2/courses/108105063/pdf/L-
2. https://nptel.ac.in/content/storage2/courses/112105127/pdf/LM-32.pdf
3. https://nptel.ac.in/content/storage2/courses/112105127/pdf/LM-34.pdf
4. https://nptel.ac.in/courses/112/107/112107143/

302046: Digital Manufacturing Laboratory					
Teaching Scheme		**Credits**		**Examination Scheme**	
Practical	**2 Hrs./Week**	**Practical**	**1**	**Term Work**	**50 Marks**

Prerequisites: Construction and operating of conventional machine tools, principles of machining and forming processes, cutting tool and machining parameters, programming languages like C, Python etc., basics of 3D printing.

Course Objectives:

1. **ACQUIRE** skills to handle conventional machines and CNC machine for manufacturing of a component.
2. **PREPARE** manual part program for given component as per ISO standards.
3. **ACCUSTOM** skills of Additive manufacturing technology.
4. **APPRECIATE** the influence of cutting tool parameters on the performance.
5. **APPLY** Digital Manufacturing tools for process simulation of manufacturing processes.
6. **SELECT** appropriate type of jigs and fixtures for a given component

Course Outcomes:

On completion of the course, learner will be able to

CO1.**DEVELOP** a component using conventional machines, CNC machines and Additive Manufacturing Techniques.

CO2.**ANALYZE** cutting tool parameters for machining given job.

CO3.**DEMONSTRATE** simulation of manufacturing process using Digital Manufacturing Tools.

CO4.**SELECT** and **DESIGN** jigs and Fixtures for a given component.

CO5.**DEMONESTRATE** different parameters for CNC retrofitting and reconditioning.

Guidelines for Laboratory Conduction

The learner shall complete the following activity as a Term Work;

1. Demonstration of cutting tool geometry and nomenclature of the tools used in conventional and CNC machines.
2. Machining of a mechanical component using conventional machines such as lathe, drilling, milling, grinding and any additional machine tool or processes as per requirement. Manufacturing drawing with appropriate geometrical and dimensional tolerances, detailed process planning to be included.
3. Preparing manual CNC part program using G Codes and M Codes as per ISO (DIN 66025) and RS274 standards for CNC lathe/mill machine.
4. Machining of mechanical component using CNC machine (Lathe/Mill/HMC/VMC). Manufacturing drawing with appropriate geometrical and dimensional tolerances, detailed process planning to be included.
5. Demonstration of Additive Manufacturing technology (from modelling to printing) (To be performed Batch-wise)
6. Demonstration of the usage of Digital Manufacturing tools for process simulation of manufacturing processes like casting, forging, sheet metal, plastic processing (free / open source software)

7. Demonstration of various types of jigs and fixtures, and a case study on design and use of Jigs & Fixture for any given component.
8. Preparing Online Calculator/Catalogue for selection of cutting parameters by using programming languages like C, Python etc.
9. Study on CNC retrofitting and reconditioning
10. Visit to an Industry which uses advanced manufacturing processes

Please note following instructions regarding Laboratory Conduction:

1. Sr. No. 1 to 7are mandatory and any 2 from Sr. No. 8 to 10.
2. Practical are to be performed under the guidance of concerned faculty member.
3. Journal should consist of Job Drawing, Process Sheet and Program, appropriate write-up and shall be part of term-work submission.

302047: Skill Development					
Teaching Scheme		**Credits**		**Examination Scheme**	
Practical	**2 Hrs./Week**	**Practical**	**1**	**TW**	**25 Marks**

Prerequisites: Students should have knowledge of Construction and working of IC engine / compressor / gear box / centrifugal pump/tail stock. Working principles of any type of mechanism / power plants. Working of electric and hydraulic systems of 4 wheeler vehicle. Working of machine tools, engine and transmission of different automotive and home appliances. Advanced manufacturing processes. Solid mechanics and design of machine elements.

Course Objectives:

1. **INTRODUCE** the skills required in an industry such as design, development, assembly & disassembly.
2. **DEVELOP** the skills required for fault diagnose of engine and transmission of different automotive and various home appliances.
3. **ESTABLISH** the skills required for maintenance of any machine tool.
4. **CREATE** awareness about industrial environment.

Course Outcomes:

On completion of the course, learner will be able to

CO1.**APPLY**& **DEMONSTRATE** procedure of assembly & disassembly of various machines.
CO2.**DESIGN & DEVELOP** a working/model of machine parts or any new product.
CO3.**EVALUATE** fault with diagnosis on the machines, machine tools and home appliances.
CO4.**IDENTIFY** & **DEMONSTRATE** the various activities performed in an industry such as maintenance, design of components, material selection.

Course Contents

1. Assembly and Disassembly of any of the following mechanical systems/ subsystems: bicycle (geared), e-Bikes, e-Motor Cycles, Drones, Flying devices, gear box, IC engines, centrifugal pump etc.
2. Assembly- Disassembly/ Fault diagnosis of home appliances such as mixer, grinder, washing machine, fan, ovens, gas geyser, chopping machine, kneading machine, exercise machines, etc.
3. Development and demonstration of working/animation model of any mechanism.
4. Design a circuit of electric and hydraulic system of4 wheelers and its verification.

   OR

   Circuit design /PCB design using software for control of BLDC electric motors used in e-Vehicles.
5. Undertake total preventive maintenance for any machine tool or mechanical system.
6. Visit to an industry for awareness about preventive maintenance.
7. Use of ergonomic principles for the design of hand tools, control in automobile dashboards, human operated mobile devices.

8. Use of alternative materials in the construction of daily activity machine and tool components
9. Interpretation of Drawings; Exercises in identifying the type of production, extracting important functional dimensions, checking the number of parts in an assembly. Checking and listing missing dimensions.
10. Exercises in -preparation of detailed production drawings as per BIS standard of simple machine parts having relevant notes and indications (limits/tolerances, surface finish, the process of production, relevant tools, materials, measuring instruments).

The documentation activity as a part of the Term work shall not be restricted to merely generation of 2D/3D CAD Drawings with dimensions (as applicable), Exploded View, Flowchart of Maintenance Work etc. but can be beyond.

Skill Development Documentation Diary must be maintained by every student.

302048: Audit Course V		
Teaching Scheme	**Credits**	**Examination Scheme**
	Non-Credit	

GUIDELINES FOR CONDUCTION OF AUDIT COURSE

Faculty mentor shall be allotted for individual courses and he/she shall monitor the progress for successful accomplishment of the course. Such monitoring is necessary for ensuring that the concept of self-learning is being pursued by the students 'in true letter and spirit'.

- If any course through Swayam/ NPTEL/ virtual platform is selected the minimum duration shall be of 8 weeks.
- However if any of the course duration is less than the desired (8 weeks) the mentor shall ensure that other activities in form of assignments, quizzes, group discussion etc. (allied with the course) for the balance duration should be undertaken.

In addition to credits courses, it is mandatory that there should be an audit course (non-credit course) from third year of Engineering. The student will be awarded grade as AP on successful completion of the audit course. The student may opt for any one of the audit courses in each semester. Such audit courses can help the student to get awareness of different issues which make an impact on human lives and enhance their skill sets to improve their employability. List of audit courses offered in the semester is provided in the curriculum. Students can choose one of the audit courses from the list of courses mentioned. Evaluation of the audit course will be done at institute level.

The student registered for audit course shall be awarded the grade AP and shall be included such grade in the Semester grade report for that course, provided student has the minimum attendance as prescribed by the Savitribai Phule Pune University and satisfactory in-semester performance and secured a passing grade in that audit course. No grade points are associated with this 'AP' grade and performance in these courses is not considered in the calculation of the performance indices SGPA and CGPA. Evaluation of the audit course will be done at institute level itself.

Selecting an Audit Course

List of Courses to be opted (Any one) under Audit Course V

- Entrepreneurship and IP strategy
- Engineering Economics
- Mangment of Inventory Systems

The titles indicated above are subject to change in time to come and such an alteration (if any) should be brought to the notice of the BOS.

Using NPTEL Platform: (preferable)

NPTEL is an initiative by MHRD to enhance learning effectiveness in the field of technical education by developing curriculum based video courses and web based e-courses. The details of NPTEL courses are available on its official website www.nptel.ac.in

- Students can select any one of the courses mentioned above and has to register for the

corresponding online course available on the NPTEL platform as an Audit course.

- Once the course is completed the student can appear for the examination as per the guidelines on the NPTEL portal.
- After clearing the examination successfully; student will be awarded with a certificate.

Assessment of an Audit Course

- The assessment of the course will be done at the institute level. The institute has to maintain the record of the various audit courses opted by the students. The audit course opted by the students could be interdisciplinary.
- During the course students will be submitting the online assignments. A copy of the same can be submitted as a part of term work for the corresponding Audit course.
- On the satisfactory submission of assignments, the institute can mark as "Present" and the student will be awarded the grade AP on the mark-sheet.

302049: Artificial Intelligence & Machine Learning					
Teaching Scheme		**Credits**		**Examination Scheme**	
Theory	**3Hrs./Week**	**Theory**	**3**	**In-Semester**	**30 Marks**
Practical	**2 Hrs./Week**	**Practical**	**1**	**End-Semester**	**70 Marks**
				Oral	**25 Marks**

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:

On completion of the course, learner will be able to

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 1	**Introduction to AI & ML**	**06 Hrs.**

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 2	**Feature Extraction and Selection**	**08 Hrs.**

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 3	**Classification & Regression**	**08 Hrs.**

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 4	Development of ML Model	07 Hrs.
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 5	**Reinforced and Deep Learning**	**08 Hrs.**
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 6	**Applications**	**08 Hrs.**
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.		

Books and other resources

Text Books:

1. Deisenroth, Faisal, Ong, Mathematics for Machine Learning, Cambridge University Press, 2020.
2. B Joshi, Machine Learning and Artificial Intelligence, Springer, 2020.
3. Parag Kulkarni and Prachi Joshi, "Artificial Intelligence – Building Intelligent Systems", PHI learning Pvt. Ltd., ISBN – 978-81-203-5046-5, 2015
4. Stuart Russell and Peter Norvig (1995), "Artificial Intelligence: A Modern Approach," Third edition, Pearson, 2003.

References Books:

1. Solanki, Kumar, Nayyar, Emerging Trends and Applications of Machine Learning, IGI Global, 2018.
2. Mohri, Rostamizdeh, Talwalkar, Foundations of Machine Learning, MIT Press, 2018.
3. Kumar, Zindani, Davim, Artificial Intelligence in Mechanical and Industrial Engineering, CRC Press, 2021.
4. Zsolt Nagy - Artificial Intelligence and Machine Learning Fundamentals-Apress (2018)
5. Artificial Intelligence by Elaine Rich, Kevin Knight and Nair, TMH

Web References:

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/

Term Work

List of 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.

Note:

- Students need to apply the computational algorithms using suitable software / programming language.
- Experiment 1, 2, 3, 6 & 7 are compulsory. Experiment 2 to 7 to be taken on same data set

302050: Computer Aided Engineering					
Teaching Scheme		**Credits**		**Examination Scheme**	
Theory	**3Hrs./Week**	**Theory**	**3**	**In-Semester**	**30 Marks**
Practical	**2 Hrs./Week**	**Practical**	**1**	**End-Semester**	**70 Marks**
				Practical	**50 Marks**

Prerequisite Courses: Solid Mechanics, Numerical and Statistical Methods, Engineering Mathematics, Manufacturing Processes, Fluid Mechanics, Heat and Mass Transfer.

Course Objectives:

1. **UNDERSTAND** the basic concepts of Computer Aided Engineering (CAE) and **CHARACTERISTICS** of various elements required for analysis.
2. **NURTURE** students about the discretization process and criteria for quality mesh.
3. **UNDERSTAND** the approaches of Finite Element Method (FEM) and to find displacement and stresses over the body.
4. **DEVELOP** the knowledge and skills needed to effectively evaluate the results using Finite Element Analysis (FEA).
5. **APPLY** computational technique to solve complex solid mechanics problems and its loading states.
6. **STUDY** the applications of CAE in the various domains of the Mechanical Engineering.

Course Outcomes:

On completion of the course, learner will be able to

CO1: **DEFINE** the use of CAE tools and **DESCRIBE** the significance of shape functions in finite element formulations.

CO2: **APPLY** the various meshing techniques for better evaluation of approximate results.

CO3: **APPLY** material properties and boundary condition to SOLVE 1-D and 2-D element stiffness matrices to obtain nodal or elemental solution.

CO4: **ANALYZE** and **APPLY** various numerical methods for different types of analysis.

CO5: **EVALUATE** and **SOLVE** non-linear and dynamic analysis problems by analyzing the results obtained from analytical and computational method.

CO6: **GENERATE** the results in the form of contour plot by the USE of CAE tools.

Course Contents

Unit 1	**Elemental Properties**	**07 Hrs.**

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 2	Meshing Techniques	06 Hrs.
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 3	**1D Finite Element Analysis**	**08 Hrs.**
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 4	**2D Finite Element Analysis**	**08 Hrs.**
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 5	**Non-Linear and Dynamic Analysis**	**08 Hrs.**
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 6	**Applications of Computer Aided Engineering**	**08 Hrs.**
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.		

Books and other resources

Text Books:

1. Gokhale N. S., Deshpande S. S., Bedekar S. V. and Thite A. N., Practical Finite Element Analysis, Finite to Infinite, Pune, 1st Edition, 2008.
2. S. S. Bhavikatti, Finite Element Analysis, New Age International Publishers, Third Edition, 2015.
3. Chandrupatla T. R. and Belegunda A. D., Introduction to Finite Elements in Engineering, Prentice Hall India, 2002.
4. G Lakshmi Narasaiah, Finite Element Analysis, BS Publications / BSP Books, 2nd edition, 2020.
5. J. N. Reddy, An Introduction to the Finite Element Method, Mcgraw Hill Series in Mechanical, 2005.
6. P. Seshu, Text book of Finite Element Analysis, PHI Learning Private Limited, New Delhi, 10th Printing, 2012.

References Books:

1. K. J. Bathe, Finite Element Procedure, Prentice-Hall of India (P) Ltd., New Delhi, 1996.
2. Cook R. D., Finite Element Modeling for Stress Analysis, John Wiley and Sons Inc, 1995.
3. G.R. Liu S. S. Quek, The Finite Element Method- A Practical Course, Butterworth Heinemann, 2013.
4. Fagan M. J., Finite Element Analysis Theory and Practice, Harlow Pearson/Prentice Hall, 2012.
5. S. Moaveni, Finite element analysis, theory and application with Ansys, Pearson, Third Edition, 2011.
6. David V. Hutton, Fundamental of Finite Element Analysis, Tata McGraw-Hill, 2017.
7. Mukhopadhyay M and Sheikh A. H., Matrix and Finite Element Analyses of Structures, Ane Books Pvt. Ltd., 2009
8. Daryl L. Logan, A First Course in the Finite Element Method, Fourth Edition, Thomson Canada Limited, 2007.
9. O.C. Zienkiewicz, The Finite Element Method: Its Basis and Fundamentals, Sixth Edition, Elsevier Butterworth-Heinemann, 2005.

Web References:

- **https://nptel.ac.in/courses/112/104/112104116/-**for Basics of Finite Element Analysis by Prof.Nachiketa Tiwari, IIT Kanpur
- **https://nptel.ac.in/courses/112/106/112106130/**for Advanced Finite Element Analysis by Dr. R. Krishnakumar, Department of Mechanical Engineering, IIT Madras
- **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.
- **https://sites.ualberta.ca/~wmoussa/AnsysTutorial/** for ANSYS Tutorials

Term Work
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:** • The lab report shall consist of completion of Practical's and Presentations. • Practical examination shall be based on the practical undertaken during the semester.

302051: Design of Transmission Systems					
Teaching Scheme		**Credits**		**Examination Scheme**	
Theory	**3Hrs./Week**	**Theory**	**3**	**In-Semester**	**30 Marks**
Practical	**2 Hrs./Week**	**Practical**	**1**	**End-Semester**	**70 Marks**
				Oral	**25 Marks**

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:

On completion of the course, learner will be able to

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**	**08 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.		

Books and other resources

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.

References 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.

Web References:

1. https://www.youtube.com/watch?v=b42_IO87X4s
2. https://www.youtube.com/watch?v=vTZ4Gah3wfo
3. https://www.youtube.com/watch?v=ER6LC7ONCD8
4. https://www.youtube.com/watch?v=nMsB6Soz4Hc
5. https://www.youtube.com/watch?v=WOTDbCPukoM
6. https://www.youtube.com/watch?v=fMNQglkUfhs
7. https://freevideolectures.com/course/2363/design-of-machine-elements

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)** 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

302052-A: Composite Materials					
Teaching Scheme		**Credits**		**Examination Scheme**	
Theory	**3Hrs./Week**	**Theory**	**3**	**In-Semester**	**30 Marks**
				End-Semester	**70 Marks**

Prerequisites: Engineering Materials, Metallurgy, Manufacturing Process, 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:

On completion of the course, learner will be able to

CO1. **DEFINE & COMPARE** composites with traditional materials.
CO2. **IDENTIFY & ESTIMATE** different parameters of the Polymer Matrix Composite
CO3. **CATEGORISE** and **APPLY** Metal Matrix Process from possessions landscape.
CO4. **DETERMINE** volume/weight fraction and strength of Composites.
CO5. **SELECT** appropriate testing and inspection method for composite materials.
CO6. **SELECT** composites materials for various applications.

Course Contents

Unit 1	**Introduction to Composites**	**07 Hrs.**

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.

Unit 2	**Polymer Matrix Composite**	**08 Hrs.**

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.

Unit 3	**Metal Matrix Composite**	**07 Hrs.**

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.

Unit 4	Mechanics of Composite Materials	08 Hrs.
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).		
Unit 5	**Testing, Inspection & Standards in Composites**	**07 Hrs.**
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.		
Unit 6	**Application of Composite Materials**	**08 Hrs.**
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.		

Books and other resources

Text Books:

1. Chawla K.K., Composite materials Science and Engineering, Springer – Springer New York-2016
2. Daniel Gay- Composite Materials- Design and Applications, CRC Press, 2014
3. Autar Kaw- Mechanics of Composite Materials, Taylor and Francis, Second Edition- 2006
4. Robert M Jones-Mechanics of Composite Material, CRC Press, 2018
5. Madhujit Mukhopadhyay - Mechanics of Composite Materials and Structure, University Pres, 2004
6. S.C. Sharma -Composite Materials, Narosa Publishing House—2000

References Books:

1. A Bent Strong- Fundamentals of Composites Manufacturing-Materials, Methods and Applications, Society of Manufacturing Engineers, 2008
2. Clyne T.W. and Withers P.J-Introduction to Metal Matrix Composites, Cambridge University Press, 1995
3. Agarwal B. D. and Broutmen L. J-Analysis and performance of Fiber Composites, Wiley Publicaions-Fourth Edition, 2017
4. M. W. Hyer, Scott R. White- Stress Analysis of Fiber-reinforced Composite Materials, DEStech Publications, Inc., 2009
5. Carl T. Herakovich- Mechanics of Fibrous Composites, Wiley Publicaions, 1998
6. Erich Fitzer, Lalit M. Manocha - Carbon Reinforcements and Carbon /carbon Composites, Springer-Verlag, 1998
7. Murray Schwartz, Mel M. Schwartz- Composite Materials Handbook, McGraw-Hill, 1992
8. Composite Materials Handbook, SAE International, 2017

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/

302052-B: Surface Engineering					
Teaching Scheme		**Credits**		**Examination Scheme**	
Theory	**3Hrs./Week**	**Theory**	**3**	**In-Semester**	**30 Marks**
				End-Semester	**70 Marks**

Prerequisites: Basic Chemistry, Engineering Materials & Basic Metallurgy concepts

Course Objectives:

1. **DEVELOP** fundamental understanding and role of materials to allow surface selection for mechanical contact surfaces
2. **UNDERSTAND** surface modification and coating method to enhance surface performance
3. **RECOGNIZE** method for testing surface properties

Course Outcomes:

On completion of the course, learner will be able to-

CO1. **DEFINE** the basic's principle & mechanism of surface degradation.
CO2. **ANALYSE & SELECT** correct corrosion prevention techniques for a different service condition.
CO3. **DEMONSTRATE** the role of surface engineering of materials to modify/improve the surface properties.
CO4. **SELECT** the suitable surface heat treatments to improve the surface properties.
CO5. **APPLY** the surface modification technique to modify surface properties.
CO6. **ANALYSE** & **EVALUTE** various surface coating defects using various testing/characterization method.

Course Contents

Unit 1	**Introduction to Surface Engineering and Surface Degradation**	**08 Hrs.**

Introduction to engineering components, surface dependent properties and failures, importance and scope of surface engineering; surface and surface energy; Structure and type of interfaces, surface and related equations; Surface engineering: classification, definition, scope and general principles. Adhesive wear, Abrasive wear, Erosion wear, Polishing wear; Corrosion: definition; Various Forms of Corrosion; Corrosion Triangle, Pilling and Bedworth rule, Formation and growth of films, Concept of Electrode Potential, Concept of Polarization, Electrochemical and galvanic series of metals.

Unit 2	**Corrosion Testing and Prevention methods**	**07 Hrs.**

Corrosion Testing –Introduction of Corrosion Testing by Physical (only weight loss & salt spray method) and Electrochemical Methods such as ASTM standard methods only G-5&A262-A.

Corrosion Prevention methods –Metallurgical and Environmental aspects of corrosion, Inhibitors, Internal & External coating, Cathodic & Anodic protection, use of special alloys, Improvement in design/ changes in design to control corrosion.

Unit 3	**Surface Treatment Methods**	**08 Hrs.**

Diffusion: Principles of diffusion, Fick‟s law, diffusion in solids, Diffusion in liquids; Surface hardening: Carburizing, Carburizing atmosphere and Heat treatment after Case Hardening, Depth of carburization, Case depth measurement, ASTM E1077-01 Depth of carburization, ASTM standard

G105, G95, Bainite control in case, Drip Feed Carburizing, dimensional changes during case hardening; Nitriding, Carbonitriding, Tufftriding, Nitrocarburising, Plasma Nitriding; Induction Hardening, Flame Hardening, Laser Hardening, Selection of steels for these treatments and their applications.

Unit 4	**Advance Surface Modification Techniques**	**07 Hrs.**

Surface modification processes: ion beam surface treatment; sol-gel coating technology; laser surface alloying. Coating for corrosion resistance: conversion coatings; compound coatings - diamond-like nanocomposites, nitrides, silicides, and carbides. Coating for wear resistance: carbon nitride thin films; sputter deposited nanostructured ceramic coatings; dielectric coatings of Si-C alloy films. Electroless coating.

Unit 5	**Surface Coating Techniques**	**07 Hrs.**

Introduction; importance of coating; types of coating: metal, inorganic, and organic. Processes of metal coatings: electrodeposition; flame spraying; Cold spray coating; cladding; hot dipping; vapor deposition. Processes of inorganic coatings: spraying; diffusion coating; chemical conversion. Processes of organic coatings: surface preparation; priming coat; top coats, Antidust coating, Hardfacing; Coatings for high temperature, Coatings for aerospace and aircrafts.

Unit 6	**Surface Evaluation and Characterizations**	**08 Hrs.**

Coating Defects & remedies: Crawling, cratering & related defects; Flooding, wrinkling, Bubbling and Pin-holing, Overspray and Dry Spray, Blushing, foaming, blistering, checking and cracking, blooming, chalking, embrittlement, orange peel, yellowing etc.

Measurement of coating thickness; porosity and adhesion of surface coating; measurement of residual stress and stability; Surface microscopy and topography by scanning probe microscopy; spectroscopic analysis of modified surfaces; Surface roughness, Atomic force microscopy.

Books and other resources

Text Books:

1. K.G. Budinski, Surface Engineering for Wear Resistances, Prentice Hall, Englewood Cliffs, 1988.
2. M. Ohring, The Materials Science of Thin Films, Academic Press Inc, 2005.
3. Peter Martin, " Introduction to Surface Engineering and Functionally Engineered Materials", John Willey
4. M. G. Fontana - Corrosion Engineering, 3rd Edition, TATA Mc Graw Hill, 2008.
5. J. R. Davis-Surface Engineering for Corrosion and Wear Resistance, ASM International, 2001
6. R. W. Revie & H.H. Uhlig - Corrosion and Corrosion Control, An Introduction to Corrosion Science & Engineering, 4th Edition, Wiley Inter science , 2008.

References Books:

1. Mircea K. Bologa, "Surface Engineering and Applied Electrochemistry", Springer.
2. Devis, J.R.," Surface Engineering for Corrosion & Wear Resistance", 2001 Maney Publicsing
3. D.R. Jones - Principals and Prevention of Corrosion, 2nd International Edition, Prentice Hall International Singapore, 1995.
4. L. L. Shreir- Corrosion Volume I & II, Butterworths, London, 1994.
5. ASM Handbook Volume 5: Surface Engineering, ASM International, USA, 1994.

Web References:

1. Aqueous Corrosion and Its Control - Course (nptel.ac.in): By Dr. V. S. Raja
2. Corrosion Failures and Analysis - Course (nptel.ac.in):By Dr. KallolMandol
3. Surface Engineering of Nanomaterials - Course (nptel.ac.in): By Prof. Kaushik Pal
4. Fundamentals of Surface Engineering: Mechanisms, Processes and Characterizations - Course (nptel.ac.in)by Prof. D.K. Dwivedi

302053: Measurement Laboratory					
Teaching Scheme		**Credits**		**Examination Scheme**	
Practical	**2 Hrs./Week**	**Practical**	**1**	**Term Work**	**50 Marks**

Prerequisites: Basics of Linear measurements and working principles of Electrical and Electronics devices.

Course Objectives:

1. **DEVELOP** necessary skills for calibration and testing of instruments
2. **APPLY** fundamentals of measuring methods by collecting data ,analysis and interpretation
3. **APPLY** knowledge of Designing limiting gauges
4. **APPLY** knowledge of Electronic/Electrical measuring instruments

Course Outcomes:

On completion of the course, learner will be able to-

CO1. **EVALUATE** causes of errors in Vernier calipers, micrometers by performing experiments in standard metrological conditions, noting deviations at actual and by plotting cause and effect diagram, to reduce uncertainty in measurement.

CO2. **ANALYZE** strain measurement parameters by taking modulus of elasticity in consideration to acknowledge its usage in failure detection and force variations.

CO3. **EXAMINE** surface Textures, surface finish using equipment's like Talysurf and analyze surface finish requirements of metrological equipment's like gauges, jaws of vernier calipers, micrometers, magnifying glasses of height gauge and more, to optimize surface finish accuracy requirements and cost of measurement.

CO4. **MEASURE** the dimensional accuracy using Comparator and limit gauges and appraise their usage in actual measurement or comparison with standards set to reduce measurement lead time.

CO5. **PERFORM** Testing of Flow rate, speed and temperature measurements and their effect on performance in machines and mechanisms like hydraulic or pneumatic trainers, lathe machine etc. to increase repeatability and reproducibility.

CO6. **COMPILE** the information of opportunities of entrepreneurships/business in various sectors of metrology like calibrations, testing, coordinate and laser metrology etc in an industry visit report.

Term Work

The student shall complete the following activity as a Term Work

1. Fundamentals of measurements and Calibration process by using Dead weight Tester/Strain Gauges/Pressure Gauge.
2. Linear and angular Measurement: Demonstration and calculations using Vernier Caliper, Screw gauge, Dial gauge, height gauge, Bevel protector etc. and plotting cause and effect diagram for their errors in measurement with the help of OER software's or software's like Minitab or in excel sheet.
3. Limit Gauges: Concepts, uses and applications of Go –No Go Gauges, Taylor's principle and Design of gauges (Numerical and student activity)
4. Surface roughness measurement of a given sample using surface tester. Students should also

plot of flow chart of its usage.

5. Determination of geometry and dimensions of given composite object / single point tool, by using Optical Projector / Tool makers' Microscope and differentiate between its usefulness in real life.
6. Verification of dimensions and geometry of given components using Electric/Mechanical/Optical/Pneumatic comparator in context of manufacturing.
7. Determination of modulus of elasticity of a mild steel specimen using strain gauges and its improvement to reduce cost of measurement.
8. Calibration of Thermocouple for temperature measurement / Experimentation by using Gear Tooth Vernier Caliper
9. Speed Measurement and calibration of photo and magnetic speed pickups for the measurement of speed by using Stroboscope.
10. Calibration for Flowrate measurement by using Anemometers, Ultrasonic flow meters and plotting of Risk Priority Number (RPN) of any of the used equipments.
11. Determination of geometry of a given sample by using Coordinate Measuring Machine as per NPL standard and also acknowledge requirements of ISO 10360-5:2020 in CMM measurement.
12. Applications of Open Education Resources like Scilab in measurement / Students should develop any online calculator/app for calculations/numerical analysis relevant to metrology.

Important Note:

1. Relevant theory to be taught during practical hours
2. Sr. No. 1, 2, 3 and 12 are mandatory and any 4 from Sr. No. 4 to 11.
3. Practical's are to be performed under the guidance of concerned faculty member.

Industry Visit to provide exposure to students (Anyone to be covered to fulfil CO6 essentially)

- Demonstration of CMM with the help of software and its futuristic improvements as per Industry 4.0 requirements.
- Design of Go –No Go gauges and Senor applications with modernization as per IOT and Industry 4.0
- Calibration Process as per NABL accreditation norms
- Laser Metrology and its relevant setup functions to be carried out by engineers along with safety precautions to reduce measurement lead time and uncertainty.
- Temperature Measurements of Furnaces, Boilers etc with its cost analysis
- Flow Measurements of Air, Fluids to reduce measurement lead time

Text Books:

1. Jain R.K., Engineering Metrology, Khanna Publication.
2. D.S.Kumar, Mechanical Measurements and Control Metropolitan Book Co.Pvt.Ltd.
3. I.C.Gupta, Engineering Metrology, Dhanpath Rai.
4. Bewoor A. K. and Kulkarni V. A., Metrology and Measurements, McGraw hill Publication.

Reference Books:

1. Narayana K.L., Engineering Metrology.
2. Galyer J.F &Shotbolt C.R., Metrology for engineers
3. Judge A.W., Engineering Precision Measurements, Chapman and Hall
4. Francis T. Farago, Mark A. Curtis, Handbook of dimensional measurement

5. ASTME, Handbook of Industrial Metrology, Prentice Hall of India Ltd.
6. Connie Dotson, Fundamentals of Dimensional Metrology, ThamsonPubln. 4th Edition.

Online Education resources: viz. NPTEL web site:

1. nptel.ac.in/courses/112106179
2. www.nptelvideos.in/2012/12/mechanical-measurements-and-metrology.html
3. https://nptel.ac.in/courses/112/107/112107242/
4. freevideolectures.com › Mechanical › IIT Madras
5. https://nptel.ac.in/courses/112/106/112106139/

302054: Fluid Power & Control Laboratory					
Teaching Scheme		**Credits**		**Examination Scheme**	
Practical	**2 Hrs./Week**	**Practical**	**1**	**Term Work**	**50 Marks**

Prerequisites: Hydraulic fluids, Relay logic and Ladder Logic/PLC programming

Course Objectives:

1. **UNDERSTAND** working principles of control devices and accessories.
2. **SELECT** different components from manufactures' catalogues.
3. **DEMONSTRATE** the capabilities to simulate and design fluid power systems.
4. **UNDERTAKE** digitalization of fluid power system.

Course Outcomes:

On completion of the course, learner will be able to

CO1.**DEFINE** working principle of components used in hydraulic and pneumatic systems.

CO2.**IDENTIFY & EXPLAIN** various applications of hydraulic and pneumatic systems.

CO3.**SELECT** an appropriate component required for hydraulic and pneumatic systems using manufactures' catalogues.

CO4.**SIMULATE & ANALYSE** various hydraulic and pneumatic systems for industrial/mobile applications.

CO5.**DESIGN** a hydraulic and pneumatic system for the industrial applications.

CO6.**DESIGN & DEMONESTRATE** various IoT, PLC based controlling system using hydraulics and pneumatics.

Practical

The student shall complete the following Practical in laboratory

1. Study of fluid power control systems
   a. Fluid Power Engineering Fundamentals
      - Fluid power basics (governing laws used in fluid power systems)
      - Discuss fluid power transmission and explain basic methods of transmission of power
      - Advantages and disadvantages of fluid power systems
      - Explain role of fluid power engineering in today's industrial automation
      - Clarify the aims of automation

   b. Components of Fluid Power System
      - Components of hydraulic system
      - Components of pneumatic systems
      - Draw symbols of hydraulic and pneumatic components
2. Study and trial on actuators
   a. Study of actuators used in hydraulics and pneumatics
      - Introduction
      - Types of actuators
        - Linear actuators
        - Rotary actuators
        - Limited rotary actuators

   b. Test on linear /rotary actuator. Calculate force/speed/rpm/torque as per case.

3. A) Study and trial on Gear/Vane/Piston pump
   a. Study of hydraulic pumps.
      - Introduction and classification
      - Advantages of positive displacement pumps
      - Types of pumps
        - External and internal gear pump
        - Vane pumps
        - Piston pumps
          - Axial pumps
          - Radial piston pumps

   b. Trial Gear/Vane/Piston pump.

   OR

   B) Study and testing of pressure control valve.
   a. Circuits with pressure control valve i.e. pressure reducing/counterbalance/brake valve/Sequencing circuit
   b. Test on pressure relief valve
4. Study and design of compressed air generation and distribution system
   a. Reservoir
   b. Driers
   c. Types of Regulators
   d. Filters
   e. Lubricators
   f. FRL
   g. Loop piping system
   h. Assignment on calculation (manual/excel sheet/simulation tool) of pressure loss in piping system
5. Study of control valves
   a. Introduction
   b. Types of control valves
      - Directional control valves
      - Pressure control valves
      - Flow control valves
      - Cartridge valves
      - Proportional control valves/Electro-hydraulics/proportional valves
      - Demonstration of cut-section/transparent/dismantling of any one valve

   c. Regenerative circuit
   d. Speed control circuits
   e. Transverse and feed circuit.
6. Study of accessory used in hydraulic systems
   a. Reservoirs
   b. Accumulators: weight loaded, spring loaded, gas loaded.
   c. Intensifier
   d. Fluid conductors/pipes; pipe fittings
   e. Demonstration of electro hydraulic circuit/accumulator/intensifier
7. Following experiments to be done on pneumatic trainer
   a. Automatic reciprocating circuit
   b. Speed control circuit/Flow control valve
   c. Pneumatic circuit involving Shuttle valve/ Quick exhaust valve / Two pressure valve
   d. Electro pneumatic circuits

8. a) Simulation of hydraulic and pneumatic circuits: Design of any two industrial hydraulics and two pneumatic circuits using manufacturers' catalogue and analysis using any open source/free/commercial software or application.

OR

b) Design of industrial hydraulic and pneumatic circuits, selection of components using the manufacturer's catalogue and analysis using any open source/free/commercial software or application.

9. A) Industrial visit. (Automotive workshop, small or medium scale /automation industry)
   B) Trouble shooting of fluid power system.
10. Study and implementation of IoT based system to operate electro-pneumatic/hydraulic circuit from a remote location.
    i.e. Demonstration of one cycle of operation of cylinder extension by actuation of solenoid and then retraction by deactivation of the solenoid through proximity sensor.

OR

Demonstration of counting and stopping a cycle once the number of the cycle's are completed (using PLC)

OR

any other application of relay ladder logic or PLC. (Equipments required for implementation include Smart Phone, Node MCU, Relay 5 volt to 24 volt and account on cloud.)

Assessment of Term Work

The student shall complete the above mentioned activities and prepare a Term Work Journal;

Important Note:

Term Work of the Student shall be evaluated based on the completion of Practical, Industrial Visit Report and Group Assignment. Continuous evaluation by the faculty shall be done for the award of the Credit associated with the course.

No practical examination shall be conducted for the award of the credit

Books and other resources

Text Books:

1. Esposito A, Fluid Power with application, Prentice Hall
2. Majumdar S.R, Oil Hydraulic system- Principle and maintenance ,Tata McGraw Hill
3. Majumdar S.R, Pneumatics Systems Principles and Maintenance ,Tata McGraw Hill
4. Stewart H. L, Hydraulics and Pneumatics , Taraporewala Publication

References Books:

1. Pipenger J.J, Industrial Hydraulics, McGraw Hill
2. Pinches, Industrial Fluid Power, Prentice Hall
3. Andrew A. Parr, Hydraulics and Pneumatics, Elsevier Science and Technology Books
4. ISO - 1219, Fluid Systems and components, Graphic Symbols
5. Standard manufacturing catalogues
6. Fundamentals of Pneumatics, Vol I, II and III. FESTO
7. Fundamentals of fluid power control, John Watton Cambridge University press 2012
8. Introduction to Fluid power, Thomson Prentcie Hall 2004
9. Hydraulic Control Systems Herbert E. Merritt John Wiley and Sons, Inc

Web References:

URL links:

1. https://nptel.ac.in/courses/112/106/112106175/
2. http://ndl.iitkgp.ac.in/document/QXBqK1czOUpyM3FlamVjTmREMWFEUFdEb25sZ01FZVRtZmhWNXlobUZ0MFJ0Zk1kU1dSYmEwK1RSZG1FMUNDNQ
   Fluid Power Control: Web-Course Module-01 Module-02 Module-03 Module-04

Links of Video Lectures:

1. https://nptel.ac.in/courses/112/106/112106300/
2. https://www.digimat.in/nptel/courses/video/112105047/L01.html

Recommended on line courses: https://nptel.ac.in/course.html

302055: Internship/Mini project				
Teaching Scheme**		**Credits**	**Examination Scheme**	
		04	**TW**	**100 Marks**

Prerequisites: Knowledge of design, manufacturing processes, modeling, and mechanical systems

Course Objectives:

Internship provides an excellent opportunity to learner to see understand the conceptual aspects learned in classes and deployed into the practical world. Industry/on project experience provides much more professional experience as value addition to classroom teaching.

1. To encourage and provide opportunities for students to get professional/personal experience through internships.
2. To learn and understand real life/industrial situations.
3. To get familiar with various tools and technologies used in industries and their applications.
4. To nurture professional and societal ethics.
5. To create awareness of social, economic and administrative considerations in the working environment of industry organizations.

Course Outcomes:

On completion of the course, learners should be able to

CO1. **DEMONSTRATE** professional competence through industry internship.

CO2. **APPLY** knowledge gained through internships to complete academic activities in a professional manner.

CO3. **CHOOSE** appropriate technology and tools to solve given problem.

CO4. **DEMONSTRATE** abilities of a responsible professional and use ethical practices in day to day life.

CO5. **DEVELOP** network and social circle, and **DEVELOPING** relationships with industry people.

CO6. **ANALYZE** various career opportunities and **DECIDE** career goals.

****Guidelines:**

Internships are educational and career development opportunities, providing practical experience in a field or discipline. Internships are far more important as the employers are looking for employees who are properly skilled and having awareness about industry environment, practices and culture. Internship is structured, short-term, supervised training often focused around particular tasks or projects with defined time scales.

Core objective is to expose technical students to the industrial environment, which cannot be simulated/experienced in the classroom and hence creating competent professionals in the industry and to understand the social, economic and administrative considerations that influence the working environment of industrial organizations.

Engineering internships are intended to provide students with an opportunity to apply conceptual knowledge from academics to the realities of the field work/training. The following guidelines are proposed to give academic credit for the internship undergone as a part of the Third Year Engineering curriculum.

Duration:

Internship is to be completed after semester 5 and before commencement of semester 6 of at least 4 to 6 weeks; and it is to be assessed and evaluated in semester 6.

Internship work Identification:

Student may choose to undergo Internship at Industry/Govt. Organizations/NGO/MSME/Rural Internship/ Innovation/IPR/Entrepreneurship. Student may choose either to work on innovation or entrepreneurial activities resulting in start-up or undergo internship with industry/NGO's/Government organizations/Micro/Small/ Medium enterprises to make themselves ready for the industry.

Students must get Internship proposals sanctioned from college authority well in advance. Internship work identification process should be initiated in the Vth semester in coordination with training and placement cell/ industry institute cell/ internship cell. This will help students to start their internship work on time. Also, it will allow students to work in vacation period after their Vth semester examination and before academic schedule of semester VI.

Student can take internship work in the form of the following but not limited to:

1. Working for consultancy/ research project,
2. Contribution in Incubation/ Innovation/ Entrepreneurship Cell/ Institutional Innovation Council/ startups cells of institute /
3. Learning at Departmental Lab/Tinkering Lab/ Institutional workshop,
4. Development of new product/ Business Plan/ registration of start-up,
5. Industry / Government Organization Internship,
6. Internship through Internshala,
7. In-house product development, intercollegiate, inter department research internship under research lab/group, micro/small/medium enterprise/online internship,
8. Research internship under professors, IISC, IIT's, Research organizations,
9. NGOs or Social Internships, rural internship,
10. Participate in open source development.

Internship Diary/ Internship Workbook:

Students must maintain Internship Diary/ Internship Workbook. The main purpose of maintaining diary/workbook is to cultivate the habit of documenting. The students should record in the daily training diary the day-to-day account of the observations, impressions, information gathered and suggestions given, if any. The training diary/workbook should be signed every day by the supervisor.

Internship Diary/workbook and Internship Report should be submitted by the students along with attendance record and an evaluation sheet duly signed and stamped by the industry to the Institute immediately after the completion of the training.

Internship Work Evaluation:

Every student is required to prepare and maintain documentary proofs of the activities done by him as internship diary or as workbook. The evaluation of these activities will be done by Program Head/Cell In-charge/ Project Head/ faculty mentor or Industry Supervisor based on- Overall compilation of internship activities, sub-activities, the level of achievement expected, evidence needed to assign the points and the duration for certain activities.

Assessment and Evaluation is to be done in consultation with internship supervisor (Internal and External – a supervisor from place of internship.

Recommended evaluation parameters-Post Internship Internal Evaluation -50 Marks + Internship Diary/Workbook and Internship Report - 50 Marks

Evaluation through Seminar Presentation/Viva-Voce at the Institute

The student will give a seminar based on his training report, before an expert committee constituted by the concerned department as per norms of the institute. The evaluation will be based on the following criteria:

- Depth of knowledge and skills
- Communication & Presentation Skills
- Team Work and Creativity
- Planning & Organizational skills
- Adaptability
- Analytical Skills
- Attitude & Behavior at work
- Societal Understanding
- Ethics
- Regularity and punctuality
- Attendance record
- Diary/Workbook
- Student's Feedback from External Internship Supervisor

After completion of Internship, the student should prepare a comprehensive report to indicate what he has observed and learnt in the training period.

Internship Diary/workbook may be evaluated on the basis of the following criteria:

- Proper and timely documented entries
- Adequacy & quality of information recorded
- Data recorded
- Thought process and recording techniques used
- Organization of the information

The report shall be presented covering following recommended fields but limited to,

- Title/Cover Page
- Internship completion certificate
- Internship Place Details- Company background-organization and activities/Scope and object of the study / Supervisor details
- Index/Table of Contents
- Introduction
- Title/Problem statement/objectives
- Motivation/Scope and rationale of the study
- Methodological details
- Results / Analysis /inferences and conclusion
- Suggestions / Recommendations for improvement to industry, if any
- Attendance Record
- Acknowledgement
- List of reference (Library books, magazines and other sources)

Feedback from internship supervisor(External and Internal)

Post internship, faculty coordinator should collect feedback about student with recommended parameters include as- Technical knowledge, Discipline, Punctuality, Commitment, Willingness to do the work, Communication skill, individual work, Team work, Leadership…

Reference:

1. https://www.aicte-india.org/sites/default/files/AICTE%20Internship%20Policy.pdf
2. https://internship.aicte-india.org/

IMPORTANT NOTE:

The student shall be encouraged to undertake the industrial internships however the Industry may provide opportunity to a limited few amongst the students available. In such scenario it becomes the moral responsibility of the faculty to create opportunity for such group of students (similar to the ones in Industry) by assigning them some real life problem as a part of the mini project and encouraging/mentoring them to attempt viable solutions. Hence the provision of Mini project is being done to accommodate such students and expose them with the Industrial practices in house. The students can be encouraged to consider analysis of the global patents available as a mini project,

Mini project					
Teaching Scheme		**Credits**		**Examination Scheme**	
Practical	**4 Hrs./Week**	**Practical**	**4**	**Term work**	100

Course Objectives:

Students shall UNDERTAKE and EXECUTE a Mini Project through a group of students to

1. **UNDERSTAND** the "Product Development Cycle", through Mini Project.
2. **PLAN** for various activities of the project and distribute the work amongst team members.
3. **LEARN** budget planning for the project.
4. **INCULCATE** mechanical/interdisciplinary implementation skills.
5. **DEVELOP** students' abilities to transmit technical information clearly and test the same by delivery of Seminar based on the Mini Project.
6. **UNDERSTAND** the importance of document design by compiling Technical Report on the Mini Project work carried out.

Course Outcomes:

On completion of the course, learner will be able to

CO1. **EXPLAIN** plan and execute a Mini Project with team.

CO2. **IMPLEMENT** hardware/software/analytical/numerical techniques, etc.

CO3. **DEVELOP** a technical report based on the Mini project.

CO4. **DELIVER** technical seminar based on the Mini Project work carried out.

Course Contents

Maximum Group Size: Minimum 2 and maximum 4 students can form a group for the mini project.

Project Type: (The selected mini project must be based on any of the following)

1. Development of a prototype mechanical system/product.
2. Investigate performance of mechanical systems using experimental method

3. Parametric analysis of components/systems/devices using suitable software
4. Investigation of optimum process/material for product development using market survey.
5. Solution for society/industry problems

The Assessment Scheme will be:

a. **Continuous Assessment 50 marks** *(based on regular interaction, circuit development)*

b. **End Semester 50 marks** *(based on poster presentation, demonstration / Seminar)*

Project domain may be from the following, but not limited to:

1.Thermal Systems
2. Robotics Mechanisms/design systems
3. Production/advance manufacturing
4. Materials: Composite/Nano
5. Automation and Control Systems
6. Mechatronic Systems
7. Agriculture system.
8. Smart systems using AI-ML

A project report with following contents shall be prepared:

1. Title
2. Objectives
3. Relevance and significance
4. Methodology
5. Analysis-Simulation/experimentation/survey/testing etc.
6. Result and Discussion
7. Conclusion

302056: Audit Course VI		
Teaching Scheme	**Credits**	**Examination Scheme**
	Non-Credit	

GUIDELINES FOR CONDUCTION OF AUDIT COURSE

Faculty mentor shall be allotted for individual courses and he/she shall monitor the progress for successful accomplishment of the course. Such monitoring is necessary for ensuring that the concept of self-learning is being pursued by the students 'in true letter and spirit'.

- If any course through Swayam/ NPTEL/ virtual platform is selected the minimum duration shall be of 8 weeks.
- However if any of the course duration is less than the desired (8 weeks) the mentor shall ensure that other activities in form of assignments, quizzes, group discussion etc. (allied with the course) for the balance duration should be undertaken.

In addition to credits courses, it is mandatory that there should be an audit course (non-credit course) from third year of Engineering. The student will be awarded grade as AP on successful completion of the audit course. The student may opt for any one of the audit courses in each semester. Such audit courses can help the student to get awareness of different issues which make an impact on human lives and enhance their skill sets to improve their employability. List of audit courses offered in the semester is provided in the curriculum. Students can choose one of the audit courses from the list of courses mentioned. Evaluation of the audit course will be done at institute level.

The student registered for audit course shall be awarded the grade AP and shall be included such grade in the Semester grade report for that course, provided student has the minimum attendance as prescribed by the Savitribai Phule Pune University and satisfactory in-semester performance and secured a passing grade in that audit course. No grade points are associated with this 'AP' grade and performance in these courses is not considered in the calculation of the performance indices SGPA and CGPA. Evaluation of the audit course will be done at institute level itself.

Selecting an Audit Course

List of Courses to be opted (Any one) under Audit Course VI

- Business and Sustainable Development
- Management Information System
- International Business

The titles indicated above are subject to change in time to come and such an alteration (if any) should be brought to the notice of the BOS.

Using NPTEL Platform: (preferable)

NPTEL is an initiative by MHRD to enhance learning effectiveness in the field of technical education by developing curriculum based video courses and web based e-courses. The details of NPTEL courses are available on its official website www.nptel.ac.in

- Students can select any one of the courses mentioned above and has to register for the corresponding online course available on the NPTEL platform as an Audit course.
- Once the course is completed the student can appear for the examination as per the guidelines on the NPTEL portal.
- After clearing the examination successfully; student will be awarded with a certificate.

Assessment of an Audit Course
• The assessment of the course will be done at the institute level. The institute has to maintain the record of the various audit courses opted by the students. The audit course opted by the students could be interdisciplinary. • During the course students will be submitting the online assignments. A copy of the same can be submitted as a part of term work for the corresponding Audit course. • On the satisfactory submission of assignments, the institute can mark as "Present" and the student will be awarded the grade AP on the mark-sheet.