Savitribai Phule Pune University
Faculty of Science & Technology

Curriculum/Syllabus
For
Third Year
Bachelor of Engineering
(Choice Based Credit System)
Mechanical Engineering [Sandwich]
(2019 Course)
Board of Studies – Mechanical and Automobile Engineering
(With Effect from Academic Year 2021-22)

Savitribai Phule Pune University
Board of Studies - Mechanical and Automobile Engineering
Undergraduate Program - Mechanical Engineering [Sandwich] (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
302061	Fundamentals of Computer Aided Engineering	3	2	-	30	70	-	50	-	150	3	1	-	4
302046	Digital Manufacturing Laboratory	-	2	-	-	-	50	-	-	50	-	1	-	1
302062	Mechanical Measurement Laboratory	-	2	-	-	-	25	-	50	75	-	1	-	1
302048	Audit course - V[$]	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**15**	**12**	**1**	**150**	**350**	**100**	**100**	**100**	**800**	**15**	**6**	**1**	**22**
Semester-VI														
302063	Industrial In-plant Training-I	-	14	-	-	-	100	-	100	200	-	7	-	7
302064	Industrial Mini-Project	-	12	-	-	-	100	-	50	150	-	6	-	6
302065	Seminar	-	2	-	-	-	-	-	50	50	-	1	-	1
302066	Process Planning & Tool Selection (Self-Study-I)	-	-	-	30	70	-	-	-	100	3	-	-	3
302067	Advanced Materials & Manufacturing (Self-Study-II)	-	-	-	30	70	-	-	-	100	3	-	-	3
302058	Audit course - VI[$]	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**-**	**28**	**-**	**60**	**140**	**200**	**-**	**200**	**600**	**6**	**14**	**-**	**20**

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 (Mechanical Engineering [Sandwich]) can opt for any one of the audit course from the list of audit courses prescribed by BOS (Mechanical and Automobile Engineering)

During Semester VI students will be in industry. Practical load for Industrial In-plant Training-I and Industrial Mini-Project will be considered 7 and 6 hours / week respectively. Seminar head will also be considered 1 hour / week. Seminar will be the extension of curriculum and based on technological developments, patents, product developments, process improvements, etc.

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. Grades awarded for the audit course shall not be calculated for grade point & CGPA.
- Online courses will be based on certification courses such as MOOCs, Industry relevant certification courses offered by an Industry, NDT, GD&T, Welding Inspector etc. shall be awarded based on completion of relevant courses (recommended by college) and producing Certificate.

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.

Unit 3	**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 equipment 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	**3 Hrs./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	**3 Hrs./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.

302061- Fundamentals Computer Aided Engineering					
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: Solid Mechanics, Numerical and Statistical Methods, Engineering Mathematics, 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 compute displacement and stresses over the body.
4. **DEVELOP** code for a component for CNC machines
5. **UNDERSTAND** various methods of automation and architecture of industrial robots.
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. **DEVELOP** code for a component for CNC machines.

CO5. **DESCRIBE** various methods of Automation and Robot Architecture.

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

Course Contents

Unit 1	**Introduction to CAE and Element 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.

Basic steps in FEM, 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	**Finite Element analysis (1D and 2D)**	**10 Hrs.**

Consistent Unit System, Introduction to approaches used in Finite Element Analysis 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.

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.

Unit 4	**Computer Aided Manufacturing**	**07 Hrs.**

Introduction and working of NC, CNC and DNC machines. Computer Aided Manufacturing.

CNC Programming. 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.

Unit 5	**Robotics & Automation**	**07 Hrs.**

Structure of Robotic System - Point to point & continuous path robotic systems, Joints, End Effectors: Grippers (Mechanical, Magnetic and Pneumatic), Drives, Controllers, Industrial Applications.

Types of Automation - Automation strategies, Group Technology & Coding Methods,

Flexible Manufacturing System – Types, Advantages, Limitations. Computer Integrated

Manufacturing and Computer Aided Process Planning, Industry 4.0

Unit 6	**Post processing Techniques and Applications**	**08 Hrs.**

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.

Common Mistakes and Errors in CAE

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.

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 Modelling 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. 9. O.C. Zienkiewicz, The Finite Element Method: Its Basis and Fundamentals, Sixth Edition, Elsevier Butterworth-Heinemann, 2005.
10. Rao P.N., Introduction to CAD/CAM Tata McGraw Hill Publishing Co
11. Groover M.P.-Automation, production systems and computer integrated manufacturing' – Prentice Hall of India
12. S. R. Deb, Robotics Technology and Flexible Automation, Tata McGraw Hill.
13. H. Versteeg, W. Malalasekera , An Introduction to Computational Fluid Dynamics: The Finite Volume Method,2nd edition, PHI Publications

Web References:

1.**https://nptel.ac.in/courses/112/104/112104116/-**for Basics of Finite Element Analysis by Prof.Nachiketa Tiwari, IIT Kanpur

2. **https://nptel.ac.in/courses/112/106/112106130/**for Advanced Finite Element Analysis by Dr. R. Krishnakumar, Department of Mechanical Engineering, IIT Madras

Term Work:

The student shall complete the following activity as a Practical using any commercial FEA software or open-source software (Any 10):

1. Stress and Deflection Analysis of Beam.

2. Truss Analysis using 1D Element

3. Stress and deflection analysis of 2D Mechanical Components.

4. Static thermal Analysis of Mechanical Structure

5. Coupled Analysis- (Structural + Thermal)

6. Machine Component Analysis of Mechanical Component using 3D Elements

7. Tool path generation for Turning – Grooving and Threading.

8. Tool path generation for Milling – Facing, Pocketing, Contouring and Drilling.

9. Modal Analysis – simply supported/Cantilever beam, etc.

10. Presentation on advanced applications of FEA, NVH, CFD, Crash, Fatigue, Manufacturing, etc.

11. Case Study: Robotics/Automation/Industry 4.0

Note:

- The lab report shall consist of completion of Practical and Presentations.
- Practical examination shall be based on the practical undertaken during the semester.

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.

302062: Mechanical Measurement Laboratory					
Teaching Scheme		**Credits**		**Examination Scheme**	
Practical	**2 Hrs./Week**	**Practical**	**1**	**TW**	**25 Marks**
				OR	**50 Marks**

Prerequisites: Basics of measurements, Engineering physics

Course Objectives:

1. **DEVELOP** necessary skills for measurement, 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** the calibration process of dial gauge by using dial calibration tester.

CO3. **EXAMINE** surface Textures, surface finish using equipment like Talysurf and analyze surface finish requirements of metrological equipments 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. **IDENTIFY** surface patterns/ flatness of given specimens by using optical flat.

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.

Course Contents

The student shall complete the following activity as a Term Work

1. Linear and angular Measurement: Demonstration and calculations using Vernier Caliper, Screw gauge, Dial gauge, height gauge. (by any two) and plotting cause and effect diagram for their errors in measurement with the help of OER software or software like Minitab or in excel sheet.

2. Measurement of Angle of given Specimen by using Sine-bar/Sine Centre and Bevel protector.

3. Calibration of Dial Gauge by using Dial Calibration Tester.

4. Limit Gauges: Concepts, uses and applications of Go –No Go Gauges, Taylor's principle and Design of gauges (Numerical and student activity)

5. Surface roughness measurement of a given sample using surface roughness tester. Students should also plot flowchart of its usage.

6. 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.

7. Identification of surface patterns of given specimen by using Optical Flat.

8. Measurement of Effective diameter of screw Thread using floating carriage micrometer.

9. Measurement of Gear Tooth Thickness by using Gear Tooth Vernier Caliper.

10. Verification of dimensions and geometry of given components using Electric/Mechanical/Optical/Pneumatic comparator in context of manufacturing.

Important Note:

1. Relevant theory to be taught during practical hours

2. 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 Sensor 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.

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

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

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
- Management 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.

302063: Industrial In-plant Training-I					
Teaching Scheme		**Credits**		**Examination Scheme**	
Practical	**14 Hrs./Week**	**Practical**	**7**	**TW**	**100 Marks**
				Oral	**100 Marks**

Prerequisites: Eagerness to have exposure to real life industrial environment and positive attitude to acquire professional skills through participation in different activities in industry during training.

Course Objectives:

1. To expose students to the industrial environment to learn the real time technical / managerial skills required for professional development.
2. To familiarize students with types of industry, various departments, processes, materials, machines, products with different industry attributes.
3. To understand the working of industrial environment with reference to professional ethics, attitude and approach to problem solving and different administrative considerations.
4. To promote academic and personal development of students imbibing individual confidence to handle various engineering assignments.
5. To provide experience in writing technical reports and technical presentations with effective communication skills.

Course Outcomes:

On completion of the course, learner will be able to

CO1. To **UNDERSTAND** industrial practices and technical details followed in industry.

CO2. To **ANALYZE** and **SOLVE** engineering problems by applying engineering knowledge with teamwork and multidisciplinary approach.

Course Contents

Students are expected to get exposure and learn the different industrial aspects during their Industrial In-Plant Training - I. Student shall undergo industrial training in Large or Medium size Core mechanical industry in various departments. During training, students are expected to focus on different aspects of industry such as type of industry, profile of industry, product and processes, machines, equipment, instrumentation, automation, energy consumption and any other relevant aspects depending on type of industry. Following are the few guidelines for the for better understanding and outcome of Industrial training.

1. **Orientation:** Types of Industry, Industrial Environment, Industrial Psychology, Industrial Management, Industrial Relations, Government Policies, Associated organizations and their role. Company profile, Organizational structure of the company, Organizational behavior, Scale and type of production, Types of products, Safety and Quality Policies of Company, Statutory Approvals, Permissions and Approvals of Products.

2. **Departments in Manufacturing Industries:** R & D (research and development), quality control, shipping, distribution, production, purchasing, recruiting or human resources, operations, finance, accounting, accounts payable, accounts receivable, billing, sales, marketing, advertising, maintenance, Engineering, Technology, Projects, etc., There could be additional departments within other departments depending on the size and type of business.

3. **Industrial Design and Drawing Practice:** Design and Drawing Standards, Study of mechanical components and component design such as gears, gear boxes, chain and belt drives, couplings, shaft, keys, bearings, brackets, bolted and welded connections. Sub-assembly and assembly drawings. Simple assignments based on the above items.

4. **Manufacturing processes**: To understand manufacturing concepts applied in industry. Study of material requirements, material standards. Heat treatments applied to products.

5. **Machine Tools**: Machine tool classifications, types of machines tool, special machine tools, machine tool design, CNC controls, Programming languages and codes, Machine tool maintenance.

6. **Manufacturing Automation**: Automation level, types of automation, application of hydraulics and pneumatics, mechatronics control, use of sensors and feedback in control, robotic control over the process.

7. **Material Handling**: Unit load concept, types of material handling equipment, selection of Material handling equipment, design requirement of material handling system.

8. **Measurement and Quality Control**: Precision measurement, Control chart, Statistical process control, Process capability, TQM, Work time measurement, software used in industry.

9. **Processes and Operation Planning**: Production planning and control, Order preparation, Material planning, Process planning, tool selection, Route sheets, documents in process planning, production control- dispatching, follow-up.

10. **Machines, Personal and Plant safety:** Safety rules in organization, posters exhibits and publicity, fire prevention and protection, Health and sanitation, Protective wearing apparel, Safety signs, Industrial safety standards.

Operational Guidelines

1. Duration of training will be full sixth semester (second semester of Third Year)

2. It is expected that students get exposure to all departments in industry.

3. The student shall be asked to complete two assignments / case studies in various departments or any Specific Industry Project.

4. Institute will assign a supervisor faculty to each student for Mentoring and Guidance.

5. Supervisor will guide and monitor student's training by visiting the industry on regular basis with specified Schedule.

6. Student shall maintain logbook (Diary Notes) during the training.

7.During training student is expected to complete two assignments / case studies with identification of industry problem.

Term Work Guidelines

Term Work shall consist of a

1. Comprehensive report based on observations, learning and contributions during training and minimum two case studies / assignments.

2. Logbook / diary maintained by student during training

Industrial In-plant Training – I report shall include points mentioned below:

1. Industry profile, Product/Service and process details, list of customers, Organizational Structure, Plant layout for small enterprise, detailed layout of shop floor, Safe working practices followed in the industry.

2. The department details where the student has undergone training. Training details (Classroom training) if given shall be included.

3. Understandings, observations and technical details of machines, equipment, instrumentation, automation and different processes available and followed in the department / industry.

3. The activities done during the training with technical details should be included in the report. Technical details in the form of drawings, figures, process sheets, machine specifications etc.

4. Two assignments / case studies other than Mini Project completed during the training should

be included in the report. Mini project work should not be included in in-plant training report to avoid duplication.

5. Assignment / case study report should contain subtopics like Introduction, problem/ task identification, Objectives, Methodology, process to be followed/action plan, Observation and solution, Comparison with the earlier status, include graphs wherever necessary, Quantification (the results should be represented in terms of %), Conclusions highlighting major outcome of assignment.

Instructions for In-Plant Training Report

Black hardbound copies of the report of Industrial In-plant Training – I to be submitted to the department. (03 Copies)

Report should be preferably of 70 - 90 pages.

Report text should be Times New Roman 12 pt. and both side justified, 1.15-line spacing, double spacing for paragraph,

Section titles should be bold with 14 pt typed in all capital letters and should be left aligned.

Header for e.g. Institute Name, Mechanical Engineering Times New Roman 10 pt. and left aligned.

Footer for e.g. Mechanical Engineering (Sandwich Pattern) Times New Roman 10 pt. and left aligned and page number at center.

Entire report shall be one chapter. No chapters for In-Plant Training - I report.

Use the paper size 8.5'' × 11'' or A4 (210 × 197 mm). Please follow the margins given below.
Top 1", Left 1.5", Bottom 1.25", Right 1".

Illustrations (charts, drawings, photographs, figures) are to be in the text. Use only illustrations really pertinent to the text. Illustrations must be sharp, clear, black and white. Illustrations downloaded from internet are not acceptable.

Examination

Oral will be based on Term Work completed during training. Oral Examination shall be conducted by appointing one Internal Examiner and one External Examiner from industry.

302064: Industrial Mini-Project					
Teaching Scheme		**Credits**		**Examination Scheme**	
Practical	**12 Hrs./Week**	**Practical**	**6**	**TW**	**100 Marks**
				Oral	**50 Marks**

Prerequisites: Better understanding of industry during training for identifying a problem statement based on need of the industry, systematic approach to provide solution to industrial problem, Readiness to participate in hands on activity.

Course Objectives:

1. To make students able to define industry problem based on theory knowledge and industry exposure received during training.
2. To understand methodological approach to provide solution to problem identified.
3. To understand professional ethics, team work and multidisciplinary approach in industrial assignments.
4. To familiarize with activities like need analysis, detailing of component specifications, critical issues involved in implementation of project, etc.
5. To promote individual level confidence for handling engineering assignments.
6. To provide experience in writing technical reports and technical presentations with effective communication skills.

Course Outcomes:

On completion of the course, learner will be able to

CO1. To **IDENTIFY** specific areas for improvement in industry with better understanding.

CO2. To **DEVELOP** and **IMPLEMENT** systematic approach to solve specific industrial problem.

CO3. To **DEVELOP** methodology for providing solution to industrial problems with teamwork and multidisciplinary approach

CO4. To **UNDERSTAND** and **IMPLEMENT** basic principles of project management.

CO5. To **SOLVE** and **ANALYZE** industrial problems.

CO6. To **PRESENT** outcome and details of project work with effective presentation skills.

Course Contents
Mini project is to be completed during the training. It could be a requirement/need based task given to the student by the industry/industry guide. It may be based on literature survey or need based analysis carried out by student. Mini project should be different than the two assignments completed under Industrial In-Plant Training – I. Task carried out for mini project should be put in the following format. 1. Introduction, problem/ task identification 2. Objectives 3. Methodology, process to be followed/action plan 4. Observation and solution 5. Comparison with the earlier status, include graphs wherever necessary 6. Quantification (the results should be represented in terms of %) 7. Conclusion. In depth analysis, quantification of results with detailed analysis with very well defined problem definition, objectives, methodology, actual work carried out, results and discussion and outcomes are expected in the report of mini project. Black hard bound report of Mini project should comprise of 50 – 70 pages. Mini Project may be 1. Task given by the industry for achieving particular objectives. 2. A physical model may be of a die, Jig or fixture, dashboards, etc. can be considered as Mini Project 3. Kaizen implementation and results (quantification of results) 4. Industrial data based task, may be including, process improvement, work study, work measurement etc. 5. Any idea implementation in order to save time, efforts, money and waste etc. to improve productivity. It must be in quantified form. (% saving compared to earlier) 6. Plant layout improvement projects (quantification of results) 7. Material handling/Material Flow projects. (quantification of results)

8. Energy audits and suggestions for improvement, results of implementation

9. Inventory management system analysis projects.

10. Any safe working idea, 3 D (danger, difficult, dirt/dust) implementation project.

11. Application of any technique under LEAN manufacturing or any other technique implementation project.

12. Any other similar task as which can be put as a mini project.

Operational Guidelines

1. Duration of training will be full sixth semester (second semester of Third Year)
2. During training period, mini project is to be completed at individual level.

Term Work Guidelines

Term Work of Mini Project shall consist of a

1. Comprehensive report based on all the steps carried out during completion of Mini project.
2. Details of mini project also should be mentioned in the Logbook / diary.

Instructions for Mini Project Report

Black hardbound copies of the report of **Mini Project** to be submitted to the department. (03 Copies)

Report should be preferably of 70 - 90 pages.

Report text should be Times New Roman 12 pt. and both side justified, 1.5-line spacing, double spacing for paragraph,

Section titles should be bold with 14 pt typed in all capital letters and should be left aligned.

Header for e.g. Institute Name, Mechanical Engineering Times New Roman 10 pt. and left aligned.

Footer for e.g. Mechanical Engineering (Sandwich Pattern) Times New Roman 10 pt. and left aligned and page number at center

Use the paper size 8.5'' × 11'' or A4 (210 × 197 mm). Please follow the margins given below.

Top 1", Left 1.5", Bottom 1.25", Right 1",

Illustrations (charts, drawings, photographs, figures) are to be in the text. Use only illustrations really pertinent to the text. Illustrations must be sharp, clear, black and white. Illustrations downloaded from internet are not acceptable. Illustrations should not be more than two per page, one per page is enough. Figure No. and Title at bottom of figure and table with 12 pt
Examination
Oral will be based on Mini Project in front of external and internal guide at the end of the semester training term.

302065: Seminar					
Teaching Scheme		**Credits**		**Examination Scheme**	
Practical	**2 Hrs./Week**	**PR**	**1**	**OR**	**50 Marks**

Prerequisites: Technologies, Products, Patents, Writing and Presenting skill, Drafting tools, Communication skills.

Course Objectives:

1. Prepare a well-organized report employing elements of technical writing and critical thinking.
2. Demonstrate the ability to describe, interpret and analyze technical issues and develop competence in presenting.

Course Outcomes:

On completion of the course, learner will be able to

CO1. Read and **UNDERSTAND** recent trends and technologies in the area of mechanical engineering.
CO2. **RECOGNIZE** problems after doing research literature survey using various resources.
CO3. **PREPARE** concise, **COMPREHEND** and conclude selective topic in area of mechanical engineering
CO4. **MAKE** use of new and recent technology (e.g. Latex) for creating technical reports

Course Contents

The Seminar topic must be related to one of the following

1. Mechanical Engineering, 2. Interdisciplinary subjects, 3. Recent trends in Engineering

INSTRUCTIONS FOR SEMINAR REPORT WRITING

It is important that the procedures listed below be carefully followed by all the students.

Prepare 3 COPIES of your Seminar report.

1. Limit your seminar report to preferably 20 – 25 pages
2. Header For e.g. ***Savtribai Phule Pune University***
3. The footer For e.g. **Mechanical Engineering**

Institute Name, Mechanical Engineering Times New Roman 10 pt. and centrally aligned.

4. Page number as second line of footer, Times New Roman 10 Pt, centrally aligned
5. Print the report using

a) Letter quality computer printing.
b) The main part of the report should be Times New Roman 12 pt. and justified.
c) Use 1.15 line spacing.
d) Entire report shall be one chapter. No chapters for Seminar report.

6. Use the paper size 8.5'' × 11'' or A4 (210 × 197 mm).

Please follow the margins given below.

Top 1" 25.4 mm
Left 1.5" 37 mm
Bottom 1.25" 32 mm
Right 1" 25.4 mm

7.All paragraphs will be 1.15 line spaced with a one blank line between each paragraph. Each paragraph will begin with without any indentation.
8. Section titles should be bold with 14 pt typed in all capital letters and should be left aligned.
9. Sub-Section headings should be aligning at the left with 12 pt, bold and Title Case (the first letter of each word is to be capitalized).
10. Illustrations (charts, drawings, photographs, figures) are to be in the text. Use only illustrations really pertinent to the text. Illustrations must be sharp, clear, black and white. Illustrations
11. Photographs if any should of glossy prints
12. Equations if any, should be typed in text (it should not be copied as image)
13. Please use the SI system of units. If students would like to add the equivalent in inch-pound (British) units, they must be stated in parenthesis after the SI units. In case the final result comes out in any other units (say due to empirical formula etc.) convert the unit to SI unit.
14. Please number the pages on the front side, centrally below the footer
15. References should be either in order as they appear in the report or in alphabetical order by last name of first author
16. Symbols and notations if any should be included in nomenclature section only
17. Following will be the order of report
i) Cover page and Front page as per specimen on separate sheet
ii) Certificate from Institute as per specimen on separate sheet
iii) Acknowledgement
iv) List of Figures
v) List of Tables
vi) Nomenclature
vii) Contents
18. All section headings and subheadings should be numbered. For sections use numbers 1, 2, 3, … and for subheadings 1.1, 1.2, … etc and section subheadings 2.1.1, 2.1.2, ... etc.
19. References should be given in the body of the text and well spread. No verbatim copy or excessive text from only one or two references. If figures and tables are taken from any reference then indicate the source of it.

302066: Process Planning & Tool Selection				
Teaching Scheme	**Credits**		**Examination Scheme**	
(Self-Study-I)	**Theory**	**3**	**In-Semester**	**30 Marks**
			End-Semester	**70 Marks**

Prerequisites: Basic knowledge of Engineering graphics, Machine Drawing, Manufacturing Processes, Cutting Tools, Production Practices.

Course Objectives:

1. To understand the role of Product and Process Engineering and to perform part print analysis.
2. To demonstrate application of geometric dimensioning and tolerance analysis.
3. To perform Work-piece control and selection of operation.
4. To analyze factors affecting Selection of Equipment & Tooling.
5. To Estimate the total unit time for a component.
6. To demonstrate process Selection, process planning and understand the benefits of CAPP.

Course Outcomes:
On completion of the course, learner will be able to

CO1. **INTERPRET** and **ANALYSE** Part print of an industrial component.

CO2. **ILLUSTRATE** the meaning of geometric dimensions and understand the tolerance chart.

CO3. **UNDERSTAND** Principles of location and clamping and **ESTABLISH** suitable manufacture sequence.

CO4. **SELECT** appropriate equipment and tooling requirements.

CO5. **ESTIMATE** the total unit time per piece for a component in mass production.

CO6. **DESIGN** of Process picture sheet and operation route sheet on GPM for batch production or a special purpose machine for mass production.

Course Contents	
Unit 1	**Process Engineering and Part Print Analysis**
Product and Process Engineering: Product design and role of product designer, Process engineering and its functions, Co-ordination of process Engineering with other departments., Organization chart, general classification of manufacturing processes, concept of design for manufacturing, communication in engineering Industry, glossary of terms used in process planning. **Analysis of Part Print**: Preliminary analysis, Its general characteristics, Principal processes, alternate processes, functional surfaces of the work piece processing areas, nature of work to be performed, finishing and identifying operations.	
Unit 2	**Geometric dimensioning and tolerance analysis**
Dimensional Analysis: Types of dimensions, concept of baseline dimensions, GDT terminology **Tolerance Analysis**: Tolerance stack-up analysis, tolerance chart, and tolerance grades and its calculations	
Unit 3	**Work-piece control and selection of operations**
Work piece control: Causes of work-piece variations, influencing work-piece control variables, techniques of work piece control – Equilibrium theories, concept of location, geometric, dimensional and mechanical control. **Classification of operations:** Basic Process Operations, Principal and Auxiliary Processes, identification of major, critical, qualifying, re-qualifying and supporting operations, product and process critical area.	
Unit 4	**Equipment & Tooling Selection**
Types of tooling: Cutting tools, forming tools, Assembly tools, Factors affecting selection of tooling, Cutting tool materials, Desirable properties of tool material, **Jigs and Fixtures**: Design principles of jigs and fixtures, Types of locators, various of clamping devices , Types of bushes, Economics of Jigs and fixtures, Indexing devices	
Unit 5	**Economics of Process Planning**
Definition, Cost accounting, Elements of cost, Estimation of cost elements, Methods of cost estimation, Data requirement for cost estimation, Steps in making cost estimation, Factors in cost estimation, Selection of process parameters, Machining time calculations, Estimation of total unit time.	

Unit 6	Process Sheet Design

Steps in process planning, Process symbols, routing description, operation number and description, Preparation of process picture sheet, Operation route sheet for complete manufacturing part, Calculation of cycle time.

Computer aided process planning: Advantages over manual process planning, approaches for CAPP: Generative Process Planning, Knowledge-based Process Planning, Feature Recognition in Computer Aided Process Planning, recent trends.

Books and other resources

Text Books:

1. Eary D. F., Johnson G. E., ―Process Engineering for manufacture, Prentice Hall of India.
2. P. C. Sharma, Production Engineering, S. Chand, ISBN 81 219 0421 8.
3. Narayana K. L., Kannaiah P., Vankata Reddy K., ―Production Drawing, New age.
4. Groover Mikell P., Automation, Production Systems.

References Books:

1. Scallan P., ―Process Planning-Design/Manufacture Interface‖, John Wiley & Sons, 1995.

302067: Advanced Materials & Manufacturing				
Teaching Scheme	**Credits**		**Examination Scheme**	
(Self-Study-II)	**Theory**	**3**	**In-Semester**	**30 Marks**
			End-Semester	**70 Marks**

Prerequisite Courses: Engineering Materials & Metallurgy, Manufacturing Process, Digital Manufacturing

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. **COMPREHEND** the advanced special metal forming processes.
5. **CLASSIFY AND DESCRIBE** various advanced welding processes.
6. **UNDERSTAND** need of Non- conventional Machining Process.

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. **ASSESS** the parameters for special forming operation and SELECT appropriate special forming operation for particular applications.
CO5. **CLASSIFY** various advanced welding processes and **SELECT** suitable welding processes for particular applications.
CO6. **COMPREHEND** various non-conventional machining processes and **SELECT** suitable processes for particular 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	**Special Forming Processes**	**07 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 5	**Advanced Welding Techniques**	**08 Hrs.**
Advanced Welding Processes: Atomic hydrogen welding, Electron beam welding, Laser Beam welding - principle, working and applications, Cold Metal Transfer - concepts, processes and applications, Friction stir welding, Underwater welding, Welding automation in aerospace, nuclear and surface transport vehicles, Robotic Welding, Plasma Arc Welding, Plasma Transferred Arc Welding.		
Unit 6	**Non-Conventional Machining Process**	**08 Hrs.**
Need of Non-Conventional Machining Process, (Principle, MRR, Process Parameters) Abrasive Jet Machining, Water Jet Machining, Ultrasonic Machining, EDM, WEDM, ECM, ECG, EBM, LBM Influence of tool material, geometry, di-electric fluid and process parameters on machining characteristics, Micro machining.		

Books and other resources
Text Books: 1. Chawla K.K., Composite materials Science and Engineering, 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. Dr. R. S. Parmar,"Welding Processes and Technology", Khanna Publications Edition 2017 5. Dr. V. D. Kodgire and S. V. Kodgire, “Material Science & Metallurgy For Engineers”, Everest Publication 6. P K Mishra, Non-Conventional Machining Narora Publication.
References Books: 1. A Bent Strong- Fundamentals of Composites Manufacturing-Materials, Methods and Applications, Society of Manufacturing Engineers, 2008 2. M. W. Hyer, Scott R. White- Stress Analysis of Fiber-reinforced Composite Materials, DEStech Publications, Inc., 2009 3. Clyne T.W. and Withers P.J-Introduction to Metal Matrix Composites, Cambridge University Press, 1995 4. Dr. Sadhu Singh, "Theory of Plasticity and Metal Forming Processes", Khanna Publishers Edition 2008 5. Ali Hasan - Islam Nawaz, "Advanced Welding Technology", SCITECH Publications India Pvt. Ltd. Edition 2018 6. Hassan EI-HOLY, Advanced Machining Process, 2nd edition (2005) McGraw Hil Mechanical Engineering Series, 2010
Web References: 1-Introduction of Composite - https://nptel.ac.in/courses/112/104/112104229/ 2-Composite Materials and Structure - https://nptel.ac.in/courses/101/104/101104010/ 3-Manufacturing of composite - https://nptel.ac.in/courses/112/104/112104221/ 4-Polymer Process - https://nptel.ac.in/courses/113/105/113105077/ 5-NPTEL Course on “Advances in welding and joining technologies” by Prof. Swarup Bag IIT Guwahati. 6-NPTEL Course on Advanced Machining Processes-https://nptel.ac.in/courses/112/103/112103202/

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.