SavitribaiPhule Pune University
Faculty of Science & Technology

Curriculum/Syllabus for

Third Year
Bachelor of Engineering
(Choice Based Credit System) Mechatronics Engineering (2019 Course)

Board of Studies – Mechatronics Engineering

(With Effect from Academic Year 2022-23)

Structure of T.E. (Mechatronic) Semester -V (Pat.2019)														
Course Code	**Course Name**	**Teaching Scheme (Hours/Week)**			**Examination Scheme & Marks**						**Credits**			
		TH	**PR**	**TUT**	**ISE**	**ESE**	**TW**	**PR**	**OR**	**TOT**	**TH**	**PR**	**TUT**	**TOT**
317541	Machine Design	03	02	---	30	70	25	---	25	150	03	01	---	04
317542	Manufacturing Processes	03	---	01	30	70	25	---	---	125	03	---	01	04
317543	Control System	03	02	---	30	70	25	25		150	03	01	---	04
317544	Digital Signal Processing	03	02	---	30	70	25	---	25	150	03	01	---	04
317545	Microcontrollers	03	02	---	30	70	---	---	25	125	03	01	---	04
317546	Metrology Laboratory	---	02	---	---	---	---	50	---	50	---	01	---	01
302048	Audit course - V[$]	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**15**	**10**	**01**	**150**	**350**	**100**	**75**	**75**	**750**	**15**	**05**	**01**	**21**

Structure of T.E. (Mechatronics) Semester -VI (Pat.2019)														
Course Code	**Course Name**	**Teaching Scheme (Hours/Week)**			**Examination Scheme & Marks**						**Credits**			
		TH	**PR**	**TUT**	**ISE**	**ESE**	**TW**	**PR**	**OR**	**TOT**	**TH**	**PR**	**TUT**	**TOT**
317547	Industrial Automation	03	---	01	30	70	25	25	---	150	03	---	01	04
317548	Electro-Mechanical System	03	02	---	30	70	25	---	25	150	03	01	---	04
317549	Finite Element Analysis	03	02	---	30	70	25	---	25	150	04	01	---	05
317550	Embedded System Design	03	02	---	30	70	—	---	25	125	03	01	---	04
317551	Artificial Intelligence & Machine Learning	03	02	---	30	70	---	---	25	125	03	01	---	04
317552	Mini Project	---	02	---	---	---	---	50	---	50	---	02	---	02
302056	Audit course - VI[$]	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**15**	**10**	**01**	**150**	**350**	**75**	**75**	**100**	**750**	**16**	**06**	**01**	**23**

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

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

Instructions

- Practical/Tutorial must be conducted in three batches per division only.
- Minimum number of required Experiments/Assignments in PR/ Tutorial shall be carried out as mentioned in the syllabi of respective subjects.
- Assessment of tutorial work has to be carried out as a term-work examination. Term-work Examination at second year of engineering course shall be internal continuous assessment only.
- Project based learning (PBL) requires continuous mentoring by faculty throughout the semester for successful completion of the tasks selected by the students per batch. While assigning the teaching workload of 2 Hrs/week/batch needs to be considered for the faculty involved. The Batch needs to be divided into sub-groups of 3 to 4 students. Assignments / activities / models/ projects etc. under project based learning is carried throughout the semester and Credit for PBL has to be awarded on the basis of internal continuous assessment and evaluation at the end of semester.
- 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.prescribed by BoS (Automobile and Mechanical Engineering)

317541 -Machine Design		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hr./Week Practical : 02 Hr./Week	04 Theory : 03 Practical : 01	In-Semester : 30 Marks End-Semester :70 Marks Term Work : 25 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: Students shall

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 its knowledge to design screw jack.
CO4.**Evaluate** dimensions of machine components under fluctuate loading conditions.
CO5.**Understand** different welded and threaded joints structure and apply its knowledge to analyze its strength.
CO6.**Apply** the design and development procedure for different types of springs.

Unit	Details	Hrs
1	**Design of Simple Machine Elements** Factor of safety, Selection of Factor of Safety, Service factor, Design of Cotter joint, Knuckle joint, Design of hand / foot lever, lever for safety valve, bell crank lever, Design of components subjected to eccentric loading.	08
2	**Design of Shafts, Keys and Couplings** Shaft design on the Strength basis, torsional rigidity basis and lateral rigidity basis, Design of shaft as per A.S.M.E. code. Design of square and rectangular keys, Kennedy key and splines. Design of Flange Coupling and Bushed-Pin Flexible Coupling.	08
3	**Design of Power Screws** Terminology of Power Screw, Torque analysis and Design of power screws with square and trapezoidal threads, Collar friction torque, Self-locking screw, Efficiency of square threaded screw, Efficiency of self-locking screw, Design of screw, nuts and C-Clamp. Design of screw jack, Differential and Compound Screw and Re-circulating Ball Screw (Theoretical treatment only).	07
4	**Design against Fluctuating loads** Stress concentration and its factors, Reduction of stress concentration factors, fluctuating stresses, fatigue failures, endurance limit, S-N curve, Notch sensitivity, Endurance limit, Endurance strength modifying factors, Reversed stresses – Design for Finite and Infinite life, Cumulative damage in fatigue failure, Soderberg, Gerber, Goodman Lines, Modified Goodman diagrams, Fatigue design under combined stresses:- (Theoretical treatment only.)	07

5	**Threaded and Welded joints** Introduction to threaded joints, Bolts of uniform strength, locking devices, eccentrically loaded bolted joint in shear, Eccentric load perpendicular and parallel to axis of bolt, Eccentric load on circular base. Introduction to welded joints, Strength of butt, parallel and transverse fillet welds, Axially loaded unsymmetrical welded joints, Eccentric load in plane of welds, Welded joints subjected to bending and torsional moments.	08
6	**Design of Springs** Types and applications of springs, Stress and deflection equations for helical compression Springs, Springs in series and parallel, Design of helical springs, concentric helical springs, surge in spring, Design of Multi-leaf springs, Nipping of Leaf springs, Shot Peening.	07

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 KamleshPurohit, Design of Machine Elements, PHILearing 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. Bhandari, V. B. Machine Design data book, Tata McGraw Hill Publication Co. Ltd.
11. 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: - Design a Mini-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

317542-Manufacturing Processes		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hr./Week	04 Theory : 03 Tutorial : 01	In-Semester : 30 Marks End-Semester : 70 Marks Term Work : 25 Marks

Prerequisite Courses:
Material Science and Metallurgy, Engineering Physics, Systems in Mechanical Enginering

Objectives:

1. Describe various sand and permanent mould casting methods, procedure and moulddesignaspects.
2. Understand basics of metal forming processes, equipment and tooling.
3. Understand sheet metal forming operations and die design procedure.
4. Classify, describe and configure the principles of various welding techniques.
5. Understand plastic processing techniques.
6. To know about composites, its fabrication processes.

Outcomes

On completion of the course, learner will be able to

CO1. SELECT appropriate moulding, core making and melting practice and estimate pouring time, solidification rate and DESIGN riser size and location for sand casting process

CO2. UNDERSTAND mechanism of metal forming techniques and CALCULATE load required for flat rolling

CO3. DEMONSTRATE press working operations and APPLY the basic principles to DESIGN dies and tools for forming and shearing operations

CO4. CLASSIFY and EXPLAIN different welding processes and EVALUATE welding characteristics

CO5. DIFFERENTIATE thermoplastics and thermosetting and EXPLAIN polymer processing techniques

CO6. UNDERSTAND processing ,assembling and packing of Electronics Circuits

Unit	Details	Hrs.
01	**1.1 Manufacturing:** Definition, classification of manufacturing processes. **1.2 Casting:** Introduction to casting, patterns, types, pattern materials, allowances. Molding types, molding sand, gating and risering, Cores & Core making. Special Casting Process- Shell, Investment, Die casting, Centrifugal Casting. **1.3 Shaping Processes for Plastics:** Extrusion, injection molding, blow molding, rotational molding, thermoforming, compression and transfer molding.	07
02	**2.1 Hot and Cold Working -** Rolling, Forging, Wire Drawing, Extrusion- types- Forward, backward and tube extrusion**.** **2.2 Sheet Metal Operations -** Blanking- blank size calculation, drawing, draw ratio, drawing force, Piercing, Punching, Trimming, Stretch forming, Shearing, Bending- simple problems- Bending force calculation, Tube forming - Embossing and coining, Types of dies: Progressive, compound and combination dies.	07

03	**3.1 Theory of Metal Cutting:** Definition of machining, orthogonal and oblique cutting, mechanics of orthogonal cutting - Shear angle and its significance, types of chips- Simple problems on machining mechanics. Classification of cutting tools - single, multipoint. Tool Nomenclature, cutting tool materials, Tool wear and tool life, machinability, cutting fluids.	08
	3.2 Machine Tools (Construction and Operations): Lathe machine, shaping, planning and slotting machine. Milling machine – classification, types of cutters, Indexing methods- Simple problems. Drilling and boring machine. Gear cutting machines- classification. Grinding machines – classification.	
04	**4.1 Welding:** Arc welding, resistance welding, oxyfuel gas welding, forge welding, friction stir welding and ultrasonic welding. **4.2 Brazing:** types of brazed joints, brazing methods. **4.3 Soldering and Adhesive Bonding:** Joint designs in soldering, solders and fluxes, soldering methods. Adhesive joint designs, adhesive types, adhesive application technology, advantages and limitations.	07
05	**5.1 Unconventional machining processes:** classification according to type of energy used for machining, basic principles, machines and applications of, Electrical discharge machining (EDM), Electron beam machining (EBM) , Plasma arc machining (PAM), Laser beam machining (LBM), Electrochemical machining (ECM), Chemical machining (CHM), Ultrasonic machining (USM). **5.2 Additive Manufacturing:** Fundamentals of rapid prototyping, stereo lithography, laminated object manufacturing, fused deposition modeling, 3D printing, selective laser sintering.	07
06	**6.1 Processing of Integrated Circuits:** processing sequence, silicon processing, photolithography, layer processes used in IC fabrication, IC packaging. **6.2 Electronic assembly and packaging:** PCB structure, types and materials. Processes used in PCB fabrication, PCB assembly.	08

References:

1. *Elements of Workshop Technology (Volume -1 & 2)* by S. K. HajraChoudhary, A. K. HajraChoudhary, Nirjhar Roy, Media promoters (2010).
2. *A Course in Workshop Technology (Vol. I & II)* by B. S. Raghuwanshi, DhanpatRai& CO. (2001).
3. *Workshop Technology Part 1, 2 and 3.* By W. A. J. Chapman, Taylor & Francis (1972).
4. *Production Technology – HMT*, Tata McGraw-Hill (1980).
5. *Manufacturing, Engineering and Technology, 4th Edition,* by SeropeKalpakjian,Steven R. Schmid, published by Pearson (2005).
6. *Fundamentals of Modern Manufacturing- Materials, Processes and Systems, 3rd Edition* by Mikell P. Groover, Wiley India (2002).
7. *Manufacturing Processes for Engineering Materials, 4th Edition,* by SeropeKalpakjian, Steven R. Schmid, published by Pearson (2007).

Practical :

Practical (Select any One Practical from Practical # 1 & 2; Select any Five Practical from Practical # 3 to 9; Perform Total Six Practicals)

1. To study and observe various stages of casting through demonstration of sand casting process from pattern making, sand mould preparation and melting and pouring of metal
2. Visit to any foundry/ permanent mould casting industry to demonstrate various stages of casting and make a report on it.
3. A compulsory visit to any one metal forming industry out of: Rolling mill, Forging plant, Wire/Tube drawing un and prepare a report on it.
4. A demonstration of any one welding technique out of TIG/ MIG/Resistance/Gas welding. A job drawing to be prepared by an individual institute with details of welding process parameters with weld joint design such as edge preparation, type and size of electrode used, welding current, voltage etc.
5. Study of centre lathe and single point cutting tool geometry
6. Demonstration on any one plastic component like bottle, bottle caps, machine handles etc. by injection moulding process/ by additive manufacturing process
7. Demonstration on cylindrical grinding/surface grinding operations, measurement of surface roughness produced and estimation of machining time.
8. Demonstration on indexing mechanism. Calculation of index crank and index plate movement by simple/compound/differential indexing and manufacture of spur gear on a milling machine using indexing head.
9.Art work and printing of simple PCB and etching and drilling of PCB.

Instructions for Laboratory Conduction :

Please note following instructions regarding Laboratory Conduction:

1. Industrial Visits to be conducted by the Teaching Faculty (subject Teacher).
2. Demonstration of Welding machines, Surface/Cylindrical Grinding, Milling machine, Indexing head and calculation of indexing to be taught by a subject Teacher in Practical slot.

317543-Control System		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hr./Week Practical : 02 Hr./Week	04 Theory : 03 Practical : 01	In-Semester : 30 Marks End-Semester :70 Marks Term Work : 25 Marks Practical : 25 Marks

Objectives:

- To Introduce elements of control system and their modeling using various Techniques.
- To get acquainted with the methods for analyzing the time response and Stability of System
- To Introduce and analyze the frequency response and Stability of System
- To Introduce concept of root locus, Bode plots, Nyquist plots.
- To Introduce State Variable Analysis method.
- To get acquainted with Concepts of PID controllers and IoT based Industrial Automation.

Outcomes: Learner will be able to

CO1: Determine and use models of physical systems in forms suitable for use in the analysis and design of control systems.
CO2: Determine the (absolute) stability of a closed-loop control system.
CO3: Perform time domain analysis of control systems required for stability analysis.
CO4: Perform frequency domain analysis of control systems required for stability analysis.
CO5: Apply root-locus, Frequency Plots technique to analyze control systems.
CO6: Express and solve system equations in state variable form.
CO7: Differentiate between various digital controllers and understand the role of the controllers in Industrial automation.

Unit	Detailed contents	Hrs.
1	**Introduction to Control Systems & its modelling** Basic Elements of Control System, Open loop and Closed loop systems, Differential equations and Transfer function, Modeling of Electric systems, Translational and rotational mechanical systems, Block diagram reduction Techniques, Signal flow graph.	06
2	**Time –Domain Analysis and Response** Time domain analysis: transient response and steady state response, standard test inputs for time domain analysis, order and type of a system, transient analysis of first and second order systems, time domain specifications of second order under damped system from its step response, Steady state error and staticerror constants.	06
3	**Stability analysis** Characteristic equation of a system, concept of pole and zero, response of various pole locations in s-plane concept of stability absolute stability, relative stability, stability of system from pole locations, RouthHurwit stability criterion, Root locus: definition, magnitude and angle conditions, construction of root locus, concept of dominant poles, effect of addition of pole and zero on root locus. Application of root locus for stability analysis.	08
4	**Frequency domain analysis-I** Introduction, Frequency domain specifications, correlation between time and frequency domain specifications, polar Plot, Nyquist plot, stability analysis using Nyquist plot.	08
5	**Frequency domain analysis-II** Introduction to Bode plot, Asymptotic approximation: sketching of Bode plot, stability analysis using Bode plot.	06
6	**Controllers and Digital Control Systems** Concept of Controller, Basic ON-OFF Controller, Introduction to P, I, D, PI, PD and PID controller, OFFSET of Controller, Integral Reset, PID Characteristics. Concept of Zeigler - Nicholas method. Concept of Industrial Automation, Need of IoT based Industrial Automation.	06

References:

1. N. J. Nagrath and M. Gopal, "Control System Engineering", New Age International Publishers, 5th Edition.

2. K. Ogata, "Modern Control Engineering", Prentice Hall India Learning Private Limited; 5th Edition.

Text Books:

1. Benjamin C. Kuo, "Automatic control systems", Prentice Hall of India, 7th Edition.

2. M. Gopal, "Control System – Principles and Design", Tata McGraw Hill, 4th Edition.

3. Schaum's Outline Series, "Feedback and Control Systems" Tata McGraw -Hill.

4. John J. D'Azzo and Constantine H. Houpis, "Linear Control System Analysis and Design", Tata

5. Richard C. Dorf and Robert H. Bishop, "Modern Control Systems", Addison – Wesley.

List of experiments:

1. Study experiment on components of control system
2. Transient response of 1st order & 2nd order system
3. Frequency response of 1st order & 2nd order system
4. Steady state error analysis of different types of systems
5. Simulation of Time response analysis
6. Simulation of Frequency response analysis
7. Simulation for Stability analysis
8. Simulation on Bode plot.
9. Effect of P, PI and PID controllers on time response of second order system.
10. Study of Zeigler Nicholas Tuning method

317544 Digital Signal Processing		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hr./Week Practical : 02 Hr./Week	04 Theory : 03 Practical : 01	In-Semester : 30 Marks End-Semester :70 Marks Term Work : 25 Marks Oral : 25 Marks

Course Objectives: The course aims:

1. To introduce discrete signals and systems.
2. To ability to analyze DT signals with Z transform, DTFT and DFT.
3. To introduce Digital filters and analyze the response.
4. To explore DSP Applications in electrical engineering.

Unit	Details	Hrs
1	**Discrete time signal and system** Analog, Discrete-time and Digital signals, Basic sequences and sequence operations, Discrete time systems, Properties of D. T. Systems and Classification, Linear Time Invariant Systems, impulse response, linear convolution and its properties, properties of LTI systems: stability, causality, Periodic Sampling, Sampling Theorem, Frequency Domain representation of sampling, reconstruction of a band limited Signal, A to D Conversion Process: Sampling, quantization and encoding.	06
2	**Z and Inverse Z transform** Revision of Z-transform, Numerical of Z transform, Inverse Z transform using partial fraction and power series method, Linear constant coefficient difference equations, solution of difference equation, stability and causality using ROC of Z-transform.	06
3	**Discrete Time Fourier Transform** Representation of Sequences by Fourier Transform, Symmetry properties of D. T., F. T. theorems: Linearity, time shifting, frequency shifting, time reversal, differentiation, convolution theorem,	06
4	**Discrete Fourier Transform** Sampling in frequency domain, The Discrete Fourier Transform, Relation with z transform Properties of DFT: Linearity, circular shift, duality, symmetry, Circular Convolution, Linear Convolution using DFT, Effective computation of DFT and FFT, DIT FFT, DIF FFT.	06
5	**Design of IIR filter** Ideal frequency selective filters, Concept of filtering, specifications of filter, IIR filter design from continuous time filters: Characteristics of Butterworth and Chebyshev, impulse invariant and bilinear transformation techniques, Design examples (Butterworth low pass filter) , Basic structures for IIR Systems: direct form, cascade form.	06
6	**Design of FIR Filter and DSP Applications** **A)** Specifications of properties of commonly used windows, Design Examples using rectangular and hanning windows. Basic Structures for FIR Systems: direct form. Comparison of IIR and FIR Filters. B) Applications: Measurement of magnitude and phase of voltage, current, power, frequency and power factor correction, vibration analysis, harmonic measurement and spectrum analysis, applications to Induction machine control.	06

List of experiment :

1) Computation of convolution for Given sequence
2) Implementation of properties on different signals
3) Computation of N- Point DFT of a Given Sequence
4) Implementation of FIR Filter for Given Sequence
5) Implementation of IIR Filter for Given Sequence
6) Implementation of DIF FFT for Given Sequence
7) Implementation of DIF FFT for Given Sequence
8) Study of various application of DSP

Reference Books:

1. Mitra S., "Digital Signal Processing: A Computer Based Approach", Tata McGraw-Hill, 1998, ISBN 0-07-044705-5
2. A.V. Oppenheim, R. W. Schafer, J. R. Buck, "Discrete Time Signal Processing", 2nd Edition Prentice Hall, ISBN 978-81-317-0492-9
3. Steven W. Smith, "Digital Signal Processing: A Practical Guide for Engineers and Scientists",1st Edition Elsevier, ISBN: 9780750674447

Text Book:

1. Proakis J., Manolakis D., "Digital signal processing", 3rd Edition, Prentice Hall, ISBN 81- 203-0720-8.
2. P. Ramesh Babu, "Digital Signal Processing", 4th Edition SciTech Publication.
Dr. S. D. Apte, "Digital Signal Processing",2nd Edition Wiley India Pvt. Ltd ISBN: 97881-265-2142-5
3. W. Rebizant, J. Szafran, A. Wiszniewski, "Digital Signal Processing in Power system Protection and Control", Springer 2011 ISBN 978-0-85729-801-0

317545- Microcontrollers		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hr./Week Practical : 02 Hr./Week	04 Theory : 03 Practical : 01	In-Semester : 30 Marks End-Semester :70 Marks Oral : 25 Marks

Prerequisite:

- Knowledge of numbering systems and Boolean algebra.
- Knowledge of combinational and sequential logic circuits.

Course Objective: Objectives of the course are to

- Explain the microcontroller architecture & describe the features of a typical microcontroller.
- To use the 8051 addressing modes and instruction set and apply this knowledge to develop programs in assembly language and C language.
- To define the protocol for serial communication and understand the microcontroller development systems.
- Explain the interrupt structure of the microcontroller and to develop programs related to interrupt handling
- To introduce students to Global System for Mobile Communication (GSM)
- To provide students with interfacing concepts and develop interfacing circuits for simple devices.

Course Outcome:

Upon successful completion of this course, the students will be able to:-

CO1: Describe the architecture and features of various types of the microcontroller.
CO2: Illustrate addressing modes and execute programs in assembly language for the microcontroller.
CO3: Write programs in C language for microcontroller 8051.
CO4: Elaborate interrupt structure of 8051 and program to handle interrupt and ADC809
CO5: Define the protocol for serial communication and understand the microcontroller development systems.
CO6: Interface input output devices and measure electrical parameters with 8051 in real time.

Unit	Details	Hrs
1	**Introduction to 8051** Introduction to concept of microcontroller, Intel 8051 Functional block diagram, Functions of pins of 8051, Memory organization of 8051, PSW and Flag Bits, Stack and Stack pointer. Overview of special function registers, Data transfer instructions and programs in assembly language.	06
2	**Instruction set** Arithmetic and logical instructions and programs in assembly language. Boolean and Program Branching instructions and programs in assembly language. Addressing modes of 8051	06
3	**Programming 8051 in C & 8051 Timers** 8051 Programming in C , Data types in C . Ports of 8051, their use, and programming in C (Byte Level and Bit-level). Time delay programming in C. Timers and counters in 8051, Timer modes 0,1,2 and its programming in C and counterprogramming.	06
4	**8051 Interrupt and Interrupt Programming** Interrupt structure of 8051 and SFR associated with interrupts. Programming of External hardware interrupts in C. Interfacing of ADC 0809 with 8051.	06
5	**Serial Port programming & Applications of 8051** Serial port Structure in 8051. Programming of Serial port for transferring and receiving data in C in mode 1. Measurement of electrical parameters such as voltage, current (Theoretical Treatment only).	06

6	**Applications of 8051** Interfacing of Stepper motor with 8051 and its programming in C. Interfacing and programming of single Key, LED, LCD and Relay with 8051 in C. Measurement of physical parameters such as Temperature, Pressure, etc. (Theoretical Treatment only).	06

List of Experiments:

1. Study and use of 8051 Microcontroller trainer kit.
2. Assembly Language Program for the arithmetic operation of 8-bit numbers.
3. Assembly Language Program for finding the largest number and smallest number from a given an array of 8-bit numbers.
4. Assembly Language program to arrange 8-bit numbers stored in an array in ascending order and descending order.
5. Implementation of Serial Communication by using 8051 serial ports.
6. Programming using a cross-assembler.
7. The blinking display of LED's interfaced with 8051.
8. Interfacing of 8 bit DAC 0808 with 8051 to generate various waveforms.
9. Interfacing of 8 bit ADC 0809 with 8051 Microcontroller.
10. Interfacing of the relay with 8051.
11. Stepper motor control by 8051 Microcontroller.
12. Interfacing of matrix keyboard/ 7 segment display with 8051.
13. Interfacing of LCD with 8051.
14. Measurement of physical parameters (Temperature/Pressure/Humidity) using 8051 and send value to GSM after an interval of the specified interval.

Text Books:

1. Muhammad Ali Mazidi, J.G. Mazidi, "The 8051 Microcontroller and Embedded Systems", Pearsons Publishers.
2. V Udayashankara and M S MallikarjunaSwamy, "8051 Microcontroller, Hardware, software and applications", TATA McGraw Hill.
3.AjayDeshmukh, "Microcontroller 8051" –TATA McGraw Hill.
4. Theagrajan," Microprocessor and Microcontroller", BS Publication.
5. K. J. Ayala, "The 8051 Microcontrollers- Architecture, Programming and Applications", Peram International Publications.
6. SubrataGhoshal, "8051 microcontroller", Pearsons Publishers.
7. Han-Way Huang," Embedded System Design with C8051", Cengage Learning

Reference Books:

1. Scott Mackenzie, "8051 Microcontroller", Pearson Education.
2. Intel Microcontroller data book. [R3] Intel Corporation 1990- 8 bit embedded controller handbook.

317546: Metrology Laboratory		
Teaching Scheme	**Credits**	**Examination Scheme**
Practical : 02 Hr./Week	01 Practical : 01	Practical : 50 Marks

Course Objectives:

1. To develop necessary skills for calibration and testing of instruments
2. To 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:

1. 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.
2. Analyze strain measurement parameters by taking modulus of elasticity in consideration to acknowledge its usage in failure detection and force variations.
3. 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.
4. Weigh dimensional accuracy using Comparator and limit gauges and appraise their usage in actual measurement or comparison with standards set to reduce measurement lead time.
5. Test 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.

Author industry visit report to report opportunities of entrepreneurships/business in various sectors of metrology like calibrations, testing, coordinate and laser metrology etc

Please note following instructions regarding Laboratory Conduction:

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 –NoGo 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, Fluidsto reduce measurement lead time

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.

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, DhanpathRai.
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

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'.

f 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 SavitribaiPhule 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

·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.

317547 -Industrial Automation		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hr./Week Practical : 02 Hr./Week	04 Theory : 03 Practical : 01	In-Semester : 30 Marks End-Semester :70 Marks Term work : 25 Marks Practical : 25 Marks

Course Outcomes (COs): The students will be able to

1. Understand the fundamentals of Industrial Automation, PLC & SCADA.
2. Develop Ladder Program using basic & advanced PLC instructions for Sequential & Continuous processes.
3. Interface Analog & Digital I/O devices, Hydraulic & Pneumatic systems and VFD with PLC.
4. Apply Analog PLC functions to given process control applications.
5. Develop SCADA system for given applications.

Unit	Detailed Contents	Hours
1	**Introduction to Automation and PLC** Automation: Fundamentals of Industrial Automation Need & Role of Automation, Types of Industrial Automation System, Evolution of Automation. Introduction to PLC: Definition of PLC, Architecture, Types of PLC, PLC Selection. Signal processing of DI-DO-AI-AO Modules, Interfacing of I/O devices to PLC, Sinking & Sourcing and Program Scan & Advantages and Disadvantages of PLC. Programming Languages: Introduction to PLC Programming Languages as per IEC 61131-3: Ladder Programming (LD), Function Block Diagram (FBD), Instruction List (IL), Structured Text (ST) & Sequential Function Chart (SFC).	06
2	**Basic PLC Programming** PLC input/output instructions, Development of Relay ladder logic, Ladder programming for logic gates & Boolean algebra, Ladder diagram for Process Control. Timers & Counters instruction, Applications of Timers & Counters for industrial process.	08
3	**Advanced PLC Programming** Comparison & Math operations: Equal, Not-equal to, Less than, Greater than, Less than or equal to, Greater than or equal to, Limit test, Mask Compare equal to, Compare expression, ADD, SUB, MUL, DIV, SQR, NEG, AND ,OR,NOR, EX-OR,NOT, CLEAR. Move, Masked Move, Jump & Label, Skip & Master Control Relay, Bit pattern in a register, Shift Register & Sequencer instructions. Applications using Advanced PLC Programming instructions.	07
4	**Analog PLC Programming** **Analog PLC Operation:** Analog Modules & Systems, Analog Signal Processing, Multi-bit data processing. Examples of analog output applications. PID Modules, PID Tuning & Typical PID Functions. Different Manufactures of PLCs and their revolution. Overview, Siemens PLC, Allen Bradley PLC, Schneider Electric PLC, Omron PLC, Mitsubishi PLC & GE FANUNC and comparison of various instructions	07
5	**Interfacing to HMI, Hydraulic, Pneumatic, VFD& Motion Control** Need of HMI, Advantages of using HMI, PLC Interfacing to Hydraulic & Pneumatic circuits. Need, Objective & Benefits of Drives, Types of Drives, Selection Criteria For Drives, Advantages & Disadvantages of Drives. Working & Construction of VFD, Different Methods of Speed Control, Applications of VFD, Different Modes of VFD Such As PU, External & Network Mode, Interfacing of VFD to PLC. Introduction of Motion Control, Block diagram, Different elements & Applications of Motion Control.	07

6	**Supervisory Control & Data Acquisition (SCADA)** General definition & SCADA Components. Need of SCADA system, application & benefits, PLCs Vs RTUs, RTU Block diagram, MTU communication interface, Types of SCADA System, Future trends, Internet based SCADA display system, Comparison of different SCADA packages. Trending, Historical data storage & Reporting, Alarm management. Programming techniques for: Creation of pages, Sequencing of pages, Creating graphics & Animation & development of application using SCADA System.	07

List of Experiments:

Students are expected to perform minimum sixteen experiments:

Any 4 from 1 to 6

1. Introduction to Ladder Programming, develop and simulate Logic gates and Boolean equations.
2. Develop and Simulate Ladder program for simple on-off applications.
3. Develop and Simulate Ladder program for timer applications.
4. Develop and Simulate Ladder program for counter applications.
5. Develop and Simulate Ladder program for cascading of timers & counters.
6. Develop and Simulate Ladder program for Alarm Annunciator System
7. Develop and Simulate Ladder program for Batch Mixer/any process application.
8. Develop and Simulate Ladder program for any process using sequencer
9. Develop and Simulate Ladder program for Comparison Instruction/ Logical Instruction.
10. Develop and Simulate Ladder program for Mathematical Instruction/Special Mathematical instructions.
11. Develop and Simulate Ladder program for Data movement instructions/ Program flow control instructions.

Any 4 from 12 to 16

12. Develop and Simulate Ladder program for one application of BCD in/Discrete out/BCD out/Analog out.
13. Develop and Simulate Ladder program for one application of Analog in/Analog out.
14. Develop and Simulate Ladder program for PID controller using PLC for Level/Flow/Temp Control Systems.
15. Interfacing PLC to hydraulic & Pneumatic circuits.
16. Interfacing Motion Control systems to PLC.

Any 4 from 17 to 21

17. Design and Develop SCADA System for application.
18. Study of VFD control using PLC.
19. Creating and Configuring a Project and tags in SCADA.
20. Introduction to FBD, develop and Simulate FBD for any process application
21. Introduction to SFC, develop and Simulate SFC for any process application.

Text Books:

1. Programmable Logic Controllers: Principles & Applications by John W. Webb, Ronald A. Reis, Prentice Hall of India, 5th ed.
2. Introduction to Programmable Logic Controllers by Gary Dunning, Delmar Thomson Learning, 3rd ed.
3. Programmable Logic Controllers: Programming methods and applications by John R. Hackworth and Frederick D. Hackworth Jr., Pearson publication

Reference Books:

1. Programmable Logic Controller by Frank D Petruzella, McGraw-Hill Education, 5th ed.
2. Programmable Logic Controllers by W. Bolton, Elsevier Newness publication, 4th ed.
3. Programmable Controller by T. A. Huges, ISA publication, 2nd ed.
4. SCADA by Stuart A. Boyer, ISA 1999.

317548 -ELECTRO-MECHANICAL SYSTEM		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hr./Week Practical : 02 Hr./Week	04 Theory : 03 Practical : 01	In-Semester : 30 Marks End-Semester :70 Marks Term work : 25 Marks Oral : 25 Marks

Objectives:

1. To study fundamentals of fluid power system.
2. To study pneumatics & hydraulic system and its components.
3. To study PLC system and its applications.

Outcomes: Learner will be able to...

1. Design the pneumatic and electro-pneumatic system.
2. Design hydraulic and electro-hydraulic system.
3. Design PLC for various applications.

Unit	Details	Hours
1	**Fluid Power Systems and Fundamentals** Introduction to fluid power, Advantages of fluid power, Application of fluid power system. Types of fluid power systems, Properties of hydraulic fluids, General types of fluids, Fluid power symbols. Basics of Hydraulics, Applications of Pascals Law, Laminar and Turbulent flow, Reynold's number, Darcy's equation, Losses in pipe, valves and fittings.	06
2	**Hydraulic System & Components** Sources of Hydraulic Power: Pumping theory, Pump classification – Gear pump, Vane Pump, piston pump, construction and working of pumps, pump performance, Variable displacement pumps. Fluid Power Actuators: Linear hydraulic actuators, Types of hydraulic cylinders – Single acting, Double acting, Cushioning mechanism, Construction of double acting cylinder.	08
3	**Design of Hydraulic Circuits** Construction of Control Components : Directional control valves, Shuttle valve, check valve, pressure control valve, pressure reducing valve, counter balance valve, unloading valves, sequence valve, Flow control valve – Fixed and adjustable, Accumulators and Intensifiers: Types of accumulators – Accumulators circuits, intensifier – Applications of Intensifier – Intensifier circuit, regenerative circuit, Meter in and meter out circuit, sequence circuit.	06
4	**Pneumatic Systems and Components** Pneumatic Components: Properties of air, Compressors, Filter, Regulator, Lubricator Unit, classification of pneumatic actuators, Air control valves, Quick exhaust valves, directional control valves, non-return valves, logic valves, time delay valves, pressure sequence valve,	06
5	**Design of Pneumatic Circuits** Pneumatic logic circuits for various applications. Displacement step diagram, Speed control circuits, hydro-pneumatic circuit, sequential circuit design for various applications using cascade and shift register method.	07

6	**Development of circuits for industrial automation** Electro-pneumatic systems, electrical control solenoid valves, Relays, Dominant OFF and Dominant ON circuit, Electro-hydraulic system, hydro- pneumatic system, Programmable Logic Controller (PLC) in automation: Basic structure, I/O processing. Ladder logic diagram, PLC for industrial process control, Selection of PLC.	07

References:

1. A text book on Fluid mechanics and Hydraulic machines: SukumarPati, 2012 Tata McGraw Hill.
2. Fluid Power with Applications by Anthony Esposito - Pearson Education 2000.
3. Power Hydraulics by Michael J, Prinches and Ashby J. G, - Prentice Hall, 1989
4. Fluid Mechanics and Fluid Power Engineering by Dr.D S Kumar , Kataria Publishers 2014
5. Fluid Mechanics and Hydraulic machines by Modi& Seth, Standard Publishers Distributors
6. Pneumatic Controls by Joji P, Wiley India Pvt.Ltd
7. Pneumatic Circuits and Low Cos by Fawcett J.R.
8. Fundamentals of pneumatics: Festo series
9. Fundamentals of hydraulics: Festo series
10. Mechatronics, A. Smaili, F. Mrad, OXFORD Higher Education.
11. Mechatronics by K P Ramachandran, G K Vijayaraghavan, M S Balasundaram, Wiley India Pvt.Ltd.

List of Practicals

- Design and implementation of pneumatics and electro-pneumatic circuits using hardware and software
- Design and implementation of hydraulics and electro-hydraulics circuits using hardware and software
- Characteristics of reciprocating pumps, gear pump etc.
- Case studies on PLC for industrial automation

Term Work:

Term work shall consist of performance of above mentioned experiments from the list and 2 numerical / case studies on each Module.

The distribution of marks for term work shall be as follows:

- Laboratory work (Experiments) : 10 marks
- Assignments / Case studies : 10 marks
- Attendance : 05 marks

The final certification and acceptance of term work ensures the satisfactory performance of laboratory wor and minimum passing in the term work.

317549- FINITE ELEMENT ANALYSIS

Teaching Scheme	Credits	Examination Scheme
Theory : 03 Hr./Week Practical : 02 Hr./Week	05 Theory : 04 Practical : 01	In-Semester : 30 Marks End-Semester :70 Marks Term work : 25 Marks Oral : 25 Marks

Pre-requisites: Fluid Mechanics, Heat transfer, Numerical methods, Programming Languages.

Course Objectives:

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

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

- Understand the different techniques used to solve mechanical engineering problems.
- Derive and use 1-D and 2-D element stiffness matrices and load vectors from various methods to solve for displacements and stresses.
- Apply mechanics of materials and machine design topics to provide preliminary results used for testing the reasonableness of finite element results.
- Explain the inner workings of a finite element code for linear stress, displacement, temperature and modal analysis.
- Use commercial finite element analysis software to solve complex problems in solid mechanics and heat transfer.

Interpret the results of finite element analyses and make an assessment of the results in terms of modeling (physics assumptions) errors, discretization (mesh density and refinement toward convergence) errors, and numerical (round-off) errors.

Unit	Details	Hours
1	**Unit 1: Fundamental Concepts of FEA Introduction:** Solution methodologies to solve engineering problems, governing equations, mathematical modelling of field problems in engineering, discrete and continuous models. Brief history of FEM, Finite Element terminology (nodes, elements, domain, continuum, degrees of freedom, loads & constraints), general steps involved in FEM, applications of FEM in various fields, advantages and disadvantages of FEM, consistent units system, essential and natural boundary conditions, symmetric boundary conditions. Introduction to different approaches used in FEA : Direct approach, VariationalformulationPrincipal of Minimum Potential Energy (PMPE), Galerkin weighted residual method, Principle of Virtual Work, Rayleigh-Ritz method, relation between FEM and Rayleigh-Ritz method Types of Analysis (Introduction) : Linear static analysis, Non-linear analysis, Dynamic analysis, Linear buckling analysis, Thermal analysis, Fatigue analysis, Crash analysis.	06

2	**Unit 2: 1D Elements** Types of 1D elements, displacement function, global and local coordinate systems, polynomial form of interpolation functions- linear, quadratic and cubic, properties of shape function, primary and secondary variables. Formulation of elemental stiffness matrix and load vector for bar, truss and beam using any approach, Formulation of load vector due to uniform temperature change (only for bar). Assembly of global stiffness matrix and load vector, properties of stiffness matrix, half bandwidth, treatment of boundary conditions- elimination approach, stress and reaction forces calculations	06
3	**Unit 3: 2D Elements** Two-Dimensional Stress Analysis: Plane Stress/Strain problems in 2D elasticity, constitutive relations Constant Strain Triangle(CST), Liner Strain Rectangle (LSR), displacement function, Pascal's triangle, compatibility and completeness requirement, geometric isotropy, convergence requirements, strain filed, stress filed, Formulation of element stiffness matrix and load vector for Plane Stress/Strain problems Assembly of global stiffness matrix and load vector, Boundary conditions, solving for primary variables (displacement), stress calculations	06
4	**Unit 4: Isoparametric Elements and Numerical Integration** Concept of isoparametric elements, Terms isoparametric, super parametric and subparametric. Coordinate mapping : Natural coordinates, Area coordinates (for triangular elements), higher order triangular and quadrilateral elements (Lagrangean and serendipity elements), geometry associative mesh, quality checks, mesh refinement- p vs h refinements, Uniqueness of mapping - Jacobian matrix. Numerical integration: Gauss Quadrature in one and two dimension, Order of Gauss integration, full and reduced integration, sub-modeling, substructuring.	06
5	**Unit 5: 1D Steady State Heat Transfer Problems** Introduction, One dimensional steady-state heat transfer problem- Governing differential equation, Finite Element formulation using Galerkin's approach for composite wall and thin Fin , essential and natural boundary conditions and solving for temperature distribution	06
6	**Unit 6: Dynamic Analysis** Types of dynamic analysis, general dynamic equation of motion, lumped and consistent mass, Mass matrices formulation of bar, truss and beam element. Undamped-free vibration: Eigenvalue problem, evaluation of eigenvalues and eigenvectors (characteristic polynomial technique).	06

Text : 1. Daryl L, A First Course in the Finite Element Method,. Logan, 2007.
2. G Lakshmi Narasaiah, Finite Element Analysis, B S Publications, 2008.
3. Y.M.Desai, T.I.Eldho and A.H.Shah, Finite Element Method with Applications in Engineering, Pearson Education, 2011
4. Chandrupatla T. R. and Belegunda A. D., Introduction to Finite Elements in Engineering, Prentice Hall India, 2002.
5. P., Seshu, Text book of Finite Element Analysis, PHI Learning Private Ltd. , New Delhi, 2010.

References : 1. Bathe K. J., Finite Element Procedures Prentice, Hall of India (P) Ltd., New Delhi.
2. R. D. Cook, et al., Concepts and Applications of Finite Element Analysis. Wiley, India
3. Kwon Y. W., Bang H., Finite Element Method using MATLAB, CRC Press, 1997
4. Peter Kattan, MATLAB Guides to Finite Elements- An Interactive Approach, Springer, 2008.
5. S. Moaveni, Finite element analysis, theory and application with Ansys, Prentice Hall
6. ErdoganMadenci and Ibrahim Guven, "The Finite Element Method and Applications in Engineering Using Ansys", Springer, 2006.
7. David V. Hutton, Fundamental of Finite Element Analysis, Tata McGraw-Hill 8. Gokhale N. S., et al., Practical Finite Element Analysis, Finite to Infinite, Pune, 2008

Term Work shall consist of following assignments:

Practical's to be performed: Minimum 7 including

· Any three practical's from Practical No. 1 to 4* and · Any three practical from Practical No. 5 to 9** · in Open source or Commercial Software

1. Computer program for stress analysis of 1D bar using linear and quadratic elements. Show the variation o stress and strain within the element for linear and quadratic bar element
2. Computer program for stress analysis of 2-D truss subjected to plane forces
3. Computer programs for (i) modal analysis and, (ii) stress analysis for 1-D beam (simply supported or cantilever beams)
4. Computer program for 1-D temperature analysis
5. Static stress concentration factor calculation for a plate with center hole subjected to axial loading in tension using FEA software
6. Modal analysis of any machine component using FEA software.
7. Stress and deflection analysis of any machine component consisting of 3-D elements using FEA software
8. Elasto-plastic stress analysis of plate using FEA software
9. Coupled Thermal-Structural Analysis using FEA software *1 Students can write the program in any of th programming language such as FORTRAN, C, C++, MATLAB, Python, VB. *2 Minimum number of elements considered should be

10 or more. *3 Validate results of the program with analytical method or commercial FEA software such as Abaqus, ANSYS, Msc-Nastran, Optistruct / Radioss, Comsol-Multiphysics, etc

**1 Students should do convergence study for all assignment problems. **2 Use different element types from element library, **3 If possible use sub model / symmetry option

317550 Embedded System Design		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hr./Week Practical : 02 Hr./Week	04 Theory : 03 Practical : 01	In-Semester : 30 Marks End-Semester :70 Marks Oral : 25 Marks

Prerequisite:

1. Knowledge of Number system and Basic logic components.
2. Programming basics of C language.
3. Advantage of Microcontroller over Microprocessor.

Course Objectives: The course aims to:

1. Help Students understand Architecture of PIC 18F458 microcontroller.
2. Create and enhance ability to write and Interpret Assembly and C language for PIC 18F458.
3. Make students understand procedure to interface peripherals with PIC 18F458 for various Applications.

Course Outcomes: At the end of this course, student will be able to

CO1	Explain architecture of PIC 18F458 microcontroller, its instructions and the addressing modes.
CO2	Use Ports and timers for peripheral interfacing and delay generation.
CO3	Interface special and generate events using CCP module.
CO4	Effectively use interrupt structure in internal and External interrupt mode.
CO5	Effectively use ADC for parameter measurement and also understand LCD interfacing.
CO6	Use Serial Communication and various serial communication protocols.

Unit	Detailed Contents	Hours
1	**PIC Architecture and Embedded C** Comparison of CISC and RISC Architectures, Data and Program memory organization, Program Counters, Stack pointer, Bank Select Register, Status register, Embedded C concepts, Header and source files and pre-processor directives, Data types, data structures, Control loops, functions, bit operations.	07
2	**Port and Timer 0 Programming** I/O Ports and related SFRs, I/O port programming in C. PIC 18 Timer 0 Programing in C. Delay programming (with and without Timer0). LED Interfacing and its programming.	05
3	**CCP Module and its applications** CCP module in PIC 18 microcontroller, Timers required for CCP Applications, Applications of CCP mode Generation of Square waveform using Compare mode of CCP module. Period measurement of unknown signal using Capture mode in CCP module, Speed control of DC motor using PWM mode of CCP module.	06
4	**Interrupt structure and its Programming** Interrupt Programming, Programming of Timer0 interrupts, Programming of External interrupts INT0.	05
5	**ADC structure and LCD interfacing** PIC ADC, Programming of ADC using interrupts, Measurement of temperature and Power. Using PIC microcontroller. Interfacing of LCD (16x2) in 4 bit mode.	07

6	**Serial Communication and its protocols** Serial Communication structure and its programming (Data transmit and Receive), Introduction to Communication protocols as SPI and MODE BUS	06

Reference Book:

1. PIC18F458 datasheet
2. MPLAB IDE user guides
3. MICROCHIP Technical Reference Manual of 18F4520
4. Embedded Design with PIC 18F452 Microcontroller by John B. Peatman, Prentice Hall

List of Experiments:

Any six experiments from section (A) and any three experiments from section (B)

Section A.

1) i) Introduction to MPLAB. ii) Addition, Subtraction and Multiplication
2) Data transfer to ports
3) Timer, Counter, Delay programming
4) Interfacing 18F458 to Keypad ,Switch and LED
5) Interfacing of LCD [16 X 2] with PIC 18F458
6) Generation of square, positive ramp, negative ramp, triangular waveforms using DAC interface
7) Generating PWM waveform using PWM mode of 18F458 timer
8) Driving relay from 18F458 using software and hardware interrupts

Section B.

1) Interfacing DC motor with PIC 18F458
2) Interfacing Stepper motor with PIC 18F458
3) Interfacing of LM35 with PIC 18F458 and displaying of temperature
4) Measurement of speed using optical encoder.
5) Measurement of level using sensors and PIC 18F458

317552- Artificial Intelligence & Machine Learning		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hr./Week Practical : 02 Hr./Week	04 Theory : 03 Practical : 01	In-Semester : 30 Marks End-Semester :70 Mark Oral : 25 Marks

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.

Unit	Details	Hours
1	**Introduction to AI & ML** History of AI, Comparison of AI with Data Science, Need of AI in Mechanical Engineering, Introduction to Machine Learning. Basics: Reasoning, problem solving, Knowledge representation, Planning, Learning, Perception, Motion and manipulation. Approaches to AI: Cybernetics and brain simulation, Symbolic, Sub-symbolic, Statistical. Approaches to ML: Supervised learning, Unsupervised learning, Reinforcement learning.	06
2	**Feature Extraction and Selection** Feature extraction: Statistical features, Principal Component Analysis. Feature selection: Ranking, Decision tree - Entropy reduction and information gain, Exhaustive, best first, Greedy forward & backward, Applications of feature extraction and selection algorithms in Mechanical Engineering.	08
3	**Classification & Regression** Classification: Decision tree, Random forest, Naive Bayes, Support vector machine. Regression: Logistic Regression, Support Vector Regression. Regression trees: Decision tree, random forest, K-Means, K-Nearest Neighbor (KNN). Applications of classification and regression algorithms in Mechanical Engineering.	08
4	**Development of ML Model** Problem identification: classification, clustering, regression, ranking. Steps in ML modeling, Data Collection, Data pre-processing, Model Selection, Model training (Training, Testing, K-fold Cross Validation), Model evaluation (understanding and interpretation of confusion matrix, Accuracy, Precision, Recall, True positive, false positive etc.), Hyper parameter Tuning, Predictions.	07

5	**Reinforced and Deep Learning** Characteristics of reinforced learning; Algorithms: Value Based, Policy Based, Model Based; Positive vs Negative Reinforced Learning; Models: Markov Decision Process, Q Learning. Characteristics of Deep Learning, Artificial Neural Network, Convolution Neural Network. Application of Reinforced and Deep Learning in Mechanical Engineering.	08
6	**Applications** Human Machine Interaction, Predictive Maintenance and Health Management, Fault Detection, Dynamic System Order Reduction, Image based part classification, Process Optimization, Material Inspection, Tuning of control algorithms.	08

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

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.

317552- Mini project		
Teaching Scheme	**Credits**	**Examination Scheme**
Practical : 02 Hr./Week	02 Practical : 02	Practical : 50 Marks

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. Robotics Mechanisms/design systems
2. Production/advance manufacturing
3. Materials: Composite/Nano
4. Automation and Control Systems
5. Mechatronic Systems
6. Agriculture system.
7. 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'.

f 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 SavitribaiPhule 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.