SAVITRIBAI PHULE PUNE UNIVERSITY

Syllabus

B. E. Mechatronics Engineering

(2019 Course- Credit Based)

Board of Studies

Mechatronics Engineering

(w.e.f. June- 2023)

Savitribai Phule Pune University

Board of Studies - Mechatronics Engineering

Undergraduate Program – Final Year Mechatronics Engineering (2019 pattern)

Structure of B.E. (Mechatronics) Semester -VII (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/OR**	**TUT**	**TOT**
417541	Robot Operating System	03	02	---	30	70	--	50	---	150	03	01	---	04
417542	Data Communication	03	02	---	30	70	--	--	50	150	03	01	---	04
417543	Micro Electro Mechanical System	03	--	---	30	70	--	--	--	100	03	--	---	03
417544	Elective I	03	02	---	30	70	---	---	50	150	03	01	---	04
417545	Elective II	03	---	---	30	70	---	---	---	100	03	---	---	03
417546	Project Stage- I	---	04	---	---	---	50	---	--	50	---	02	---	02
417547	Audit Course- VII	--	---	---	---	---	---	---	---	---	---	---	---	---
	Total	**16**	**10**	**---**	**150**	**350**	**50**	**50**	**100**	**700**	**15**	**05**	**---**	**20**

Structure of B.E. (Mechatronics) Semester -VIII (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/OR**	**TUT**	**TOT**
417548	Internet of Things	03	02	---	30	70	25	---	50	175	03	01	---	04
417549	Vibration Analysis & Control	03	02	---	30	70	25	--	50	175	03	01	---	04
417550	Elective III	03	--	---	30	70	--	---	---	100	03	--	---	03
417551	Elective IV	03	---	---	30	70	---	---	---	100	03	--	---	03
417552	Project Stage- II	---	12	---	---	---	100	---	50	150	---	06	---	06
417553	Audit Course- VIII	--	---	---	---	---	---	---	---	---	---	---	---	---
	Total	**12**	**16**	**00**	**120**	**280**	**150**	**00**	**150**	**700**	**12**	**08**	**---**	**20**

Elective-I		**Elective-III**	
417544-A	Image Processing & Computer Vision	417550-A	App Development
417544-B	Medical Mechatronics	417550-B	Rapid Prototyping
417544-C	Virtual Instrumentation	417550-C	Advanced Control Systems
Elective- II		**Elective-IV**	
417545-A	Product Design & Development	417551-A	Industrial Robotics
417545-B	Operation Research	417551-B	Human Machine Interface
417545-C	Industry 4.0	417551-C	Electric Vehicles

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

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 Mechatronics Engineering

Program Outcomes (POs)

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

PO2. Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts and demonstrate the knowledge of, and need for sustainable development.

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

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

PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

Semester-I

417541: Robot Operating System

Teaching Scheme:	Examination Scheme:	Credits:
Lectures: 3 Hrs/ Week	Paper: (30+70) 100 Marks	Theory: 3
Practical: 2 Hrs/ Week	In semester Assessment: 30 Marks	Practical: 1
	End Semester Assessment: 70 Marks.	Total: 4 credits
	Practical: 50 Marks	

Prerequisites: Basics of the programming languages.

Course Outcomes (COs): On completion of the course, the students will be able to

1. Select Use of any robotic simulation software to model the different types of robots and calculate work volume for different robots
2. Read and Analyse variety of industrial robots
3. Apply Concept of Robot design and program for different field applications.
4. Evaluate the significance of industrial robot

Unit I: Robot Operating Systems (06)

Introduction – History, The ROS Equation, Distributions & difference from other meta-operating systems. ROS framework: Operating system and its various releases.

Unit II: Robot Programming (08)

Introduction to Robotic Programming, On-line and off-line programming, programming examples. Various Teaching Methods, Survey of Robot Level Programming Languages, A Robot Program as a Path in Space, Motion Interpolation, various Textual Robot Languages, Typical Programming Examples such as Palletizing, Loading a Machine, etc.

Unit III: Robot Language: VAL Language (07)

Classifications, Structures- VAL language commands motion control, hand control, program control, pick and place applications, palletizing applications using VAL, Robot welding application using VAL program-WAIT, SIGNAL and DELAY commands for communications using simple applications. VAL-II programming-basic commands, applications- Simple problem using conditional statements-Simple pick and place applications-Production rate calculations using robot.

Unit IV: Robot Language: RAPID Language (08)

Motion Instructions-Pick and place operation using Industrial robot- manual mode, automatic mode, and subroutine command based programming. Move master command language- Introduction, syntax, simple problems. AML Language-General description, elements and functions, Statements, constants and variables-Program control statements-Operating systems, Motion, Sensor commands-Data processing

Unit V: Virtual Robot System (06)

Introduction to soft robotics; Robotic Process Automation (RPA); Computer Vision, AR & VR in Robotics. Multiple robot and machine Interference-Process chart-Simple problems-Virtual robotics, Robot studio online software- Introduction, Jogging, components, work planning, program modules, input and output signals-Singularities-Collision detection-Repeatability measurement of robot-Robot economics.

Unit VI: **System Simulation (07)**

Basics of simulation, Steps in simulation, Discrete event system simulation, Advantages and disadvantages of simulation, Decision making with simulation. Techniques of simulation, Monte Carlo method, Experimental nature of simulation, Distributed lag models, Cobweb models, Continuous system models, Analog and Hybrid simulation, Feedback systems, Computers in simulation studies. Simulation software: Comparison of simulation packages with programming languages, classification of simulation software, Description of a general purpose simulation package, Design of scenario and modules, dialog box, database, animation, plots and output, interfacing with other software, summary of results. Examples with MATLAB/ AWESIM / ARENA.

List of Experiments:

Students are expected to perform minimum eight experiments.

1. Demonstration of Robot Anatomy.
2. Study of Robot Configuration – PUMA/SCARA, etc. with detailed specification
3. Study of Types of Robot Programming – Brief discussions
4. Demonstration of Basic Robot Programming languages, Basic commands for operations, etc.
5. Demonstration of Industrial Robot / Visit
6. To study the Robot programming for industrial applications
7. To study Palletizing application using AI
8. To study Palletizing application using KAREL
9. To study the Robot programming application in VAL II.
10. To perform the Robot programming exercise for Pick and Place operation.
11. VLab Robot teaching using VAL -http://vlabs.iitkgp.ernet.in/mr/exp0/index.html
12. V lab -Palletizing application in VAL II (https://vlab.amrita.edu/?sub=3&brch=271&sim=1642&cnt=3525)
13. Case study: Robot application for Spray painting, welding, etc.
14. Presentation by students on some case study – Self study

Text Books:

1. .Lentin Joseph, "Robot Operating Systems (ROS) for Absolute Beginners, A press, 2018
2. Patrick Gabriel, "ROS by Example: A do it yourself guide to Robot Operating System", Lulu, 2012.

Reference Books:

1. Jason M O'Kane, "A Gentle Introduction to ROS", CreateSpace, 2013.
2. Anis Koubaa, "Robot Operating System (ROS) – The Complete Reference (Vol.3), Springer, 2018.
3. Kumar Bipin, "Robot Operating System Cookbook", Packt Publishing, 2018.
4. Wyatt Newman, "A Systematic Approach to learning Robot Programming with ROS", CRC Press, 2017.

417542: Data Communication

Teaching Scheme:	Examination Scheme:	Credits:
Lectures: 3 Hrs/ Week	Paper: (30+70) 100 Marks	Theory: 3
Practical: 2 Hrs/ Week	In semester Assessment: 30 Marks	Oral: 1
	End Semester Assessment: 70 Marks.	Total: 4 credits
	Oral: 50 Marks	

Prerequisites: Basics of the Signal Processing and Digital Electronics

Course Outcomes (COs): On completion of the course, the students will be able to

1. Compare and contrast the significance and limitations of analog and digital communication systems.
2. Demonstrate the knowledge of antennas in communication systems
3. Demonstrate a clear understanding of fundamentals of wireless and mobile communication systems and standards.

Unit I: Basics of Communication System (05)

Block diagram, electromagnetic spectrum, signal bandwidth and power, types of communication channelsTypes of noise, signal to noise ratio, noise figure, and noise temperature

Unit II: Analog Communication (08)

Amplitude Modulation: Basic concept, signal representation, need for modulation, **S**pectrum, waveforms, modulation index, bandwidth, voltage distribution, and power calculation.

DSBFC: Principles, modulation, circuit and high level transmitters

DSB suppressed carrier:- Multiplier modulator, nonlinear modulator, and switching modulator

Single Side Band (SSB):-Principle, Filter method, phase shift method and third Method

Amplitude demodulation: Diode detector, practical diode detector, and square law detector

Unit III: Frequency and Phase Modulation (09)

Frequency modulation (FM): Basic concept, mathematical analysis, frequency spectrum of FM wave, sensitivity, phase deviation and modulation index, frequency deviation and percent modulated waves, bandwidth requirement of angle modulated waves, deviation ratio, narrow Band FM, and Wide Band FM.

Transmitter: Direct FM transmitter, indirect FM Transmitter, noise triangle in FM, pre-emphasis and de-emphasis.

Phase modulation (PM): Principle and working of Transistor direct PM modulator and relationship and comparison between FM and PM.

FM demodulation: Balanced slope detector, Foster-Seely discriminator, ratio detector, Phase lock loop(PLL) FM demodulator, amplitude limiting and thresholding, comparison between FM demodulators, comparison between AM, FM and PM.

Unit IV: Digital Communication (06)
Introduction to digital communication system, significance of AWGN channel, pulse dispersion in the channel. Digital Modulation formats, coherent and non-coherent reception.

Binary Modulation Techniques: BPSK, BFSK and BASK.

M-ary Modulation techniques: QPSK, M-ary PSK, MSK, M-ary FSK, M-ary QAM, Differential encoded BPSK & D-QPSK.

Unit V: Antennas and Wave Propagation (07)
Antenna Parameters: Radiation intensity, directive gain, directivity, power gain, beam width, band width, gain and radiation resistance of current element.

Half-wave dipole and folded dipole: Reciprocity principle, effective length and effective area, radiation from small loop and its radiation resistance, Helical antenna.

Types of wave propagation: Ground, space, and surface wave propagation, tilt and surface waves, impact of imperfect earth and earth's behavior at different frequencies.

Unit VI: Wireless Networks and Mobile Communication Systems (07)
Description of cellular system, Frequency Reuse, Co-channel and Adjacent channel interference, Propagation Models for Wireless Networks, Multipath Effects in Mobile Communication, Models for Multipath Reception.

Evolution of Modern Mobile Wireless Communication System - First Generation Wireless Networks, Second Generation (2G) Wireless Cellular Networks, Major 2G standards, 2.5G Wireless Networks, Third Generation 3G Wireless Networks, Wireless Local Area Networks (WLANs)

List of Experiments:
Students are expected to perform minimum eight experiments.

1. Experiment on amplitude modulation
2. Experiment on amplitude demodulation
3. Experiment on frequency modulation
4. Experiment on FM demodulation
5. Experiment on digital communication
6. Experiment on antennas
7. Experiment on wireless networks
8. Experiment on mobile communication
9. Study of wireless communication systems.

Text Books:

1. Kennedy and Davis, "*Electronics Communication System*", Tata McGraw Hill, Fourth edition.
2. Taub Schilling and Saha, "*Principles Of Communication Systems*", Tata Mc-Graw Hill, Third Ed.

Reference Books:

1. R.K. Shevgaonkar, "*Electromagnetic Waves*", TATA McGraw Hill Companies, 3rd Edition, 2009.
2. Theodore S. Rappaport, "Wireless Communications", Prentice Hall of India, PTR publication

417543: Micro Electromechanical System

Teaching Scheme:	**Examination Scheme:**	**Credits:**
Lectures: 3 Hrs/ Week	Paper: (30+70) 100 Marks	Theory: 3
	In semester Assessment: 30 Marks	Total: 3 credits
	End Semester Assessment: 70 Marks.	

Prerequisites: Basics of the Signal Processing and Digital Electronics

Course Outcomes (COs): On completion of the course, the students will be able to

1. Understand fabrication process of MEMS.
2. Identify characterization techniques developed for MEMS.
3. Develops a physics-based model of MEMS.

Unit I: Introduction to MEMS (06)

Definition of MEMS. MEMS devices. Silicon as a MEMS material – mechanical properties of silicon. Mechanical components in MEMS. Design concepts of mechanical components. Working Principles of Microsystems. Engineering Science for Microsystems design and Fabrication.

Unit II: Sensors and Actuators in MEMS (08)

Sensors, Biomedical sensors and Biosensors, Chemical sensors, Pressure sensors, Thermal sensors. Micro actuation: Actuation using thermal forces, shape memory alloys, Piezoelectric crystals, Electrostatic forces. MEMS with Micro actuators: Microgrippers, Micromotors, Microvalves, Micropumps, Micro accelerators, Microfluidics.

Unit III: Fabrication Methods (07)

Materials for MEMS and Microsystems. Fabrication technologies Photolithography – Ion implantation – diffusion – oxidation – CVD – Physical Vapor Deposition – Etching. Micro manufacturing – Bulk and surface micromachining – LIGA

Unit IV: Scaling Laws in Miniaturization (08)

Introduction to scaling, Scaling in Geometry, Scaling in Rigid-Body Dynamics, Scaling in Electrostatic Forces, Scaling in Electromagnetic

Forces, Scaling in Electricity, Scaling in Fluid Mechanics, Scaling in Heat Transfer. Materials for MEMS and Microsystems: Introduction, Substrates and wafers, Active substrate materials, Silicon as a substrate material. Silicon compounds, Silicon piezo resistors, Gallium Arsenide, Quartz, Piezoelectric crystals, Polymers, Packing materials.

Unit V: Characterization Techniques (07)

Topography Methods (Optical, Electrical and Mechanical Methods) Microscopy, STM (Scanning Tunnelling Microscopes), SEM (Scanning Electron Microscopes), AFM (Atomic Force Microscopes) Interferometry Techniques, ESPI (Electronic Speckle Pattern Interferometry)

Unit VI: Introduction to Nanotechnology (06)

CNT (Carbon Nano Tubes) Applications, its properties, and Fabrication Method, Nano-mechanical Systems (NEMS), Nano-tribology, &nano-indentation techniques, Domestic and Industrial Applications of nanotechnology.

Text Books:

1. Tai-Ran Hsu, MEMS and Microsystems: Design and Manufacture, Tata McGraw Hill, (2002).
2. Gabriel M. Rebeiz, RF MEMS Theory, Design and Technology, Wiley India PvtLtd.

Reference Books:

1. Chang Liu, "Foundations of MEMS", Pearson International Edition, 2006.
2. Charles P.Poole, Frank J.Owens, "Introduction to nanotechnology" John Wiley & sons, 2003.

Elective- I

Elective I 417544 A: Image Processing & Computer Vision

Teaching Scheme:	**Examination Scheme:**	**Credits:**
Lectures: 3 Hrs/ Week	Paper: (30+70) 100 Marks	Theory: 3
Practical: 2 Hrs/ Week	In semester Assessment: 30 Marks	Oral: 1
	End Semester Assessment: 70 Marks.	Total: 4 credits
	Oral: 50 Marks	

Prerequisites: Basics of the Signal Processing and Programming languages.

Course Outcomes (COs): On completion of the course, the students will be able to

1. To Apply Relevant Mathematics Required for Digital Image Processing
2. Apply Method for Image Enhancement and Algorithmic Approaches for Image Segmentation.
3. To Demonstrate Image Descriptors and Features for computer vision
4. To Apply the Machine Learning for Computer Vision.
5. To Demonstrate Computer Vision using OpenCV and Python
6. To Explore the application areas of image processing and computer vision

Unit I: Introduction To Image Processing (06)

Introduction: Introduction to Image processing System, Human Visual System, and Elements of an Image Processing System.

Fundamental Concepts of Image Formation: Radiometry, Geometric Transformations, Geometric Camera Models.

Image Transforms: Fourier Transform, 2-D discrete Fourier Transform, KL Transform.

Unit II: Image Enhancement And Segmentation (07)

Image Enhancement: Introduction, Image Enhancement in spatial domain, Enhancement through point operation, Types of point operation,
Image Filtering, Colour Image Processing,

Image Segmentation: Introduction, Classification of Image segmentation techniques, Region Approach to Image segmentation, Clustering Techniques, Image segmentation based on Thresholding, Edge-based Segmentation.

Unit III: Image Descriptors and Features (07)

Texture Descriptors, Colour Features, Edges/Boundaries, Object Boundary and Shape Representations, Interest or Corner Point Detectors, Histogram of Oriented Gradients, Scale Invariant Feature Transform, Speeded up Robust Features, Saliency

Unit IV: Machine Learning for Computer Vision (07)

Machine Learning- Parameter Estimation, Clustering for Knowledge Representation, Dimension Reduction, Linear Discriminant Analysis., Image Classification, Image Classification with Localization, Object Detection, Image classification vs. object detection, Semantic Segmentation

Unit V: Computer vision - OpenCV with python (08)
Image operation, video operation, draw shape, arithmetic operation, threshold and blurring, contours and its properties, Scale-Invariant Feature Transform (SIFT), Feature Matching, Common problems with OpenCV.

Unit VI: Applications of Computer Vision (07)
Artificial Neural Network for Pattern Classification, Convolutional Neural Networks, Autoencoders.
Gesture Recognition, Motion Estimation and Object Tracking, Programming Assignments.

List of Experiments:
Students are expected to perform minimum four experiments from Group A and Group B.

Group A

1. Edge Detection and Image Gradients-
   Use the OpenCV function Sobel() to calculate the derivatives from an image.
   Use the OpenCV function Scharr() to calculate a more accurate derivative for a kernel of size 3·3
2. Dilation, Opening, Closing, And Erosion-
   Apply two very common morphological operators: Erosion and Dilation. For this purpose, you will use the following OpenCV functions:
   a. cv::erode
   b. cv::dilate
3. Perspective Transformation- To apply different geometric transformations to images, like translation, rotation, affine transformation etc. You will see these functions: cv.get Perspective Transform
4. Perform image cropping using OpenCV
5. Scaling, Interpolations, And Re-Sizing- Use resize() function which takes parameters such as image, output size image, interpolation, x scale, and y scale.
6. Thresholding, Adaptive Thresholding, And Binarization- simple thresholding, adaptive thresholding and Otsu's thresholding. Use the functions cv. threshold and cv.adaptive Threshold.

Group B

1. A. Sharpening- Use the OpenCV function filter2D() to create your own linear filters.

   OR

   B. Blurring- Use the OpenCV function filter2D() to create your own linear filters.
2. Contours-
   Use the OpenCV function cv::find Contours
   Use the OpenCV function cv::draw Contours
3. Line Detection Using Hough Lines- Use the OpenCV functions Hough Lines() and Hough LinesP() to detect lines in an image.
4. Finding Corners- understand the concepts behind Harris Corner Detection and use the following functions: cv.cornerHarris(), cv.cornerSubPix() to find corners

5. Counting Circles And Ellipses- Count Circles and Ellipse in an image, use the Simple Blob Detector function from OpenCV

Text Books:

1. Rafael C. Gonzalez, Richard E. Woods, Steven L. Eddins, ―Digital Image processing‖, Pearson Education, Fourth Impression, 2008, ISBN: 978-81-7758-898- 9
2. A. K. Jain, ―Fundamentals of Digital Image Processing‖, PHI, ISBN-978-81- 203- 0929- 6
3. Forsyth & Ponce, "Computer Vision-A Modern Approach", Pearson Education.
4. Joseph Howse and Joe Minichino, "Learning OpenCV 4 Computer Vision with Python 3: Get to grips with tools, techniques, and algorithms for computer vision and machine learning", 3rd Edition, Packt Publishing Limited ISBN-10 : 1789531616

Reference Books:

1. Jayaraman, Esakkirajan, Veerakumar, ―Digital image processing‖ , , McGraw Hill, Second reprint- 2010, ISBN(13): 978-0-07-01447-8, ISBN(10):0-07-014479-6.
2. Adrian Kaehler and Gary Bradski, Learning OpenCV 3: Computer Vision in C++ with the OpenCV Library, First edition, Shroff/O'Reilly; ISBN-13 : 978-9352135080
3. M.K. Bhuyan , " Computer Vision and Image Processing: Fundamentals and Applications", CRC Press, USA, ISBN 9780815370840 - CAT# K338147.
4. Richard Szeliski, "Computer Vision- Algorithms & Applications", Springer.

Elective I 417544 B: Medical Mechatronics

Teaching Scheme:	Examination Scheme:	Credits:
Lectures: 3 Hrs/ Week	Paper: (30+70) 100 Marks	Theory: 3
Practical: 2 Hrs/ Week	In semester Assessment: 30 Marks	Oral: 1
	End Semester Assessment: 70 Marks.	Total: 4 credits
	Oral: 50 Marks	

Prerequisites: Basics of Engineering Sciences

Course Outcomes (COs): On completion of the course, the students will be able to

1. Select proper electrodes and electrolyte for different measurement of parameters.
2. Explain the principle and working of any biomedical equipment.
3. Identify different types of biomedical unit for measurement and analysis techniques.
4. Design suitable orthotic and prosthetic devices and applications
5. Explain the working of different imaging techniques in Biomedical Engineering
6. Demonstrate the significance of safety, telemetry and hospital information system in biomedical Instrumentation.

Unit I: Sources of Bioelectric potential, Electrodes and Transducers (06)
Generation of electrical signal in human cell, Resting and Action potential
Different types of Electrodes, Electrolytes and their significance, Biosensors, Biomaterials

Unit II: Biopotential Amplifiers and recorders (07)
The origin of bio-potential ECG, EMG, EEG etc. The signal conditioners and amplifiers. Recording systems for the bio-potential listed above and patient monitoring system
Signal Sources for Simulation, Testing and Calibration

Unit III: Measurement and analysis techniques (07)
Blood flow meters, Cardiac output measurement, and Pulmonary Function Testing machine. Blood gas analysers, Oximeters, Audiometers, Blood Pressure measurement

Unit IV: Therapeutic and Prosthetic Equipment (07)
Cardiac Pacemakers, Cardiac defibrillators, Hemodialysis machine, Electrosurgical unit, Ventilators, Infant incubator, drug delivery devices.

Orthotic and Prosthetic devices, Normal Human Locomotion, Gait Cycle, Upper and Lower limb Prosthetic devices. Upper and Lower limb Orthotic devices

Unit V: Fundamentals of medical imaging (07)
Clinical use & Biological effects and safety: X-ray computed Tomography, Spiral or Helical C T: Slip Ring Technology, C T Angiography, Magnetic resonance imaging, Nuclear medical imaging, Infrared imaging, Liquid crystal thermography. Microwave Hermography. Study of Endoscopy, gastroscope, bronchoscope, cystoscope, colonoscope

Unit VI: Electrical safety, Telemetry and Hospital Information system (08)
Macroshocks and microshocks hazards, electrical safety and EMI/RFI interference and its testing, Biomedical telemetry, wireless and multi patient telemetry

Hospital Information system: Role of database in HIS. Need of Networking in HIS. Overview of Networking, topologies and its configuration. Structuring medical record.

List of Experiments:
Students are expected to perform minimum eight experiments.

1. Study and demonstration of Electromyography (EMG)
2. Study and demonstration of Electrocardiogram (ECG)
3. Study and demonstration of Electroencephalogram (EEG)
4. Demonstration of Pulmonary Function Testing machine.
5. Study of Endoscopy,
6. Study of Gastroscope,
7. Study of Bronchoscope,
8. Study of cystoscope,
9. Study of colonoscope
10. Study of Blood flowmeters,

Text Books:

1. Khandpur R. S., Handbook of Biomedical Instrumentation, Tata McGraw Hill, second edition, 2003
2. Carr and Brown, Introduction to biomedical equipment technology, fourth edition, Pearson press, 2003
3. Sujata V. Bhat, Biomaterials, Narosa Publishing House, 2002.
4. W.R.Hendee&E.R.Ritenour, Medical Imaging Physics (3rd eds), Mosbey Year-Book, Inc., 1992.
5. Lesslie Cromwell, Fred J. Weibell, rich J. Pfeiffer Biomedical Instrumentation and Measurements, 2nd Edition, PHI

Reference Books:

1. John G. Webster, Bioinstrumentation John Wiley and sons, 2004
2. Joseph Bronzino (Editor-in-Chief), Handbook of Biomedical Engineering, CRC Press, 1995.
3. L.A.Geddes and L.E.Baker,.Principles of Applied Bio-Medical Instrumentation. John Wiley & Sons 1975.
4. Harold E. Smalley, .Hospital Management Engineering . A guide to the improvement of hospital management system. PHI.
5. Dr. Archana B. Kanwade, Dr. VinayakBairagi, Chronic Obstructive Pulmonary Disease (COPD) Diagnosis using Electromyography (EMG), Elsevier, Academic Press, 1st Edition - 2022.

Elective I 417544 C: Virtual Instrumentation

Teaching Scheme:	**Examination Scheme:**	**Credits:**
Lectures: 3 Hrs/ Week	Paper: (30+70) 100 Marks	Theory: 3
Practical: 2 Hrs/ Week	In semester Assessment: 30 Marks	Oral: 1
	End Semester Assessment: 70 Marks.	Total: 4 credits
	Oral: 50 Marks	

Prerequisites: Basics of programming and coding

Course Outcomes (COs): On completion of the course, the students will be able to

1. Understand the structure of Virtual Instruments.
2. Understanding the programming in VI
3. Explain the different tool kits in VI
4. Develop applications using Virtual Instrumentation software.

Unit I: Introduction to VI (07)

Virtual Instrumentation: Historical perspective - advantages - block diagram and architecture of a virtual instrument – Conventional Instruments versus Traditional Instruments - data-flow techniques, graphical programming in data flow, comparison with conventional programming. VI Debugging Techniques, Help and Resources for LabVIEW

Unit II: VI Programming Techniques (06)

VIs and sub-VIs, loops and charts, arrays, clusters and graphs, case and sequence structures, formula nodes, local and global variables, State machine, string and file I/O, Instrument Drivers, Publishing measurement data in the web, Internet Connectivity.

Unit III: Data Acquisition in VI (08)

Introduction to data acquisition on PC, Sampling fundamentals, Input- Output techniques and buses. Latest ADCs, DACs, Digital I/O, counters and timers, Software and hardware installation, Calibration, Resolution, Data acquisition interface requirements – Issues involved in selection of Data acquisition cards – Data acquisition cards with serial communication - VI Chassis requirements. SCSI, PCI, PXI system controllers, Ethernet control of PXI. Networking basics for office & Industrial applications,

Unit IV: VI Toolsets (07)

Use of Analysis tools, Fourier transforms, power spectrum, correlation methods, windowing and filtering. Application of VI in process control designing of equipments like oscilloscope, Digital multimeter, Design of digital Voltmeters with transducer input Virtual Laboratory, Web based Laboratory , Control and Simulation Toolkit, PID Control.

Unit V: Math Toolsets (07)

Linear algebra, trigonometry, optimization toolset, math script and formula nodes, elementary and special functions, integral and differential equations. Matlab interface. Hybrid Programming Concept

Unit VI: Applications of VI (07)
Distributed I/O modules- Application of Virtual Instrumentation: Instrument Control, Development of process database management system,
Simulation of systems using VI, Development of Control system, Industrial Communication, Image acquisition and processing, Motion control. Development of Virtual Instrument using GUI.

List of Experiments:
Students are expected to perform minimum eight experiments.

1. Installation and configuration of software
2. Preparing simple VIs (learning front panel and block diagram environment).
3. Study of different data types in LabVIEW
4. Developing simulation examples using the LabVIEW software.
5. Developing VI using signal processing toolkit
6. Developing VI using Control system toolkit.
7. Developing VI using DSP toolkit
8. Hardware software interfacing.
9. Developing Web based application using Vis.
10. Developing application to interface with Matlab.
11. Creating SubVIs and Its usage in High Level Applications
12. Data Acquisition in LabVIEW

Text Books:

1. LabVIEW Graphical programming, Gray W. Johnson, Richard Jennings, 4th ed. The McGraw-Hill.
2. Virtual Instrumentation Using LabVIEW, Sanjay Gupta, 2nd ed. Tata McGraw-Hill.
3. Robert H. Bishop, 'Learning with Lab-view', Prentice Hall, 2003

Reference Books:

1. Hands on Introduction to LabVIEW for Scientists and Engineers, John Essick, Oxford University Press.
2. Virtual Instrumentation using LabVIEW, Jovitha Jerome, Kindle edition, PHI
3. 'LabVIEW for everyone',Lisa K Wells & Jeffrey Travels, Prentice Hall, 1997

Elective- II

Elective II 417545 A: Product Design and Development

Teaching Scheme:	**Examination Scheme:**	**Credits:**
Lectures: 3 Hrs/ Week	Paper: (30+70) 100 Marks	Theory: 3
	In semester Assessment: 30 Marks	Total: 3 credits
	End Semester Assessment: 70 Marks.	

Prerequisites: Basic Engineering Science - Physics, Chemistry, Material Science, Engineering Metallurgy, Manufacturing processes Etc.

Course Outcomes (COs): On completion of the course, the students will be able to

1. Understand Product design and Product development processes.
2. Understand Processes, tools and techniques for Market Survey & Product Specification Finalization
3. Understand Processes, tools and techniques for Concept Inception, Verification and selection
4. Understand Processes, tools and techniques for Concept Exploration & Development
5. Understand Processes, tools and techniques for Design Verification and Validation
6. Understand Processes, tools and techniques for Robust Design and Development

Unit I: Introduction to Product Design and Development (07)

Definition of product design, Essential Factors for product design, stages of product design ,Modern approaches to product design, standardization, simplification and specialization in product design product development, product development versus product design, modern product development process, product testing and validation.

Unit II: Product Development –Technical and Business Concerns (07)

Mission Statement and Technical Questioning, Technology Forecasting and S Curve, Customer Needs and Satisfaction, Customer Needs - Types and Models, tools for Gathering Customer Needs, Customer Population and Market Segmentation.

Unit III: Product Development from Concept to Product Function (07)

Product information gathering, brainstorming and lateral thinking, morphological analysis of product, generating concepts, concept selection - design evaluation, estimation of technical feasibility, concept selection process, Pugh's concept, selection charts, concept scoring, process of concept embodiment, system modeling, functional modeling and decomposition, fast method, subtract and operate procedure, Simulation driven design.

Unit IV: Reverse Engineering (07)

Product Teardown Process, Tear Down Methods, Force Flow Diagrams, Measurement and Experimentation, Applications of Product Teardown, Benchmarking Approach and Detailed Procedure, Tools Used in Benchmarking Indented Assembly Cost Analysis, Function -Form

Diagrams, Trend Analysis, Setting Product Specifications, Introduction to Product Portfolio and Architecture.

Unit V:Design For X (07)

Design for manufacture, Design for assembly, Design for robustness, Design for safety, Design for reliability, Design for environment, Design for piece part production, manufacturing cost analysis. Local, Regional and Global issues, basic life cycle assessment - basic method, weighed sum assessment method (Numerical), Design Failure mode effect analysis.

Unit VI: Product Life Cycle Management and Product Data Management (07)

Introduction, Concept of Product Life Cycle management, Components/Elements of PLM, Customer Involvement, Product Data and Product Workflow, The Link Between Product Data and Product Workflow, Different Phases of Product Life Cycle and corresponding technology.

Text Books:

1. K. Chitale; R.C. Gupta, Product Design and Manufacturing, Prentice Hall India.
2. Dieter George E., Engineering Design McGraw Hill Pub. Company, 2000.

Reference Books:

1. Kevin Otto and Kristin Wood, Product Design: Techniques in Reverse Engineering and New Product Development, Pearson Education Inc.
2. Grieves, Michael, Product Lifecycle Management McGraw Hill
3. Bralla, James G., Handbook of Product Design for Manufacturing, McGraw Hill Pub.
4. Karl Ulrich, product design and development, TMH.

Elective II 417545 B: Operation Research

Teaching Scheme:	Examination Scheme:	Credits:
Lectures: 3 Hrs/ Week	Paper: (30+70) 100 Marks	Theory: 3
	In semester Assessment: 30 Marks	Total: 3 credits
	End Semester Assessment: 70 Marks.	

Prerequisites: Engineering Mathematics, Theory of Probability, Statistics, Basic Industrial Functions and Business Environment

Course Outcomes (COs): On completion of the course, the students will be able to

1. Evaluate various situations of Games theory and Decision techniques and apply them to solve them in real life for decision making.
2. Select appropriate model for queuing situations and sequencing situations and find the optimal solutions using models for different situations.
3. Formulate various management problems and solve them using Linear programming using graphical method and simplex method.
4. Formulate variety of problems such as transportation, assignment, travelling salesman and solve these problems using linear programming approach.
5. Plan optimum project schedule for network models arising from a wide range of applications and for replacement situations find the optimal solutions using appropriate models for the situation.
6. Apply concepts of simulation and Dynamic programming

Unit I: Introduction: Operation Research (07)

Introduction: Definition, Evolution and Classification of Quantitative Methods and Operations Research Techniques, Methodology, Advantages and Limitations. Linear Programming Problem: Introduction, Formulation of LPP, Solution of LPP by Two Phase Method only. Decision Theory: Meaning and Steps in Decision Making, Types of Management Decisions, Decision under Certainty, under Risk, under Uncertainty, Decision Trees

Unit II: Transportation & Assignment Model (07)

Introduction, Formulation, Basic Method of Solving Transportation Problem, Optimization Methods like UV and Stepping Stone Method, Assignment Problem- Hungarian Method to solve Assignment Problem.

Unit III: Theory of Games and Linear Programming (07)

Theory of Games : Introduction, Minimax and Maximin Principle, Solution of Game with Saddle Point, Solution by Dominance, Solution by Graphical Method, m x n size Game Problem, Iterative method, Introduction to formulation of games using Linear Programming. Replacement Analysis: Replacement of Items that Deteriorate, Replacement of Items that Fail

Unit IV: Project Management (07)
Network Models: Fulkerson's rule, concept and types of floats, CPM and PERT, Crashing Analysis and Resource Scheduling. Simulation: Introduction, Monte-Carlo Simulation method, Simulation of Inventory and Queuing Problems.

Unit V: Queuing Theory and Sequencing Models (07)
Queuing Theory: Introduction, Basis Structure, Terminology (Kendal's Notations) and Applications. Queuing Model M/M/1: /FIFO, M/M/c. Sequencing models : Solution of sequencing Problem - Processing of n jobs through two machines, Processing of n jobs through three machines, Processing of two jobs through m Machines, Processing of n jobs through m Machines

Unit VI: Integer and Dynamic Programming (07)
Integer Programming Introduction to Integer Programming, Cutting plane method and Branch and Bound Method. Dynamic Programming: Introduction, DP Model, Applications of DP Model to shortest route problems. Solution of LPP by Dynamic Programming

Text Books:

1. Prem Kumar Gupta, D. S. Hira, Problems in Operations Research: Principles and Solutions, S. Chand, 1991 2. J. K. Sharma,
2. Operations Research: Theory and Application, Laxmi pub. India, 2010.
3. Operations Research, S. D. Sharma, Kedar Nath Ram Nath-Meerut, 2015.
4. L.C.Jhamb, Quantative Techniques Vol. I &II, Everest Publication, 2007.
5. Manohar Mahajan, Operation Research, Dhanpatrai Publication, 2006.
6. V. K. Kapoor, Operations Research: Quantitative Techniques for Management, Sultan Chand Publications, 2013.

Reference Books:

1. Hillier F.S., and Lieberman G.J., Operations Research, Eight Edition, Mc. Tata McGraw Hill, India, 2011.
2. Ravindran, ―Engineering optimization Methods and Applications‖, 2nd edition, Wiley, India
3. Ravindran, Phillips and Solberg, Operations Research Principles and Practice, Second Edition, Mc. WSE Willey,
4. Operations Research - An introduction, Hamdy A Taha, Pearson Education, 2010

Elective II 417545 C: Industry 4.0

Teaching Scheme:	**Examination Scheme:**	**Credits:**
Lectures: 3 Hrs/ Week	Paper: (30+70) 100 Marks	Theory: 3
	In semester Assessment: 30 Marks	Total: 3 credits
	End Semester Assessment: 70 Marks.	

Course Outcomes (COs): On completion of the course, the students will be able to

1. Understand the basic concepts of Industry 4.0 and the other related fields.
2. Understand cyber physical system and the emerging applications.
3. Analyse the different energy storage systems
4. Analyse a smart grid system.
5. Implement the industry 4.0 to solve engineering problems.
6. Design of smart vehicle and analyse its performance.

Unit I: Introduction To Industry 4.0 (07)
Introduction, Historical Context, General framework, Application areas, Dissemination of Industry 4.0 and the disciplines that contribute to its development, Artificial intelligence, The Internet of Things and Industrial Internet of Things, Additive manufacturing, Robotization and automation, Current situation of Industry 4.0. Introduction to Industry 4.0 to Industry 5.0 Advances

Unit II: Industry 4.0 And Cyber Physical System (07)
Introduction to Cyber Physical Systems (CPS), Architecture of CPS- Components, Data science and technology for CPS, Emerging applications in CPS in different fields. Case study: Application of CPS in health care domain.

Unit III: Smart Energy Sources (07)
Energy Storage for Mitigating the Variability of Renewable Electricity Sources-Types of electric energy storage, Potential of Sodium-Sulfur Battery Energy Storage to Enable Integration of Wind-Case study. Electric Vehicles as Energy Storage: V2G Capacity Estimation.

Unit IV: Smart Grid (07)
Smart grid definition and development Smart Grid, Understanding the Smart Grid, Smart grid solutions, Design challenges of smart grid and Industry 4.0.

Unit V: Smart Applications (07)
Understanding Smart Appliances -Smart Operation-Smart Monitoring-Smart Energy Savings-Smart Maintenance, Case study-Smart Cars, Self-Driving Cars, Introducing Google's Self-Driving Car, Intellectual Property Rights.

Unit VI: Introduction to Industrial Internet of Things (07)

History of IOT, Definition, Architecture. Industry revolutions, Industry Revolution 4.0 – technology, opportunities and challenges, Hardware required: Sensors, Actuators, Routers, Switches, platforms for IOT.

Text Books:

1. Jean-Claude André, ―Industry 4.0‖, Wiley- ISTE, July 2019, ISBN: 781786304827,2019.
2. Diego Galar Pascual, Pasquale Daponte, Uday Kumar, ―Handbook of Industry 4.0 and SMART Systems‖ Taylor and Francis,2020
3. Miller M, ―The internet of things: How smart TVs, smart cars, smart homes, and smart cities are changing the world‖, Pearson Education, 2015, ISBN: 9780134021300

Reference Books:

1. Pengwei Du and Ning Lu, ―Energy storage for smart grids: planning and operation for renewable and variable energy resources VERs ‖, Academic Press, 2018, Reprint edition , ISBN-13: 978-0128100714
2. Hossam A. Gabbar, ―Smart Energy Grid Engineering‖, Academic Press, 2017, ISBN 978-0-12-805343-0.
3. Mini S. Thomas, John Douglas McDonald, ―Power System SCADA and Smart Grids‖, CRC Press, 2017.

417546 : Project Stage- I

Teaching Scheme:	Examination Scheme:	Credits:
Practical: 4 Hrs/ Week	Term Work: 50 Marks	TW: 2
		Total: 2 credits

Prerequisites: Project Based Learning, Internship/Mini Project, Laboratory works, Skill Development, Audit Courses, Industrial Visits

Course Outcomes (COs): On completion of the course, the students will be able to

1. IMPLEMENT systems approach.
2. CONCEPTUALIZE a novel idea / technique into a product.
3. THINK in terms of a multi-disciplinary environment.
4. TAKE ON the challenges of teamwork, and DOCUMENT all aspects of design work.
5. UNDERSTAND the management techniques of implementing a project.
6. DEMONSTRATE the final product for Functionality, Designability, and Manufacturability.

Guidelines for Project Execution

At the end of the VI th Semester.

1. A group of 3-4 students shall be formed according to their suitability.
2. Department faculty will float prospective Project Titles through Project Coordinator.
3. Department will take care of a list of titles at least two times of the groups.
4. Students will interact with guides for scope and outline of the project.
5. Maximum of two groups will be given to a guide.
6. Guide and Project groups will be finalized at the end of sixth semester so that project work can be started at the start of Seventh semester.

During the VII th Semester

1. Project work is expected to be done in the Project Lab.
2. Projects must be executed in association with industrial experts/facilities.
3. Progress of project work is monitored regularly on weekly project slots/project day.
4. Regular interval presentations are to be arranged to review and assess the work.
5. Project work is monitored and continuous assessment is done by guide and authorities.

Term Work

- The student shall prepare the duly certified final report of project work in standard format for satisfactory completion of the work by the concerned guide and head of the Department/Institute.
- Recommended performance measure parameters may Include-Problem definition and scope of the project, Literature Survey, Appropriate Engineering approach used, Exhaustive and Rational Requirement Analysis.

- Comprehensive Implementation - Design, modeling, documentation, Usability, Optimization considerations (Time, Resources, Costing), Thorough Testing, Project Presentation and Demonstration (ease of use and usability), Social and environment aspects
- The term work under project submitted by students shall include work Diary; Work Diary to be maintained by a group and countersigned by the guide (weekly).The contents of work diary shall reflect the efforts taken by project group for;
    a. Searching suitable project work
    b. Brief report preferably on journals/research or conference papers/books or literature surveyed to select and bring up the project.
    c. Brief report of feasibility studies carried to implement the conclusion.
    d. Rough Sketches/ Design Calculations
    e. Synopsis
- The group should submit the synopsis in the following form.

i. Title of Project
ii. Names of Students
iii. Name of Guide
iv. Relevance
v. Present Theory and Practices
vi. Proposed work
vii. Expenditure
viii. References

- The synopsis shall be signed by each student in the group, approved by the guide (along with external guide in case of sponsored projects) and endorsed by the Head of the Department.
- Presentation: The group has to make a presentation in front of the faculty of department at the end of semester.

Examination Scheme

- During university examination internal examiner (preferably the guide) and External examiners (appointed by HOD from the department/ institute) jointly, evaluate the project work.
- Evaluation will be done internally. HOD will constitute a committee of senior staff members form department or institute for the evaluations purpose.
- During the process of monitoring and continuous assessment & evaluation the individual and team performance is to be measured.
- The project term work shall be evaluated on the basis of reviews. In first semester two reviews are to be taken and evaluated for total 50 marks (25 marks each)
- Review 1 and 2 will be based on synopsis submission (team members, Title of the Project Work, Abstract, Problem Definition, work done earlier, Objectives of the Project, Methodology of the Project, Application / Significance of the Project, Duration of the Project, Individual Role of the Student, References, sponsored etc.)
- The final presentation shall be taken in front of external examiner and to be evaluated for 50 marks, 20 marks for presentation (Oral, Written) 30 marks for quality of the

project work.

Project Report

- Stage I report shall be in the booklet form
- Plagiarism check is must, and certificate shall be attached in the report

References

- References format MUST BE STANDARD – ASME, SAE or IEEE .

417547: Audit Course- VII

In addition to credits course, it is recommended that there should be audit course (non-credit course) preferably in each semester from second year. The student will be awarded grade as AC on successful completion of audit course. The student must opt for one of the audit courses per semester, starting in final year first semester. Such audit courses can help the student to get awareness of different issues which make impact on human lives and enhance their skill sets to improve their employability. List of audit courses offered in each semester is provided in curriculum. Each student must choose one audit course from the list per semester. Evaluation of audit course will be done at institute level. Method of conduction and method of assessment for audit courses is suggested.

The student registered for audit course shall be awarded the grade AC 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 'AC' grade and performance in these courses is not accounted in the calculation of the performance indices SGPA and CGPA. Evaluation of audit course will be done at institute level itself.

(Ref-http://www.unipune.ac.in/Syllabi_PDF/revised-2015/engineering/UG_RULE_REGULATIONS_FOR_CREDIT_SYSTEM-2015_18June.pdf)

Guidelines for Conduction (Any one or more of following but not limited to)

- Lectures/ Guest Lectures
- Visits (Social/Field) and reports
- Demonstrations
- Surveys
- Mini Project
- Hands on experience on specific focused topic
- Any relevant courses from NPTEL/ SWAYAM/ MOOCs/ ARPIT etc.

Guidelines for Assessment (Any one or more of following but not limited to)

- Written Test
- Demonstrations/ Practical Test
- Presentations
- IPR/Publication
- Report
- Assignments from NPTEL/ SWAYAM/ MOOCs/ ARPIT etc.

Audit courses suggested by BoS, Mechatronics Engineering:

1. Green Buildings

2. Environment Sustainability.

3. Constitution of India

Semester-II

417548 : Internet of Things

Teaching Scheme:	Examination Scheme:	Credits:
Lectures: 3 Hrs/ Week	Paper: (30+70) 100 Marks	Theory: 3
Practical: 2 Hrs/ Week	In semester Assessment: 30 Marks	Oral+TW: 1
	End Semester Assessment: 70 Marks.	Total: 4 credits
	Oral: 50 Marks, Term Work: 25 Marks	

Prerequisites: Digital Electronics, Embedded Systems.

Course Outcomes (COs): On completion of the course, the students will be able to

1. Present a survey on building blocks of IOT.
2. Compare the connectivity technologies and protocols in IOT.
3. Use IOT platform for application development
4. Discuss Security issues in IOT.
5. Develop Architectural Approach for IOT application

Unit I: Introduction (05)

Industry revolutions, Industry Revolution 4.0 – technology. Definition and characteristic for IOT, Physical Design of IOT, Logical Design of IOT, IOT enabling technologies, IOT levels and Deployment, opportunities and challenges. Building blocks of IOT,

Architecture framework: Cisco Architecture, Underlying Standard, Architecture framework, Industrial Internet Architecture Framework, Industrial Internet Reference Architecture, Industrial Internet Viewpoints, Business Viewpoint, Usage Viewpoint, Functional Viewpoint, Implementation Viewpoint, System Characteristics and Their Assurance,

Hardware required: Sensors, Actuators, Routers, Switches, platforms for IOT.

Unit II : Network (07)

point to point, point to multi point data transfer, OSI model, connectivity terminology, gateway prefix allotment, impact of mobility on addressing, multi homing, IOT protocols: IPV4, IPV6

Physical Layers **-** IEEE 802.15.4 - The IEEE 802 Committee Family of Protocols - The Physical Layer- The Media-Access Control Layer - Uses of 802.15.4 - The Future of 802.15.4: 802.15.4e and 802.15.4g. The Layering concepts, IOT Communication Pattern, IOT protocol Architecture, The 6LoWPAN Security aspects in IOT

Wireless communication, Wi-HART protocol, MAP/RAP communication, Hardware requirements, OPC-UA protocol, IO-Link Sensors

Unit III: IOT Platform (08)

Definition, Roll, Selection: Scalability, Ease of Use, Third party integration, Deployment option, Data Security, Function of IOT platform, Types of platforms: Application enablement and development, Network, Data and Subscriber Management, Device Management

Physical device – Ardino / Raspberry Pi Interfaces, Hardware requirement of Ardino / Pi, Connecting remotely to the Ardino /Raspberry Pi,GPIO Basics, Controlling GPIO

Using a Web Interface– Programming, APIs / Packages, Arduino Interfaces, Integration of Sensors and Actuators with Arduino, Introduction to Python programming, Industry accepted IOT Protocols like MQTT, Limitations, OSI PI.

Unit IV: Resource Management (07)

Cloud Computing: Architecture, characteristics, deployment cloud models : public, private, hybrid, community cloud, multi cloud, distributed cloud, inter, big data, HPC , Service Models: Infrastructure as a service, Platforms a Service, Software as a service, Data Synchronization.

Identity portrayal, Identity management, various identity management models: Local, Network, Federated and global web identity, user-centric identity management, device centric identity management and hybrid-identity management, Identity and trust.

Unit V: Security in IOT (07)

Concepts, IoT Reference Model, IoT Security, Threats, IoT Security Requirements, IoT Security Overview, IoT Protocols, Network and Transport Layer Challenges, IoT Gateways and security, IoT Routing Attacks, Bootstrapping and Authentication, Authorization Mechanisms IoT OAS, Security Frameworks for IoT, Light Weight Cryptography, Asymmetric LWC Algorithms, Key Agreement, Distribution, and Bootstrapping , Privacy in IoT Networks, Secure Data Aggregation

Unit VI: Advanced IOT Applications (08)

Smart home: Smart Home Technologies, Smart Home Implementations, Home Area Network, Smart Grid: Characteristics, Architecture, Benefits, components, Communication, Security, Smart Grid and Cloud.

Smart Cities: Characteristics, framework, Challenges, Data Fusion, Smart Parking, Energy Management.

Smart Health Care System: Clinical Care, Remote Monitoring, Other Interesting Use Cases of IoT, Enabling Technologies which Make IoT in Health Care Possible, Challenges in the IoT Health Care Sector, Future Trends for IoT in Health Care, Ingestible Sensor, Digital Medicine , Mobile Apps in Health Care Sector , Cloud and Big Data Analytics in the Health Care Sector, Cloud Services in Health Care Sector.

List of Experiments:

Students are expected to perform minimum eight experiments:

Following experiments can be performed using any available IOT platform like Arduino/Raspberry Pi/Node32/Intel Edison etc.

1. Interfacing of digital sensor/switch with developing board and display of condition on LED and on LCD
2. Interfacing analogue sensor with developing board and displaying it's value on LCD.
3. Changing brightness of LED using Potentiometer using PWM technique.
4. Interfacing of development boards with python.
5. Data transfer from one development board to other using Wi-Fi.
6. Data transfer from one development board to other using Bluetooth.
7. Sending data from development board using GSM using SMS
8. Connecting development board to internet either with Wi-Fi or GSM

9. Sending information to cloud using development board.
10. Receiving data from cloud to development board and displaying it on LCD.

Text Books:

1. Arshdeep Bahga, Vijay Madisetti, "Internet of Things – A hands-on approach", Universities Press, 2015.
2. The Industrial Internet of Things Volume G1: Reference Architecture
3. Jeeva Jose, Internet of Things, Khanna Publisher, Edition: First, ISBN: 9789386173591

Reference Books:

1. Hakima Chaouchi, " The Internet of Things Connecting Objects to the Web" ISBN : 978-1-84821-140-7, Willy Publications.
2. Dieter Uckelmann, Mark Harrison, Florian Michahelles,Architecting theInternet of Things, Springer, ISBN 978-3-642-19156-5
3. Rajkumar Buyya, Amir Vahid Dastjerdi, Internet of Things Principles and Paradigms, Morgan Kaufmann, ISBN: 978-0-12-805395-9

417549 : Vibration Analysis & Control

Teaching Scheme:	Examination Scheme:	Credits:
Lectures: 3 Hrs/ Week	Paper: (30+70) 100 Marks	Theory: 3
Practical: 2 Hrs/ Week	In semester Assessment: 30 Marks	Oral+TW: 1
	End Semester Assessment: 70 Marks.	Total: 4 credits
	Oral: 50 Marks, Term Work: 25 Marks	

Prerequisites: Strength of Materials, Engineering Mechanics, Kinematics of Machinery, Engineering, Mathematics and Numerical Methods

Course Outcomes (COs): On completion of the course, the students will be able to

1. APPLY balancing technique for static and dynamic balancing of multi cylinder inline and radial engines.
2. ANALYZE the gyroscopic couple or effect for stabilization of Ship, Airplane and Four wheeler vehicles.
3. ESTIMATE natural frequency for single DOF un-damped & damped free vibratory systems.
4. DETERMINE response to forced vibrations due to harmonic excitation, base excitation and excitation due to unbalance forces.
5. ESTIMATE natural frequencies, mode shapes for 2 DOF un-damped free longitudinal and torsional vibratory systems.
6. DESCRIBE noise and vibration measuring instruments for industrial / real life applications along with suitable method for noise and vibration control.

Unit I: Balancing (07)

Static and dynamic balancing, balancing of rotating masses in single and several planes, primary and secondary balancing of reciprocating masses, balancing in single cylinder engines, balancing in multi-cylinder in-line engines, direct and reverse cranks method -radial and V engines. Introduction to Balancing machines - Types, Classification and Methods

Unit II: Gyroscope (07)

Introduction, Processional angular motion, Gyroscopic couple, Effect of gyroscopic couple on an airplane, Effect of gyroscopic couple on a naval ship during steering, pitching and rolling, Stability of a Four Wheel

drive moving in a curved path, Stability of a two wheel vehicle taking a turn, Effect of gyroscopic couple on a disc fixed rigidly at a certain angle to a rotating shaft.

Unit III: Single Degree of Freedom Systems – Free Vibration: Fundamentals of Vibration (07)

Elements of a vibratory system, vector representation of S.H.M., degrees of freedom, Introduction to Physical and Mathematical modeling of vibratory systems: Bicycle, Motor bike and Quarter Car. types of vibration, equivalent stiffness and damping, formulation of differential equation of motion (Newton, D'Alembert and energy method)

Un-damped free vibrations: Natural frequency for longitudinal, transverse and torsional vibratory systems.

Damped free vibrations: Different types of damping, Viscous damping - overdamped, critically damped and under damped systems, initial conditions, logarithmic decrement, Dry friction or coulomb damping - frequency and rate of decay of oscillations.

Unit IV: Single Degree of Freedom Systems - Forced Vibrations (07)

Forced vibrations of longitudinal and torsional systems, Frequency Response to harmonic excitation, excitation due to rotating and reciprocating unbalance, base excitation, magnification factor, Force and Motion transmissibility, Quality Factor. Half power bandwidth method, Critical speed of shaft having single rotor of un-damped systems.

Unit V: Two Degree of Freedom Systems – Un-damped Vibrations (07)

Free vibration of spring coupled systems - longitudinal and torsional, torsionally equivalent shafts, natural frequency and mode shapes, Eigen value and Eigen vector by Matrix method, Combined rectilinear and angular motion, Vibrations of Geared systems.

Unit VI: Measurement and Control of Vibrations (07)

A) Measurement: Vibration Measuring Instruments, Accelerometers, Impact hammer, Vibration shakers,Vibration Analyzer, Vibration based condition monitoring, Analysis of Vibration Spectrum, Standards related to measurement of vibration.

B) Control: Vibration control methods - passive, semi active and active vibration control, control of excitation at the source, control of natural frequency, Vibration isolators, Tuned Dynamic Vibration Absorbers.

List of Experiments:

A] Compulsory Experiments (Sr. No. 1 to 6)

1. Balancing of wheel / rotor on computerized balancing machine OR Experimental verification of dynamic balancing of rotating masses,
2. To determine the natural frequency of damped vibration of single degree freedom system and to find it's damping coefficient.
3. To obtain frequency response curves of single degree freedom system of vibration for different amount of damping.
4. To verify natural frequency of torsional vibration of two rotor system and position of node.
5. To measure vibration of healthy and faulty beam using FFT analyzer in time and/ or frequency domain and further classify the condition.
6. To measure noise of any healthy and faulty machine element and represent it into time and/ or frequency domain and further predict the condition in future.

B] Any Two Experiments from the following:

1. To determine critical speed of shaft with single rotor.
2. Experimental verification of principle of dynamic vibration absorber.
3. Experiment on shock absorbers and to plot its characteristic curve.

4. To determine the effect of active gyroscopic couple on a spinning disc and verify the gyroscopic effect.
5. Industrial visit based on Conditioning Monitoring and Fault Diagnosis.

C] List of Compulsory Assignment:

1. Simulation (using suitable software) of free response of SDOF damped system to demonstrate different damping conditions by solving differential equation numerically.

OR

2. Simulation (using suitable software) of total response of SDOF damped system to harmonic excitation by solving differential equation numerically.

OR

3. A case study based on conditioning monitoring and fault diagnosis using machine learning.

Text Books:

1. S. S. Rao, Mechanical Vibrations, Pearson Education Inc. New Delhi.
2. G. K. Grover, Mechanical Vibrations, New Chand and Bros.,Roorkee
3. Wiiliam J Palm III, Mechanical Vibration, Wiley India Pvt. Ltd, New Delhi
4. Uicker J. John, Jr, Pennock Gordon R, Shigley Joseph E., Theory of Machines And Mechanisms, International Version, OXFORD University Press, New Delhi.
5. M L Munjal, Noise and Vibration Control, Cambridge University Press India
6. S. S. Rattan, Theory of Machines, Third Edition, McGraw Hill Education (India) Pvt. Ltd. New Delhi.

Reference Books:

1. Weaver, Vibration Problems in Engineering, 5th Edition Wiley India Pvt. Ltd, New Delhi.
2. Bell, L. H. and Bell, D. H., Industrial Noise Control – Fundamentals and Applications‖, Marcel Dekker
3. Alok Sinha, Vibration of Mechanical System, Cambridge university Press, India
4. Debabrata Nag, Mechanical Vibrations, Wiley India Pvt. Ltd, New Delhi.
5. Kelly S. G., Mechanical Vibrations, Schaums outlines, Tata McGraw Hill Publishing Co. Ltd.
6. Meirovitch, L., Elements of Mechanical Vibrations‖, McGraw Hill.
7. Ver, Noise and Vibration Control Engineering, Wiley India Pvt. Ltd, New Delhi.
8. Bies, D. and Hansen, C., Engineering Noise Control - Theory and Practice, Taylor and Francis.
9. Shrikant Bhave, Mechanical Vibrations Theory and Practice, Pearson, New Delhi

Elective- III

Elective III- 417550 A : App Development

Teaching Scheme:	Examination Scheme:	Credits:
Lectures: 3 Hrs/ Week	Paper: (30+70) 100 Marks	Theory: 3
	In semester Assessment: 30 Marks	Total: 3 credits
	End Semester Assessment: 70 Marks.	

Prerequisites: Object-Oriented Programming System

Course Outcomes (COs): On completion of the course, the students will be able to

1. Make use of basic android development and environment
2. Make use of basic software tools and android development tools
3. Develop a program with android UI representations.
4. Develop a program with connectivity and SQLite Database
5. Deployment & make a use of security in Application Deployment
6. Make use of basic web development and application

Unit I: Introduction to Android (07)

Introduction to Android, open handset alliance, Android Ecosystem. Need of Android, Features Of Android Tools and software required for developing an Android Application, Android Architecture, Introduction to Android Development: Android Core Building Blocks, Android Emulator

Unit II: Introduction to Software's and Tools (07)

Android Studio. Introduction to Building Tools: Java, JDK, JRE, Android SDK, Android Developer Tools. Setting up Android Environment, Introduction to Android OS: Android Architecture.: Overview of the Stack , Linux Kernel , Native Libraries , Dalvik Virtual Machine, Android Virtual Machine (ADT), Dalvik Debug Monitor Server (DDMS), LogCat, Application Framework, Application Licensing, Gradle.

Unit III: Android User Interface (07)

AndroidManifest.xml, R.java file, uses-permission, Project Structure, Layout resource. Hello World User Interface: Working with Button, Toast, Button, Toggle Button, Switch Button, Image Button, Check Box, Alert Dialog, Spinner, Auto Complete Text View, Rating Bar, Date Picker, Time Picker, Progress Bar. Android Life Cycle: Activity, Intent, Android Menus, Layout Manger.

Unit IV: Android activities and fragments (07)

Broadcast Lifecycle Content Provider; Fragments Multimedia framework, Play Audio and Video, Text to speech, Sensors, Async tasks Audio Capture, Camera Bluetooth, Animation of TEC SQLite Database, necessity of SQLite, Creation and connection

Unit V: Android Security (07)

Model, Declaring and Using Permissions, Using Custom Permission. Application Deployment: Creating Small Application, signing of application, Deploying app on Google Play Store, Become a Publisher, Developer Console

Unit VI: Introduction to Web (07)

In Perspective, Origin. Before the web: TCP/IP. Birth of WWW: HTTP. Web Servers, Web Browsers. HTML & its Roots, XML & Applications, Dynamic Web Applications, Approaches to web application development

Text Books:

1. Valentino Lee, Heather Schneider, Robbie Schell, Mobile Applications: Architecture, Design, and Development, Prentice Hall, April 2004, ISBN-13: 978-0131172630.
2. Sajal Kumar Das, Mobile Handset Design, John Wiley & Sons, ISBN-13:9781118684573
3. Bill Evjenet and Kent Sharkey, Professional XML, Wrox, I Edn, 2007, ISBN13:9780471777779
4. Leonard Richardson and Sam Ruby, RESTful Web Services: Web services for the real world, O'Reilly Media, I Edn, May 2007, ISBN-13: 978-0596529260
5. Mark L. Murphy, The Busy Coder's Guide to Android Development, Commons Ware, LLC, 2015, ISBN-13:978-0981678009.
6. Wallace Jackson, Android Apps for Absolute Beginners, Apress, 2012. ISBN-13:978-1430247883.

   Bill Phillips, Chris Stewart, Android Programming: The Big Nerd Ranch Guide, AddisonWesley Professional, 2015, ISBN-13: 978-0134171456.

Reference Books:

1. Rosen, Boris Lublinsky, Kevin T. Smith, and Marc J. Balcer, Applied SOA: Service-Oriented Architecture and Design Strategies, Wiley (Kindle Edn), (2010), ISBN13: 978-1118079799
2. Dawn Griffiths, Head First Android Development, O'Reilly Media, Inc, 2015. ISBN13:978-1449362188.
3. B V Kumar and S.V Subrahmanya; Web Services: An Introduction, McGraw Hill Education (India) Private Limited, 2 edn (2012), ISBN-13: 978-1259002762

   Valentino Lee, Heather Schneider, Robbie Schell, Mobile Applications: Architecture, Design, and Development, Prentice Hall, April 2004, ISBN-13: 978-0131172630.

Elective III- 417550 B : Rapid Prototyping

Teaching Scheme:	Examination Scheme:	Credits:
Lectures: 3 Hrs/ Week	Paper: (30+70) 100 Marks	Theory: 3
	In semester Assessment: 30 Marks	Total: 3 credits
	End Semester Assessment: 70 Marks.	

Prerequisites: Machine Design , Manufacturing Processes

Course Outcomes (COs): On completion of the course, the students will be able to

1. Understand and use techniques for processing of CAD models for rapid prototyping.
2. Understand and apply fundamentals of rapid prototyping techniques.
3. Use appropriate tooling for rapid prototyping process.
4. Use rapid prototyping techniques for reverse engineering.

Unit I: Introduction (07)

Introduction to Prototyping, Traditional Prototyping Vs. Rapid Prototyping (RP), Need for time compression in product development, Usage of RP parts, Generic RP process, Distinction between RP and CNC, other related technologies, Classification of RP. Relevance of RP in Industry 4.0, Current industry and manufacturing trends driving RP, AM Process-Chain, Reverse engineering, Advantages, Types of materials, Classification of AM Processes

Unit II: Liquid And Powder Based RP Systems (07)

Introduction, Process and mechanism, Materials, Process Physics, Parameters, Benefits, Drawbacks, Limitations and Applications of

Light-Based Photo-curing: Stereolithography (SLA), Digital Light Processing (DLP),

Direct Laser Writing (DLW), Continuous Liquid Interface Production (CLIP)

Laser-Based Melting: Selective Laser Sintering (SLS), Direct Metal Laser Sintering (DMLS), Selective Laser Melting (SLM), Electron-Beam Melting (EBM), Laser Blown Powder, Laser Wire Deposition

Unit III: Solid Based RP Systems (07)

Introduction, Process and mechanism, Materials, Process Physics, Parameters, Benefits, Drawbacks, Limitations and Applications of

Extrusion-Based Deposition: Fused Deposition Modeling (FDM), Fused Filament Fabrication (FFF), Direct Ink Writing (DIW),

Inkjet(droplet)-Based Deposition and Fusion: Multi-jet Modeling (MJM), Polyjet Printing, Nanoparticle Jetting, Binder Jetting, Multi-Jet Fusion, Color-jet Printing (CJP),

Energy Deposition Techniques: Plasma/TIG/MIG/Arc Deposition, Electron Beam-based DED, Direct Metal Deposition (DMD)

Unit IV: Material and Design (07)
Introduction, Materials: Metals, Polymers, Ceramics & Bio-ceramics, Composites, Hierarchical Materials, Biomimetic Materials, Shape-Memory Alloys, 4D Printing & Bio-active materials,

Additive Manufacturing Material specific Process Parameters: Processes, Heat or Chemical Treatments, Phase Transformations, Process Selection for various applications,

Quality considerations and Post-Processing techniques: Requirements and Techniques, Support Removal, Sanding, Acetone treatment, Polishing, Heat treatments, Hot isostatic pressing, Materials science, Surface enhancement Techniques and its Material Science Analysis of RP's error sources

Unit V: Software and Hardware (07)
Software and Controller: Types of In-fill, Types of slicing, Software Integration (with Process, Slicing, etc), Control system (PLC and safety PLC, micro control/ Microcontroller, Microprocessor control), CAD Software and Controller Interfacing, CURA Software, Relevant G/M Codes, Standard firmware (Merlin Software, etc), In-process Monitoring, Calibration

Construction of Basic RP Machines: Equipment Layout and sub-system Design, Construction, Working, Equipment Topology/Layout Frame Designs, 3D Printer Design Considerations (Filament, Frame, Build Platform, Extruder Design, Nozzles, Print Bed, Heated build/Base Plate, Heater, Dispenser, Optical system, Cooling system, Gas Recirculation System, Laser controller, Gas Filtration, Inert Gas Cooling system, Powder Handling System, Loading/unloading System, Moving Parts and end stops, Sensors, Actuators, Motors and Control Electronics, Power supply, Machine Tool Peripheral),

Unit VI: Case Studies, Application (07)
Case Studies and Application of RP: 3D printing in prominent industries (Aerospace, Electronics, Defense, Automotive, Construction, Architectural, Machine-Tools), Other industrial applications (Health-Care, Personalized Surgery, Bio-medical Applications, Assistive Devices, Food-Processing, Food & Consumer Applications, Art, Fashion, Jewelry, Toys & Other Applications, etc)

Text Books:

1. Chua C K, Leong K F, Chu S L, Rapid Prototyping: Principles and Applications in Manufacturing, World Scientific.
2. Gibson D W Rosen, Brent Stucker., Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, Springer

Reference Books:

1. Noorani R, Rapid Prototyping: Principles and Applications in Manufacturing, John Wiley & Sons.
2. Hilton P, Jacobs P F, Rapid Tooling: Technologies and Industrial Applications, CRC press.
3. Liou W L, Liou F W, Rapid Prototyping and Engineering applications: A tool box for prototype development, CRC Press.
4. Kamrani A K, Nasr E A, Rapid Prototyping: Theory and practice, Springer,
5. Amit Bandyopadhyay, Susmita Bose, "Additive manufacturing", CRC Press, Taylor & Francis Group, 2016 3
6. Chee Kai, Kah Fai, Chu Sing, 'Rapid Prototyping: Principles and Applications", 2nd Ed., 2003

Elective III- 417550 C: Advanced Control Systems

Teaching Scheme:	**Examination Scheme:**	**Credits:**
Lectures: 3 Hrs/ Week	Paper: (30+70) 100 Marks	Theory: 3
	In semester Assessment: 30 Marks	Total: 3 Credits
	End Semester Assessment: 70 Marks.	

Prerequisites: Control Systems, Modern Control Theory, z transform, Matrices

Course Outcomes (COs): On completion of the course, the students will be able to

1. Compute pulse transfer and time response of digital control systems.
2. Realize pulse transfer function and investigate stability of digital control systems using pole locations, Jury stability test, bilinear transformation and Routh stability test.
3. Compute state model from pulse transfer function, pulse transfer function from state model and state transition matrix of digital control systems.
4. Investigate state controllability, state observability and design state regulator, full order state observer and optimal state regulator for digital control systems.
5. Investigate stability of continuous and discrete time LTI systems represented in state space using Lyapunov method.
6. Analyze non-linear systems using describing function and phase plane method.

Unit I: Introduction to Digital Control Systems (07)

Functional and analytical block diagrams of digital (sampled data) control system, sampling and reconstruction, data conversion and quantization, zero order hold and its transfer function, pulse transfer function, computation of pulse transfer function, systems with zero order hold and computation of their pulse transfer function, impulse response and step response

Unit II: Realization and Stability of Digital Control Systems (07)

Realization of pulse transfer function: direct realization, cascade realization and parallel realization, mapping between s and z plane, stability of digital control systems from pole locations, Jury stability test, bilinear transformation and Routh stability test

Unit III: State Space Representation of Digital Control Systems (08)

State space representation of digital control systems represented by pulse transfer function (controllable canonical, observable canonical forms, diagonal/Jordon canonical form), conversion of state model into pulse transfer function, solution of homogeneous and non-homogeneous state equations of digital control systems, state transition matrix of digital control systems, its properties, computation by z transform method, Caley Hamilton theorem method

Unit IV: Design of Digital Control Systems in State Space (07)

Concept of state controllability and state observability, investigation of state controllability and state observability using Kalman and Gilbert tests, design of state regulator via pole placement (all three methods), design of full order state observer, design of dynamic and steady state optimal state regulator for quadratic performance index

Unit V: Stability Analysis of Continuous and Discrete Time LTI systems using Lyapunov Stability (06)

Positive definiteness, positive semi-definiteness, negative definiteness, negative semi-definiteness and indefiniteness of quadratic function, Sylvestor criterion, stability in the sense of Lyapunov, asymptotic stability, Lyapunov's direct and second method for stability analysis of Continuous and Discrete Time LTI systems

Unit VI: Non-linear Systems and their Stability Analysis (07)

Peculiar characteristics of non-linear systems, common non-linearities (inherent and intentional), describing function, describing function of ideal relay and saturation, stability analysis using describing function, phase plane analysis, singular points and their types, phase trajectory and phase portrait, construction of phase trajectory using isocline method

Text Books:

1. Gopal. M., "Digital Control and State Variable Methods", 2nd Ed., Tata McGrahill Publication, New Delhi, 2003.
2. K. Ogata, "Discrete-Time Control Systems", 2nd Ed., Prentice Hall India, New Delhi, 2005
3. M. Vidyasagar, "Nonlinear Systems Analysis", 2nd Ed., Prentice Hall, 1993.

Reference Books:

1. B. C. Kuo, "Digital Control Systems", 2nd Ed., Oxford University Press, 2012.
2. Graham C., Goodwill, S. F. Graebe and M. E. Salgado, "Control System Design" Pearson; US edition (2000).

Elective- IV

Elective IV- 417551 A: Industrial Robotics

Teaching Scheme:	Examination Scheme:	Credits:
Lectures: 3 Hrs/ Week	Paper: (30+70) 100 Marks	Theory: 3
	In semester Assessment: 30 Marks	Total: 3 Credits
	End Semester Assessment: 70 Marks.	

Prerequisites: Control Systems, Modern Control Theory, z transform, Matrices

Course Outcomes (COs): On completion of the course, the students will be able to

1. Select Use of any robotic simulation software to model the different types of robots and calculate work volume for different robots
2. Read and Analyze variety of industrial robots
3. Apply Concept of Robot design and program for different field application.
4. Evaluate the significance of industrial robot

Unit I: Fundamentals of Robotics (07)

Historical development of Robotics, Definitions of Industrial Robot, Type and Classification of Robots, Asimov's laws of robotics, Robot configurations, Robot Components, Robot Degrees of Freedom, Work volume and work envelope, Robot Joints and symbols, Robot Coordinates, Robot Reference Frames, Resolution, accuracy and precision of Robot, Work cell control

Unit II: Robot Drive systems (07)

Pneumatic Drives, Hydraulic Drives, Mechanical Drives, Electrical Drives- D.C. Servo Motors, Stepper Motors, A.C. Servo Motors, BLDC-Salient Features, Applications and Comparison of all these Drives, Micro actuators, selection of drive, Power transmission systems for robot, Motion conversion, Determination of HP of motor.

Unit III: End Effectors (07)

Grippers, Mechanical Grippers, Pneumatic and Hydraulic-Grippers, Magnetic Grippers, Vacuum Grippers; Two Fingered and Three Fingered Grippers; Internal Grippers and External Grippers; Advance Grippers-Adaptive grippers, Soft Robotics Grippers, Tactile Sensor Grippers; Considerations in gripper selection and design.

Unit IV: Robot Sensors (07)

Transducers and sensors, Sensors in robotics, Principles and applications of the following types of sensors-Proximity Sensors, Photo Electric Sensors, Laser Scanners, Position sensors–Piezo Electric Sensor, LVDT, Resolvers.

Encoders: Absolute and Incremental: - Optical, Magnetic, Capacitive, pneumatic Position Sensors

Range Sensors: Range Finders, Laser Range Meters, Touch Sensors, Force and torque sensors.

Safety Sensor: Light Curtain, Laser Area Scanner, Safety Switches; Machine vision

Unit V: Robot Motion Analysis

Kinematics : Transformation matrices and their arithmetic, link and joint description, Denavit–Hartenberg parameters, frame assignment to links, direct kinematics, kinematics redundancy, kinematics calibration, inverse kinematics of two joints, solvability, algebraic and geometrical methods.

Velocities and Static Forces in Manipulators: Motion of the manipulator links, Jacobians, singularities, static forces, Jacobian in force domain.

Unit VI: Trajectory Planning

Introduction to Dynamics, Trajectory generations, Motion planning and control: Joint and Cartesian
space trajectory planning and generation, potential field method for motion planning Manipulator
Mechanism Design, Force control and hybrid position/force control

Text Books:

1. S.R. Deb, " Robotics Technology and Flexible Automation", TMH, 2nd Edition, 2010.
2. M.P. Groover , "Automation, Production Systems & Computer Integrated Manufacturing", PHI, 3rd Edition, 2012
3. M.P. Groover, M.Naegel, "Industrial Robotics, Technology, Programming & Applications", TMH, 2nd Edition, 2012.

Reference Books:

1. J.G. Keramas, "Robotics Technology Fundamentals", Thompson Learning, 2nd Edition, 2002.
2. J.J.Craig "Introduction to Robotics Mechanics & Control", Pearson Education, 3rd Edition, 2004.
3. Fu. K. S., Gonzalez. R. C. & Lee C.S.G., "Robotics Control, Sensing, Vision and Intelligence", McGraw Hill Book co, 1987.
4. Mike Wilson, "Implementation of Robotic Systems" S B Niku, Introduction to Robotics, Analysis, Control, Applications, 2nd Edition, Wiley Publication, 2015.
5. John Craig, Introduction to Robotics, Mechanics and Control, 3rd Edition, Pearson Education, 2009
6. Mathia, Robotics for Electronics Manufacturing, Cambridge Uni. Press, India
7. A Ghosal, Robotics: Fundamental Concepts and Analysis, Oxford University Press, 2013.
8. R K Mittal & I J Nagrath, Robotics and Control, McGraw Hill Publication, 2015.

Elective IV- 417551 B: Human Machine Interface

Teaching Scheme:	**Examination Scheme:**	**Credits:**
Lectures: 3 Hrs/ Week	Paper: (30+70) 100 Marks	Theory: 3
	In semester Assessment: 30 Marks	Total: 3 Credits
	End Semester Assessment: 70 Marks.	

Prerequisites: Object Oriented Programming Laboratory.

Course Outcomes (COs): On completion of the course, the students will be able to

1. Design innovative and user-friendly interfaces for industrial application.
2. Criticize existing interface designs, and improve them.
3. Design application for social and technical task with safety concern

Unit I: Introduction (07)

Introduction to Human Machine Interface, Hardware, software and operating environment to use HMI in various fields. The psychopathology of everyday things – complexity of modern devices; human-centered design; fundamental principles of interaction; Psychology of everyday actions- how people do things; the seven stages of action and three levels of processing; human error

Unit II: Graphical User Interface (07)

benefits of a good UI; popularity of graphics; concept of direct manipulation advantages and disadvantages; characteristics of GUI; characteristics of Web UI; General design principles, **User Interface Design Process:** Steps in UI design

Unit III: Graphical screen design (07)

graphical design concepts, components of visible language, graphical design by grids Beyond screen design: characteristics of good representations, information visualization, Tufte's guidelines, visual variables, metaphors direct manipulation

Unit IV: Communication (07)

Interaction styles and communication – menus; windows; device-based controls, screen based controls, feedback and guidance, icons, colors.

Societal and Individual Impact of User Interfaces: Future Interfaces, Ten Plagues of the Information Age, Overcoming the Obstacle of Animism

Unit V: Design Specifications in HMI (07)

Design principles and usability heuristics: design principles, principles to support usability, golden rules and heuristics, Human Computer Interaction (HCI) patterns, **HCI design standards:** process-oriented standards, product-oriented standards, strengths and limitations of HCI Standards.

Unit VI: Case studies (07)

Designing and evaluating Human-Machine Interface (HMI) for Process control application. Flight control system Robotics Welding Air-conditioning system Smart phones Medical Devices

Text Books:

1. Donald A. Normann, "Design of everyday things", Basic Books; Reprint edition 2002.
2. Wilbert O. Galitz, "The Essential Guide to User Interface Design", Wiley publication.
3. Ben Shneidermanand Catherine Plaisant,: Desinging the user Interface:,Pearson,Addison Wesley.
4. Alan Cooper, Robert Reimann, David Cronin, "About Face3: Essentials of Interaction design", Wiley publication.
5. Jeff Johnson, "Designing with the mind in mind", Morgan Kaufmann Publication.

Reference Books:

1. "Human-Machine Interface Design for Process Control Applications", Jean-Yves Fiset, ISA,2009
2. Dix A. et al., Human-Computer Interaction. Harlow, England: Prentice Hall, 2004, ISBN-10: 0130461091
3. Yvonne Rogers, Helen Sharp, Jenny Preece, Interaction Design: Beyond Human Computer Interaction, 3rd Edition, Wiley, 2011, ISBN-10: 0470665769
4. Guy A. Boy "The Handbook of Human Machine Interaction", Ashgate publishing Ltd.

Elective IV- 417551 C: Electric Vehicles

Teaching Scheme:	**Examination Scheme:**	**Credits:**
Lectures: 3 Hrs/ Week	Paper: (30+70) 100 Marks	Theory: 3
	In semester Assessment: 30 Marks	Total: 3 Credits
	End Semester Assessment: 70 Marks.	

Prerequisites: Basic Electrical Engineering, Electrical and Electronics Engineering, Kinematics of Machinery

Course Outcomes (COs): On completion of the course, the students will be able to

1. **UNDERSTAND** the basics related to e-vehicle
2. **CLASSIFY** the different hybrid vehicles
3. **IDENTIFY** and **EVALUATE** the Prime Movers, Energy Storage and Controllers
4. **DISCOVER** and **CATAGORIZE** the Electric Vehicle Configuration with respect to Propulsion, Power distribution and Drive-Train Topologies
5. **DEVELOP** body frame with appropriate suspension system and **TESTING** of for e-Vehicles
6. **CLASSIFY** and **EVALUATE** Battery Charging techniques and management

Unit I: Introduction to Electric and Hybrid Vehicle (07)

History and evolution of Electric Vehicles, Comparison of Electric with Internal Combustion Engine Vehicles, Limitations of IC Engine Vehicles (ICEV), Exhaust Emission and Global warming, Environmental importance of Hybrid and Electric Vehicles, Overview of EV Challenges, Classification, Overview of EV Technologies, Advantages and Disadvantages, Economic and Environmental impacts of using Electrical Vehicles, Emerging Technologies for Electric Vehicle Drives, Case Studies of Two-Wheeler, Three-Wheeler, and Four-Wheeler Electric Vehicles, Brief introduction to Autonomous and self-driving Vehicles

Unit II: Hybrid Electric Vehicle (07)

Classification of HEV: Architecture, Construction, Working, Advantages and Limitations of Conventional and Gridable HEV, Classification of Conventional HEV, Types of Gridable HEV, Tractive force, Power and Energy requirements for standard drive cycles of HEV

Hybrid Electric Drive-Trains: Basic concept of Hybrid Traction, introduction to various hybrid Drive-Train Topologies, Power flow Control in Hybrid Drive-Train Topologies, Fuel Efficiency Analysis

Control Strategy: Supervisory Control, Selection of Modes

Unit III: Prime Movers, Energy Storage and Controllers (08)

Brief introduction to Motors: Classification, Construction, Working, Control, Design criteria, Application and Design Examples, Selection of Motor, Structural Configuration of Motor Layout, Motor Safety and Maintenance, Motor Torque and Power Rating

Brief introduction to Energy Storage Systems: Classification - Types and Packs, Construction, Working, Comparison and Selection, Principle of Operation, Units of Battery/Fuel Cell Energy Storage, Battery Performance Parameters Estimation, Battery/Cell Modeling, Traction Batteries and their Capacity Calculation and Power Rating for standard drive cycles, Lifetime and Sizing Considerations, Power and Efficiency, Characteristic Curves, Battery Cooling/Thermal Control and Protection, Battery Safety and Maintenance,

Auxiliary battery, Hybridization of energy storage devices, Ultra capacitor and Ultra flywheel

Controllers: Configuration based on power electronics, Torque/Speed Coupling, Speed and Torque Controllers, BCU, MCU, Speed Control for Constant Torque/Power Operation of all electric motors, Control Methods

Unit IV: Electric Vehicle Configuration and Mechanics of Vehicle Movement (07)

Electric Vehicle Configuration with respect to Propulsion and Power distribution: Unicycle, Two-Wheeler (Bicycle, Dicycle, Motorcycle, Scooter, Scooteretts, Mopeds and Underbone), Three-Wheeler, and Four-Wheeler Electric Vehicles, Steering and Propulsion Configuration, Placement of Motors, Battery and Motion Transmission Systems

Electric Drive-Trains: Basic concept of Electric Traction, introduction to various Electric Drive-Train Topologies, Power flow Control in Electric Drive-Train Topologies, Fuel Efficiency Analysis, Mechanical Differential Vs. Electric Differential

Mechanics of Vehicle Movement: General description of vehicle movement, Power train Components and Sizing, Wheels and Tires, Load calculation, Torque/Traction Calculations, Power Calculation, Effect of Rolling, Pitch & Yaw on velocity and moments, Rolling resistance and its equation, Aerodynamic Drag/Lift and its equation, Grading resistance, Road resistance, Acceleration resistance, Total driving resistance, Dynamic equation, Brake System

Unit V: Electric Vehicle Design, Manufacturing, Testing & Homologation (07)

Frames and Suspension Design for varieties of Electric Vehicle Configuration: Introduction to Body loads, Driving dynamics and Comfort, Strength and Stiffness of chassis/frames, Types and constructional details of frames, Frame Materials, Frame building Problems, frame components, Front and Rear Suspension Systems, Panel meters and controls on Handle-bar/Dash-board, Body Manufacturing, Aesthetics and Ergonomics Consideration, Retrofitting and its associated Problems

Vehicle Testing & Homologation: Need of vehicle Testing and Homologation, National/International Testing/Regulation/Licensing/Approval Organizations and their Standards (AIS) for e-Vehicles, Hierarchy of Testing, Conformity of Production tests, Crash test, Side Impact Test, Rollover Test, Impact Test, Track Testing

Unit VI: EV Charging Infrastructure Management (06)

Battery Charging: Basic Requirements for Charging System, Charging Methods and Standards, Converters, Charger Architectures, Grid Voltages, Frequencies and Wiring, Charger Functions, Real Power, Apparent Power, and Power Factor, Boost Converter for Power Factor Correction, Examples, Vehicle to Grid operation of EV's

Battery Management Systems: Necessity of Battery Management Systems, Typical Structure of BMSs, Representative Products, Keypoints of BMSs in Future Generation, Hazard/Safety Management

Text Books:

1. Iqbal Hussein, (2021), "Electric and Hybrid Vehicles: Design Fundamentals," CRC Press, ISBN: 9780367693930
2. Denton, Tom, (2020), "Electric and Hybrid Vehicles," 2nd Ed., Routledge, ISBN:9780367273248
3. John Lowry, James Larminie, (2012), "Electric Vehicle Technology Explained," Wiley, ISBN: 9781119942733
4. Knowles, Don, (2011), "Automotive Suspension & Steering Systems," Cengage learning, ISBN: 9781435481152
5. Malen, Donald E., (2011), "Fundamentals of Automobile Body Structure Design," SAE International, ISBN: 9780768021691
6. R. Krishnan, (2001), "Electric Motor Drives: Modeling, Analysis, and Control," Pearson, ISBN: 9780130910141
7. Mohammad Saad Alam, Reji Kumar Pillai, N. Murugesan, (2021), "Developing Charging Infrastructure and Technologies for Electric Vehicles," IGI Global/ Business Science Reference, ISBN: 9781799868583

Reference Books:

1. Mehrdad Ehsani, Yimi Gao, Sefano Longo, Kambiz Ebrahimi, (2019), "Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design," CRC Press, ISBN: 9780367137465
2. Tariq Muneer, Mohan Kolhe, Aisling Doyle, (2017), "Electric Vehicles: Prospects and Challenges," Electric Vehicles: Prospects and Challenges, ISBN: 9780128030219
3. Sandeep Dhameja, (2001), "Electric Vehicle Battery Systems,", Newnes, ISBN: 9780750699167
4. Bruno Scrosati, Jürgen Garche, Werner Tillmetz, (2015), "Advances in Battery Technologies for Electric Vehicles," Woodhead Publishing, ISBN: 9781782423775
5. Shunli Wang, Carlos Fernandez, Yu Chunmei, Yongcun Fan, Cao Wen, Daniel-Ioan Stroe, Zonghai Chen, (2021), "Battery System Modeling," Elsevier, ISBN: 9780323904728
6. Andrea, Davide, (2010), "Battery management systems for large lithium battery packs,"Artech House Publishers, ISBN: 9781608071043
7. Dixon, John C., (2009), "Suspension Analysis and Computational Geometry," Wiley, ISBN: 9780470510216
8. Day, Andrew J., (2014), "Braking of Road Vehicles," Butterworth Heinemann, ISBN: 9780123973146
9. Guiggiani, Massimo, (2018), "The Science of Vehicle Dynamics: Handling, Braking, and Ride of Road and Race Cars," Springer, ISBN: 978-3319732190
10. Chen, Yong, (2021), "Automotive Transmissions: Design, Theory and Applications," Springer, ISBN: 9789811567025
11. Bentley Publishers, (2002), "Bosch Automotive Handbook," Bentley Publishers, ISBN: 0837610974
12. Prasad, Priya and Belwafa, Jamel E., (2004), "Vehicle Crashworthiness and Occupant Protection," American Iron and Steel Institute Southfield, Michigan, www.roadsafellc.com

13. Macey, Stuart and Wardle, Geoff, (2008), "H-Point: The Fundamentals of Car Design & Packaging," designstudio Press, ISBN: 9781933492377
14. Sulabh Sachan, Sanjeevikumar Padmanaban, and Sanchari Deb, (2022), "Smart Charging Solutions for Hybrid and Electric Vehicles," Scrivener Publishing, ISBN: 9781119768951

417552: Project Stage- II

Teaching Scheme:	Examination Scheme:	Credits:
Practical: 12 Hrs/ Week	Term Work: 100 Marks	TW: 4
	Oral: 50 Marks	OR: 2
		Total: 6 Credits

Prerequisites: Project Based Learning, Internship/Mini Project, Laboratory works, Skill Development, Audit Courses, Industrial Visits, Project (Stage I)

Project Stage II is the extension of Project Stage I.
Course Outcomes, Course Contents and Guidelines for Project Execution are same as that of Project Stage I

Term Work Evaluation

1. In Project Stage II, two reviews shall be taken for total 100 marks (50 marks each)
2. Review III shall be based on the approximate end of fabrication / design validation etc. in front of an expert panel from the department.
3. Review IV shall be third party evaluation by Faculty/Student/Industry person/Alumni
4. Evaluation committee shall consist of Guide, One Industry person and One Faculty appointed by the Institution.
5. Students shall be encouraged to publish a research paper/patent/technical no
6. Their credential shall be considered while term work evaluation.

Examination Scheme

1. Examination committee shall consist of Internal Examiner and External Examiner appointed by University. (External Examiner shall be a competent Industry/Research/Laboratory person. A list shall be provided by Board of Studies)
2. Well in advance soft copies of the project shall be shared with examination committee.

Presentation of Project Work

Presentation of work in the form of Project Report (s), Understanding individual capacity, Role & involvement in the project, Team Work (Distribution of work, intra-team communication and togetherness), Participation in various contests, Publications and IPR, Manuals (Project Report, Quick reference, System, Installation guide) among other parameters. Team members with guide information shall be added at the end of the report.

Project Report

1. The report shall be both side print hard bound. A hardbound report shall be made after examination and examiner and guide's expected correction, before that report must be loosely bound.
2. Plagiarism check is must, and certificate shall be attached in the report.
3. A group activity shall be presented in report.
4. Report copies shall be submitted in the department, one for university and one for supervisor.
5. For standardization of the project reports the following format shall be strictly followed.

Page size: Trimmed A4
Top Margin: 1″
Bottom Margin: 1.32″
Left Margin: 1.5″
Right Margin: 1″
Para Text: Times New Roman 12-point font
Line Spacing: 1.15 Lines
Page Numbers: Right aligned at footer. Font 12 point Times New Roman
Headings: Times New Roman, 14 Points, Boldface 10.

Index of Report

1. Title Sheet
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3. Certificate (Company, if sponsored by company)
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5. Abstract of the Project
6. List of Figures
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9. Table of Contents
10. Introduction
11. Literature Survey / Theory
12. Design / Experimentation / Fabrication / Production / Actual work carried out for the same
13. Observation Results
14. Discussion on Result and Conclusion
15. Student and Guide details. (A common photograph with project)

417553: Audit Course- VIII

In addition to credits course, it is recommended that there should be audit course (non-credit course) preferably in each semester from second year. The student will be awarded grade as AC on successful completion of audit course. The student must opt for one of the audit courses per semester, starting in final year first semester. Such audit courses can help the student to get awareness of different issues which make impact on human lives and enhance their skill sets to improve their employability. List of audit courses offered in each semester is provided in curriculum. Each student must choose one audit course from the list per semester. Evaluation of audit course will be done at institute level. Method of conduction and method of assessment for audit courses is suggested.

The student registered for audit course shall be awarded the grade AC 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 'AC' grade and performance in these courses is not accounted in the calculation of the performance indices SGPA and CGPA. Evaluation of audit course will be done at institute level itself.

(Ref-http://www.unipune.ac.in/Syllabi_PDF/revised-2015/engineering/UG_RULE_REGULATIONS_FOR_CREDIT_SYSTEM-2015_18June.pdf)

Guidelines for Conduction (Any one or more of following but not limited to)

- Lectures/ Guest Lectures
- Visits (Social/Field) and reports
- Demonstrations
- Surveys
- Mini Project
- Hands on experience on specific focused topic
- Any relevant courses from NPTEL/ SWAYAM/ MOOCs/ ARPIT etc.

Guidelines for Assessment (Any one or more of following but not limited to)

- Written Test
- Demonstrations/ Practical Test
- Presentations
- IPR/Publication
- Report
- Assignments from NPTEL/ SWAYAM/ MOOCs/ ARPIT etc.

Audit courses suggested by BoS, Mechatronics Engineering:

1. Global Warming

2. Indian Culture

3. History of India