Credit Structure and Syllabus
of
Minor Degree Courses

Offered By

DEPARTMENT OF MECHANICAL ENGINEERING
M. M. M. UNIVERSITY OF TECHNOLOGY
GORAKHPUR-273 010, UP

Minor Degree 1: Robotics and Automation

S. N.	Category	Paper Code	Subject	L	T	P	Credit
1.	PE-1	EME-101	Introduction to Robotics	3	1	0	4
2.	PE-3	EEC-352	Introduction to Embedded Systems & Microcontroller Programming	3	0	2	4
3.	PE-5	EME-501	Sensors and Actuators	3	1	0	4
4.	PE-7	EME-701	Industrial Automation	3	1	0	4
		EEC-752	Robotics System and Intelligent Automation	3	1	0	4
5.	PE-9	EME-901	Mechanics of Robotics	3	1	0	4

Minor Degree 2: Energy and Environment

S. N.	Category	Paper Code	Subject	L	T	P	Credit
1.	PE-1	EME-102	Fundamentals of Renewable Energy Sources	3	1	0	4
2.	PE-3	EME-302	Renewable Energy Technologies	3	1	0	4
3.	PE-5	EME-502	Energy Storage Systems	3	1	0	4
4.	PE-7	EME-702	Environmental Impact Assessment	3	1	0	4
5.	PE-9	EME-902	Performance Assessment and Economics	3	1	0	4
Total							20

Minor Degree 3: Smart Manufacturing

S. N.	Category	Paper Code	Subject	L	T	P	Credit
1.	PE-1	EME-103	Smart Manufacturing	3	1	0	4
2.	PE-3	EME-303	Additive Manufacturing	3	1	0	4
3.	PE-5	EME-503	Smart Materials and Structures	3	1	0	4
4.	PE-7	EME-703	Automation in Manufacturing	3	1	0	4
5.	PE-9	EME-903	Machine Learning for Production Optimization	3	1	0	4
Total							20

Minor Degree 4: Computational Engineering

S. N.	Category	Paper Code	Subject	L	T	P	Credit
1.	PE-1	EME-104	Numerical Methods for Engineers	3	1	0	4
2.	PE-3	EME-304	Software Application for Engineering Problem	2	0	4	4
3.	PE-5	EME-504	Computational Modelling & Simulation	3	0	2	4
4.	PE-7	EME-704	Optimization Techniques in Engineering	3	1	0	4
5.	PE-9	EME-904	Finite Element Methods	3	1	0	4
Total							20

The Department of Mechanical Engineering offers the following minor degree courses for undergraduate B.Tech. Students. Program of other departments in MMMUT Gorakhpur.

Minor Degree Courses offered by the Mechanical Engineering Department
(For the B.Tech. students of another Department)

1. For the holistic development of students, in accordance with the NEP-2020 and AICTE guidelines, students may earn an additional 20 credits through minor degree courses offered by various departments of the University from Semester IV to VIII.
2. Minor degree courses are optional, but it will be helpful to align with the needs of industries.
3. Students can only opt for one minor degree course during their studies of the B.Tech. program
4. If students complete all 5 PE (professional elective) category courses offered for the minor degree (a total of 20 credits) from another department for a minor degree, they will receive a B.Tech. Degree in his/her branch.
5. No extra fee for a minor degree course will be charged to the students
6. In case a student is unable to complete all 5 PE courses as offered by the other department for a minor degree at the time of completion of B. Tech. program in his/her own branch, then the student will get B. Tech. degree in his/her own branch without completing the minor degree course from another Department.
7. The minor degree course may be offered by the department through MOOC, as per the guidelines in B. Tech. ordinance 3.0 for the MOOC course.

Minor Degree 1: Robotics and Automation

S. N.	Category	Paper Code	Subject	L	T	P	Credit
1.	PE-1	EME-101	Introduction to Robotics	3	1	0	4
2.	PE-3	EEC-352	Introduction to Embedded Systems & Microcontroller Programming	3	0	2	4
3.	PE-5	EME-501	Sensors and Actuators	3	1	0	4
4.	PE-7	EME-701	Industrial Automation	3	1	0	4
		EEC-752	Robotics System and Intelligent Automation	3	1	0	4
5.	PE-9	EME-901	Mechanics of Robotics	3	1	0	4

EME-101	**INTRODUCTION TO ROBOTICS**	
Course category	:	Professional Elective (PE)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial: 1, Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment is done through tutorials, attendance, home assignments, quizzes, a minor test, and a major theory.
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills, and attitudes after completing this course

1. The students should be to classify the manipulators and understand the specification.
2. Students should be able to understand the mechanical engineering concepts used in robotics.
3. The students should be able to perform a simple kinematics analysis of the manipulator.
4. The students should understand the concept of control techniques.
5. The students should be able to write a computer program for the robot.
6. Students should be able to understand the application of robots in various fields.

Topics Covered	
UNIT-I	
Introduction Definition, Classification of Robots, Geometric classification and control classification, Robot Components, manipulator, controller and its elements, sensory devices, Functions of a robot system, and Robot specifications and applications. **Robot Sensors** Introduction, Classification, position sensors, velocity sensors, acceleration sensors, and proximity sensors. Developments in sensor technology using sensory control Vision.	9
UNIT-II	
Mechanical Components Introduction, Linear motion, Rotational motion, Moment of Inertia-calculation and measurement, Mechanical work and power, Motion conversion, Rotary-to-rotary motion, Rotary-to-linear motion. **Manipulator Kinematics** Position and orientation of a rigid body, Coordinate transformations-translational, rotational, Matrix operators, Coordinate reference frames, Homogeneous coordinates, Homogeneous transformations, manipulator forward solution, inverse solution,	9
UNIT-III	
Robot Control Control Techniques, Dynamics Systems, Transfer Function and State-Space Representation, Performance and stability of Feedback Control, Closed-loop control in position servo, Effect of friction and gravity, DC servomotor, PID Control, Multivariable Robot Control, Stability of Multi-DOF Robot, PD Position Control, Inverse Dynamic Control, Force control	9
UNIT-IV	
Programming Language Industrial robot programming languages examples, VAL language, robot programming for welding, machine tools, material handling etc. **Robot applications** Application of robots in surgery, manufacturing industries, space and underwater. Mobile robots, obstacle avoiding systems, walking devices.	9
Books & References	

1. Introduction to Robotics – J.J. Craig, Pearson Education 2. Introduction to Robotics, S.K.Saha, McGraw Hill Publication 3. Robot Dynamics and Control, Mark W. Spong, M. Vidyasagar, John Wiley & Sons 4. Robotic Engineering-R.D. Klafter, T.A. Chmielewski and M. Negin, Prentice-Hall International 5. Robotics – K.S. Fu, R.C. Gonzalez & CSG Lee, McGraw Hill International 6. Robotics Engineering-an Integrated Approach - Richard D, Klafter, Thomason A Chmiel Owski, Michel Nagin, PHI 7. Robotics & Control- R.K. Mittal & I.J. Nagrath, TMH 8. Industrial Robotics, Technology, Programming, and Application-Groover. M.P. Mc-Graw Hill 9. Robotics Technology and Flexible Automation, S.R. Deb and S. Deb, McGraw Hill Education

EEC-352	**Introduction to Embedded Systems & Microcontroller Programming**	
Course Category	**:**	**Program Electives (PE)**
Pre-requisite Subject	**:**	**NIL**
Contact hours/week	**:**	Lecture:3, Tutorial:0, Practical:2
Number of Credits	**:**	4
Course Assessment methods	**:**	Continuous assessments through teaching assessment, attendance, home assignments, quizzes, one minor test, and one major theory examination.
Course Objectives	**:**	This course introduces students to embedded systems and microcontrollers, focusing on system architecture, programming, and real-world interfacing. It covers the 8051 microcontroller, Arduino platform, and Raspberry Pi, enabling students to design and simulate embedded applications such as sensor monitoring, motor control, and multimedia analytics using C/C++ and Python.
Course Outcomes	**:**	After completing this course, students will be able to show the following knowledge and skills.

1: Understand what embedded systems are and how they differ from general computers. **2:** Learn about the 8051 microcontroller and write simple programs using assembly language. **3:** Know the basics of Arduino, its parts, and how it works. **4:** Write programs in Arduino to control lights, motors, sensors, and displays. **5:** Use Raspberry Pi with Python to work on sound, image, and sensor-based projects.	
Topics Covered	
Unit I	**9**
Introduction to Embedded Systems : Introduction to Embedded Systems, Embedded System Applications, Block diagram of embedded systems, Trends in Embedded Industry, Basic Embedded System Models, Embedded System development cycle, Challenges for Embedded System Design, Evolution of computing systems and applications. Basic Computer architecture: Von-Neumann and Harvard Architecture. Computing performance, Throughput and Latency, Basic high-performance CPU architectures, Microcomputer.	
Unit II	**9**
Microprocessor: 8086 Microprocessor and its Internal Architecture, Pin Configuration and their functions, Mode of Operation, Introduction to I/O and Memory, Timing Diagrams, Introduction to Interrupts. Introduction to C language, Instruction format, C language programming format, Addressing mode, Instruction Sets, Programming 8086 microprocessor.	
Unit III:	**9**
Microcontroller: Introduction to Microcontroller and its families, Criteria for Choosing Microcontroller, 8051-architecture, operation, pin configuration and functions, memory organization, register, I/O ports, addressing modes, instruction sets, instruction classification. Assembly language programming, Interrupts in 8051. Timer/Counter programming for time delay	

generation and waveform generation. Interfacing with ADC, DAC, LEDs and seven segment display	
Unit IV:	**9**
Arduino and Raspberry Pi: Introduction to the Arduino, creating an Arduino programming Environment, Arduino IDE, Arduino programming. Introduction to the Raspberry Pi, basic functionality of the Raspberry Pi board and its processor, setting and configuring the board, programming on Raspberry Pi	

List of Experiments:

1. Write an assembly language code to Perform 8 Bit Addition/Subtraction.
2. To Find the Largest/Smallest Element in an Array Using 8051
3. Write a program of Flashing LED connected to port 1 of the 8051 Microcontroller.
4. Familiarization of Arduino UNO board and Arduino IDE
5. Blinking an LED using Arduino UNO.
6. Write a Program to measure Temperature and Humidity using DHT11 Sensor using Arduino.
7. Building Intrusion Detection System with Arduino and Ultrasonic Sensor
8. Introduction to Raspberry Pi Boards and installation of its Operating System
9. Find distance using Ultrasonic Sensor with Raspberry Pi.
10. Measurement of light intensity and controlling LED using LDR sensor on Raspberry Pi board.

Text and Reference Book

Textbook:

1. Muhammod Ali Mazidi, Rolin D. Mckinlay & Danny Sansey, "PIC Microcontroller and Embedded System SPI, UART using Assembly & C for PICI8," Pearson International Edition, 2008.
2. A. N. Sloss, D. Symes, and C. Wright, "ARM System Developer's Guide: Designing and Optimizing System Software", Elsevier, 2008
3. S. Monk, "Programming the Raspberry Pi" McGraw-Hill Education, 2013.
4. Raj Kamal, Embedded Systems Architecture, Programming, and Design. (2/e), Tata McGraw Hill, 2008.
5. K. V. Shibu, "Introduction to embedded system", McGraw Hill.

EME-501	**SENSORS AND ACTUATORS**	
Course category	:	Professional Elective (PE)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial: 1, Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment is done through tutorials, attendance, home assignments, quizzes, a minor test, and a major theory.
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Understanding of measurement and measuring instruments, sensors, and transducers.
2. The knowledge of measurements of displacement, pressure, strain, temperature, force, torque with different principles.
3. Knowledge of different micro-fabrication techniques.
4. Able to understand the fundamentals of micro manufacturing, bulk manufacturing, etc.
5. The knowledge of different types of actuators such as pneumatic actuators, hydraulic actuators, single-phase motor, 3-phase motor, induction motor, synchronous motor, stepper motors, and servo motors.
6. The knowledge of different actuation materials such as piezo electric and shape memory alloys etc.

Topics Covered	
UNIT-I	
Brief overview of measurement:	9

Measurement systems, measurement variables, Introduction to Instruments, Simple instrument model, Modifying and Interfering Inputs, characteristics of instruments, Static characteristics, Accuracy, Precision, Resolution, sensitivity, linearity, and stability etc., Dynamic characteristics, speed of response, fidelity, lag, dynamic errors etc., calibration of instruments.	
UNIT-II	
Sensors: Classification of sensors, Measurement of physical quantities with working principles, displacement sensors, position sensors, motion sensors, tactile and proximity sensors, strain gauge sensors, force sensors, temperature sensors. Optical encoder, ultrasonic transducers etc.	9
UNIT-III	
Sensor-fabrication technologies: Miniaturization, need of miniaturization, classification of micro-fabrication, Ion-implantation, Diffusion, Photolithography, Introduction to micro-fabrication technologies, Bulk micromachining, surface micromachining, LIGA, assembly, and packaging.	9
UNIT-IV	
Pneumatic and hydraulic actuation systems: definition, example, types, selection. Pneumatic actuator. Electro-pneumatic actuator. Hydraulic actuator, control valves and valve selection. **Electrical actuation systems:** Electric motors; single phase motor; 3-phase motor; induction motor; synchronous motor; stepper motors and servo motors, solid-state switches, solenoids.	9

Books & References

1. Measurement, Instrumentation, and Sensors Handbook. John G. Webster, Editor-in-chief, CRC Press 1999).
2. Handbook of modern Sensors. Jacob Fraden, AIP Press, Woodbury (1997).
3. An Introduction to Microelectromechanical Systems Engineering. Nadim Maluf, Artech House Publishers, Boston (2000).
4. Fundamentals of Microfabrication. Marc Madou, CRC Press, Boca Raton (1997).
5. Micromachined Transducers. Gregory Kovacs, “”, McGraw-Hill, New York (1998).
6. Measurement Systems – Application and Design. E. O. Deobelin and D. Manik, Tata McGraw-Hill (2004).
7. Principles of Industrial Instrumentation. D. Patranabis, Tata McGraw-Hill, eleventh reprint (2004).
8. Instrument Engineers’ Handbook: Process Measurement and Analysis. B. G. Liptak, CRC (2003).

EME-701		**Industrial Automation**
Course category	:	Professional Elective (PE)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial: 1, Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment is done through tutorials, attendance, home assignments, quizzes, a minor test, and one major examination.
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Understand the principles, strategies, and levels of automation in modern production systems, including production economics
2. Analyze various methods of automated material transport, flow lines, transfer mechanisms, and buffer storage systems.
3. Evaluate types and design aspects of material handling equipment, AGVs, and conveyor systems in automated environments.
4. Understand automated storage and retrieval systems (AS/RS) and product identification technologies like barcodes and RFID.
5. Explore the design and types of automated assembly systems and different control technologies used in industrial automation.

6. Apply principles and methods of automated inspection and testing, including CMMs, sensors, and machine vision systems.

Topics Covered	
UNIT-I	9
Introduction: Definition and scope of industrial automation, Benefits and challenges of automation, Types of automation, Overview of automation pyramid, Industry 4.0 and smart manufacturing, Automation in Production System, Principles and Strategies of Automation, Basic Elements of an Automated System, Advanced Automation Functions, Levels of Automations. Production Economics.	
UNIT-II	9
Material Transport and Safety and Standards in Automation: Automated Flow lines, Methods of work part Transport, Transfer Mechanism, and Buffer Storage. Functional safety, Interlocks and fail-safe systems, Industrial standards, Hazardous area classification.	
UNIT-III	9
Material handling and Identification Technologies: The material handling function, Types of Material Handling Equipment, Analysis for Material Handling Systems, Design of the System, Conveyor Systems, Automated Guided Vehicle Systems. **Automated Storage Systems:** Storage System Performance, Automated Storage/Retrieval Systems, Work-in-process Storage, Product identification system: Barcode, RFID etc.	
UNIT-IV	9
Automated Assembly Systems: Design & Types of Automated Assembly Systems. Different control technologies in automation: Automated Inspection and Testing: Automated Inspection Principles and Methods, Sensor Technologies for Automated Inspection, Coordinate Measuring Machines, Other Contact Inspection Methods, Machine Vision and other optical Inspection Methods.	
Books & References	

1. **Industrial Automation: Hands On** byFrank Lamb McGraw Hill; 1st edition
2. Computer Based Industrial Control by Krishna Kant, PHI Learning Pvt. Ltd
3. An Introduction to Automated Process Planning Systems by Tien Chien Chang & Richard A. Wysk, Prentice Hall Professional Technical Reference
4. Anatomy of Automation by Amber, George H, Prentice-Hall.

EEC-752		**Robotics Systems and Intelligent Automation**
Course Category	:	**Program Electives**
Pre-requisite Subject	:	**NIL**
Contact hours/week	:	Lecture:3, Tutorial:1, Practical:0
Number of Credits	:	4
Course Assessment Methods	:	Continuous assessments through teaching assessment, attendance, home assignments, quizzes, one minor test and one major theory examination.
Course Objectives	:	This course introduces students to the fundamentals of robotics and mechatronics, focusing on robot types, kinematics, dynamics, and trajectory planning. It covers key concepts like sensors, actuators, transformation matrices, control systems, and robotic vision. Students will gain theoretical and practical knowledge to analyze, model, and design robotic systems for real-world applications, with hands-on exposure to simulation and control techniques.
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course.

1. Understand the basic types, structure, and movements of robots, including serial and parallel robots.
2. Learn how to calculate robot motion, speed, force, and plan smooth movement paths.
3. Identify and explain key mechatronic components like sensors, actuators, and electric circuits used in automation.

4. Understand the basics of robotic vision and how robots use cameras and sensors to see and respond to their environment. 5. Learn how control systems work in robots and apply basic control methods like PID and advanced techniques for precise movement.	
Topics Covered	
Unit I:	**9**
Fundamentals of Robotics and Kinematics Introduction – Types and classification of robots, science of robots, technology of robots Elements of Robots – Homogeneous transformation, joints and links, link transformation matrices, actuators, transmission systems, and sensors Kinematics of Serial Robots – Direct and inverse kinematics of serial robots, inverse kinematics of a general 6R robot Kinematics of Parallel Robots – Loop-closure constraint equations, direct and inverse kinematics of parallel robots, mobility of parallel manipulators.	
Unit II:	**9**
Analysis, Dynamics, and Trajectory Planning Velocity and Static Analysis of Manipulators – Linear and angular velocity of links, Jacobian for serial and parallel manipulators, singularities, statics of manipulators Dynamics of Serial and Parallel Robots – Lagrangian formulation, equations of motion, inverse dynamics, and simulation Trajectory Planning – Planning smooth and accurate motion paths for robotic systems, Visualization in simulation environment.	
Unit III:	**9**
Introduction to Mechatronics and Components Introduction to Mechatronics – Concept and scope of mechatronics, system design with practical examples Electric Circuits and Components – Basic circuit elements, passive and active components, applications in automation Sensors – Measurement of position, speed, stress, strain, temperature, vibration, acceleration, pressure, and flow Actuators – Working principles and types, electromagnetic actuators, solenoids, relays, electric motors (DC, AC, Stepper, Servo), hydraulic and pneumatic actuators.	
Unit IV:	**9**
Fundamentals of Robotic Vision and Control Systems Robotic Vision – Basics of robotic vision systems, use of cameras and sensors for environmental perception and Visualization in simulation environment, Control System Analysis – Feedback control fundamentals, system stability, and frequency domain analysis Control System Design – State-space representation, Internal Model Control (IMC), PID control design Manipulator Control Techniques – Computed torque control, robust and adaptive control, advanced control methods including neural networks, soft computing, and force control.	
Text and Reference Books	
Textbook: 1. Fu, K.S., Gonzalez, R.C., and Lee, C.S.G., Robotics: Control, Sensing, Vision and Intelligence, Tata McGraw-Hill, 2008. 2. Ghosal, A., Robotics: Fundamental Concepts and Analysis, Oxford University Press, 2006. 3. Craig, J.J., Introduction to Robotics: Mechanics and Control, Pearson Prentice Hall, 2005. 4. Wilamowski, B.M., and Irwin, J.D., The Industrial Electronics Handbook – Control and Mechatronics (2nd Edition), CRC Press, Taylor and Francis Group LLC, 2011. 5. Bolton, W., Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, Pearson Education Limited, 2008. 6. Horn, B.K.P., Robot Vision, MIT Press, 1986. 7. Corke, P., Robotics, Vision and Control: Fundamental Algorithms in MATLAB, Springer Tracts in Advanced Robotics, 2011.	

EME-901	MECHANICS OF ROBOTICS	
Course category	:	Professional Elective (PE)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial: 1, Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment is conducted through tutorials, attendance, homework assignments, quizzes, a minor test, and a major theory examination.
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Understanding the types of manipulators and its components.
2. The students should be able to calculate the degrees of freedom of the manipulator and the transformation matrix.
3. The students should be able to perform the kinematics of a serial manipulator using D-H conventions.
4. The students should understand the concepts of workspace and singularity.
5. The students should be able to generate the path and trajectory.
6. The students should be able to perform the dynamics of the manipulator.

Topics Covered	
UNIT-I	9
Introduction Manipulator, Classification, End-Effector, locomotion, and manipulation. Serial and parallel manipulators. Descriptions, Degree of Freedom, Examples. **Transformation** Position and orientation, transformation and homogeneous transformation matrix.	
UNIT-II	9
Kinematics of Serial Manipulator Kinematic parameters, different notations, Denavit-Hartenberg (DH) representation, arm matrix. Forward and inverse kinematics. Analytical and numerical solutions. Examples.	
UNIT-III	9
Jacobian matrix and Manipulator statics Mapping between configuration-space to operational-space. Jacobian matrix and Pseudo inverse concepts. Introduction to workspace singularities. Manipulator statics: Conservation of energy or power, the mapping between operation-space to configuration-space inputs, examples	
UNIT-IV	9
Trajectory generation Path and Trajectory. Configuration (joint) space trajectory and operational (task) space trajectory generations. **Manipulator dynamics** Motion dynamics: Forward and inverse dynamics. Lagrangian (Lagrange-Euler) and Newton-Euler formulations. Examples.	

Books & References

1. Introduction to Robotics – J.J. Craig, Pearson Education
2. Introduction to Robotics, S.K.Saha, McGraw Hill Publication
3. Robot Dynamics and Control, Mark W. Spong, M. Vidyasagar, John Wiley & Sons
4. Robotic Engineering-R.D. Klafter, T.A. Chmielewski and M. Negin, Prentice-Hall International
5. Robotics – K.S. Fu, R.C. Gonzalez & CSG Lee, McGraw Hill International

6. Robotics Engineering-an Integrated Approach - Richard D, Klafter, Thomason A Chmiel Owski, Michel Nagin, PHI
7. Robotics & Control- R.K. Mittal & I.J. Nagrath, TMH
8. Industrial Robotics, Technology, Programming, and Application-Groover. M.P. Mc-Graw Hill
9. Robotics Technology and Flexible Automation, S.R. Deb and S. Deb, McGraw Hill Education

Minor Degree 2: Energy and Environment

S. N.	Category	Paper Code	Subject	L	T	P	Credit
1.	PE-1	EME-102	Fundamentals of Renewable Energy Sources	3	1	0	4
2.	PE-3	EME-302	Renewable Energy Technologies	3	1	0	4
3.	PE-5	EME-502	Energy Storage Systems	3	1	0	4
4.	PE-7	EME-702	Environmental Impact Assessment	3	1	0	4
5.	PE-9	EME-902	Performance Assessment and Economics	3	1	0	4
Total							20

EME-102	Fundamentals of Renewable Energy Sources	
Course category	:	Professional Elective (PE)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial: 1, Practical: 0
Number of Credits	:	4
Course Assessment Methods	:	Continuous assessment is done through tutorials, attendance, home assignments, quizzes, a minor test, and a major theory.
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills, and attitudes after completing this course

1. Explain the principles of renewable energy conversion processes and analyze the global and Indian renewable energy availability.
2. Introduction of various renewable energy sources with its social as well as environmental implications and the concept of the Internet of Energy (IoE).
3. Fundamentals of solar energy with its characteristics as well as measurements and various hydraulic energy systems.
4. Principles, characteristics and limitations of wind and tidal energy.
5. Introduction to biomass energy with its conversion technologies and various practical applications.
6. Principles, limitations, and applications of geothermal energy.

Topics Covered	
UNIT-I	9
Introduction to Renewable Energy Principles of renewable energy and sustainable development, Global and Indian renewable energy availability and potential, Overview of solar, wind, hydraulic, tidal, wave, ocean thermal, biomass, geothermal, and oil shale energy, Social and environmental implications of renewable energy, Introduction to the Internet of Energy (IoE) and its applications.	
UNIT-II	9
Solar and Hydraulic Energy Fundamentals Solar radiation: Characteristics, estimation on horizontal and inclined surfaces, Solar radiation measurement: Pyrheliometers, Pyrometers, Sunshine Recorders, Solar photovoltaic systems: Principles, advantages, and limitations, Hydraulic energy: Principles of hydropower, types of turbines (Pelton, Francis, Kaplan), and small-scale hydropower systems.	
UNIT-III	9
Wind and Tidal Energy **Wind energy:** Properties, availability in India, wind velocity, and power estimation. Wind Energy Conversion Systems (WECS): Components, classification (Horizontal axis: single, double, multi-blade; Vertical axis: Savonius, Darrieus). **Tidal energy:** Mechanics, characteristics, and harnessing methods, Advantages and limitations of tidal energy systems.	
UNIT-IV	9
Biomass and Geothermal Energy **Biomass energy**: photosynthesis, biofuels, and biomass resources; Biomass conversion technologies: fixed dome, urban waste to energy, gasification; Geothermal energy: Principles, availability, and extraction methods; Challenges and opportunities in biomass and geothermal energy utilization.	
Books & References	

1. Duffie, J. A., & Beckman, W. A. (2013). *Solar Engineering of Thermal Processes*, Fourth Edition, Wiley.
2. Tiwari, G. N., & Ghosal, M. K. (2007). *Fundamentals of Renewable Energy Sources*. Alpha Science International Limited.
3. Mukherjee, D., & Chakrabarti, S. (2004). *Fundamentals of Renewable Energy Systems*. New Age International.
4. Kothari, D. P., Singal, K. C., & Ranjan, R. (2011). *Renewable Energy Sources and Emerging Technologies*. PHI Learning Pvt. Ltd.
5. Paish, O. (2002). *Small Hydropower: Technology and Current Status*. Renewable and Sustainable Energy Reviews.

EME-302	Renewable Energy Technologies	
Course category	:	Professional Elective (PE)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial: 1, Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment is done through tutorials, attendance, home assignments, quizzes, a minor test, and a major theory.
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills, and attitudes after completing this course.

1. Design solar thermal and photovoltaic systems for energy generation.
2. Analyze wind energy conversion technologies for efficiency.
3. Evaluate hydraulic and ocean energy systems for practical applications.
4. Apply biomass conversion technologies for energy production.
5. Develop hybrid renewable energy systems for decentralized power.
6. Integrate renewable technologies into existing energy infrastructure.

Topics Covered	
UNIT-I	9
Advanced Solar Energy Technologies Solar thermal power plants: Parabolic trough, solar tower, and dish systems. Photovoltaic systems: Module efficiency, balance of systems, and performance analysis. Energy storage for solar: Batteries, thermal storage, and emerging technologies. Applications of solar energy in rural and urban settings.	
UNIT-II	9
Wind and Hydraulic Energy Systems Aerodynamics of wind turbines: Blade design and performance optimization. Hydropower technologies: Large-scale dams, run-of-river, and micro-hydropower systems. Hydraulic Turbine Design and Efficiency: Selection Criteria for Turbines. Wind farm planning: Site selection, layout, and grid integration.	
UNIT-III	9
Ocean and Tidal Energy Technologies Ocean Thermal Energy Conversion (OTEC): Principles, types, and global installations. Wave energy converters: Oscillating water columns, point absorbers, attenuators. Tidal barrages and tidal stream systems: Design and environmental considerations. Future prospects of ocean energy technologies.	
UNIT-IV	9
Biomass and Hybrid Systems Advanced biomass conversion: Anaerobic digestion, pyrolysis, and co-firing. Hybrid renewable energy systems: Solar-wind, solar-hydraulic, and multi-source integration. Energy management in decentralized power systems, Case studies on renewable energy technology implementations.	
Books & References	

1. Sukhatme, S. P. (2005). Solar Energy: Principles of Thermal Collection and Storage. Tata McGraw Hill.
2. Sørensen, B. (2017). Renewable Energy: Physics, Engineering, Environmental Impacts, Economics and Planning. Academic Press.
3. Boyle, G. (2012). Renewable Energy: Power for a Sustainable Future. Oxford University Press.
4. Kalogirou, S. A. (2013). Solar Energy Engineering: Processes and Systems. Academic Press.
5. Dixon, S. L., & Hall, C. A. (2014). Fluid Mechanics and Thermodynamics of Turbomachinery. Butterworth-Heinemann.

EME-502	Energy Storage Systems	
Course category	:	Professional Elective (PE)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial: 1, Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce and One Minor test and One Major Theory.
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Explain the principles of various energy storage technologies.
2. Analyze the performance of battery storage systems.
3. Evaluate thermal and mechanical storage systems for renewable integration.
4. Design energy storage solutions for specific applications.
5. Assess the economic viability of storage systems.
6. Integrate storage systems with renewable energy technologies including hydraulic systems.

Topics Covered	
UNIT-I	
Introduction to Energy Storage Need for energy storage in renewable energy systems, including hydraulic energy, Types of energy storage: Electrochemical, thermal, mechanical, and electrical, Key parameters: Energy density, power density, efficiency, and lifespan, Role of energy storage in grid stability and renewable integration.	9
UNIT-II	
Battery Storage Systems Principles of electrochemical storage: Lead-acid, lithium-ion, and flow batteries, Battery performance: Charge-discharge cycles, efficiency, and degradation, Battery management systems (BMS) and safety considerations, Applications of batteries in renewable energy systems, including hydropower.	9
UNIT-III	
Thermal and Mechanical Storage Thermal storage: Sensible heat, latent heat, and thermochemical storage, Mechanical storage: Pumped hydro, compressed air energy storage (CAES), flywheels, Performance analysis and efficiency of thermal and mechanical systems, Integration with solar thermal, hydraulic, and other renewable systems.	9
UNIT-IV	
Emerging Storage Technologies and Applications Emerging technologies: Solid-state batteries, hydrogen storage, supercapacitors, Hybrid storage systems: Combining multiple storage technologies for renewable integration, Case studies on energy storage in microgrids and off-grid systems, including hydropower, Challenges and future trends in energy storage development.	9
Books & References	

1. Huggins, R. A. (2010). Energy Storage. Springer.
2. Dunn, B., Kamath, H., & Tarascon, J. M. (2011). Electrical Energy Storage for the Grid: A Battery of Choices. Science.
3. Züttel, A., et al. (2011). Hydrogen as a Future Energy Carrier. Wiley.
4. Ter-Gazarian, A. (2011). Energy Storage for Power Systems. IET.

EME-702		**Environmental Impact Assessment**
Course category	:	Professional Elective (PE)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial: 1, Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment is conducted through tutorials, attendance, homework assignments, quizzes, a minor test, and a major theory examination.
Course Objectives	:	The objective of this course is to provide students with knowledge of the concepts, procedures, and methodologies used in Environmental Impact Assessment (EIA) to assess the positive and negative impacts of a project.
Course Outcomes	:	Upon completion of this course, the student will demonstrate the ability to: 1. Understand the basic concepts of Environmental Impact Assessment (EIA). 2. Understand the processes involved in Environmental Impact Assessment (EIA) for various projects. 3. Apply various methodologies for adopting Environmental Impact Assessment at different stages. 4. Understand the concept and scope of Environmental auditing by applying it in different types of projects. 5. Apply the concept of Environmental Impact Assessment in various sectors, like energy, transport, mining etc. 6. Apply the concept of EIA integrated with recent emerging technologies.

Topics Covered	
UNIT-I	9
Basic Concepts Definition and Purpose of Environmental Impact Assessment (EIA), Origin and development of EIA, Methods to carry out EIA, Hierarchy in EIA, Types of EIA **EIA Process** Components of an Environmental Impact Assessment, Potential impacts of a project, Prediction and Mitigation, Management and monitoring, Environment Management Plan, Importance of EIA	
UNIT-II	9

EIA Methodologies Introduction, Criteria for the selection of EIA Methodology, EIA methods, EIA Screening and Scoping, Prediction and Assessment of Environmental Impacts, Mitigation Measures and Impact Management, Monitoring, Auditing, and Post-Assessment, Ad Hoc Method, Overlay Method	
UNIT-III	9
Environmental Auditing (EA) Basic Concepts: Introduction, Objectives, Scope, Types of environmental audits, General Audit Methodology EA Process, Strategy and Management: Elements of Audit Process, Waste Audits and Pollution Prevention Assessments, EA in Industrial Projects	
UNIT-IV	9
Sectoral Applications of EIA EIA in Energy Sector (Thermal Power Projects, Oil & Gas Exploration), Land use planning and management, EIA in Agriculture, Cement Industries, and Mining Projects Emerging Trends in EIA Strategic Environmental Assessment, Climate Change and EIA, Public Participation and Social Impact Assessment	

Textbooks and References:

1. Wathern P., "Environmental Impact Assessment: Theory and Practice", Routledge Publishers,1990
2. Glasson J., Therivel Riki, Chadwick Andrew, "Introduction to Environmental Impact Assessment", Oxford Brookes University 2012/ 4th edition
3. Shrivastava A.K., Baxter Nicola, Grimm Jacob, "Environmental Impact Assessment", APH Publishers, 2003
4. Marriott B., "Environmental Impact Assessment: A Practical Guide", McGraw-Hill Publication,1997
5. Anjaneyulu Y., Manickam Valli, "Environmental Impact Assessment Methodologies", CRC Press 2011
6. Whitelaw, K. and Butterworth, ISO 14001: Environmental System Handbook, 1997

EME-902	**Performance Assessment and Economics**	
Course category	:	Professional Elective (PE)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial: 1, Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment is conducted through tutorials, attendance, homework assignments, quizzes, a minor test, and a major theory examination.
Course Outcomes	:	Upon completing this course, students are expected to demonstrate the following knowledge, skills, and attitudes.

1. Evaluate the performance of renewable energy systems, including hydraulic energy.
2. Conduct economic analysis of renewable energy projects.

3. Apply performance metrics to optimize system efficiency. 4. Assess financial viability using cost-benefit analysis. 5. Analyze policy incentives for renewable energy adoption. 6. Develop strategies for cost-effective renewable energy deployment.	
Topics Covered	
UNIT-I	9
Performance Metrics for Renewable Energy Systems **Key performance indicators:** Efficiency, capacity factor, and energy yield, Performance assessment of solar, wind, hydraulic, and biomass systems. Data collection and monitoring techniques for renewable systems. **Factors affecting system performance:** Environmental and operational.	
UNIT-II	9
Economics of Renewable Energy Systems **Cost components:** Capital, operational, and maintenance costs for renewable systems, including hydropower. **Economic metrics:** Net present value (NPV), internal rate of return (IRR), payback period. Levelized cost of energy (LCOE) for renewable energy systems, Sensitivity analysis for economic feasibility.	
UNIT-III	9
Financial Mechanisms and Policy Incentives **Financing models:** Grants, loans, and public-private partnerships for renewable projects, Government policies and subsidies for renewable energy, including hydropower, Impact of carbon pricing and renewable energy certificates. Case studies on successful renewable energy financing.	
UNIT-IV	9
Optimization and Cost Reduction Strategies **System optimization:** Design improvements and technology upgrades for renewable systems; Strategies for reducing their lifecycle costs, including hydraulic energy. Role of digital tools and IoT in performance monitoring. Future trends in cost-effective renewable energy deployment.	
Books & References	
1. Short, W., Packey, D. J., & Holt, T. (1995). A Manual for the Economic Evaluation of Energy Efficiency and Renewable Energy Technologies. NREL. 2. Stoft, S. (2002). Power System Economics: Designing Markets for Electricity. Wiley-IEEE Press. 3. Sørensen, B. (2017). Renewable Energy: Physics, Engineering, Environmental Impacts, Economics and Planning. Academic Press. 4. Twidell, J., & Weir, T. (2015). Renewable Energy Resources. Routledge.	

Minor Degree 3: Smart Manufacturing

S. N.	Category	Paper Code	Subject	L	T	P	Credit
1.	PE-1	EME-103	Smart Manufacturing	3	1	0	4
2.	PE-3	EME-303	Additive Manufacturing	3	1	0	4
3.	PE-5	EME-503	Smart Materials and Structures	3	1	0	4
4.	PE-7	EME-703	Automation in Manufacturing	3	1	0	4
5.	PE-9	EME-903	Machine Learning for Production Optimization	3	1	0	4
Total							20

EME-103	Smart Manufacturing	
Course category	:	Professional Electives (PE)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 4, Tutorial: 0, Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, one Minor test and one Major Theory
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Discuss the importance and be able to critically discuss the role of smart manufacturing systems in industry.
2. To understand basic concept of Smart Manufacturing/Industry-4.0.
3. To proficient with various hardware and software used in Advanced Automation, and Smart Manufacturing systems.
4. To build and assess cyber security enabled applications for manufacturing and supply chain.
5. To provide consulting services in the field of Smart Manufacturing Systems.
6. To pursue higher education in advancements in the field of Smart Manufacturing Systems.

Topics Covered	
UNIT-I	**9**
Introduction to Smart Manufacturing Introduction to smart manufacturing, difference from conventional/legacy manufacturing; Smart Manufacturing Processes Dimensions: Demand Driven and Integrated Supply Chains; Dynamically Optimized Manufacturing Enterprises (plant + enterprise operations); Real Time, Sustainable Resource Management (intelligent energy demand management, production energy optimization and reduction of GHG).	
UNIT-II	**9**
Smart Design/ Fabrication Smart Design/Fabrication - Digital Tools, Product Representation and Exchange Technologies and Standards, Agile (Additive) Manufacturing Systems and Standards. Mass Customization, Smart Machine Tools, Robotics and Automation (perception, manipulation, mobility, autonomy), Smart Perception – Sensor networks and Devices.	
UNIT-III	**9**
Smart Communication system Information, Mobility, Communication Technologies, Protocols, Cyber Physical Systems – the next generation of Embedded Systems and Networks, IT and OT convergence, co-creation and collaboration enablement. Smart Cloud- Hyper scale Computing; Application Delivery.	
UNIT-IV	**9**
Smart Applications Online Predictive Modeling, Monitoring and Intelligent Control of Machining/Manufacturing and Logistics/Supply Chain Processes; Smart Energy Management of manufacturing processes and facilities.	
Books & References	

1. Bahga and V. Madisetti, Internet of Things, A hands-on approach, CreateSpace Independent Publishing Platform, 1st edition, 2014, ISBN: 978-0996025515.
2. R. Zurawski, Integration Technologies for Industrial Automated Systems, 1st edition, CRC Press, 2006, ISBN: 9780849392627
3. S. Jeschke, C. Brecher, H. Song, and D. B. Rawat, Industrial Internet of Things: Cybermanufacturing Systems, Springer, 1st edition, 2017, ISBN: 978-3319425580.
4. D. Boswarthick, O. Elloumi, and O. Hersent, M2M communications: A systems approach, Wiley, 1st edition, 2012, ISBN: 978-1119994756.
5. Anton-Haro and M. Dohler, Machine-to-machine (M2M) Communications: Architecture, Performance and Applications, Woodhead Publishing, 1st edition, 2015, ISBN: 978-1782421023.
6. G. Alciatore and M. B. Histand, Introduction to Mechatronics and Measurement Systems, McGraw-Hill, 4th edition, 2014, ISBN: 978-9339204365.
7. F. Cecelja, Manufacturing Information and Data Systems, 1st edition, ButterworthHeinemann, 2002, ISBN: 9781857180312.

EME 303		**Additive Manufacturing**
Course category	:	Professional Electives (PE)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial: 1, Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, one Minor test and one Major Theory
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills, and attitudes after completing this course

CO1: Understand the fundamental principles and historical evolution of Additive Manufacturing (AM) technologies
CO2: Analyze and resolve data-related issues in AM including STL file errors, digital inspection, and network-based operations
CO3: Demonstrate knowledge of materials used in AM and understand the impact of solidification, microstructure, and material properties on part performance
CO4: Compare and contrast various AM processes based on materials and working principles (e.g., powder-based, solid-based, droplet-based)
CO5: Apply concepts of monitoring, control, and defect mitigation in AM to enhance product quality
CO6: Integrate the knowledge of reverse engineering and traditional manufacturing with AM for applications like rapid prototyping and tooling

Topics Covered	
UNIT-I	9
Introduction to Additive Manufacturing (AM) Historical developments, Fundamentals of RP/AM Systems and their Classification, Rapid prototyping process chains, 3D modelling and mesh generation, Data conversion and transmission.	
UNIT-II	9
Additive manufacturing Data base Rapid prototyping data formats, STL format, STL file problems, STL file repair, Network based operations, Digital inspection, Data warehousing and learning from process data; Types of curves and its application in AM.	
UNIT-III	9
Materials and Mechanics for AM	

Discussion on different materials, multifunctional and graded materials in AM, Role of solidification rate, Evolution of non-equilibrium structure, Structure property relationship, Grain microstructure.	
UNIT-IV	9
Processing and Applications of different AM Techniques Powder-based AM processes involving sintering and melting (selective laser sintering, shaping, electron beam melting. involvement). Printing processes (droplet based 3D Solid-based AM processes, extrusion based fused deposition modeling, Stereolithography, Micro- and nano-additive. Discussion on applications of different AM processes. Monitoring and control of defects. Introduction to reverse engineering Traditional manufacturing via AM, Direct processes – Rapid Prototyping, Rapid Tooling.	

Books & References

1. Rapid Manufacturing: An Industrial Revolution for the Digital Age. Neil Hopkinson, Richard Hague, Philip Dickens (Editors); Wiley; Jan., 2006; ISBN: 10: 0470016132; 13: 978-0470016138.
2. Additive Manufacturing Technologies; Rapid Prototyping to Direct Digital Manufacturing. Ian Gibson, David W. Rosen, Brent Stucker; Springer; January, 2010; ISBN: 978-1-4419-1119-3.
3. Rapid Prototyping: Principles and Applications. Rafiq I. Noorani; Wiley; Oct., 2005; ISBN: 10: 0471730017; 13: 978-0471730019.
4. User's Guide to Rapid Prototyping. Todd Grimm; Society of Manufacturing Engineers; February, 2004; ISBN: 0-87263-697-6.
5. Rapid Prototyping - Laser-based and Other Technologies. Patri K. Venuvinod and Weiyin Ma; Kluwer Academic Publishers; October, 2003; ISBN: 1-4020-7577-4.

EME-503		**Smart Materials and Structures**
Course category	:	Professional Electives (PE)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial: 1, Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, one Minor test and one Major Theory
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

CO1: Understand the fundamental principles and types of smart materials including piezoelectric, magnetostrictive, electro-active, shape memory materials, and smart fluids.

CO2: Explain the working principles and applications of various sensors and actuators used in smart structures, including their role in vibration control and structural health monitoring.

CO3: Analyze the behavior of smart composites using micro- and macro-mechanics principles, and model laminated composite structures based on classical plate theory.

CO4: Formulate and simulate the governing equations of motion for smart composite beams and apply finite element modeling for dynamic analysis.

CO5: Apply knowledge of data acquisition, signal processing, and control systems in the context of smart materials and structures.

CO6: Evaluate the latest advancements in smart structures including self-sensing transducers, energy harvesting materials, self-healing polymers, and emergent intelligent systems.

Topics Covered	
UNIT-I	9
Introduction to different types of crystal system Introduction to Single Crystals and Polycrystalline, metallic, ionic, covalent and mixed bonding; fundamentals of crystallography, crystal systems, unit cells, primitive cells, structures of metals, ceramics, polymers, and glass used in composite materials.	
UNIT-II	9
Smart Composites Piezoelectric Polymers, Magneto strictive materials, Electro-active Materials, Electronic Materials, Polymer Matrix Composite (PMC), Metal Matrix Composite (MMC), Ceramic Matrix Composite (CMC), Nanocomposite, Biomaterials and Biocomposite, Shape Memory Effect, Shape Memory Alloys.	
UNIT-III	9
Applications of Smart materials Strain gauges, optical fiber sensors, piezoelectric sensors, MEMS sensors, Actuators: Types, working principles (piezoelectric, SMA-based, electrostatic, and magnetic), Control systems: Basic control strategies for smart structures (PID, fuzzy logic, neural networks).	
UNIT-IV	9
Future Trends of Smart Materials Smart structures in aerospace (adaptive wings, morphing structures), Civil infrastructure monitoring (bridges, buildings, seismic damping), Biomedical applications (smart implants, drug delivery systems), Smart composites and morphing materials. Challenges, limitations, and research trends in smart materials and structures.	
Books & References	

1. A.V. Srinivasan, Smart Structures –Analysis and Design, 1st Edition, Cambridge University Press, New York, 2001.
2. M. V. Gandhi and B. S. Thompson, Smart Materials and Structures, Chapmen & Hall, London, 1992
3. C. Brian, Smart Structures and Materials, Artech House, 2000
4. P. Gauenzi, Smart Structures, Wiley, 2009
5. W. G. Cady, Piezoelectricity, Dover Publication, New York, 2014.

EME-703	**Automation in Manufacturing**	
Course category	:	Professional Electives (PE)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 4, Tutorial: 0, Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, one Minor test, and one Major Theory
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course
1. Underline the Basics of knowledge of various automation components and systems.		

2. Identify the architecture of the industrial automation system.
3. Construct the block diagram of an industrial automation and control system and supervisory control and data acquisition (SCADA).
4. Categorize industrial parameters like temperature, pressure, force, displacement, speed, flow, level, humidity and pH.
5. Combine the automation process of industry through Internet of Things.
6. Interpret the programmable logic controllers for industrial automation and use of robot for industrial applications.

Topics Covered

UNIT-I	9
Introduction to Automation Automation overview, Requirement of automation systems, Architecture of Industrial Automation system, Introduction of PLC and supervisory control and data acquisition (SCADA). Industrial bus systems: modbus & profibus. Levels of automation, Automation principles and strategies. Advanced automation functions: safety, maintenance.	
UNIT-II	9
Mechanization and Automation Introduction to Material storage/handling and transport systems, and its automation using AS/RS, AGVS and conveyors etc. Mechanization and automation, product cycle, hard vs. flexible automation, Capital- intensive vs. low cost automation. Assembly line Automation: automated assembly systems, transfer systems, vibratory bowl feeders, non-vibratory feeders, part orienting.	
UNIT-III	9
Automation based components Sensors for temperature, pressure, force, displacement, speed, flow, level, humidity and pH measurement. Actuators - Principle and selection of mechano-electrical actuators, DC motors, Stepper Motors, Servo Motors, Brushless DC Motor, Solenoid Actuators, process control valves.	
UNIT-IV	9
Computer-aided measurement and control systems Role of computers in measurement and control, Elements of computer-aided measurement and control, man-machine interface, computer-aided process control hardware, process-related interfaces, Communication and networking, Industrial communication systems, Data transfer techniques, Computer-aided process control software	

Books & References

1. Industrial Instrumentation and Control By. S.K. Singh The McGraw Hill Companies, 2003, ISBN 0-07-048290-X
2. Industrial control handbook, Parr, Butterworth-Heinemann; 3rd edition, 1998, ISBN: 9780750639347
3. Programmable logic controller, G. Dunning, Delmar, ISBN- 9781401884260
4. Automation, Production Systems and Computer-Integrated Manufacturing, Mikell P. Groover, Prentice Hall, 2007, ISBN-13: 978-8120334182
5. Industrial Instrumentation, Control and Automation, S. Mukhopadhyay, S. Sen and A. K. Deb, Jaico Publishing House, 2013, ISBN: 9788184954098.
6. Electric Motor Drives, Modelling, Analysis and Control, R. Krishnan, Prentice Hall India, 2002, ISBN: 978-0130910141

EME-903		Machine Learning for Production Optimization
Course category	:	Professional Electives (PE)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial: 1, Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, one Minor test, and one Major Theory
Course Outcomes	:	Upon completing this course, students are expected to demonstrate the following knowledge, skills, and attitudes.

CO1: Understand the foundational concepts of Machine Learning, including types of learning, workflows, essential mathematics, and programming tools like Python, NumPy, Pandas, and Scikit-learn.
CO2: Apply data manipulation, model building, and evaluation techniques for supervised and unsupervised learning in production environments.
CO3: Demonstrate the ability to handle data ingestion, transformation, deployment strategies, and monitoring of ML models in real-time production systems.
CO4: Analyze and implement production optimization techniques such as A/B testing, hyperparameter tuning, and model explainability while addressing challenges like data drift, retraining, and security.
CO5: Evaluate real-world case studies on ML applications in production optimization including predictive maintenance, quality control, and inventory management.
CO6: Design, develop, and deploy a machine learning model for a real-world production optimization problem using project-based learning and present findings effectively.

Topics Covered

UNIT-I	9
Introduction to Machine learning Define Machine learning, Types of learning (Supervised, Unsupervised, Reinforcement), machine learning workflow, basic mathematics for machine learning, and programming basics (Python: NumPy, Pandas, Scikit-learn).	
UNIT-II	9
Machine Learning in Production Data ingestion and transformation, model training and evaluation, model deployment and monitoring.	
UNIT-III	9
Production Optimization Techniques: A/B testing and experimentation, hyperparameter tuning, model Explainability. **Production Challenges and Solutions:** Data drift and concept drift, model degradation and retraining and security and privacy considerations.	
UNIT-IV	9
Project-Based Learning Students will work on a real-world production optimization problem, develop a machine learning model and deploy it in a simulated environment, present their findings and discuss challenges and solution.	

Books & References

1. Machine Learning in Production: Developing and Optimizing Data Science Workflows and Applications (Addison-Wesley Data & Analytics Series)
2. Optimization in Machine Learning and Applications (Anand J. Kulkarni, Suresh Chandra Satapathy, Springer Nature)
3. Python Crash Course, 2nd Edition: A Hand: A Hands-On, Project-Based Introduction to Programming by Eric Matthes

Minor Degree 4: Computational Engineering

S. N.	Category	Paper Code	Subject	L	T	P	Credit
1.	PE-1	EME-104	Numerical Methods for Engineers	3	1	0	4
2.	PE-3	EME-304	Software Application for Engineering Problem	2	0	4	4
3.	PE-5	EME-504	Computational Modelling & Simulation	3	0	2	4
4.	PE-7	EME-704	Optimization Techniques in Engineering	3	1	0	4
5.	PE-9	EME-904	Finite Element Methods	3	1	0	4
Total							20

EME-104	Numerical Methods for Engineers	
Course category	:	Professional Electives (PEs)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial: 1, Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, viva voce, one Minor tests and One Major Theory exam.
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Understanding of fundamentals and errors in numerical methods and their application in engineering.
2. Ability to solve linear and nonlinear algebraic equations using numerical methods.
3. Knowledge of interpolation, curve fitting, numerical differentiation and integration techniques.
4. Ability to solve ordinary and partial differential equations numerically.
5. Develop algorithms and code using MATLAB/Python to solve practical engineering problems.
6. Critical comparison of methods with respect to accuracy, efficiency and convergence.

Topics Covered	
UNIT-I	9
Fundamentals of Numerical Methods Introduction to numerical computation, sources of error, error propagation and stability. Solution of algebraic and transcendental equations: Bisection, Regula-Falsi, Newton-Raphson methods. **Linear system of equations**: Gauss Elimination, Gauss-Seidel, LU Decomposition.	
UNIT-II	9
Interpolation and Curve Fitting Finite difference operators, Newton's forward, backward and central difference interpolation, Lagrange interpolation. **Curve fitting:** Least squares method, Linear and polynomial regression. Numerical Differentiation and Integration: Finite difference approximations, Trapezoidal rule, Simpson's rules. Thermometers, bimetallic thermocouples, thermistors, and pyrometers	
UNIT-III	9
Ordinary Differential Equations Euler's method, Modified Euler's, Runge-Kutta methods of 2nd and 4th order, Predictor-Corrector methods. Boundary Value Problems and Applications in Engineering.	
UNIT-IV	9
Partial Differential Equations and Advanced Applications Finite difference methods for PDEs: Elliptic, Parabolic and Hyperbolic equations., Stability and convergence of numerical schemes. Introduction to numerical linear algebra and eigenvalue problems.	

Books & References

1. S.S. Sastry, Introductory Methods of Numerical Analysis, PHI.
2. Steven C. Chapra & Raymond P. Canale, Numerical Methods for Engineers, McGraw-Hill.
3. Jain, Iyengar & Jain, Numerical Methods for Scientific and Engineering Computation, New Age International.
4. Balagurusamy E, Numerical Methods, Tata McGraw-Hill.
5. Mathews J.H. & Fink K.D., Numerical Methods Using MATLAB, Pearson Education.

EME-304		Software Applications for Engineering Problems
Course category	:	Professional Electives (PE)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 2, Tutorial: 0, Practical: 4
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce, one minor test, and one major theory & practical examination
Course Objectives	:	To develop skills for using different software's for solving mechanical engineering problems.
Course Outcomes	:	Upon completion of this course, the student will demonstrate the ability to: 1. Understand the concept of EES software for mechanical engineering applications 2. Understand the concept of MATLAB software for mechanical engineering applications 3. Understand the concept of ANSYS software for mechanical engineering applications 4. To analyze the mechanical engineering problems using different software's. 5. Ability to analyze structural problems using ANSYS 6. Acquire ability to analyze fluid flow problems using EES

Topics Covered	
UNIT-I:	6
Introduction to EES and Its applications for Integration, Differential Equations and Thermal Problems	
UNIT-II	6
Introduction to MATLAB and its applications for Engineering mechanics and Vibration problems.	
UNIT-III	6
Introduction to ANSYS Workbench, Types of analysis that can be done using ANSYS.	
UNIT-IV	6
Structural Analysis, Thermal and Fluid Flow Analysis	

List of Practical:

1. To find out the integration with Runga-Kutta method using EES
2. To use the Integral function with parametric Table using ES
3. To determine the thermal efficiency of vapor power cycle using EES.
4. To determine the diagram efficiency of impulse steam turbine using EES.
5. To write a MATLAB program to determine the magnitude and direction of the resultant of 3-coplanar forces.
6. To write a MATLAB script for plotting the non-dimensional response magnitude for a system with harmonically moving base
7. To Find the deflection of simply supported beams using ANSYS
8. To Find the deflection of cantilever beams using ANSYS
9. To find out the velocity and pressure variations in pipe flow using ANSYS.
10. To perform analysis on duct flow using ANSYS

Textbooks and References:

1. MATLAB: An Introduction with Applications by Rao V Dukkipati New Age International Pvt Ltd
2. Getting Started with MATLAB: A Quick Introduction for Scientists & Engineers by Rudra Pratap, Oxford; Edition (1 January 2010)
3. ANSYS Manual
4. EES Manual

EME-504	Computational Modeling and Simulation	
Course category	:	Professional Electives
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial: 0, Practical: 2
Number of Credits	:	4
Course Assessment Methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce, one minor test, and one major theory & practical examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Understanding the techniques of modelling
2. Knowledge of different types of simulation techniques.
3. The knowledge to simulate the models for optimum control by using software.
4. The knowledge of neurons, the architecture of neural networks, knowledge representation, and learning algorithms.
   able to understand the optimizations and design of Systems.
5. The modeling knowledge based on expert knowledge like: Fuzzy sets, Fuzzy models etc.

Topics Covered	
UNIT-I	9
Introduction System, environment, input and output variables, State variables; Static and Dynamic systems; Hierarchy of knowledge about a system and Modeling Strategy **Physical Modeling** Dimensions analysis, Dimensionless grouping of input and output variables of find empirical relations, similarity criteria and their application to physical models.	
UNIT-II	9
Modeling of System with Structure Review of conservation laws and the governing equation for heat, mass and momentum transfer, Deterministic model-(a) distributed parameter models in terms of partial identification and their solutions and (b) lumped parameter models in terms of differential and difference equations, state space model, transfer functions block diagram and sub systems, stability of transfer functions, modeling for control	
UNIT-III	9
Optimizations and Design of Systems Summary of gradient-based techniques: Nontraditional optimization techniques (1) genetic Algorithm (GA)- coding, GA operations, elitism, Application using MATLAB:(ii) Simulated Annealing. **Neural Network Modeling of Systems only with Input-output Database:** Neurons, architecture of neural networks, knowledge representation, learning algorithm. Multilayer feed forward network and its back propagation learning algorithm, Application to complex engineering systems and strategy for optimum output	
UNIT-IV	9
Modeling Based on Expert Knowledge: Fuzzy sets, Membership functions, Fuzzy Inference systems, Expert Knowledge and Fuzzy Models, Design of Fuzzy Controllers. **Simulation of Engineering Systems:** Monte-Carlo simulation, Simulation of continuous and discrete processes with suitable examples from engineering problems	
EXPERIMENTS **Minimum five experiments are to be conducted from the following:**	
1. Introductions to programming with MATLAB	

2. Find the response of a lumped variable model expressed in terms of transfer function using MATLAB for input of (i) unit step function (ii) unit impact function and (iii) unit ramp function 3. Use of Simulink in MATLAB for engineering problems 4. Use of Neural Network in MATLAB for engineering problems 5. Use of FIS and ANFIS in MATLAB for engineering problems 6. Monte Carlo simulation
Books & References
1. Zeigler B.P. Praehofer. H. and Kim I.G. "Theory of modeling and simulation", 2 nd Edition. Academic press 2000 2. Ogata K " Modern control Engineering" 3 rd edition. Prentice hall of India 2001 3. Jang J.S.R. sun C.T and Mizutani E,, "Neuro-Fuzzy and soft Computing ", 3 rd edition, Prentice hall of India 2002 4. Shannon, R. E., "System Simulation: the Art and Science", Prentice Hall Inc. 1990 5. Pratab.R " Getting started with MATLAB" Oxford university Press 2009

EME-704	**Optimization Techniques in Engineering**	
Course category	:	Professional Electives (PE)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial: 1, Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, viva voce, one minor test and one major theory exam.
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

CO1: Comprehend the techniques and applications of Engineering optimization.
CO2: Analyze characteristics of a general linear programming problem.
CO3: Apply basic concepts of mathematics to formulate an optimization problem.
CO4: Analyze various methods of solving the unconstrained minimization problem.
CO5: Analyze and appreciate a variety of performance measures for various optimization problems.

Topics Covered	
UNIT-I	
Transportation problems: Finding an initial basic feasible solution by Northwest Corner rule, Least Cost rule, Vogel's approximation method, Degeneracy, Optimality test, MODI method, Stepping stone method. **Assignment problems:** Hungarian method for solution of Assignment problems. Integer Programming: Branch and Bound algorithm for solution of integer programming problems.	9
UNIT-II	
Non-linear programming: Introduction to non-linear programming. Unconstraint optimization: Fibonacci and Golden Section Search method. Constrained optimization with equality constraint: Lagrange multiplier, Projected gradient method. Constrained optimization with inequality constraint: Kuhn-Tucker condition, Quadratic programming.	9
UNIT-III	
Non-linear programming: Introduction to non-linear programming. Unconstraint optimization: Fibonacci and Golden Section Search method. Constrained optimization with equality constraint:	9

Lagrange multiplier, Projected gradient method. Constrained optimization with inequality constraint: Kuhn-Tucker condition, Quadratic programming	
UNIT-IV	
Queuing models: General characteristics, Markovian queuing model, M/M/1 model, Limited queue capacity, multiple server, Finite sources, Queue discipline.	9

Books & References

1. Operations Research- Principle and Practice, A. Ravindran, D. T. Philips, J. Solberg,
2. Second edition, Wiley India Pvt Ltd.
3. Operation Research, Prabhakar Pai ,Oxford University Press
4. Optimization for Engineering Design, Kalyanmoy Deb, PHI Learning Pvt Ltd.
5. Operations Research, H.A.Taha, A.M. Natarajan, P. Balasubramanie, A. Tamilarasi,
6. Pearson Education, Eighth Edition.
7. Engineering Optimization, S S Rao, New Age International Pvt Ltd, 2003.
8. Linear and Non-linear Optimization, Stephen G. Nash, A. Sofer, McGraw
9. Hill, 2nd Edition.
10. Engineering Optimization, A.Ravindran, K.M. Ragsdell, G.V. Reklaitis, Wiley India Pvt. Ltd, Second edition.
11. Operations Research, F.S.Hiller, G.J.Lieberman, Tata McGraw Hill, Eighth Edition,
12. 2005.
13. Operations Research, P.K.Gupta, D.S.Hira, S.Chand and Company Ltd, 2014.

EME- 904		**Finite Element Methods in Engineering**
Course category	:	Professional Elective (PE)
Pre-requisite Subject	:	NIL
Contact hours/week	:	Lecture: 3, Tutorial: 1, Practical: 0
Number of Credits	:	4
Course Assessment methods	:	Continuous assessment through tutorials, attendance, home assignments, quizzes, practical work, record, viva voce, one minor test, and one major theory & practical examination
Course Outcomes	:	The students are expected to be able to demonstrate the following knowledge, skills and attitudes after completing this course

1. Elaborate the fundamental theory of the FEA method
2. Develop the governing FE equations for systems governed by partial differential equations
3. Formulate with Rayleigh-Ritz and Galerkin Method
4. Construct the finite element models for structural applications like truss and beam
5. Apply the FE method for heat transfer problems
6. Outline the application and use of the FE method to solve various engineering problems

Topics Covered

UNIT-I	
Introduction to Finite Element Analysis: Basic Concepts, applicability and applications, basic equations of solid mechanics, boundary and initial conditions, Euler-Lagrange equation, Generalization of finite element concepts. Discretization, Interpolation models, weighted residual and variational approaches, the Principle of minimum potential energy, and virtual work.	9
UNIT-II	
Element types– Line element (bar, truss, beam, and frame element), Plane elements- Triangular, rectangular, quadrilateral, sector, Solid elements – tetrahedron and hexahedron.	9

Curved and isoperimetric elements, coordinate systems, and numerical integration, Mesh generation.	
UNIT-III	
One-dimensional finite element analysis: bar element, beam element, frame element - Heat transfer problems.	9
UNIT-IV	
Two-dimensional finite element analysis. Additional Applications of FEM: Finite Elements for Elastic Stability, Finite Elements in Fluid Mechanics, Dynamic Analysis	
Books & References	

1. J. N. Reddy, An introduction to the Finite Element Method, 3rd edition, McGraw-Hill, 2006.
2. C.S. Krishnamoorty, Finite Element Analysis, Tata McGraw-Hill
3. David V. Hutton, Fundamentals of Finite Element Analysis, McGraw Hill D. Maity,
4. Erik G. Thompson, Introduction to the Finite Element Method: Theory, Programming and Applications, John Wiley
5. K. J.Bathe, Finite Element Procedures, Prentice-Hall of India, New Delhi, India