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RAMDEOBABA UNIVERSITY, NAGPUR

Formerly Shri Ramdeobaba College of Engineering & Management (RCOEM) Est. 1984

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RAMDEOBABA UNIVERSITY,

NAGPUR–440013

School of Engineering Sciences

Department of Mechanical Engineering

PROGRAMME SCHEME & SYLLABI

M. Tech. in Industrial Automation and Robotics

2025-26

SEM-I

SN	Course Code	Course Name	L	P	S	Total	Credits	Maximum Marks		Total	Exam Duration (Hrs)	Category
								Continuous Assessment	End Sem. Examination			
1	24ES55TH1175	Research Methodology and IPR	3		2	3	3	50	50	100	3	PC
2	24ES55TH1176	Principles of Robotics	3		2	3	3	50	50	100	3	PC
3	24ES55TH1177	Robot Drives and Actuators	3		2	3	3	50	50	100	3	PC
4	24ES55TH1178	Control System	3	-	2	3	3	50	50	100	3	PC
5	24ES55TH1179	Economics and Financial Management	3		2	3	3	50	50	100	3	PC
6	24ES55TH1180	Program Elective-1	3	-	2	3	3	50	50	100	3	PE
7	24ES55PR1181	Robotics Lab		4		4	2	50		50		PC
8	24ES55PR1182	Control System Lab	-	4		4	2	50		50		PC
9	24ES55PR1183	Design thinking, Innovation and Entrepreneurship		2		2	1	50		50		PC
10	24ES55TH1184	Professional Practices and Ethics	1	-		1	1	50		50		PC
		Total	**19**	**10**	**12**	**29**	**24**	**500**	**300**	**800**		

Program Elective-1

Course Code	Program Elective-1
24ES55TH1180-1	Mobile Robotics
24ES55TH1180-2	Advanced Optimization Techniques
24ES55TH1180-3	Product Design and Process Planning

SEM-II

SN	Course Code	Course Name	L	P	S	Total	Credits	Maximum Marks		Total	Exam Duration (Hrs)	Category
								Continuous Assessment	End Semester Examination			
1	24ES55TH1285	Industrial Automation	3		2	3	3	50	50	100	3 Hrs	PC
2	24ES55TH1286	Artificial Intelligence and Machine Learning in Robotics	3	-	2	3	3	50	50	100	3 Hrs	PC
3	24ES55TH1287	Robotic Vision Systems	3	-	2	3	3	50	50	100	3 Hrs	PC
4	24ES55TH1288	Industrial Hydraulics and Pneumatics	3	-	2	3	3	50	50	100	3 Hrs	PC
5	24ES55TH1289	Program Elective -2	3	-	2	3	3	50	50	100	3 Hrs	PE
6	24ES55TH1290	Open Elective-1	3	-	2	3	3	50	50	100	3 Hrs	OE
7	24ES55PR1291	Industrial Automation and IoT Lab		4		4	2	50		50		PC
9	24ES55PR1292	Artificial Intelligence and Machine Learning in Robotics Lab	-	4		4	2	50		50		PC
10	24ES55PR1293	Technical Seminar		4		4	2	50		50		PC
		Total	**18**	**12**	**12**	**30**	**24**	**450**	**300**	**750**		

Course Code	Program Elective -2
24ES55TH1289-1	Bioinspired Robotics
24ES55TH1289-2	Digital Manufacturing
24ES55TH1289-3	Industrial Internet of Things (IIoT)

Course Code	Open Elective
24ES55TH1290-1	Industrial robotics
24ES55TH1290-2	Automation Engineering

Exit Option: On completion of the first year and the eight-week industry internship, students have the EXIT option to qualify for a PG Diploma in Industrial Automation and Robotics

SEM-III

SN	Course Code	Course Name	L	P	S	Total	Credits	Maximum Marks		Total	Exam Duration (Hrs)	Category
								Continuous Assessment	End Semester Examination			
1	24ES55TH1394	Program Elective -3	2	-	2	2	2	50	50	100	3 Hrs	PC
2	24ES55PR1395	Dessertation Phase - I	-	3		3	12	100	100	200		PC
		Total	**2**	**3**	**2**	**5**	**14**	**150**	**250**	**400**		
OR												
3	24ES55PR1396	Industry Internship-Phase-I / Research Internship-Phase-I / TBI Internship-Phase-I					14	150	250	400		PC

Course Code	Program Elective-3
24ES55TH1394-1	Supply Chain Management
24ES55TH1394-2	Rapid Prototyping
24ES55TH1394-3	Project Management

SEM-IV												
SN	**Course Code**	**Course Name**	**L**	**P**	**S**	**Total**	**Credits**	**Maximum Marks**		**Total**	**Exam Duration (Hrs)**	**Category**
								Continuous Assessment	**End Semester Examination**			
1	24ES55PR1497	Dessertation Phase-II	-	6		6	18	200	200	400		PC
OR												
2	24ES55PR1498	Industry Internship-Phase-II / Research Internship-Phase-II/TBI Internship-Phase-II					18	200	200	400		PC

Total Credits: 24 + 24 + 14 + 18 = 80

Semester I

Course Code: 24ES55TH1175			Course: Research Methodology and IPR
L: 3	T: 0	P: 3	Total Credits: 3

Course Outcomes

1. The graduates will be able to define and explain research concepts, objectives, and significance, and identify and formulate research problems.

2. The graduates will be able to apply various research methodologies, data collection techniques, and perform data analysis including regression and hypothesis testing.

3. The graduates will be able to choose research topics, write structured research papers, and adhere to plagiarism rules and ethical standards.

4. The graduates will be able to understand the evolution, development, and types of IPR, including the roles of WIPO and WTO, and the functions of UNESCO in IPR.

5. The graduates will be able to grasp patent objectives, features, and processes, including application, examination, grant, and licensing of patents.

Syllabus:

What is Research?, How to do Research, The Objective of Research, Motivation in Research, Types of Research, Various Research Approaches, Significance of Research.

Research Methods, What is Research Methodology, Research Process, What is Research Problem, Various Components of Research Problem, How to Identify the Research Problem, Steps involved in formulation of Research Problem, Necessity and Techniques involved in Defining Research Problem, Feasibility Check.

What is Hypothesis?, its Characteristics, Examples and Types, Hypothesis Testing, Concepts and Procedure of Hypothesis Testing.

Data Collection, Methods of data collection, Primary Data, Secondary Data, Analysis of data, Simple regression, Multiple regression, linear and non linear correlation and regression

Research Paper and its contents, Choice on topic, Method of writing research paper, Plagiarism including rules of plagiarism

Intellectual Property – The concept of IPR, Evolution and development of the concept of IPR, IPR development process, Trade secrets, utility Models, IPR & Bio diversity, Role of WIPO and WTO in IPR establishments, Right of Property, Common rules of IPR practices, Types and Features of IPR Agreement, Trademark, Functions of UNESCO in IPR maintenance.

Patents – objectives and benefits of patent, Concept, features of patent, Inventive step, Specification, Types of patent application, process E-filling, Examination of patent, Grant of patent, Revocation, Equitable Assignments, Licences, Licensing of related patents, patent agents, Registration of patent agents.

References:

1. Research Methodology Methods and Techniques: Kothari C.K. (2004), New Age International, New Delhi
2. Simulation Modeling and Analysis, Law, A. M., and W. D. Kelton, 1991, McGraw Hill
3. Applied Statistics; Probability for Engineers: Montgomery, Douglas C.; Runger, George C. (2007), (Wiley India)
4. Patents myths and reality, Shiva, V., Penguin Books India (P) Ltd., New Delhi
5. Schaum's Quick Guide to Writing Great Research Papers: Laurie Rozakis, 2nd edition, McGraw.
6. Intellectual Property Rights:Text And Cases, Radhakrishnan , R. &Balsubramaian, S., Excel Books Publishers, New Delhi.
7. Catherine J. Holland, "Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets", Entrepreneur Press, 2007.
8. David Hunt, Long Nguyen, Matthew Rodgers, "Patent searching: tools & techniques", Wiley, 2012.

Semester I

Course Code: 24ES55TH1176			Course: Principles of Robotics
L: 3	T: 0	P: 3	Total Credits: 3

Objectives: To impart knowledge about kinematic and dynamic analysis of robot manipulators.

Course Outcomes: The students will able to

CO1: Understand the history, evolution and anatomy of robot.

CO2: Comprehend the concept of Mapping and Transformations for kinematic of manipulator.

CO3: Understand and apply the concept of forward and inverse kinematics of manipulator.

CO4: Explore the computational challenges of Manipulator differential motion.

CO5: Develop dynamic modeling of manipulator

Unit I: Introduction to robotics

Evolution of robots and robotics, Laws of robotics, Progressive advancement in robots, Robot anatomy: links, joint and joint notation scheme, degree of freedom, arm configuration, wrist configuration, End-effector and Grippers, Classification of robot, Human arm characteristics, Design and control issues, Manipulation and control, Sensors and vision, Programming robot, Future aspect.

Unit II: Coordinate Frames, Mapping and Transformations

Coordinate frames: Mapping, Mapping between rotated frames, Mapping between translated frames, Mapping between rotated and translated frames. Description of object in space.

Transformation of vectors: Rotation of vector, translation of vector, combined rotation and translation of vectors, composite transformation, inverting a homogeneous transform.

Fundamental Rotation matrix: Principal axis rotation, fixed angle representation, Euler angle representation, Equivalent angle axis representation.

Unit III: Direct/Forward kinematics modeling

Mechanical Structure and notation, Description of links and joints, Kinematic modeling of manipulator, Denavit-hartenberg notation, Kinematic relationship between adjacent links, Manipulator transformation matrix.

Inverse kinematic modeling

Manipulator workspace, Solvability of inverse kinematic model: existence of solution, multiple solution, Solution technique, closed form solution.

Unit IV: Manipulator differential motion and statics

Linear and angular velocity of rigid body, relationship between transformation matrix and angular velocity, mapping velocity vector, velocity propagation along links, Manipulator Jacobian, Jacobian inverse, Jacobian singularity, static analysis.

Unit V: Dynamic modeling

Lagrangian Mechanics, Dynamic modeling of two degree of freedom manipulator, Langrange-Euler Formulation, Newtion-Euler formulation, Comparison of Langrange-Euler Formulation and Newtion-Euler formulation, Inverse dynamics.

Text Books:

1. John J. Craig, Introduction to Robotics Mechanics and Control, Second Edition, Addison Wesly Longman Inc. International Student edition, 1999.

2. R. K. Mittal and I J Nagrath, Robotics and Control, McGraw Hill Education (India) Private Limited, 2017.

Reference Books:

1. R. N Jazar, Theory of Applied Robotics: Kinematics, Dynamics, and Control, Springer; 2nd ed. 2010.

Semester I

Course Code: 24ES55TH1177			Course: Robot Drives and Actuators
L: 3	T: 0	P: 3	Total Credits: 3

Course Objectives

1. Understand the fundamental principles and types of drives and actuators used in robotic systems.
2. Explore the dynamics, modeling, and control of electric, hydraulic, and pneumatic actuators.
3. Develop the ability to select suitable actuation systems for various robotic applications.
4. Analyze drive systems in terms of performance, efficiency, response, and suitability.
5. Apply theoretical concepts to real-world robotic drive system design and control.

Course Outcomes (COs)

After successful completion of the course, students will be able to:

CO1: Classify and analyse various types of actuators and drive systems used in robots.
CO2: Model and evaluate the performance of electric, hydraulic, and pneumatic actuators.
CO3: Design motion control strategies for actuators in robotic systems.
CO4: Select and integrate appropriate drive systems based on task and application requirements.
CO5: Solve engineering problems related to drive sizing, dynamics, and control implementation.

Course Content

Module 1: Introduction to Drives and Actuation Systems

Overview of robotic drive systems: electric, hydraulic, pneumatic, Comparison of drive systems: efficiency, precision, speed, torque, cost. Performance requirements of robot actuators, Torque-speed characteristics and actuator selection criteria

Module 2: Electric Drives and Actuators

DC motors: brushed, brushless, Stepper motors: types, working principles, drive techniques, Servo motors: characteristics, feedback control, encoders, Motor drivers and control circuits, Torque and velocity control using PWM and current regulation, Inverter-based drives and motion controllers

Module 3: Hydraulic and Pneumatic Drives

Principles of fluid power systems, Components: pumps, compressors, valves, cylinders, actuators, Hydraulic actuators: linear and rotary, modeling and control, Pneumatic actuators and control logic, Directional control valves and electro-pneumatic systems, Energy efficiency and response time comparison

Module 4: Modeling and Dynamics of Actuators

Modeling of electrical, hydraulic, and pneumatic actuators, Transfer functions and state-space models, Dynamic response, steady-state and transient analysis, Friction, backlash, compliance, and other non-ideal effects, Force/torque generation and motion equations

Module 5: Drive System Integration and Control

Motor sizing and selection for robotic joints, Drive architecture in industrial robots, Closed-loop control of actuators: PID, feedforward, cascade control, Sensor feedback and encoder interfacing, Safety and protection systems for drive units, Case studies: industrial robot arms, AGVs, collaborative robots

Textbooks

1. **Bolton, W.**, *Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering*, Pearson.
2. **Craig, J.J.**, *Introduction to Robotics: Mechanics and Control*, Pearson.
3. **Mohan, N.**, *Electric Machines and Drives: A First Course*, Wiley.
4. **Esposito, A.**, *Fluid Power with Applications*, Pearson.

Reference Books

1. **Fu, Gonzalez, and Lee**, *Robotics: Control, Sensing, Vision, and Intelligence*, McGraw-Hill.
2. **Deb, S.R.**, *Robotics Technology and Flexible Automation*, McGraw-Hill Education.
3. **Groover, M.P.**, *Industrial Robotics: Technology, Programming, and Applications*, McGraw-Hill.
4. **Mansour and Thayer**, *Analysis and Design of Hydraulic and Pneumatic Systems*, Prentice Hall.
5. **Schröder, D.**, *Electric Drives: Fundamentals, Types and Applications*, Springer.

Suggested Laboratory Experiments / Practical (Optional but Recommended)

If included with a lab component, the following experiments can be conducted:

1. Torque-speed characterization of DC/BLDC motors
2. Position control of a servo motor using encoder feedback
3. Stepper motor interfacing and microstepping techniques
4. Simulation and control of hydraulic actuators (MATLAB/Simulink or Automation Studio)
5. Design and control of pneumatic circuits for linear actuation
6. Tuning a PID controller for an actuator drive system

Semester I

Course Code: 24ES55TH1178			Course: Control System
L: 3	T: 0	P: 3	Total Credits: 3

Course objective: To design the control strategy of the robotic systems.

Course Outcome: The students will able to:

1. Understand the concept of system modelling for control strategy.
2. Understand and apply the concept of linear control
3. Understand and apply the concept of non-linear control
4. Understand and apply the concept of joint and task space for trajectory planning
5. Understand the various methods for system stability.

Unit 1: Introduction and System Modeling

Introduction to manipulator control problem, open and closed loop control, forward and inverse dynamics considerations, properties of the dynamic model, introduction to nonlinear systems and control schemes.

Unit 2: Linear Control

Introduction, control techniques, block diagram, transfer function, signal flow diagram, state space representation, performance and stability of feedback control, Proportional-Derivative-Integral (PID) control, selection of PID controller gains, state feedback control, joint controllers.

Unit 3: Nonlinear Control

Introduction, multivariable robot control, linearized control, Proportional-Derivative (PD) control, computed torque control, robust control, adaptive control, cartesian control, hybrid control.

Unit 4: Joint Space and Task Space Control Schemes

Introduction, manipulator interaction with environment, compliance control, impedance control, force control, position control, velocity control, trajectory control.

Unit 5: System Stability and Optimal Control

Introduction to Lyapunov stability analysis, direct and indirect methods, time varying optimal control, applications and examples.

Text Books:

1. Huang, A., Chien, M. (2010). Adaptive Control Of Robot Manipulators: A Unified Regressor-free Approach. Singapore: World Scientific Publishing Company.
2. Santibáñez, V., Loría Perez, J. A., Loría, A., Davila, V. S., Kelly, R. (2006). Control of Robot Manipulators in Joint Space. Germany: Springer London.
3. Siciliano, B., Bastin, G., Canudas de Wit, C. (2012). Theory of Robot Control. United Kingdom: Springer London.

Reference Books:

1. Villani, L., Oriolo, G., Siciliano, B., Sciavicco, L. (2009). Robotics: Modelling, Planning and Control. Germany: Springer.
2. Park, F. C., Lynch, K. M. (2017). Modern Robotics: Mechanics, Planning, and Control. United Kingdom: Cambridge University Press.
3. Dawson, D. M., Abdallah, C. T., Lewis, F. L. (2003). Robot Manipulator Control: Theory and Practice. Ukraine: CRC Press.
4. Hutchinson, S., Spong, M. W., Vidyasagar, M. (2020). Robot Modeling and Control. United Kingdom: Wiley.

Semester I

Course Code: 24ES55TH1179			Course: Economics and Financial Management
L: 3	T: 0	P: 3	Total Credits: 3

Course Objectives:
To learn the basic Business types, impact of the Economy on Business and Firms specifically.
To analyse the Business from the Financial Perspective.

Course Outcomes:
At the end of the course, student will be able to:
1. Understand the various Forms of Business and the impact of economic variables on the Business.
2. Understand the Demand, Supply, Production, Cost, Market Structure, Pricing aspects of Product.
3. Study the firm's financial position by analysing the Financial Statements of a Company.

COURSE CONTENTS
Unit I. Introduction to Business and Economics
Business: Structure of Business Firm, Theory of Firm, Types of Business Entities, Limited Liability Companies, Sources of Capital for a Company, Non-Conventional Sources of Finance.
Economics: Significance of Economics, Micro and Macro Economic Concepts, Concepts and Importance of National Income, Inflation, Money Supply in Inflation, Business Cycle, Features and Phases of Business Cycle. Nature and Scope of Business Economics, Role of Business Economist, Multidisciplinary nature of Business Economics. Introduction to Start-up Finance, Introduction to Financial Terms, Financial Ratios, Capital Funding, VC's , Funding Rounds, Series A, B..
Unit II. Demand and Supply Analysis (09)
Elasticity of Demand: Elasticity, Types of Elasticity, Law of Demand, Measurement and Significance of Elasticity of Demand, Factors affecting Elasticity of Demand, Elasticity of Demand in decision making, Demand Forecasting: Characteristics of Good Demand Forecasting, Steps in Demand Forecasting, Methods of Demand Forecasting.
Supply Analysis: Determinants of Supply, Supply Function & Law of Supply

Unit III. Production, Cost, Market Structures & Pricing
Production Analysis: Factors of Production, Production Function, Production Function with one variable input, two variable inputs, Returns to Scale, Different Types of Production Functions.

Cost analysis: Types of Costs, Short run and Long run Cost Functions. Market Structures: Nature of Competition, Features of Perfect competition, Monopoly, Oligopoly, and Monopolistic Competition.
Pricing: Types of Pricing, Product Life Cycle based Pricing, Break Even Analysis, and Cost Volume Profit Analysis.

Unit IV. Financial Accounting
Accounting concepts and Conventions, Accounting Equation, Accounting, Cost accounting & Management accounting, Various types of business entities, Accounting principles, postulates & meaning of accounting standards, Accounting cycle, Capital and revenue, Revenue, Expenses, Gains & Losses, Types of accounts & their rules, Journal Entries, Double-Entry system of Accounting, Rules for maintaining Books of Accounts, Journal, Posting to Ledger, Preparation of Trial Balance, Elements of Financial Statements, Preparation of Final Accounts. Create ledger, Preparation of Trial Balance, Finalizations, Preparation of Trading & Profit & Loss account, Understanding of Assets & Liabilities, Concept of Balance Sheet, Preparation of Balance sheet.

Unit V. Financial Analysis (09)
Financial Analysis through Ratios: Concept of Ratio Analysis, Liquidity Ratios, Turnover Ratios, Profitability Ratios, Proprietary Ratios, Solvency, Leverage Ratios (simple problems) Introduction to Break even analysis – Decision Making. Return and Risk, Time Value of Money, Annuities and Accumulation, Discounted Payback period, Net Present Value, IRR , Introduction to Fund Flow and Cash Flow Analysis

Text Books:
1. D. D. Chaturvedi, S. L. Gupta, Business Economics - Theory and Applications, International Book House Pvt. Ltd. 2013.
2. “Financial Accounting”, Dr. Kaustubh Sontakke [Himalaya Publishing House].
3. Dhanesh K Khatri, Financial Accounting, Tata McGraw Hill, 2011.
4. Chandra, Prasanna (2004). Financial Management: Theory and Practice. New Delhi: TATA McGraw Hill.
Reference Books:
1. Accounting Theory & Practice Prof Jawahar Lal [Himalaya Publishing House] Geethika Ghosh, Piyali Gosh, Purba Roy Choudhury, Managerial Economics, 2e, Tata McGraw Hill Education Pvt. Ltd. 2012.

Semester I

Course Code: 24ES55TH1180-1			Course: Mobile Robotics
L: 3	T: 0	P: 3	Total Credits: 3

Course Objective: This course will present various aspects of design, fabrication, motion planning, and control of intelligent mobile robotic systems.

Course Description: This course introduces the fundamentals of robotics with an emphasis on mobile robots, which are integrated mechanical, electrical and computational systems functioning in the physical world. The course aims to provide both theoretical and practical experience to students through lectures and hands-on experiments with real robots and simulation software.

Course Outcomes:

At the end of this course students will able to

1. Explain about mobile robot and robot locomotion also solve problems related to robot kinematics and dynamics.
2. Explain and apply the concept of mobile robot perception.
3. Use and apply any one of the localization techniques.
4. apply path planning and navigation algorithms.

5. Understand and use advanced techniques for robot navigation and to design intelligent robots.

Unit1: Introduction to mobile robots:

Mobile robot, definition, types of robots, Applications of Mobile Robot.

Robot Hardware Robot locomotion, Types of locomotion, hopping robots, legged robots, wheeled robots, stability, maneuverability, controllability,

Robot kinematics and dynamics:

Forward and inverse kinematics, holonomic and nonholonomic constraints, kinematic models of simple car and legged robots, dynamics simulation of mobile robots;

Unit 2: Perception:

Sensors Proprioceptive/Exteroceptive and passive/active sensors, performance measures of sensors, sensors for mobile robots like global positioning system (GPS), Doppler effect-based sensors, vision-based sensors, uncertainty in sensing, filtering;

Unit 3: Localization:

Odometric position estimation, belief representation, probabilistic mapping, Markov localization, Bayesian localization, Kalman localization, positioning beacon systems;

Unit 4: Introduction to Path Planning and Navigation:

Introduction, Path Planning, offline and online path planning, obstacle avoidance, path planning algorithms based on A-star, Dijkstra, Voronoi diagrams, probabilistic roadmaps (PRM), Potential field etc.

Unit 5: Advanced Topics: AI based techniques for navigation, Bio Inspired Algorithm, Multiple robot coordination. Design of intelligent robots

Text Book:

1. R. Siegwart, I. R. Nourbakhsh, “Introduction to Autonomous Mobile Robots”, The MIT Press, 2011

Reference Books:

1. Selected readings from the research literature, to be distributed in class.

Semester I

Course Code: 24ES55TH1180-2			Course: Optimization Techniques
L: 3	T: 0	P: 3	Total Credits: 3

Course Objectives:

1. Student can familiarize the basics formulation of optimization.
2. Study the various decision making and multi criteria approaches.
3. Study of non-linear optimization techniques and multi-objective optimization.
4. Study of non-traditional optimization techniques.

Course Outcomes: The students will able to…..

1. Learn the basics formulation of optimization methods.
2. Learn and apply the various decision analysis techniques.
3. Learn the MCDM method and Multi-objective methods.

4. Learn the non-traditional optimization methods.

COURSE CONTENT

Unit I. Introduction

General Characteristics of mechanical elements, adequate and optimum design, principles of optimization, formulation of objective function, design constraints – Classification of optimization problem. Single variable and multivariable optimization, Techniques of unconstrained minimization

Unit II. Decision Analysis

Golden section, Random, pattern and gradient search methods – Interpolation methods; Optimization with equality and inequality constraints. Hooks and Jeeves Method.

Unit III. Non-Linear Optimization

Decision Trees, Utility theory, Game theory, Multi Objective Optimization, MCDM- Goal Programming, Analytic Hierarchy process

Unit IV. Non-Traditional Optimization-1

Classes P and NP, Polynomial time reductions, Introduction to NP- Hard problems, Overview of Genetic algorithms, Simulated Annealing, neural network based optimization.

Unit V. Non-Traditional Optimization-2

Automotive communication technologies – Design of automotive X-by-Wire systems, - The LIN standard –The IEC/IEEE Train communication network: Applying train communication network for data communications in electrical substations.

Reference Books:

1. Singiresu S.Rao, “Engineering optimization – Theory and practices”, New Age International Publishers, 2013.

2. Ravindran – Phillips –Solberg, “Operations Research – Principles and Practice”, John Wiley India, 2007.

3. Fredrick S.Hillier and G.J. Liberman, “Introduction to Operations Research”, McGraw Hill Inc. 2017.

4. Kalymanoy Deb, “Optimization for Engineering Design”, PHI, 2012.

5. Christos H. Papadimitriou, Kenneth Stieglitz, “Combinatorial Optimization”, PHI 2006.

6. Marius Durea, “An Introduction to Nonlinear optimization theory”, De Gruyter 1st edition 2014.

Semester I

Course Code: 24ES55TH1180-3			**Course: Product Design and Process Planning**
L: 3	**T: 0**	**P: 3**	**Total Credits: 3**

Course objectives:

1. To be Conversant with a set of tools and methods for product design and development.

2. To Develop own abilities to create a new product.

3. To be Aware of the role of multiple functions in creating a new product (e.g. marketing, finance, industrial design, engineering, production).

4. To Coordinate multiple, interdisciplinary tasks in order to achieve a common objective and enhance team-working skills.

COURSE OUTCOMES:

On completion of the course, students will be able to

1. Understand the product design and development process.

2. Apply creative thinking skills for idea generation for Product design.

3. Translate conceptual ideas into products.

4. Present ideas using various types of model prototypes.

5. Test the Prototypes in order to evaluate outcome.

Unit I. Introduction to Product Design

Characteristics of successful product development, Design and development of products, duration and cost of product development, the challenges of product development. Development Processes and Organizations, the front-end process, adopting the generic product development process, the AMF development process, product development organizations, the AMF organization.

Unit II. Product Planning

The product planning process, identifying opportunities. Evaluate and prioritize projects, allocate resources and plan timing, complete pre-project planning, reflect all the results and the process. Identifying Customer Needs: Gather raw data from customers, interpret raw data in terms of customer needs, organize the needs into a hierarchy, establish the relative importance of the needs and reflect on the results and the process.

Unit III. Concept Generation

Product Specifications: What are specifications, when are specifications established, establishing target specifications, setting the final specifications. Concept Generation: The activity of concept generation, clarify the problem, search externally, search internally, explore systematically, reflect on the results and the process. Concept Selection, Overview of methodology, concept screening, and concept scoring.

Unit IV. Concept Testing

Concept Testing: Define the purpose of concept test, choose a survey population, choose a survey format, communicate the concept, measure customer response, interpret the result, reflect on the results and the process. Industrial Design: Assessing the need for industrial design, the impact of industrial design, industrial design process, managing the industrial design process and assessing the quality of industrial design.

Unit V. Design for Manufacturing and Assembly

Design for Manufacturing: Definition, estimation of manufacturing cost, reducing the cost of components, assembly, supporting production, impact of DFM on other factors. Prototyping, Prototyping basics, principles of prototyping, technologies, planning for prototypes.

REFERENCE BOOKS:

1. Product Design and Development - Karl.T. Ulrich, Steven D Eppinger - Irwin McGraw Hill - 2000. 21

2. Product Design and Manufacturing - A C Chitale and R C Gupta, PHI, - 3rd Edition, 2003.

3. New Product Development - Timjones. Butterworth Heinmann - Oxford. UCI -1997.

4. Product Design for Manufacture and Assembly – Geoffery Boothroyd, Peter Dewhurst and Winston Knight –2002.

Semester I

Course Code: 24ES55PR1181			**Course: Robotic Lab**
L: 3	**T: 0**	**P: 3**	**Total Credits: 3**

Semester I

Course Code: 24ES55PR1182			Course: Control System Lab
L: 3	T: 0	P: 3	Total Credits: 3

Semester I

Course Code: 24ES55PR1183			Course: Design Thinking, Innovation and Entrepreneurship
L: 0	P: 2	S	Total Credits: 3

Course Outcomes

1. Be familiar with processes and methods of creative problem solving:
2. Enhance their creative and innovative thinking skills
3. Practice thinking creatively and innovative design and development

UNIT1. Introduction: Making a case for creativity, Creative thinking as a skill, Valuing diversity in thinking: Thinking preferences, Creativity styles, Creativity in problem solving

UNIT2. Pattern Breaking: Thinking differently, Lateral thinking, Mind stimulation: games, brain- twisters and puzzles, Idea-collection processes, Brainstorming/Brain writing, The SCAMPER methods, Metaphoric thinking, Outrageous thinking, Mapping thoughts, other (new approaches)

UNIT3. Using Math and Science, Systematic logical thinking, Using math concepts, Eight- Dimensional (8D) Approach to Ideation: Uniqueness, Dimensionality, Directionality, Consolidation, Segmentation, Modification, Similarity, and Experimentation

UNIT4. Systematic Inventive Thinking: Systematic inventive thinking: The TRIZ methodology, Decision and Evaluation: Focused thinking framework, six thinking hats, and Ethical considerations.

UNIT 5. Design for Innovation: Introduction to design for interaction, nine lessons for innovation, difference in creativity and innovation, Building blocks for innovation

UNIT6.IntellectualProperty: Introduction to intellectual property: Patents, Trademarks

, Trade Secret, Unfair Competition.

Reference Books and TextBook

1. Creative Problem Solving for Managers-Tony Proctor-Routledge Taylor &Francis Group
2. 101Activities for Teaching creativity and Problem Solving-By Arthur B. Vangundy-Pfeiffer
3. H .S. Fogler and S .E. LeBlanc, Strategies for Creative Problem Solving ,Prentice Hall
4. E. Lumsdaine and M. Lumsdaine, Creative Problem Solving, McGraw Hill,

Semester I

Course Code: 24ES55PR1184			Course: Professional Practices and Ethics
L: 1	P: 0	S	Total Credits: 1

Course Objectives

The objectives of the course are to familiarize the students with the prevailing professional practices and to develop professional skills in them. The course also aims at imbibing ethical and moral values among the students.

Course outcomes

At the end of this course students will demonstrate the ability to

1. Develop the moral values of a good human being and a responsible citizen
2. Imbibe the professional ethics appropriate with the engineering profession
3. Become familiar with the professional practices in engineering profession

Introduction to morals, ethics and human values in professional and personal life. Ethical and moral dilemmas and challenges.

Understanding the professional practices in the industry necessary for effective working and adapting to the work culture of the corporate world. Developing professional approach towards work and developing communication and presentation skills.

Case studies related to professional practices and ethics.

Books

Professional Ethics and Human Values by R.S Naagarazan, New Age International Publishers

Semester II

Course Code: 24ES55PR1285			Course: Industrial Automation
L: 3	P: 0	S	Total Credits: 3

Course Objectives

1. The students will gain knowledge of automation in manufacturing field and FMS flexibility.
2. To impart the role of programmable logic controllers in industrial automation and process development.

Course outcomes

At the end of this course students will be able to:

1. Understanding the automation knowledge, in terms of production line analysis.
2. Understand flexible manufacturing systems to improve the manufacturing flexibility.
3. Gain knowledge of process control, PLC architecture and interfacing
4. Understand the development of PLC ladder logic for industrial applications
5. Development of SCADA/HMI for industrial processes

Unit1:

Automation and Production flow lines: Definition, automation principles and strategies, scope of automation, socio-economicconsideration, Production concepts and mathematical models, Methods of workpart transport, Transfer mechanisms,Part feeding devices, analysis of transfer lines without storage, automated flow lines with storage buffers.

Unit2:

Flexible manufacturing systems: Components of FMS, Workstations and Machine centers in FMS, FMS layout configuration, FMS data files, system reports, FMS applications, planning and implementation issues, Types of material handling equipment,Conveyor systems, Automated Guided Vehicle Systems and applications, Analysis of AGVS systems, Automated Storage & Retrieval System, Analysis of AS/RS.

Unit3:

Process Control &Automation: Process control principles, Analog and Digital control, Architecture of Industrial Automation Systems,I/Os: Sensors and switches, Solenoids, Relays and Contactors.

Unit4: Programmable logic controller: PLC Architecture, Interfacing Input and Output devices with PLC, PLC based automated systems, High frequency inputs, PLC standards IEC-61131,latching and internal relays, Data handling,Timer & Counter Instructions, Data Handling Instructions, Sequencing Instructions, Typical PLC Programming Exercises for Industrial Applications.

Unit5:

SCADA & Distributed control system: Elements of SCADA, Features of SCADA, MTU, RTUFunctions, Applications of SCADA, Communications in SCADA, Introduction to DCS, Architecture, Input and output modules, Specifications of DCS.

Text Books:

1. Programmable Logic Controllers, Principles and Applications: John W. Webb, Ronold A Reis, Prentice Hall of India, New Delhi
2. Automation, production System & CIMS: M. P. Groover, Prentice Hall of India, New Delhi
3. SCADA supervisory control and data acquisition: Stuart A. Boyer, ISA Publication.

Reference Books:

1. Computer Control of Manufacturing Systems: YoramKoren, Mcgraw Hill, Delhi
2. CAD/CAM: M. Groover& E. Zimmers , Pearson Education, Delhi
3. Process Control Instrumentation Technology: Curtis Johnson, 8th Edition, Pearson Education

4. Programmable Logic Controllers: Bolton, Elsevier India; Fifth edition
5. Programmable Logic Controllers: Frank D. Petruzella McGraw Hill, Delhi

Semester II

Course Code: 24ES55PR1286			Course: Artificial Intelligence and Machine Learning in Robotics
L: 3	P: 0	S	Total Credits: 3

Course Objective: To introduce the artificial intelligence and machine learning used in the field of robotics.

Course Outcomes: The students shall able to

CO1: Apply the basic principle of AI and its application.
CO2: Understand apply the concept of planning.
CO3: Illustrate the various algorithm for reasoning
CO4: Understand apply the concept of supervised learning.
CO5: Understand apply the concept of unsupervised learning.

Unit 1: Introduction to Artificial Intelligence

History, state of the art, Need for AI in Robotics. thinking and acting humanly, intelligent agents, structureof agents.

Solving problems by searching, informed search and exploration, constraint satisfaction problems, knowledge and reasoning, knowledge representation, first order logic.

Unit 2: Planning

Introduction, planning with forward and backward state space search, partial order planning, planning graphs, planning with propositional logic, planning and acting in real world.

Unit 3: Reasoning

Introduction, uncertainty, probabilistic reasoning, filtering and prediction, Hidden Markov models, Kalman filters, Dynamic Bayesian Networks, Speech recognition, making decisions.

Unit 4: Supervised Learning

Introduction to machine learning, learning input- output functions, types of learning, performance evaluation, noise.
Decision trees and inductive bias, geometry and nearest neighbours, logistic regression, binary classification.

Unit 5: Unsupervised Learning

Introduction, curse of dimensionality, dimensionality Reduction, PCA, clustering, K-means, expectation maximization algorithm, hierarchical clustering, applications in robotics.

Text Books:

1. Stuart Russell, Peter Norvig, "Artificial Intelligence: A modern approach", Pearson Education, India,2016.
2. Negnevitsky, M, "Artificial Intelligence: A guide to Intelligent Systems",. Harlow: AddisonWesley,2002.
3. Michalski, Carbonell, Tom Mitchell, 'Machine Learning', Springer, 2014
4. Rogers, S., Girolami, M. (2016). A First Course in Machine Learning, Second Edition. United Kingdom: CRC Press.

Reference Books:

1. David Jefferis, "Artificial Intelligence: Robotics and Machine Evolution", Crabtree PublishingCompany, 1992.
2. Huimin Lu, Xing Lu, "Artificial Intelligence and Robotics", Springer, 2017.
3. David MacKay, 'Information Theory, Inference and Learning Algorithms', Cambridge, 2003
4. Christopher M. Bishop, "Pattern Recognition and Machine Learning", Springer Pub.

Semester II

Course Code: 24ES55PR1287			Course: Robotic Vision Systems
L: 3	P: 0	S	Total Credits: 3

Course Objectives:

1. To introduce fundamental concepts and techniques in computer vision as applied to robotic systems.
2. To enable understanding of how robots perceive, interpret, and interact with their visual environment.
3. To develop skills in 2D/3D vision, camera modeling, image processing, and vision-based control.
4. To explore practical implementations of vision algorithms in robotic tasks such as navigation, object detection, and manipulation.
5. To provide exposure to real-time robotic vision system design using simulation and hardware platforms.

Course Outcomes:

At the end of the course, students will be able to:

- CO1: Understand principles of image formation, camera models, and image processing techniques for robotic applications.
- CO2: Apply feature detection and image segmentation techniques in real-world robotic tasks.
- CO3: Design and implement 2D and 3D vision algorithms for object recognition and environment mapping.
- CO4: Integrate vision systems with robotic platforms for visual servoing and autonomous navigation.
- CO5: Evaluate performance and limitations of robotic vision systems through simulations and case studies.

Course Modules:

Module 1: Fundamentals of Robotic Vision

Image formation and camera geometry, Pinhole and perspective projection models, Camera calibration (intrinsic and extrinsic parameters), Image acquisition systems and sensors (RGB, IR, Depth), Radiometry and color models

Module 2: Image Processing and Feature Extraction

Image filtering, enhancement, edge detection, Feature detection: corners, blobs (Harris, SIFT, SURF, ORB), Image descriptors and matching, Morphological operations and region growing, Object tracking basics (Kalman and Particle filters)

Module 3: 3D Vision and Scene Understanding

Stereo vision and disparity maps, Structure from motion (SfM), Depth sensing with RGB-D and LiDAR, Point cloud processing and 3D object reconstruction, SLAM (Visual and RGB-D based overview)

Module 4: Vision-Based Robotic Control

Visual servoing (position-based and image-based), Object pose estimation, Grasping and manipulation using vision, Human-robot interaction using vision (gesture, face, posture detection), Vision-based obstacle avoidance

Module 5: Applications and Tools

Machine learning and deep learning in robotic vision (CNN basics), Object detection with YOLO/SSD for robots, ROS-based integration of robotic vision, Case studies: industrial inspection, autonomous vehicles, drones, Hands-on tools: OpenCV, ROS, MATLAB, RealSense, ZED cameras

Textbooks & References:

Textbooks:

1. **"Computer Vision: Algorithms and Applications"** by Richard Szeliski
2. **"Robotics, Vision and Control"** by Peter Corke (Springer)
3. **"Learning OpenCV 4"** by Adrian Kaehler and Gary Bradski

References:

- **"Multiple View Geometry in Computer Vision"** by Richard Hartley and Andrew Zisserman
- **"Digital Image Processing"** by Rafael C. Gonzalez and Richard E. Woods
- **OpenCV and ROS online documentation and tutorials**
- Research papers on visual SLAM, robotic grasping, and visual servoing

Semester II

Course Code: 24ES55PR1288			**Course: Industrial Hydraulics and Pneumatics**
L: 3	**P: 0**	**S**	**Total Credits: 3**

Course objectives:

1. Understanding different fluid properties and applying those while selection of hydraulic fluid in the system.
2. Study and compare different components of hydraulic system based on internal structure.
3. Develop different hydraulic circuits for industrial application.
4. Study different components of pneumatic system and develop circuits for industrial application.
5. Design of Hydraulic or pneumatic system according to application.

COURSE OUTCOMES:

After the successful completion of this course, the student will be able to:

1. Make out working principle of various components used for hydraulic & pneumatic systems.
2. Identify various components of hydraulic & pneumatic systems.
3. Select and design hydraulic and pneumatic system for industrial applications.
4. Understand industrial applications of hydraulic and pneumatic system.
5. Find out the troubleshooting of hydraulic & pneumatic circuits

COURSE CONTENTS

Unit I. Fluid Power Principles And Fundamentals (08)

Introduction to Fluid power- Advantages and Applications- Fluid power systems-Hydraulic power pack and compressor system layout-Comparison of Pneumatics with Hydraulic system – Types of fluids- Properties of fluids Basics of Hydraulics – Hydrostatic Law- Principles of flow – Work, Power and Torque. Properties of air– Perfect Gas Laws.

Unit II. Hydraulic and Pneumatic system symbols And Components (10)

Fluid Power ISO Symbol for Hydraulics and Pneumatics, Hydraulic Actuators: Cylinders – Types and construction, Hydraulic motors Control Components: Direction control, Flow control and Pressure control valves, Introduction to servo and proportional valves - Applications -Types of actuation. Introduction to seals and leakages in Hydraulic system-Cushioning of double acting cylinders

Unit III. Hydraulic Systems (09)

Pumps: Types, classification, principle of working and constructional details of vane pumps, gear pumps, radial and axial plunger pumps, screw pumps, power and efficiency calculations, characteristics curves, selection of pumps for hydraulic Power transmission. Industrial hydraulic circuits-Operation of single acting and double acting cylinders, Speed control circuits, Regenerative, Pump Unloading, Double pump, Sequence, Reciprocation, Synchronization, Fail-safe, Speed control, Electro hydraulic circuits, Mechanical Hydraulic servo systems.

Unit IV. Pneumatic Systems (09)

Working principal of compressors-Filter, Regulator, Lubricator, Muffler -Air control Valves, Pressure regulating valves-Direction control valves, two way, three way, four way valves. Solenoid operated valves, push button, lever control valves. Speed regulating - Methods used in Pneumatics. Pneumatic actuatorsrotary, reciprocating. Air motors- radial piston, vane and axial piston. Basic pneumatic circuit, selection of components. Application of pneumatics in low cost automation and in industrial automation.

Unit V. Circuit design for industrial application (09)

Design of circuits using the components of hydraulic system for Drilling, Planning, Shaping, Punching, and Press. – Selection, Installation fault finding and maintenance of hydraulic and pneumatic components.

TEXT BOOKS:

1. Esposito, “ Fluid Power with application”, Prentice Hall
2. Majumdar S.R, “Oil Hydraulic system- Principle and maintenance”, Tata McGraw Hill
3. Majumdar S.R , “Pneumatics Systems Principles and Maintenance”, Tata McGraw Hill

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REFERENCE BOOKS:

1. J. J. Pipenger, “Industrial Hydraulics”, McGraw Hill
2. Pinches, “Industrial Fluid Power”, Prentice Hall
3. D. A. Pease, “Basic Fluid Power”, Prentice Hall, B. Lall, “Oil Hydraulics”, International Literature Association

Semester II

Course Code: 24ES55PR1289-1			Course: Bio-Inspired Robotics
L: 3	P: 0	S	Total Credits: 3

Course Objectives: The objective of the course is to prepare the students:

1. To understand the biological systems with reference to robotic system
2. To develop biologically inspired robotic applications

Course Outcomes: The expected learning outcome is that the students will be able to:

1. Understand the Bioinspired sensing.
2. Formulate bioinspired motion
3. Differentiate Soft and Hard Robotics
4. Analyse control architecture and behaviour with reference to kinematics
5. Evaluate collective and Biohybrid robotics/ create electromechanical robotic system

UNIT 1:

Fundamentals of Traditional Robots, Biologically-inspired Robots, Introduction, Bio-inspired morphologies, Bio-inspired sensors, Vision, Audition, Touch, Smell, taste, Idiothetic sensors.

UNIT 2:

Fundamentals of Biologically Inspired Robots, Bio-inspired actuators, locomotion, crawling, walking, wall climbing, jumping, swimming, flying, grasping, drilling

UNIT 3:

Soft Robotics, Structural Difference between Hard and Soft Robots, Bio-inspiration in Soft Robotics, Hydrostatic Skeletons, Muscular Hydrostats, Soft Active Plant Structure, Soft Robots, Actuators, Pneumatic Artificial Muscles, Electroactive Polymers, Shape Memory Alloys

UNIT 4:

Bio-inspired control architectures, Behavior-based robotics, learning robots, Evolving robots, Developing robots, Bio-inspired Robot Design Considering Load-bearing and Kinematic Ontogeny of Sea Turtles

UNIT 5:

Energetic anatomy, Collective robotics, Biohybrid robots. Case studies and mini projects in Design and Fabrication of Biologically Inspired Robots

Text Book

1. J.J. Craig. Introduction to Robotics: Mechanics and Control. Prentice Hall; 3rd edition, 2003.

Reference Books

1. G. A. Bekey. Autonomous Robots. MIT Press, 2005.
2. Karl Williams. Amphibionics: Build Your Own Biologically Inspired Reptilian Robot. McGraw-Hill/TAB Electronics, 2003.
3. David Cook. Robot Building for Beginners. Apress, 2002.
4. Handbook of Robotics, Jean-Arcady Meyer and AgnèsGuillot

Web references

https://www.youtube.com/watch?time_continue=7&v=JlSayvpQH54

https://www.youtube.com/watch?time_continue=74&v=vIgpATwOpD0

https://www.youtube.com/watch?time_continue=36&v=IbXRiTbuDvY

Semester II

Course Code: 24ES55PR1289-2			Course: Digital Manufacturing
L: 3	P: 0	S	Total Credits: 3

Course Objectives:

1. To introduce the concepts and technologies underpinning digital transformation in manufacturing.
2. To impart knowledge on integrating digital tools such as CAD/CAM, IoT, cloud platforms, and digital twins.
3. To explore the role of data, automation, and connectivity in creating smart factories.
4. To develop competence in simulation, virtual manufacturing, and additive manufacturing.
5. To prepare students for implementing Industry 4.0 principles in real-world manufacturing systems.

Course Outcomes:

After completing the course, students will be able to:

- **CO1:** Understand the fundamentals and evolution of digital manufacturing technologies.
- **CO2:** Apply CAD/CAM and simulation tools in digital product development.
- **CO3:** Analyze and implement automation and data-driven decision-making in smart factories.
- **CO4:** Integrate cyber-physical systems, IoT, and digital twins into manufacturing workflows.
- **CO5:** Evaluate the benefits and challenges of deploying digital manufacturing in various industries.

Course Modules:

Module 1: Introduction to Digital Manufacturing

- Definition and evolution of digital manufacturing
- Components: digital design, digital production, and digital operations
- Industry 4.0 and Smart Manufacturing frameworks
- Cyber-physical systems (CPS) and digital thread

- Overview of manufacturing execution systems (MES)

Module 2: CAD/CAM and Virtual Manufacturing

- Advanced CAD tools and parametric modeling
- CAM programming and toolpath simulation
- Digital process planning and validation
- CNC machining and post-processing
- Virtual manufacturing and virtual commissioning

Module 3: Automation and Robotics in Digital Manufacturing

- Industrial automation architecture
- Robotics and robotic cells
- Programmable Logic Controllers (PLCs) and SCADA
- Digital control systems and Human-Machine Interface (HMI)
- Safety systems and standards in automated environments

Module 4: Data-Driven Manufacturing

- Role of data analytics and AI in manufacturing
- IoT and sensor integration in production lines
- Cloud platforms and edge computing
- Digital twins and predictive maintenance
- Quality monitoring and statistical process control (SPC)

Module 5: Emerging Technologies and Applications

- Additive manufacturing (3D printing) and hybrid manufacturing
- Augmented Reality (AR)/Virtual Reality (VR) in training and operations
- Sustainability and energy efficiency in digital factories
- Case studies from automotive, aerospace, and electronics sectors
- Future trends: 5G, blockchain in manufacturing, cognitive factories

Textbooks:

1. **“Digital Manufacturing & Automation”** by Rajesh Radhakrishnan and P. K. Suresh
2. **“Manufacturing Automation: Metal Cutting Mechanics, Machine Tool Vibrations, and CNC Design”** by Yusuf Altintas
3. **“Smart Manufacturing: Concepts and Methods”** by Masoud Soroush et al.

Reference Books:

- **“Industry 4.0: The Industrial Internet of Things”** by Alasdair Gilchrist
- **“CAD/CAM: Computer-Aided Design and Manufacturing”** by Mikell P. Groover
- **“Additive Manufacturing Technologies”** by Ian Gibson, David Rosen, Brent Stucker
- Research articles and white papers from Siemens, Rockwell, and NASSCOM on Digital Manufacturing

Semester II

Course Code: 24ES55PR1289-3			Course: IIoT
L: 3	P: 0	S	Total Credits: 3

For developing the IoT based technologies in various engineering applications

Course Outcomes

The expected learning outcome is that the students will be able to:

1. Understand the components of IoT systems.
2. Formulate building blocks of IoT
3. Apply IoT protocols
4. Analyse outcomes of implemented IoT framework/architecture.
5. Create IoT applications to specific engineering domain

Syllabus

UNIT 1: The Internet of Things

An Overview Internet of Things, Conceptual framework and architecture, Internet of Things, Machine to Machine (M2M).

UNIT 2: Internet Principles

The IP Protocol Suite (TCP/IP), IPv6, Application Layer Protocols: HTTP, Encrypted HTTP, Other Application Layer Protocols.

UNIT 3: Communication Protocols

Networking and communication protocols, Application layers, standard libraries, Blutooth, Wifi, Zigbee, WSN.

UNIT 4: Introduction to Arduino sketch Programming

Microcontroller and microprocessor, Arduino and Raspberry pi hardware, Intel Adison, Gallilio, RFID, ARM Cortex boards.

UNIT 5: Applications of IoT

Case studies or mini projects in some of the areas like: Home Automation, Agriculture sector, health sector, Automotive etc.

Text Books

1. Internet of Things, Architechture and Design principles, Raj Kamal, 1st Edition, McGraw Hill education (India) Pvt. Ltd.
2. Designing the Internet of Things, Adrian McEwen and Hakim Cassimally, 1st Edition John Wiley and Sons, Ltd.

Reference Books

1. Learning of Internet of Things, Peter Waher, 1st Edition, Packt Publishing
2. N. Ida, Sensors, Actuators and Their Interfaces, Scitech Publishers, 2014.

Semester II

Course Code: 24ES55TR1290-1			Industrial Robotics
L: 3	P: 0	S	Total Credits: 3

Course Objectives: To understand the basic concepts associated with the design, functioning and applications of Robots.

Course Outcomes

The expected learning outcome is that the students will be able to:

1. Understand the basic of Robotics.
2. Understand the kinematic analysis of Robotics.
3. Understand the dynamics and trajectory planning for manipulator
4. Understand the Sensing, Actuation and control issues of robot
5. Understand the Motion planning and control of mobile robot and explore the various application of robot

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Syllabus

Unit 1: Introduction

Introduction to robots and their evolution, Anatomy and classification of robot, what is and what is not a robot, progressive advancements in robots.

Unit 2: Kinematics of serial robots

Coordinate frame, mapping and transformation, Forward & inverse kinematics, Representation of joints, link representation using D-H parameters, Examples of D-H parameters and link transforms

Unit-3: Dynamics and trajectory planning of serial robot

Linear and angular velocity of links, Manipulator Jacobians, singularity, dexterity for serial manipulators, Euler-Lagrangian formulation for equations of motion for serial manipulators, Joint and Cartesian space trajectory planning and generation.

Unit-4: Sensing, Actuation and control

Kinds of actuators – stepper, DC servo and brushless motors, model of a DC servo motor, Types of transmissions, Purpose of sensors, internal and external sensors, common sensors – encoders, tachometers, strain gauge based force-torque sensors, proximity and distance measuring sensors, vision. Classical control concepts using the example of control of a single link, Independent joint PID control, Control of a multi-link manipulator.

Unit 5: Mobile Robotics and Robot Applications

Mobile robotics, sensing, control, navigation, path planning algorithms (holonomic, non-holonomic)

Industrial application of robots: material handling, processing, assembly, inspection, welding, and painting. Non industrial applications: domestic, medical, military operations, children toys, humanoids. Robot safety.

Text Books:

R. K. Mittal, I. J. Nagrath, “Robotics and Control”, McGraw Hill Education, 2017.

Reference Books:

1. Mikell P Groover, Nicholas G Odrey, Mitchel Weiss, Roger N Nagel, Ashish Dutta, “Industrial

Robotics, Technology programming and Applications", McGraw Hill, 2012.

2. Craig. J. J. “Introduction to Robotics- mechanics and control”, Addison- Wesley, 1999.

Semester II

Course Code: 24ES55TH1290-2			Automation Engineering
L: 3	P: 0	S	Total Credits: 3

Course Objectives

3. The students will gain knowledge of automation in manufacturing field and FMS flexibility.
4. To impart the role of programmable logic controllers in industrial automation and process development.

Course outcomes

At the end of this course students will be able to:

6. Understanding the automation knowledge, in terms of production line analysis.
7. Understand flexible manufacturing systems to improve the manufacturing flexibility.
8. Gain knowledge of process control, PLC architecture and interfacing
9. Understand the development of PLC ladder logic for industrial applications
10. Development of SCADA/HMI for industrial processes

Unit1:

Automation and Production flow lines: Definition, automation principles and strategies, scope of automation, socio-economicconsideration, Production concepts and mathematical models, Methods of workpart transport, Transfer mechanisms,Part feeding devices, analysis of transfer lines without storage, automated flow lines with storage buffers.

Unit2:

Flexible manufacturing systems: Components of FMS, Workstations and Machine centers in FMS, FMS layout configuration, FMS data files, system reports, FMS applications, planning and implementation issues, Types of material handling equipment,Conveyor systems, Automated Guided Vehicle Systems and applications, Analysis of AGVS systems, Automated Storage & Retrieval System, Analysis of AS/RS.

Unit3:

Process Control &Automation: Process control principles, Analog and Digital control, Architecture of Industrial Automation Systems,I/Os: Sensors and switches, Solenoids, Relays and Contactors.

Unit4: Programmable logic controller: PLC Architecture, Interfacing Input and Output devices with PLC, PLC based automated systems, High frequency inputs, PLC standards IEC-61131,latching and internal relays, Data handling,Timer & Counter Instructions, Data Handling Instructions, Sequencing Instructions, Typical PLC Programming Exercises for Industrial Applications.

Unit5:

SCADA & Distributed control system: Elements of SCADA, Features of SCADA, MTU, RTUFunctions, Applications of SCADA, Communications in SCADA, Introduction to DCS, Architecture, Input and output modules, Specifications of DCS.

Text Books:

4. Programmable Logic Controllers, Principles and Applications: John W. Webb, Ronold A Reis, Prentice Hall of India, New Delhi
5. Automation, production System & CIMS: M. P. Groover, Prentice Hall of India, New Delhi
6. SCADA supervisory control and data acquisition: Stuart A. Boyer, ISA Publication.

Reference Books:

6. Computer Control of Manufacturing Systems: YoramKoren, Mcgraw Hill, Delhi
7. CAD/CAM: M. Groover& E. Zimmers , Pearson Education, Delhi
8. Process Control Instrumentation Technology: Curtis Johnson, 8th Edition, Pearson Education
9. Programmable Logic Controllers: Bolton, Elsevier India; Fifth edition
10. Programmable Logic Controllers: Frank D. Petruzella McGraw Hill, Delhi

Semester II

Course Code: 24ES55PR1291	**Industrial Automation and IoT Lab**

L: 3	P: 0	S	Total Credits: 3

List of Experiments

Industrial Automation

- Sensor interfacing with Arduino/Raspberry Pi
- Sending sensor data to cloud via MQTT (ThingSpeak/AWS/Node-RED)
- Implementing edge analytics with Python
- OPC-UA communication between devices
- Dashboard development for remote monitoring

Industrial Internet of Things (IIoT)

- Sensor interfacing with Arduino/Raspberry Pi
- Sending sensor data to cloud via MQTT (ThingSpeak/AWS/Node-RED)
- Implementing edge analytics with Python
- OPC-UA communication between devices
- Dashboard development for remote monitoring

Semester II

Course Code: 24ES55PR1292			AIML in Robotics Lab
L: 3	P: 0	S	Total Credits: 3

- *Implementation of Search Algorithms (BFS, DFS, A) for Robot Path Planning in a Grid World**
- **Object Classification Using Supervised Learning (k-NN / SVM) with Camera Images**
- **Clustering of Sensor Data Using K-Means to Identify Obstacles and Free Space**
- **Image Classification Using Convolutional Neural Networks (CNN) for Robot Vision**
- **Real-Time Object Detection Using YOLOv5/SSD with Robot Camera Feed**
- **Q-Learning-Based Path Optimization for a Mobile Robot in a Simulated Environment**
- **Voice-Controlled Robot Using ML-Based Speech Recognition**
- **Gesture Recognition Using MediaPipe and Machine Learning for Robot Control**
- **Line Following Robot with PID and Adaptive Learning**
- **Data Collection from Sensors and Applying PCA for Dimensionality Reduction and Visualization**

Semester III

Course Code: 24ES55PR1394-1	Supply Chain Management

L: 3	P: 0	S	Total Credits: 3

Course Objective

Understand the strategic importance of Supply Chain Design, Planning and execution for discreet product manufacturing

Course Outcomes

After completing this course, students will be able to:

1. Identify the nature of Supply Chain, Basic Concepts, Supply Chain Performance and Supply Chain Drivers
2. Identify the critical factors in a distribution network and transportation network of a product for an enterprise.
3. Demonstrate the different analytical methods for forecasting and managing the demand for monitoring the inventory
4. Apply the different measures of Product Availability and Understand the Role of Safety Inventory in Supply Chain .

Unit-I : Building a Strategic Framework to Analyze Supply Chains

Understanding the Supply Chain : What is Supply Chain, Historical Perspective, The Objective of a Supply Chain, The Importance of Supply Chain Decisions, Decision Phases in a Supply Chain, Process Views of a Supply Chain.

Supply Chain Performance : Achieving Strategic Fit And Scope : Competitive and Supply Chain Strategies, Achieving Strategic Fit, Expanding Strategic Scope, Challenges to Achieving and Maintaining Strategic Fit, Achieving and Maintaining Strategic Fit in Emerging Retail Markets: The Indian Scenario, The Experience, Adaptation.

Supply Chain Drivers And Metrics : Impellers of Supply Chain, Financial Measures of Performance, Drivers of Supply Chain Performance ,Framework for Structuring Drivers, Facilities, Inventory, Transportation, Information, Sourcing, Pricing, Infrastructure, International Logistics.

Unit-II : Designing the Supply Chains Network

Designing Distribution Networks And Applications To Online Sales : The Role of Distribution in the Supply Chain, Factors Influencing Distribution Network Design, Design Options for a Distribution Network, Online Sales and the Distribution Network, Indian Agricultural Produce Distribution Channels: Ripe for Major Transformation, Indian fmcg Sector-Distribution Channels, Indian Commodities Distribution Channels, Distribution Networks in Practice.

Network Design In The Supply Chain : The Role of Network Design in the Supply Chain, Factors Influencing Network Design Decisions, Framework for Network Design Decision, Models for Facility Locations and Capacity Allocation, Jaipur Rugs- Networking Tradition with Modernity, The Impact of Uncertainty on Network Design.

Unit-III : Planning And Coordinating Demand And Supply in a Supply Chain

Demand Forecasting in a Supply Chain : The Role of Forecasting in a Supply Chain, Characteristics of Forecasts, Components of a Forecast and Forecasting Methods, Basic Approach to Demand Forecasting, Time-Series Forecasting Methods, Measures of Forecast Error, Selecting the Best Smoothing Constant, Forecasting Demand at Tahoe Salt, The Role of IT in Forecasting.

Sales And Operations Planning : Planning Supply And Demand In a Supply Chain : Responding to Predictable Variability in the Supply Chain, Managing Supply, Managing Demand, Sales and Operations Planning at Red Tomato, Implementing Sales and Operations Planning in Practice.

Coordination in a Supply Chain : Lack of Supply Chain Coordination and the Bullwhip Effect, The Effect on Performance of Lack of Coordination, Obstacles to Coordination in a Supply Chain, Managerial Levers to Achieve Coordination, Continuous Replenishment and Vendor-Managed Inventories, Collaborative Planning, Forecasting and Replenishment.

Unit-IV : Planning And Managing Inventories in a Supply Chain

Managing Economies of Scale in a Supply Chain : Cycle Inventory : The Role of Cycle Inventory in a Supply Chain, Estimating Cycle Inventory Related Costs in Practice, Economies of Scale to Exploit Fixed Costs, Aggregating Multiple Products in a Single Order, Economies of Scale to Exploit Quantity Discounts, Short term Discounting : Trade Promotions, Managing Multiechelon Cycle Inventory, Cycle Inventory Optimisation in Indian Distribution Channels.

Managing Uncertainty in a Supply Chain : Safety Inventory : The Role of Safety Inventory in a Supply Chain, Factors Affecting the Level of Safety Inventory, Determining the Appropriate Level of Safety Inventory, Impact of Supply Uncertainty on Safety Inventory, Impact of Aggregation on Safety Inventory, Managing Uncertainty in Supply Chain Through Postponement –Indian Paint Industry, Impact of Replenishment Policies on Safety Inventory, Managing Safety Inventory in a multiechelon Supply Chain, The Role of IT in Inventory Management .

Textbooks :

1.Supply Chain Management: BY Sunil Chopra and Peter Meindl - Pearson Education, Asia.

Reference Books :.

2. Designing and Managing the Supply Chain, Simchi-levi & Kaminsky, McGraw-Hill Publication.

3. Logistics and Supply Chain Management, D.K. Agarwal

Semester III

Course Code: 24ES55PR1394-2			**Rapid Prototyping**
L: 3	**P: 0**	**S**	**Total Credits: 3**

Course Objectives:

1. To introduce the principles and processes of Rapid Prototyping (RP) and Additive Manufacturing (AM).
2. To familiarize students with CAD-to-part workflow, process planning, and prototyping techniques.
3. To understand the selection and application of materials used in various RP systems.
4. To explore the role of RP in product development, reverse engineering, and tooling.
5. To impart hands-on knowledge of slicing, printing, and post-processing techniques.

Course Outcomes (CO):

After successful completion of the course, students will be able to:

- **CO1:** Understand various rapid prototyping processes and their classification.
- **CO2:** Apply CAD modeling and data preparation techniques for additive manufacturing.
- **CO3:** Select appropriate RP process and materials for specific applications.
- **CO4:** Analyze the role of RP in product design, validation, and manufacturing.
- **CO5:** Use RP tools and software to produce functional prototypes and conceptual models.

Course Modules:

Module 1: Introduction to Rapid Prototyping

- Evolution of RP and need for prototyping
- Classification: Additive, Subtractive, and Formative manufacturing
- Advantages and limitations of RP
- RP in the context of product development and Industry 4.0
- Overview of digital manufacturing and mass customization

Module 2: CAD and Data Preparation

- Role of CAD in RP

- File formats: STL, AMF, 3MF
- STL file generation, verification, and repair
- Slicing techniques and support generation
- Software tools: Cura, PrusaSlicer, Autodesk Netfabb

Module 3: Rapid Prototyping Processes

- Vat photopolymerization: SLA, DLP
- Material extrusion: FDM, FFF
- Powder bed fusion: SLS, DMLS, EBM
- Material jetting and binder jetting
- Sheet lamination and hybrid systems
- Process parameters and machine components

Module 4: Materials for Additive Manufacturing

- Thermoplastics: PLA, ABS, PETG, Nylon
- Photopolymers: Resins for SLA/DLP
- Metals: Titanium, Stainless Steel, Aluminum
- Ceramics, composites, and bio-materials
- Material selection criteria and testing

Module 5: Applications, Challenges, and Future Trends

- RP in automotive, aerospace, biomedical, and consumer products
- Tooling and mold making (Rapid Tooling)
- Reverse engineering and 3D scanning
- Surface finish, accuracy, and post-processing methods
- Environmental and economic considerations
- Future of RP: 4D printing, AI-integrated printing, micro-AM

Textbooks:

1. **“Rapid Prototyping: Principles and Applications”** by Chua Chee Kai, Leong Kah Fai, and Lim Chu-Sing (World Scientific)
2. **“Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing”** by Ian Gibson, David Rosen, Brent Stucker (Springer)

Reference Books:

- **“Rapid Prototyping and Engineering Applications: A Toolbox for Prototype Development”** by Frank W. Liou
- **“3D Printing and Additive Manufacturing: Principles and Applications”** by Andreas Gebhardt
- Journals: *Additive Manufacturing*, *Rapid Prototyping Journal*, *Journal of Manufacturing Processes*
- Software Manuals: Cura, PrusaSlicer, Netfabb, Fusion 360 Additive Module

Semester III

Course Code: 24ES55TH1394-3			**Project Management**
L: 3	**P: 0**	**S**	**Total Credits: 3**

Course Objectives:

1. To provide foundational knowledge of project planning, execution, monitoring, and closure.
2. To enable students to manage project constraints such as time, cost, quality, and risk.
3. To introduce tools and techniques like Gantt charts, CPM, PERT, and Earned Value Analysis.
4. To impart knowledge of resource allocation, team management, and stakeholder communication.
5. To develop competencies in using software tools for managing real-world projects effectively.

Course Outcomes (CO):

After completing this course, students will be able to:

- **CO1:** Understand project management principles, life cycle, and organizational structures.
- **CO2:** Develop detailed project plans with appropriate scheduling and resource allocation techniques.
- **CO3:** Apply quantitative tools like CPM, PERT, and EVA for project analysis and monitoring.
- **CO4:** Identify, analyze, and mitigate project risks and quality concerns.
- **CO5:** Demonstrate competency in project closure, performance evaluation, and documentation.

Course Modules:

Module 1: Introduction to Project Management

- Definition, characteristics, and objectives of a project
- Project life cycle and phases
- Project management processes: Initiating, Planning, Executing, Controlling, Closing
- Project stakeholders and organization structures (functional, matrix, projectized)
- Role and responsibilities of a project manager

Module 2: Project Planning and Scheduling

- Project scope, Work Breakdown Structure (WBS)

- Time estimation techniques
- Gantt charts, Network diagrams
- Critical Path Method (CPM)
- Program Evaluation and Review Technique (PERT)
- Milestone charts and precedence networks

Module 3: Cost Estimation and Budgeting

- Project cost management: direct and indirect costs
- Estimation methods: Analogous, Parametric, Bottom-Up
- Budgeting and cost baseline
- Earned Value Management (EVM): SPI, CPI, BAC, EAC
- Cost control and performance indices

Module 4: Project Risk, Quality, and Resource Management

- Risk identification, analysis (qualitative and quantitative)
- Risk response planning and mitigation
- Quality planning, assurance, and control
- Resource leveling and allocation
- Communication and stakeholder management
- Procurement management and contracts

Module 5: Project Execution, Monitoring and Closure

- Execution strategies and progress tracking
- Project monitoring tools and Key Performance Indicators (KPIs)
- Project documentation and reporting
- Lessons learned and knowledge management
- Project closure steps: administrative and contractual
- Case studies on successful and failed projects

Textbooks:

1. **“Project Management: A Systems Approach to Planning, Scheduling, and Controlling”** by Harold Kerzner
2. **“Project Management”** by S. Choudhury (TMH)
3. **“Project Management for Engineering and Construction”** by Garold D. Oberlender

Reference Books:

- **“Project Management: The Managerial Process”** by Erik Larson and Clifford Gray
- **“Fundamentals of Project Management”** by Joseph Heagney
- **PMBOK® Guide (Project Management Body of Knowledge)** by Project Management Institute (PMI)
- NPTEL/MOOC modules on Project Management

Semester III

Course Code: 24ES55PR1395			**Dissertation Phase-I**
L: 3	**P: 0**	**S**	**Total Credits: 3**

Course Objective: To inbuilt the skills in the areas like project management, concept development, planning, implementation, testing and validation while developing robotics and automation applications.

Course Outcomes: The students will able

1. To carry out exhaustive literature review to define the problem.
2. To understand the concept and scope of project work
3. To identify the appropriate Methodology to carry out the project work.

Students can select the appropriate problem in the field of robotics and automation.

Semester III

Course Code: 24ES55PR1396	**Industry Internship-Phase-I or Research Internship-Phase-I or TBI Internship-Phase-I**

L: 3	**P: 0**	**S**	**Total Credits: 3**

Course Objective: To inbuilt the skills in the areas like project management, concept development, planning, implementation, testing and validation while developing robotics and automation applications.

Course Outcomes: The students will able

1. To carry out exhaustive literature review to define the problem.

2. To understand the concept and scope of project work

3. To identify the appropriate Methodology to carry out the project work.

Students opted Industry Internship-Phase-I or Research Internship-Phase-I or TBI Internship-Phase-I can select the appropriate problem in the field of robotics and automation.

Semester IV

Course Code: 24ES55PR1397	**Dissertation Phase-II**

L: 3	P: 0	S	Total Credits: 3

Course objective: To inbuilt the skills in the areas like project management, concept development, planning,implementation, testing and validation while developing robotics and automation applications.

Course Outcomes: The students will able

1. To perform kinematics and dynamic analysis of defined problem and to select the suitable drives, actuator and sensors based on application.

2. To decide the appropriate control strategy to perform the task

3. To apply the tools like ANN, AI to make the system intelligent and autonomous along with to get the proficiency in mathematical and programming tools like MATLAB, ROS.

The M. Tech. Project is aimed to train the students to identify and analyze the research topic independently based on the subject knowledge gained in the previous semesters. The projects should include the problem in the field of robotics and automation applications. The project may be a purely analytical piece of work, a completely experimental or a combination of both. The students should validate the approach used in the project work through testing and experimentation. It is expected to submit the final project report which includes detailed literature review, objective, problem definition, methodology, experimentation, testing, result and conclusion.

Semester IV

Course Code: 24ES55PR1398			Industry Internship-Phase-II or Research Internship-Phase-II or TBI Internship-Phase-II
L: 3	P: 0	S	Total Credits: 3

Course objective: To inbuilt the skills in the areas like project management, concept development, planning, implementation, testing and validation while developing robotics and automation applications.

Course Outcomes: The students will able

1. To perform kinematics and dynamic analysis of defined problem and to select the suitable drives, actuator and sensors based on application.

2. To decide the appropriate control strategy to perform the task

3. To apply the tools like ANN, AI to make the system intelligent and autonomous along with to get the proficiency in mathematical and programming tools like MATLAB, ROS.

The M. Tech. Project is aimed to train the students to identify and analyze the research topic independently based on the subject knowledge gained in the previous semesters. The projects should include the problem in the field of robotics and automation applications. The project may be a purely analytical piece of work, a completely experimental or a combination of both. The students should validate the approach used in the project work through testing and experimentation. It is expected to submit the final project report which includes detailed literature review, objective, problem definition, methodology, experimentation, testing, result and conclusion.