ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH
Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

School of Mechanical Sciences

CURRICULUM AND SYLLABI (2023-24)

B. Tech. Robotics and Artificial Intelligence

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus Structure (Admission Batch: 2023-24)

School of Mechanical Sciences
Programme: Robotics and Artificial Intelligence

Abbreviation used:

AC	Audit course	LC	Laboratory Course	PA	Practical Assessment
PC	Professional Core	PR	Project/ Practical/ Internship	L	Lecture
PE	Professional Elective	SE	Seminar/ Expert Lecture/ Etc.	T	Tutorial
OE	Open Elective	IA*	Internal Assessment	P	Practical
MC/BS/HS	Mandatory/ Common Course	EA	End-Semester Assessment		
ACC	Advanced Competency Course				
*Internal Assessment Mark (40 marks) consists of (i) Mid Semester (20 marks), (ii) Quiz/ Assignment/Attendance (20 marks)					

3rd Semester

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
				L	T	P		IA	EA	PA	Total
1	BS	BH2459	Mathematics – III	3	0	0	3	40	60	-	100
2	PC	MS2127	Introduction to Robotics	3	0	0	3	40	60	-	100
3	PC	MS2101	Kinematics and Dynamics of Machines	3	0	0	3	40	60	-	100
4	PC	MS2129	Introduction to AI	3	0	0	3	40	60	-	100
5	ACC	MS2125	Digital Manufacturing and Industry 4.0	3	0	0	2	40	60	-	100
6	HS	BH2437	Organizational Behaviour	3	0	0	2	40	60	-	100
7	LC	MS2521	Machine Drawing Laboratory	0	0	3	1.5	-	-	100	100
8	LC	MS2529	Artificial Intelligence Lab	0	0	3	1.5	-	-	100	100
9	LC	MS2531	Robotics Programming Lab	0	0	3	1.5	-	-	100	100
10	ACC	MS2527	Advanced Digital Manufacturing Lab	0	0	3	1.5	-	-	100	100
Total				**18**	**0**	**12**	**22**	**240**	**360**	**400**	**1000**

4th Semester

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
				L	T	P		IA	EA	PA	Total
1	PC	MS2122	Robot Dynamics and Control	3	0	0	3	40	60	-	100
2	PC	MS2124	Soft Computing and Applications	3	0	0	3	40	60	-	100
3	PC	MS2126	Solid Mechanics and Design	3	0	0	3	40	60	-	100
4	PC	MS2128	Thermal and Fluid Science	3	0	0	3	40	60	-	100
5	ACC	MS2130	Intelligent Manufacturing	3	0	0	2	40	60	-	100
6	HS	BH2439	Engineering Economics	3	0	0	2	40	60	-	100
7	LC	MS2522	CAD/CAE Laboratory	0	0	3	1.5	-	-	100	100
8	LC	MS2524	Material Testing and Machine Dynamics Laboratory	0	0	3	1.5	-	-	100	100
9	LC	MS2530	Soft Computing Laboratory	0	0	3	1.5	-	-	100	100
10	LC	MS2528	Fluid Thermal Laboratory	0	0	3	1.5	-	-	100	100
11	Summer Internship and Research Experience (SIRE - I) *										
Total				**18**	**0**	**12**	**22**	**240**	**360**	**400**	**1000**

***Minimum 4 weeks of Summer Course / Training / Internship / Skill Course / etc. after 4th Semester**

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OE	Open Elective	IA*	Internal Assessment	P	Practical
MC/BS/HS	Mandatory/ Common Course	EA	End-Semester Assessment		
ACC	Advanced Competency Course				
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5th Semester

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
				L	T	P		IA	EA	PA	Total
1	PC	MS3121	Robot Navigation and Path Planning	3	0	0	3	40	60	-	100
2	PC	MS3123	Design of Manipulators	3	0	0	3	40	60	-	100
3	PC	MS3125	Knowledge Engineering and Expert System	3	0	0	3	40	60	-	100
4	PE-1	MS3221	Mechatronics System Design	3	0	0	3	40	60	-	100
		MS3223	Sensors and Actuators in Robotics	3	0	0	3	40	60	-	100
		MS3225	Applications of Robotics	3	0	0	3	40	60	-	100
5	HS	BH3401/ BH3403	Business Management / Entrepreneurship Development	3	0	0	2	40	60	-	100
6	MC	IP3401/I P3403	Environmental Engineering/ Industrial Safety Engineering	3	0	0	2	40	60	-	100
7	LC	MS3521	Robot Modeling and Simulation Lab	0	0	3	1.5	-	-	100	100
8	LC	MS3523	Advanced Mechatronics Lab	0	0	3	1.5	-	-	100	100
9	LC	MS3525	Sensors and Actuators Lab	0	0	3	1.5	-	-	100	100
10	PSI	MS3701	Seminar on SIRE – I	0	0	3	1.5	-	-	100	100
Total				**18**	**0**	**12**	**22**	**240**	**360**	**400**	**1000**

6th Semester

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
				L	T	P		IA	EA	PA	Total
1	PC	MS3122	Instrumentation and Control in Robotics	3	0	0	3	40	60	-	100
2	PC	CS3112	Machine Learning	3	0	0	3	40	60	-	100
3	PE-2	MS3222	Drone Technology	3	0	0	3	40	60	-	100
		MS3224	Autonomous Robot	3	0	0	3	40	60	-	100
		MS3226	Mobile Robotics	3	0	0	3	40	60	-	100
4	PE-3	EI3233	Introduction to Micro Electro Mechanical Systems	3	0	0	3	40	60	-	100
		EI3234	Microcontrollers Architecture and Programming	3	0	0	3	40	60	-	100
		EI3236	Digital Electronics and Microprocessor	3	0	0	3	40	60	-	100
5	HS	BH3401/ BH3403	Business Management / Entrepreneurship Development	3	0	0	2	40	60	-	100
6	MC	IP3401/I P3403	Environmental Engineering/ Industrial Safety Engineering	3	0	0	2	40	60	-	100
7	LC	MS3622	Project for Product Development - I	0	0	6	3	-	-	100	100
8	LC	CS3512	Machine Learning for Robotics Lab	0	0	3	1.5	-	-	100	100
9	LC	EI3503	Microprocessor and Microcontroller Lab	0	0	3	1.5	-	-	100	100
10	Summer Internship and Research Experience (SIRE - II) *										
Total				**18**	**0**	**12**	**22**	**240**	**360**	**400**	**1000**

FOURTH YEAR (SEVENTH SEMESTER)

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
				L	T	P		IA	EA	PA	Total
1	PE-4	MS4221	Field and Service Robotics	3	0	0	3	40	60	-	100
		MS4223	Bio Inspired Robotics	3	0	0	3	40	60	-	100
		MS4225	Medical Robotics	3	0	0	3	40	60	-	100
2	PE-5		Computer Vision & Image Processing	3	0	0	3	40	60	-	100
			Deep Learning	3	0	0	3	40	60	-	100
			Data Modeling and Visualization	3	0	0	3	40	60	-	100
3	OE-1	MS4301 MS4303 MS4305	Open Elective – I 1. Decision Modelling 2. Soft Computing Techniques 3. Statistical Methods for Engineers	3	0	0	2	40	60	-	100
4	PC (ACC)		Virtual Reality	3	0	0	2	40	60	-	100
5	LC	MS4701	Seminar on SIRE – II	0	0	6	1	-	-	100	100
6	LC	MS4601/ MS4603	Project for Product Development – II / Internship Project – I	0	0	6	3	-	-	100	100
Total				**12**	**0**	**12**	**15**	**160**	**240**	**400**	**1000**

***Project / Seminar / Internship**

FOURTH YEAR (EIGHTH SEMESTER)

Sl. No.	Course Code	Subject	Contact Hrs. L-T-P	Credit
1	MS4302 MS4304 MS4306	Open Elective – II 1. Design of Experiment 2. Introduction to Robotics 3. Automobile Engineering	3-0-0	3
2	MS4308 MS4310 MS4312	Open Elective – III 1. Refrigeration and Air Conditioning system 2. Power Generation Technologies 3. Solar Technology	3-0-0	3
3	MS4314 MS4316 MS4318	Open Elective – IV 1. Digital Manufacturing 2. Sensors and Actuators 3. Production and Operations Management	3-0-0	3
Sessional				
4	MS4702	Seminar on Project	0-0-6	3
5	MS4602/MS4604	Project for Product Development – III / Internship Project - II	0-0-12	6
Total			**6-0-18**	**15**

***Project / Seminar / Internship**

Honors in Design and Dynamics

Sl. No.	Subject Type	Subject Code	Subject Name	Semester	Teaching Hours L	Teaching Hours T	Teaching Hours P	Credit
1	Theory	MS3173	Robotic Materials	5th	3	0	0	3
2	Theory	MS3174	Analysis & Synthesis of Mechanism	6th	3	0	0	3
3	Theory	MS4175	Design of Robotics Components	7th	3	0	0	3
4	Theory	MS4177	Mechanical Vibration	7th	3	0	0	3
5	Theory	MS4174	Human Robot Interaction	8th	3	0	0	3
6	Laboratory Course	MS3574	Innovation and Entrepreneurship Lab	6th	0	0	3	1.5
7	Laboratory Course	MS4573	KDM and Design Lab	7th	0	0	3	1.5
Total					**15**	**0**	**6**	**18**

Minor in Robotics

Sl. No.	Subject Type	Subject Code	Subject Name	Semester	Teaching Hours L	Teaching Hours T	Teaching Hours P	Credit
1	Theory	MS3263	Introduction to Robotics and AI	5th	3	0	0	3
2	Theory	MS3264	Intelligent Manufacturing	6th	3	0	0	3
3	Theory	MS4265	Robot Dynamics and Control	7th	3	0	0	3
4	Theory	MS4264	Robot Navigation and Path Planning	8th	3	0	0	3
5	Theory	MS4267	Automation Engineering	7th	3	0	0	3
6	Laboratory Course	MS3564	Artificial Intelligence Lab	6th	0	0	3	1.5
7	Laboratory Course	MS4563	Robotics Programming Lab	7th	0	0	3	1.5
Total					**15**	**0**	**6**	**18**

School/ Department: School of Mechanical Sciences
Programme: Robotics and Artificial Intelligence

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3rd Semester

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
				L	T	P		IA	EA	PA	Total
1	BS	BH2459	Mathematics – III	3	0	0	3	40	60	-	100
2	PC	MS2127	Introduction to Robotics	3	0	0	3	40	60	-	100
3	PC	MS2101	Kinematics and Dynamics of Machines	3	0	0	3	40	60	-	100
4	PC	MS2129	Introduction to AI	3	0	0	3	40	60	-	100
5	ACC	MS2125	Digital Manufacturing and Industry 4.0	3	0	0	2	40	60	-	100
6	HS	BH2437	Organizational Behaviour	3	0	0	2	40	60	-	100
7	LC	MS2521	Machine Drawing Laboratory	0	0	3	1.5	-	-	100	100
8	LC	MS2529	Artificial Intelligence Lab	0	0	3	1.5	-	-	100	100
9	LC	MS2531	Robotics Programming Lab	0	0	3	1.5	-	-	100	100
10	ACC	MS2527	Advanced Digital Manufacturing Lab	0	0	3	1.5	-	-	100	100
			Total	**18**	**0**	**12**	**22**	**240**	**360**	**400**	**1000**

Mathematics – III			
Hours/Week L-T-P :	3-0-0	Credits:	3

Course Type :	Mandatory/ Common Course	Course Code:	BH2459

Prerequisite: Basic knowledge of calculus, linear algebra, differential equations, and elementary probability is required.

Course Objectives :

1. Apply numerical methods for solving equations, interpolation, and numerical integration.
2. Solve applied partial differential equations using separation of variables and Fourier series.
3. Explain probability concepts and standard probability distributions.
4. Perform parameter estimation, hypothesis testing, regression, and correlation analysis.

Course Outcome :

At the end of the course the student will be able to:

CO1: Demonstrate the use of common numerical methods such as numerical solutions of equations, interpolation, differentiation and integration etc.

CO2: Recognize mathematical model of heat equations, wave equations and their solution by appropriate method.

CO3: Understand the different terminology in probability and have clear concept on probability distribution functions both in continuous and discrete case.

CO4: Select appropriate statistical tools to investigate a research hypothesis, perform data analysis by applying relevant methodology and interpret result in a variety of settings.

Module-1*:* Elementary Numerical Methods **(7Hours)**

Solution of algebraic and transcendental equations by Newton-Raphson and secant method.

Interpolation: Lagrange's method, divided difference method, Newton's forward and backward method. Numerical Integration: Trapezoidal and Simpson's Rule.

Module- 2*:* Applied PDE's **(7 Hours)**

Elementary PDE's: separation of variables method to simple problems. One dimensional wave equation: solution by separation of variables and use of Fourier series, D' Alembert's solution of wave equation. Normal forms of PDE's.One dimensional heat equation: solution by Fourier series.

Module-3: Basic Probability and Probability Distributions **(7 Hours)**

Probability spaces, conditional probability, independence, Random variables (discrete and continuous), probability mass and density functions, cumulative distribution functions, moments of random variables, mean and variance.

Discrete Probability distributions: Binomial, Poisson and hyper-geometric distributions. Continuous Probability distributions: exponential, uniform and normal distributions.

Module-4*:* Applied Statistics **(7 Hours)**

Random sampling, estimation of parameters, maximum likelihood estimation, confidence intervals, testing of hypotheses for mean and variance.

Regression and correlation analysis: fitting of straight lines (method of lest squares), correlation coefficient with basic properties.

Text Books:

1. Advanced Engineering Mathematics by E. Kreyszig, John Willey & Sons Inc. 10^{th} Edition.
2. Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers & Keying Ye, "Probability & Statistics for Engineers & Scientists", Eighth Edition, 2007, Pearson Education Inc., New Delhi.

Reference Books:

1. Ordinary and Partial Differential equations by J. Sinha Roy and S. Padhy, Kalyani

Publishers.
2. Higher Engineering Mathematics by B. V. Ramana, McGraw Hill Education.
3. Engineering Mathematics by Pal and S. Bhunia, Oxford Publication.
4. Stochastic Processes, 2nd Edition by Roy D. Yates, Rutgers and David J. Goodman, John Wiley and Sons, INC.

COs and POs Mapping

Course Outcome	Expected Mapping with Programme Outcomes *(1- Weak Correlation; 2- Medium correlation; 3- Strong Correlation)*										
	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**	**PO-7**	**PO-8**	**PO-9**	**PO-10**	**PO-11**
CO-1	3	3	3	3	3	3	2	-	2	-	2
CO-2	3	3	3	3	3	2	2	-	-	-	2
CO-3	3	3	3	3	3	2	3	-	2	-	-
CO-4	3	3	3	3	3	2	2	-	2	-	2

Introduction to Robotics

Hours/Week L-T-P :	3-0-0	Credits:	3

Course Type :	Professional Core	Course Code:	MS2127

Prerequisites: Basic understanding of physics, mathematics (geometry and vectors), and fundamentals of mechanics is required.

Course Objectives :

1. Introduce the fundamentals, components, classifications, and societal impacts of robotics.
2. Explain robot anatomy, configurations, degrees of freedom, and basic kinematics.
3. Describe robot drive systems, end effectors, and control methods used in robotics.
4. Illustrate various robotic applications in industries, healthcare, agriculture, and unmanned systems.

Course Outcome :

CO1: Understand the significance, social impact and future prospects of robotics and automation in various engineering applications.

CO2: Identify and describe the components and anatomy of robotic system.

CO3: Know about various path planning techniques and analyze different motions of robotics system

CO4: Use the suitable drives and end-effectors for a given robotics application

Module 1: Introduction To Robotics **(8 Hours)**

Introduction to Robotics and Automation, laws of robot, brief history of robotics, basic components of robot, robot specifications, classification of robots, human system and robotics, safety measures in robotics, social impact, Robotics market and the future prospects, advantages and disadvantages of robots.

Module 2: Robot Anatomy and Motion Analysis (**10 Hours)**

Anatomy of a Robot, Robot configurations: polar, cylindrical, Cartesian, and jointed arm configurations, Robot links and joints, Degrees of freedom: types of movements, vertical, radial and rotational traverse, roll, pitch and yaw, Wok volume/envelope, Robot kinematics: Introduction to direct and inverse kinematics, transformations and rotation matrix.

Module 3: Robot Drives and End Effectors (**8 Hours)**

Robot drive systems: Hydraulic, Pneumatic and Electric drive systems, classification of end effectors, mechanical grippers, vacuum grippers, magnetic grippers, adhesive gripper, gripper force analysis and gripper design, 1 DoF, 2 DoF, multiple degrees of freedom robot hand, tools as end effectors, Robot control types: limited sequence control, point-to-point control, playback with continuous path control, and intelligent control.

Module 4: Robotics Applications (**8 Hours)**

Material Handling: pick and place, palletizing and depalletizing, machining loading and unloading, welding & assembly, Medical, agricultural and space applications, unmanned vehicles: ground, Ariel and underwater applications, robotic for computer integrated manufacturing. Types of robots: Manipulator, Legged robot, wheeled robot, aerial robots, Industrial robots, Humanoids, Robots, Autonomous robots, and Swarm robots.

Text Books:

1. S.R. Deb, Robotics Technology and flexible automation, Tata McGraw-Hill Education, 2009.

2. Mikell P. Grooveret. al., "Industrial Robots - Technology, Programming and Applications", McGraw Hill, Special Edition, (2012).

3. Ganesh S Hegde, “A textbook on Industrial Robotics”, University science press, 3rdedition, 2017.

Reference Books:

1. Richard D Klafter, Thomas A Chmielewski, Michael Negin, "Robotics Engineering – An Integrated Approach", Eastern Economy Edition, Prentice Hall of India Pvt. Ltd., 2006.

2. Fu K S, Gonzalez R C, Lee C.S.G, "Robotics: Control, Sensing, Vision and Intelligence",McGrawHill, 1987. https://www.robots.com/applications.

CO	PO 1	PO2	PO 3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3	3	1	1	1	-	-	-	3	3	3	3
CO2	3	2	3	2	1	-	2	-	-	-	3	3	3	1
CO3	3	3	3	2	1	-	3	-	-	-	3	3	3	2
CO4	2	2	3	2	1	-	3	-	-	-	-	3	3	3

Kinematics and Dynamics of Machines			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	Professional Core	Course Code:	MS2101

Prerequisites: Engineering Mechanics, Mechanics of Solid, Engineering Mathematics, Material Science

Course objectives:

The objectives of the course learning are:

1. This course is ideal vehicle for introducing the mechanical engineering students to the process of design.
2. To achieve various means of transforming motion to a specific kind needed in various applications.
3. To analyse of the behaviour of a given machine or mechanism when subjected to dynamic force.
4. To use the general concepts and develop methods for performing analysis of real designs.

Course Outcome:

On successful completion of this course, the students should be able to:

CO1: Describe basic concepts of mechanisms and carry out its kinematic analysis and synthesis .

CO2: Design and analyze the mechanical power transmission systems.

CO3: Analyze Gyroscope for Navigation and Stabilization, Governor and flywheel for speed regulation, and CAMS for motion control.

CO4: Carry out balancing of rotating and reciprocating masses in static and dynamic mechanical system.

Module-1 **(9 Hours)**

Kinematic fundamental: Introduction to mechanisms and its terminologies - Degree of freedom –

Mobility - Kutzbach criterion - Grubler's criterion for planar mechanisms, Grashoff's law, Kinematic Inversions of 4-bar chain - Single slider and double slider crank chains, Quick return mechanism, Limiting positions, Mechanical advantage - Transmission angle and toggle position.

Kinematic Analysis: Graphical analysis of position, velocity and acceleration of simple mechanisms having turning, sliding and rolling pair, Coriolis acceleration using graphical relative motion method, Aronhold-Kennedy Theorem, Instantaneous center method - Four bar and slider crank mechanisms - Analytical method for four bar and slider crank mechanisms.

Mechanism Synthesis: Classification of kinematic synthesis problems, Chebychev spacing for precision positions, Freudenstein analytical method.

Module-2 **(9 Hours)**

Cams: Fundamental law of Cam, Cam Terminology, Classification of Cams and followers, Analysis of follower motions (Displacement, velocity, Acceleration and jerk) – Simple Harmonic, Uniform Velocity and Constant Acceleration & Retardation Types, Generation of Cam Profiles by Graphical Method.

Mechanism Trains: Spur gear terminology and definitions, fundamental law of gearing, Theory of shape and action of tooth properties and methods of generation of standard tooth profiles, Standard proportions, Force analysis, Interference and Undercutting, Gear trains, Speed ratio, train value, Parallel axis gear trains, Epicyclic Gear Trains

Friction Effects: Single plate and cone clutches, Anti friction bearing, friction circle, friction axis.

Flexible Mechanical Elements: Belt and chain drives, Initial tension, Effect of centrifugal tension on power transmission, Maximum power transmission capacity, Belt creep and slip.

Brakes: Internal expanding shoe brake.

Module-3 **(9Hours)**

Mechanism for Control (Governors): Governors - Watt, Porter, Proell, Hartnell. Performance parameters: Sensitiveness, Stability, Hunting, Isochronism. Governor Effort and Power, Controlling Force & Controlling Force Curve, Friction & insensitiveness, flywheel, Turning Moment diagram.

Mechanism for Control (Gyroscope): Introduction to Gyroscopes. Gyroscopic forces and Couple. Effect of Gyroscopic Couple on Aeroplanes, Gyroscopic stabilization of ship.

Module-4 **(9 Hours)**

Balancing of rotating components and linkages: Static and Dynamic Balancing, Balancing of Single Rotating Mass by Balancing Masses in Same plane and in Different planes. Balancing of Several Rotating Masses rotating in same plane and in Different planes. Effect of Inertia Force due to Reciprocating Mass on Engine Frame, Partial balance of single cylinder engines. Balancing of locomotive: variation of tractive force, swaying couple, hammer blow.

Text Books:

1. Kinematics and Dynamics of Machinery by R L Norton, Tata MacGrawHill
2. Theory of Machines and Mechanisms by John J. Uicker Jr., Gordon R. Pennock and Joseph E. Shigley, Oxford University Press
3. Theory of Machines by S.S.Rattan, Tata MacGrawHill
4. Theory of Machines by Thomas Bevan, CBS Publications

Reference Books:

5. Kinematics and Dynamics of Machinery by Charles E. Wilson and J. Peter Saddler, Pearson Education

6. Mechanism and Machine Theory by J.S. Rao and R.V. Dukipatti, New Age International.
7. Theory of Mechanisms and Machines by A. Ghosh & A. K. Mallick, East WestPress.
8. Kinematics and Dynamics of Machines by G.H. Martin, McGraw-Hill.
9. Mechanisms and Dynamics of Machinery by Hamilton H Mabie and Charles F Reinholtz, John- Wiley and Sons.
10. Kinematics, Dynamics, and Design of Machinery by Kenneth J Waldron and Gary L Kinzel, John-Wiley and Sons.

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	-	2	-	-	1	-	-	2	3	-	-
CO2	3	2	2	-	2	-	1	1	1	-	2	3	-	-
CO3	3	2	2	-	2	-	1	1	1	-	2	3	-	-
CO4	3	2	2	-	2	-	-	1	-	-	2	3	-	-

Introduction to AI			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	Professional Core	Course Code:	MS2129

Prerequisite: Basic knowledge of data structures, algorithms, and discrete mathematics.

Course Objectives:

1. To understand the foundational concepts and problem-solving techniques in Artificial Intelligence.
2. To apply search algorithms, logic-based reasoning, and constraint satisfaction strategies in AI problem domains.
3. To develop knowledge-based systems using propositional and first-order logic.
4. To explore reasoning under uncertainty using probabilistic models and Bayesian networks.

Course Outcomes (COs):

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

CO1: Apply informed and uninformed search techniques to solve well-defined problems.

CO2: Formulate and solve problems using constraint satisfaction and logical inference.

CO3: Implement knowledge representation using first-order logic and ontologies.

CO4: Analyze and apply probabilistic reasoning for decision-making in uncertain environments.

Module – 1 **(8 Hours)**

Introduction to AI - Intelligent Agents, Problem-Solving Agents, Searching for Solutions - Breadth-first search, Depth-first search, Hill-climbing search, Simulated annealing search, Local Search in Continuous Spaces.

Module – 2 **(8 Hours)**

Alpha–Beta Pruning, Defining Constraint Satisfaction Problems, Constraint Propagation, Backtracking Search for CSPs, Knowledge-Based Agents, Logic- Propositional Logic, Propositional Theorem Proving: Inference and proofs, Proof by resolution, Horn clauses and definite clauses.

Module - 3 **(8 Hours)**

First-Order Logic - Syntax and Semantics of First-Order Logic, Using First Order Logic, Knowledge Engineering in First-Order Logic. Inference in First-Order Logic: Propositional vs. First-Order Inference, Unification, Forward Chaining, Backward Chaining, Resolution. Knowledge Representation: Ontological Engineering, Categories and Objects, Events.

Module - 4 **(8 Hours)**

Probabilistic Reasoning: Acting under Uncertainty, Basic Probability Notation, Bayes' Rule and Its Use, Probabilistic Reasoning, Representing Knowledge in an Uncertain Domain, The Semantics of Bayesian Networks, Efficient Representation of Conditional Distributions, Approximate Inference in Bayesian Networks, Relational and First-Order Probability.

Text book:

1. Artificial Intelligence: A Modern Approach, Third Edition, Stuart Russell and Peter Norvig, Pearson Education.

Reference books:

1. Artificial Intelligence, 3rd Edn., E. Rich and K. Knight (TMH)
2. Artificial Intelligence, 3rd Edn., Patrick Henny Winston, Pearson Education.
3. Artificial Intelligence, Shivani Goel, Pearson Education.
4. Artificial Intelligence and Expert systems – Patterson, Pearson Education.

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	3	3	1	0	0	1	1	1	3	2	2
CO2	3	2	3	3	3	1	0	0	1	2	1	3	3	2
CO3	3	2	3	2	3	1	0	0	2	1	1	3	3	3
CO4	3	2	3	3	3	1	0	0	1	2	1	3	3	2

Digital Manufacturing and Industry 4.0			
Hours/Week L-T-P :	3-0-0	Credits :	2
Course Type :	Advanced Competency Course	Course Code:	MS2125

Prerequisites: Basic knowledge of manufacturing processes, industrial engineering, computer fundamentals, and familiarity with supply chain concepts.

Course Objectives:

1. Introduce the fundamentals and practical significance of digital manufacturing, including its evolution and future potential.
2. Explain digital product lifecycle management, digital supply chains, and their role in efficient production systems.

3. Describe key technologies and principles of smart factories and their integration with IoT and cybersecurity.
4. Explore the concepts, implementation, and applications of digital twins in modern manufacturing environments.

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

CO1: Impart knowledge to use various elements in the digital manufacturing.
CO2: Differentiate the concepts involved in digital product development life cycle process and supply chain management in digital environment.
CO3: Select the proper procedure of validating practical work through digital validation in Factories.
CO4: Implementation the concepts of IoT and its role in digital manufacturing.

Module-1 Introduction **(10 Hours)**
Need – Overview of Digital Manufacturing and the Past – Aspects of Digital Manufacturing: Product life cycle, Smart factory, and value chain management – Practical Benefits of Digital Manufacturing – The Future of Digital Manufacturing.

Module-2 Digital Life Cycle & Supply Chain Management **(12 Hours)**
Collaborative Product Development, Mapping Requirements to specifications – Part Numbering, Engineering Vaulting, and Product reuse – Engineering Change Management, Bill of Material and Process Consistency – Digital Mock up and Prototype development – Virtual testing and collateral. Overview of Digital Supply Chain - Scope& Challenges in Digital SC - Effective Digital Transformation - Future Practices in SCM.

Smart Factory – Levels of Smart Factories – Benefits – Technologies used in Smart Factory – Smart Factory in IoT- Key Principles of a Smart Factory – Creating a Smart Factory – Smart Factories and Cybersecurity.

Module-3 Industry 4.0 **(8 Hours)**
Introduction – Industry 4.0 –Internet of Things – Industrial Internet of Things – Framework: Connectivity devices and services – Intelligent networks of manufacturing – Cloud computing – Data analytics –Cyber physical systems –Machine-to-Machine communication – Case Studies.

Module-4 Study of Digital Twin: Basic Concepts **(8 Hours)**
– Features and Implementation – Digital Twin: Digital Thread and Digital Shadow- Building Blocks – Types – Characteristics of a Good Digital Twin Platform – Benefits, Impact & Challenges – Future of Digital Twins.

Text Books:
1. Zude Zhou, Shane (Shengquan) Xie and Dejun Chen, Fundamentals of Digital Manufacturing Science, Springer-Verlag London Limited, 2012.

2. Alasdair Gilchrist, “Industry 4.0: The Industrial Internet of Things”, A press, 2016.

Reference Books:

1. Lihui Wang and Andrew Yeh Ching Nee, Collaborative Design and Planning for Digital Manufacturing, Springer-Verlag London Limited, 2009

2. Andrew Yeh Chris Nee, Fei Tao, and Meng Zhang, “Digital Twin Driven Smart Manufacturing”, Elsevier Science., United States, 2019.

3. Alp Ustundag and Emre Cevikcan, “Industry 4.0: Managing The Digital Transformation”, Springer Series in Advanced Manufacturing., Switzerland, 2017

4. Ronald R. Yager and Jordan Pascual Espada, “New Advances in the Internet of Things”, Springer., Switzerland, 2018.

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	1	1	3	3	-	1	2	2	2	2	2	1
CO2	3	2	3	1	3	3	2	2	2	2	2	2	2	3
CO3	3	-	3	1	3	3	2	-	3	2	2	2	2	3
CO4	3	2	2	2	3	3	2	2	2	2	2	2	2	3

Organizational Behaviour			
Hours/Week L-T-P :	3-0-0	Credits:	2
Course Type :	Mandatory/ Common Course	Course Code:	BH2437

Prerequisites: Basic understanding of psychology, human behavior, and communication skills in an organizational or social context.

Course Objectives:

1. To understand how individual, groups and structure have impacts on the organizational effectiveness.
2. To learn the basic concepts of Organizational Behavior and its applications in contemporary organizations.
3. To appreciate the theories and models of organizations in the workplace to creatively and innovatively engage in solving organizational challenges.
4. To learn and appreciate different cultures and diversity in the workplace.

Course Outcome:

CO1: Able to analyse and compare different models used to explain individual behavior related to motivation.

CO2: Understanding how individual, groups and structure have impacts on the organizational effectiveness.

CO3: Learning the basic concepts of Organizational Behavior and its applications in contemporary organizations.

CO4: Learning and appreciating the different cultures and diversity in the workplace. Understanding the group dynamics and demonstrating skills required to work in teams.

Module-1: Individual Level **(11 Hours)**

The study of Organizational Behaviour: Definition, Meaning, Why study OB; Learning – Principles of learning and learning theories: Classical Conditioning and Operant conditioning, Personality- Meaning, Determinants, Types of Personality, Perception- Perceptual Process, perceptual errors, Attitude (cognitive dissonance), Motives and Motivation-Nature and Process, Theories of Motivation (Herzberg, Maslow, ERG, Vroom’s expectancy theory) .

Module-2: Group level-I **(6 Hours)**

Groups in Organizations –Nature, Types, Group formation, Determinants, factors contributing to Group Cohesiveness, Group Decision Making Process: Brainstorming and Nominal group technique

Module-3: Group level-II **(6 Hours)**

Types of Leadership- Effective Leadership, Styles of leadership: Autocratic, Democratic and Lassiez faire, Leadership Theories-Trait Theory and Contingency Theory(SLT, Path-goal theory and Fred Fiedler's model), Conflict- Types of conflict, Conflict Resolution Techniques, Emotional Intelligence, Emotions and Stress in workplace.

Module-4: Structural level **(7 Hours)**

Organizational Culture: Cultural dimension and organizational effectiveness, Organizational Change: Types of change, Process of change, Reasons to change, Resistance to change and managing resistance to change.

Text Books:

1. Stephens P Robbins, Organisational Behaviour, PHI
2. K. Aswatthappa, Organisational Behaviour, HPH

Reference Books:

1. Kavita Singh, Organisational Behaviour, Pearson
2. D.K.Bhttacharya, Organisational Behaviour, OUP
3. PradeepKhandelwal, Organisational Behaviour, TMH
4. Keith Davis, Organisational Behaviour, McGrawHill
5. Nelson Quick, ORGB, Cengage Learning

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	2	1	-	-	-	2	3	2	2	2	-	2	-
CO2	2	1	-	-	-	2	2	3	3	3	-	2	-
CO3	2	-	-	-	-	3	3	3	2	3	-	2	-
CO4	2	1	-	-	-	3	2	2	2	2	-	2	-

Machine Drawing Laboratory

Hours/Week L-T-P :	0-0-3	Credits:	1.5
Course Type :	LC	Course Code:	MS2521

Course Objectives:

This course is expected to:

11. To understand and apply standards in drawing machine component
12. To understand the concept of various tolerances and fits used for component design
13. To familiarize in drawing assembly, orthographic and sectional views of various machine components
14. Use CAD packages to Create solid models and Generate orthographic projections of machine components and assembly

Course Outcomes:

CO1: Follow the standards to create machine drawings.
CO2: Apply limits and tolerances to assemblies and choose appropriate fit.
CO3: Develop solid models of machine components and assembly, and Construct sectional and orthographic views of components.
CO4: Make use of CAD packages for solid modeling of machine parts and Create bill of materials.

(Sheets: 5, CAD: 3)

List of Experiments:

1. Introduction to Standardization, Inter-changeability, Selective Assembly, Limits, Fits, Tolerance, Tolerance of form and position, Grades of tolerance, Standard tolerances Symbols used in machine drawing: Machining symbols, Welding symbols.

2. Drawing of Machine Elements (Any 4)
1. Cotter Joint,
2. Knuckle Joint
3. Flange Coupling
4. Flexible Coupling
5. Oldham Coupling
6. Solid and Bush shaft bearing
7. Socket and Spigot Joint

3. Assembly Drawings (Manual & Using Application Packages): (Any 2)
1. Screw jack.
2. Engine: Piston and connecting rod.
3. Stop Valve
4. Relief Valve

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	3	2	2	-	1	1	2	1	1	1	3	2	2
CO2	1	2	1	2	-	1	1	2	2	2	1	2	2	1
CO3	3	1	1	1	-	2	1	2	2	1	1	2	2	1
CO4	2	2	1	2	-	2	1	1	2	2	1	2	2	1

Artificial intelligence laboratory			
Hours/Week L-T-P :	0-0-3	Credits:	1.5
Course Type :	Laboratory Course	Course Code:	MS2529

Course Objectives (COs):

1. To develop logical thinking and coding skills using Python for solving basic computational problems.
2. To implement classical AI and search algorithms for solving problem-based tasks.
3. To build simple applications and games to understand real-time interaction, data

Course Outcomes (COs):

CO1: Apply fundamental programming constructs like loops, conditionals, and functions to solve basic computational problems.

CO2: Implement search and AI algorithms such as BFS, DFS, A*, and hill climbing in Python.

CO3: Develop small-scale applications such as calculators, chatbots, and games using logical programming techniques.

CO4: Design and analyze algorithmic solutions for classical problems like Towers of Hanoi and the Water Jug Problem. processing, and decision-making.

List of Experiments

1. To write a program to print the multiplication table for the given number.
2. To write a program to find the factorial of a number.
3. To write a program to check whether the given number is prime or not.
4. To write a program to implement a simple calculator program.
5. To write a program to generate a calendar for the given month and year.
6. To write a program to illustrate different set operations?
7. To write a program to implement simple chat bot.
8. To write a program to remove punctuations from the given string
9. To write a program to sort the sentence in alphabetical order.
10. To write a program to implement of towers of hanoi problem.
11. To write a program to implement breadth first search.
12. To write a program to implement depth first search.
13. To write a program to implement hill climbing algorithm.
14. To write a program to implement a* algorithm.
15. To write a program to implement tic-tac-toe game.
16. To write a program to implement water jug problem.

(CO)	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1:	3	2	2	1	2	-	-	-	-	1	-	-	3	2
CO2:	3	3	3	2	2	-	-	-	-	1	-	-	3	2
CO3:	2	2	3	2	3	-	-	-	1	2	-	-	3	3
CO4:	3	3	3	3	2	-	-	-	-	2	-	-	3	2

Robotics Programming Laboratory			
Hours/Week L-T-P :	0-0-3	Credits:	1.5
Course Type :	Laboratory Course	Course Code:	MS2531

course Objectives:

1. Understand the operation and safety protocols of industrial robotic systems and their controllers.
2. Develop and debug robot programs using teach pendants and advanced logic structures.
3. Configure and manage robotic system inputs, outputs, coordinate systems, and recovery processes.

Course Outcomes (CO):

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

CO1: Safely operate and initialize industrial robots using controller interfaces and teach pendants.

CO2: Write and troubleshoot basic to advanced robot programs involving logic commands and signal assignments.

CO3: Configure robotic coordinate systems, home positions, and user-defined functions for task automation.

CO4: Perform system recovery, backup, and maintenance operations including mastering and program conversion.

List of experiments:

Any 10 experiments from the following

1. Safely power up the robot and controller from a fully shutdown position.
2. Understand general robotic safety within working envelopes.
3. Know the purpose and operation of the teach pendant.
4. Basic programming overview, refresher.
5. Definition and theory of harmonious programming.
6. Input and Output signal assignment.
7. System Mastering (robot and external axis.)
8. Advanced logic commands and program structure.
9. Total system recovery/tool shift for program correction.
10. Advanced Input/Output programming for system allocation.
11. Teach pendant layout and customization.
12. System back-up and program data.
13. How to set-up and use user coordinate systems.
14. How to set-up and use home position fields.
15. How to create and use function grouping.
16. Use and manipulate program conversion functions.

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	2	3	1	1	2	1	1	1	3	2	2
CO2	3	2	1	2	3	1	1	2	3	2	1	2	2	2
CO3	3	2	2	2	3	2	1	2	2	1	1	2	2	1
CO4	3	2	1	2	3	2	1	1	2	2	1	2	2	1

Advanced Digital Manufacturing Lab			
Hours/Week L-T-P :	0-0-3	Credits:	1.5
Course Type :	Laboratory Course	Course Code:	MS2527

Course Objective:

1. To analyze the different software to solve manufacturing problems
2. To learn the codes of CNC
3. To Perform experiments in EDM,ECM and 3D printing.

Course Outcomes:

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

CO1: Use the softwares like Auto MOD,PROOD,SLAM-II to solve real world problems

CO2: Write programs for CNC machining

CO3: Prepare model using 3D printing

CO4: Analyze MRR,TWR and other parameters in unconventional machining processes

List of experiments:

1. To learn the application of the following software to manufacturing problems:
   Auto MOD Software., PROMOD, SLAM-II , CAFIMS , Flexsim
2. Introduction to CNC machines

3. Study of different codes for different operations
4. Write a program for CNC to obtain a specified job
5. Experimental Study of MRR on EDM
6. Experimental Study of TWR on EDM
7. Experimental Study of Surface Roughness on EDM
8. Experimental Study on ECM
9. Experimental Study on 3D Printing

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	2	3	1	1	2	1	1	1	3	2	2
CO2	3	2	1	2	3	1	1	2	3	2	1	2	2	2
CO3	3	2	2	2	3	2	1	2	2	1	1	2	2	1
CO4	3	2	1	2	3	2	1	1	2	2	1	2	2	1

School/ Department: School of Mechanical Sciences

Course: B. Tech., Programme: Mechanical Engineering (Robotics and Artificial Intelligence)

Abbreviation used:

AC	Audit course	LC	Laboratory Course	PA	Practical Assessment
PC	Professional Core	PR	Project/ Practical/ Internship	L	Lecture
PE	Professional Elective	SE	Seminar/ Expert Lecture/ Etc.	T	Tutorial
OE	Open Elective	IA*	Internal Assessment	P	Practical
MC/BS/HS	Mandatory/ Common Course	EA	End-Semester Assessment		
ACC	Advanced Competency Course				
*Internal Assessment Mark (40 marks) consists of (i) Mid Semester (20 marks), (ii) Quiz/ Assignment/Attendance (20 marks)					

4th Semester

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
				L	T	P		IA	EA	PA	Total
1	PC	MS2122	Robot Dynamics and Control	3	0	0	3	40	60	-	100
2	PC	MS2124	Soft Computing and Applications	3	0	0	3	40	60	-	100
3	PC	MS2126	Solid Mechanics and Design	3	0	0	3	40	60	-	100
4	PC	MS2128	Thermal and Fluid Science	3	0	0	3	40	60	-	100
5	ACC	MS2130	Intelligent Manufacturing	3	0	0	2	40	60	-	100
6	HS	BH2439	Engineering Economics	3	0	0	2	40	60	-	100
7	LC	MS2522	CAD/CAE Laboratory	0	0	3	1.5	-	-	100	100
8	LC	MS2524	Material Testing and Machine Dynamics Laboratory	0	0	3	1.5	-	-	100	100
9	LC	MS2530	Soft Computing Laboratory	0	0	3	1.5	-	-	100	100
10	LC	MS2528	Fluid Thermal Laboratory	0	0	3	1.5	-	-	100	100
11	Summer Internship and Research Experience (SIRE - I) *										
			Total	**18**	**0**	**12**	**22**	**240**	**360**	**400**	**1000**

***Minimum 4 weeks of Summer Course / Training / Internship / Skill Course / etc. after 4th Semester**

ROBOT DYNAMICS AND CONTROL			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	PC	Course Code:	MS2122

Prerequisites: Basic knowledge of engineering mechanics, linear algebra, differential equations, control systems, and introductory robotics.

Course Objectives :

1. To understand the kinematic structure and velocity relationships of robotic manipulators using Jacobians.
2. To analyze the dynamic behavior of robotic systems using Lagrangian and Newton-Euler formulations.
3. To study force control strategies applicable to constrained tasks and industrial applications.
4. To design and evaluate control techniques for precise and compliant motion of robotic joints.

Course Outcomes (COs):

CO1: Apply forward and inverse kinematics, velocity propagation, and Jacobian matrices to analyze robot motion.

CO2: Formulate dynamic models of manipulators using Lagrange and Newton-Euler methods and analyze static forces.

CO3: Implement hybrid position/force control strategies for manipulators in partially constrained environments.

CO4: Design and tune control laws such as PD, PID, and impedance control for joint motion and force compliance.

Module-1 Jacobians: Velocities Analysis **(9 Hours)**

Forward Kinematics. (DH parameter) Inverse Kinematics Workspace, Differential kinematics , notation for time-varying position and orientation, linear and rotational velocity of rigid bodies, more on angular velocity, motion of the links of a robot, velocity "propagation" from link to link, jacobians, singularities.

Module-2 Dynamics analysis and static forces **(9 Hours)**

Jacobian derivation Manipulability , Lagrange equation of motion Kinetic and Potential energyInertia tensor Reflected/ effective moment of inertia, Manipulator Equation Examples and properties Forward and inverse dynamics, Newton-Euler algorithm. Static Force analysis of robot, Transformations of forces and moments between co-ordinate frames.

Module-3 Force control of manipulators **(9 Hours)**

Application of industrial robots to assembly tasks, a framework for control in partially constrained tasks, the hybrid position/force control problem, force control of a mass—spring system, the hybrid position/force control scheme. Feedback control of single link manipulator.

Module-4 Robot Control **(9 Hours)**

Joint PD control Selecting gains Practical considerations, Joint PID control Feedforward control PD control feedforward, Stiffness and compliance Impedance control

TEXT BOOKS:

1. John J. Craig, "Introduction to Robotics – Mechanics and control", 3rd edition, Prentice hall, 2022.
2. Groover. M.P., Weis. M., Nagel. R.N. and Odrey.N.G. "Industrial Robotics Technology, Programming and Applications", Mc Graw-Hill, Int., 2012.

REFERENCES:

1. K.S.Fu, Gonzalez, R.C. and Lee, C.S.G. "Robotics Control, Sensing, Vision and Intelligence", McGraw Hill, 1987.
2. Saeed B. Niku, "Introduction to Robotics: Analysis, Control, Applications", 2nd edition, John Wiley & sons, Inc., 2020
3. Klafter. R.D., Chmielewski, T.A. and Negin. M. "Robotics Engineering – An Integrated Approach", Prentice-Hall of India Pvt. Ltd., 2006.

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	3	2	1	1	1	1	1	1	3	2	2
CO2	3	3	3	3	2	1	1	1	1	1	1	3	3	2
CO3	3	2	2	3	3	1	1	1	1	1	1	2	3	2
CO4	3	3	3	3	3	1	1	1	1	1	1	3	3	3

SOFT COMPUTING AND APPLICATIONS			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	PC	Course Code:	MS2124

Prerequisite: Basic knowledge of linear algebra, probability, calculus, and fundamentals of artificial intelligence or machine learning.

Course Objectives:

1. To introduce the fundamental concepts of soft computing and its components such as fuzzy logic, neural networks, and genetic algorithms.
2. To enable students to design and apply fuzzy systems for reasoning and inference under uncertainty.
3. To develop an understanding of supervised and unsupervised neural network architectures and their applications.
4. To familiarize students with hybrid soft computing techniques like Neuro-Fuzzy systems and genetic algorithms for problem-solving.

Course Outcomes (COs):

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

CO1: Apply fuzzy logic concepts to solve problems involving uncertainty and vagueness.

CO2: Analyze and design neural networks for classification and pattern recognition tasks.

CO3: Implement genetic algorithms for optimization problems in engineering domains.

CO4: Develop and evaluate Neuro-Fuzzy models for real-time intelligent systems.

Module -1
INTRODUCTION TO SOFT COMPUTING AND FUZZY LOGIC **(8 Hours)**
Introduction - Fuzzy Logic - Fuzzy Sets, Fuzzy Membership Functions, Operations on Fuzzy Sets, Fuzzy Relations, Operations on Fuzzy Relations, Fuzzy Rules and Fuzzy Reasoning, Fuzzy Inference Systems

Module -2
NEURAL NETWORKS **(8 Hours)**
Supervised Learning Neural Networks – Perceptrons - Backpropagation -Multilayer Perceptrons –Unsupervised Learning Neural Networks – Kohonen Self-Organizing Networks

Module -3
GENETIC ALGORITHMS **(8 Hours)**
Chromosome Encoding Schemes -Population initialization and selection methods – Evaluation function - Genetic operators- Cross over – Mutation - Fitness Function – Maximizing function.

Module -4
NEURO FUZZY MODELING **(8 Hours)**
ANFIS architecture – hybrid learning – ANFIS as universal approximator – Coactive Neuro fuzzy modeling – Framework – Neuron functions for adaptive networks – Neuro fuzzy spectrum – Analysis of Adaptive Learning Capability

Text Books:
1. J.S.R.Jang, C.T. Sun and E.Mizutani, "Neuro-Fuzzy and Soft Computing", PHI / Pearson Education 2004.
2. S.N.Sivanandam and S.N.Deepa, "Principles of Soft Computing", Wiley India Pvt Ltd, 2011.

Reference Book:
1. S.Rajasekaran and G.A.VijayalakshmiPai, "Neural Networks, Fuzzy Logic and Genetic Algorithm: Synthesis & Applications", Prentice-Hall of India Pvt. Ltd., 2006.
2. George J. Klir, Ute St. Clair, Bo Yuan, "Fuzzy Set Theory: Foundations and Applications" Prentice Hall, 1997.
3. David E. Goldberg, "Genetic Algorithm in Search Optimization and Machine Learning" Pearson Education India, 2013.
4. James A. Freeman, David M. Skapura, "Neural Networks Algorithms, Applications, and Programming Techniques, Pearson Education India, 1991.
5. Simon Haykin, "Neural Networks Comprehensive Foundation" Second Edition, Pearson Education, 2005

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	2	3	1	1	1	1	2	1	3	2	2
CO2	3	2	3	2	3	1	1	1	2	2	1	3	2	2
CO3	3	3	3	3	3	1	1	1	2	2	1	3	2	2
CO4	3	2	3	3	3	1	1	1	2	2	2	3	3	2

SOLID MECHANICS AND DESIGN			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	PC	Course Code:	MS2126

Prerequisites: Engineering Mechanics, Engineering Mathematics, and Basic Engineering Drawing.

Course Objectives:

1. To introduce the basic concepts of stress, strain, and deformation in mechanical elements.
2. To enable analysis of beams and shafts under different loading conditions.
3. To impart understanding of the design principles for mechanical elements like shafts and springs.
4. To develop competency in designing joints (riveted and welded) under various loads.

Course Outcomes (COs)

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

CO1: Analyze stress, strain and deformation in structural members.

CO2: Construct shear force and bending moment diagrams for different beam loadings.

CO3: Design machine components like shafts and helical springs using strength-based methods.

CO4: Design and analyze riveted and welded joints for mechanical applications.

Module-1 **(10Hours)**

SIMPLE STRESSES & STRAINS: Elasticity and plasticity – Types of stresses & strains–Hooke's law–stress–straindiagramformildsteel–Lateralstrain,Poisson'sratio&volumetricstrain–Barsofvaryingsection–compositebars–Temperaturestresses-Principalplanes and principal stresses -Mohr's circle - Relation between elastic constants.

SHEAR FORCE AND BENDING MOMENT: Definition of beam–Types of beams–Concept of shear force and bending moment – S.F and B.M diagrams for cantilever, simply supported and overhanging beamssubjectedtopointloads,u.d.l,uniformlyvaryingloadsandcombinationoftheseloads–Pointof contra flexure – Relation between S.F, B.M and rate of loading at a section of abeam.

Module-2 **(10 Hours)**

FLEXURAL STRESSES: Theory of simple bending – Assumptions – Derivation of bending equation, Determination bending stresses – section modulus of rectangular and circular sections(Solid and Hollow).

DEFLECTION OF BEAMS: Bending into a circular arc – slope, deflection and radius of curvature–Differentialequationfortheelasticlineofabeam–Determinationofslopeanddeflectionforcantil ever and simplysupportedbeamssubjectedtopointloads,-U.D.Luniformlyvaryingload.

Module-3 **(8 Hours)**

CONCEPTS OF MACHINE DESIGN: Modes of failure, factor of safety concepts. Design of shafts based on strength, Torsional Rigidity, Types of helical springs, Design of Helical springs.

Module-4 **(6 Hours)**

Design of Joints: Riveted joint, welded joints

Text Books:

1. Strength of materials -GH Ryder, Mc Millan publishers IndiaLtd.
2. Solid Mechanics, byPopov.
3. Mechanical Engineering Design, J.E.Shigley, C.R.Mischke, R.G.Budynas and K.J.Nisbett, TMH.
4. Design of Machine Elements, V.B. Bhandari, Tata McGrawHill.
5. Machine Design Theory and Practice, Deutschman, D., Michels, W.J. and Wilson, C.E. Macmillan,

Reference Books:

1. Strength of Materials -By Jindal, UmeshPublications.
2. Analysis of structures by VaziraniandRatwani.
3. Mechanics of Structures Vol-III, byS.B.Junnarkar.
4. Strength of Materials byS.Timoshenko
5. Strength of Materials by Andrew Pytel and FerdinondL. SingerLongman.
6. Fundamentals of Machine Component Design by R.C.Juvinall and K.M.Marshek, John Wiley & Sons
7. Machine Design, P.C.Sharma and D.K.Agrawal, S.K.Kataria&Sons
8. Machine Design, Pandya and Shah, CharotarBookStall
9. Machine Design, Robert L. Norton, Pearson EducationAsia.

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	2	2	1	1	1	1	1	1	3	2	1
CO2	3	2	3	2	2	1	1	1	1	1	1	3	2	2

CO3	3	2	3	2	3	1	1	1	1	1	1	3	2	3
CO4	3	2	3	2	3	1	1	1	1	2	1	3	2	2

THERMAL AND FLUID SCIENCE			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	PC	Course Code:	MS2128

Prerequisites: Basic Thermodynamics, Engineering Physics, and Fluid Mechanics.

Course Objectives:

1. Understand and apply the laws of thermodynamics to various thermal systems including nozzles and compressors.
2. Analyze air-standard and vapor power cycles along with steam and gas turbine systems.
3. Explore fluid flow principles and apply them to internal flows and hydraulic devices.
4. Understand working principles and efficiency analysis of turbomachines and hydraulic equipment.

Course Outcomes (COs)

By the end of this course, students will be able to:

CO1: Apply first and second laws of thermodynamics to flow systems and analyze performance of nozzles and compressors.

CO2: Analyze and compare thermodynamic cycles and components used in IC engines and steam power plants.

CO3: Evaluate internal flows using Bernoulli's principle and apply it to flow devices like venturimeters and diffusers.

CO4: Explain the working and performance characteristics of turbines and pumps using fluid mechanics principles.

Module-1 **(8 Hours)**

First law of thermodynamics for control mass and control volume systems, combined first and second laws of thermodynamics: flow and non-flow processes. Flow analysis of steam in nozzle using SFEE, nozzle efficiency and factors that affect the efficiency. Second Law of thermodynamics, Properties of pure substances, Vapor compression and reverse Brayton cycles, vapor absorption cycle, basics of psychrometry, reciprocating, rotary and centrifugal compressors

Module-2 **(8 Hours)**

Air-standard cycles: Otto cycle, Diesel Cycle, Dual cycle, thermodynamic analysis of SI & CI Engine, Engine Efficiencies.

Description of steam power plant: ideal and actual Rankine cycles, reheat and regenerative cycles, and their limitations, feed water heaters and analysis, application of Rankine to nuclear power plants.

Basics of boiler, boiler attachments, super heaters, impulse and reaction steam turbines, flow nozzles, types of condensers, and cooling towers and their analysis

Module-3 **(8 Hours)**

Introduction to Bernoulli's principle and application convergent nozzle, divergent nozzles, diffusers, venturimeter, orifice meter and siphon.

Viscous flow in pipes, Reynold's number, friction factor, pipe network, calculations for flow rate, head loss in pumping power.

Module-4 **(8 Hours)**

Euler's equation for turbo machines, basics of Pelton wheel, Francis turbine, Kaplan Turbine, and centrifugal pump: hydraulic, mechanical and different energy efficiencies, performance characteristics and working principle.

Text Books:

1. Fundamentals of Thermodynamics, C. Borgnakke, R.E. Sonntag, John Wiley and Sons, 7th Edition
2. Fundamentals of Heat and Mass Transfer, F. P. Incropera, D. P. Dewitt, T. L. Bergman, A. S. Lavine, Wiley India Publication, 6th Edition
3. S. K. Som, G. Biswas, S. Chakraborty, Introduction to fluid Mechanics and Fluid Machines, 3rd Edition, McGrawhill

Reference books:

1. Thermal engineering by P. L. Ballaney
2. Thermodynamics - An Engineering Approach, Y. Cengel, M.A. Boles, M. KanogluMcGraw Hill, 9th Edition
3. Fluid Mechanics - Fundamentals and Applications, Y.Cengel, J.M.Cimbala

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	2	2	1	0	0	1	1	1	3	2	1
CO2	3	2	2	2	3	1	0	0	1	1	1	3	2	2
CO3	3	2	2	2	2	1	0	0	1	1	1	2	2	2
CO4	3	2	3	2	3	1	0	0	1	1	1	3	2	2

INTELLIGENT MANUFACTURING			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	ACC	Course Code:	MS2130

Prerequisite: Basic knowledge of Manufacturing Processes, CAD/CAM, and Industrial Automation.

Course Objectives:

1. To provide knowledge about CIM system structure and its components such as CAD, CAM, CAPP, and CAQC.
2. To understand the principles and techniques of automated process planning and expert systems.
3. To apply group technology methods and algorithms to manufacturing systems.
4. To explore knowledge-based and AI-based approaches for industrial decision-making and planning.

Course Outcomes (COs):

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

CO1: Explain the structure and components of a CIM system and their roles in integrated manufacturing.

CO2: Apply automated and knowledge-based process planning methods to real-world manufacturing problems.

CO3: Utilize group technology algorithms for efficient part classification and layout planning.

CO4: Analyze and implement AI-based strategies in manufacturing decision-making and planning tasks.

Module-1 **(8 Hours)**

Computer Integrated Manufacturing Systems Structure and functional areas of CIM system,- CAD, CAPP, CAM, CAQC, ASRS. Advantages of CIM. Manufacturing Communication Systems - MAP/TOP, OSI Model, Data Redundancy, Top- down and Bottom-up Approach, Volume of Information. Intelligent Manufacturing System Components, System Architecture and Data Flow, System Operation.

Module-2 **(8 Hours)**

Automated Process Planning - Variant Approach, Generative Approach, Expert Systems for Process Planning, Feature Recognition, Phases of Process planning. Knowledge Based System for Equipment Selection (KBSES) - Manufacturing system design. Equipment Selection Problem, Modeling the Manufacturing Equipment Selection Problem, Problem Solving approach in KBSES, Structure of the KRSES.

Module-3 **(8 Hours)**

Group Technology: Models and Algorithms Visual Method, Coding Method, Cluster Analysis Method, Matrix Formation-Similarity Co efficient Method, Sorting-based Algorithms, Bond Energy Algorithm, Cost Based method, Cluster Identification Method, Extended CI Method.

Knowledge Based Group Technology - Group Technology in Automated Manufacturing System. Structure of Knowledge based system for group technology (KBSC IT) — Data Base, Knowledge Base, Clustering Algorithm.

Module-4 **(8 Hours)**

Application of AI to Industrial Planning and Decision Making, Speicial Purpose Resource, Design in Planning to Make More Efficient Plans.

Text Books:

1. Andrew Kusiak, “Intelligent Manufacturing Systems”,PrenticeHall, 1990.
2. Mikell P. Groover, “Automation, Production Systems and Computer integrated Manufacturing”, 8th edition, PHI,2008

Reference Books:

1. Mohammad Jamshidi,“Design and Implementation of Intelligent Manufacturing Systems: From Expert Systems, Neural Networks to Fuzzy Logic”, 1st Edition, 1995.
2. Lucia Knapčíková, Michal Balog,“ Industry 4.0:Trends in Management of Intelligent ManufacturingSystems”,Springer,2019835441

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	1	2	1	0	0	1	2	1	3	2	1
CO2	3	3	3	2	3	1	0	0	1	2	2	3	3	2
CO3	3	2	3	2	3	1	0	0	2	2	2	3	3	2
CO4	3	3	3	3	3	1	0	0	2	2	2	3	3	2

ENGINEERING ECONOMICS			
Hours/Week L-T-P :	3-0-0	Credits :	2

Course Type :	HS	Course Code:	BH2439

Prerequisite: Basic understanding of mathematics and introductory business or economics concepts.

Course Objectives:

1. To provide foundational knowledge on the time value of money, depreciation, and economic evaluation of projects.
2. To introduce key economic concepts including demand, supply, inflation, and national income.
3. To analyze cost and revenue relationships and understand market structures.
4. To relate economic theory to engineering decision-making in project evaluations and resource allocation.

Course Outcomes (COs):

Upon successful completion, the student will be able to:

CO1: Apply time value of money and economic equivalence principles to evaluate engineering alternatives.

CO2: Analyze project viability using economic methods like present worth, annual worth, and IRR.

CO3: Explain core economic concepts such as inflation, national income, unemployment, and banking systems.

CO4: Evaluate the influence of demand, supply, and market structures in decision-making.

Module-1 **(6 Hours)**

Time value of money- Interest - Simple and compound, nominal and effective rate of interest, Cash flow diagrams, Principles of economic equivalence.

Evaluation of engineering projects-Present worth method, Future worth method, Annual worth method, Internal rate of return method, Cost benefit analysis for public projects.

Depreciation- Depreciation of capital assert, Causes of depreciation, Methods of calculating depreciation (Straight-line method, Declining balance method), after tax comparison of project.

Module-2 **(8 Hours)**

Cost and revenue concepts, Basic understanding of different market structures, Determination of equilibrium price under perfect competition (Simple numerical problems to be solved), Break Even Analysis-linear approach (Simple numerical problems to be solved).

Banking -Commercial bank, Functions of commercial bank, Central bank, Functions of Central Bank.

Inflation-Meaning of inflation, types, causes, measures to control inflation.

National Income-Definition, Concepts of national income, Method of measuring national income.The Circular Flow of Income, Different measures of National Income, GNP, GDP. Concept of Money and its function; Unemployment, its types, causes and Stagflation; Exchange Rate and its determination.

Module-3 **(6 Hours)**

Engineering Economics- Nature, Scope, Basic problems of an economy, Micro Economics and Macro Economics.

Demand- Meaning of demand, Demand function, Law of Demand and its exceptions, Determinants of demand, Demand Estimation and Forecasting, Elasticity of demand & its measurement (Simple numerical problems to be solved)

Module-4 **(6 Hours)**

Supply-Meaning of supply, Law of supply and its exception, Determinants of supply, Elasticity of supply, Determination of market equilibrium (Simple numerical problems to be solved).

Production-Production function, Laws of returns: Law of variable proportion,
Law of returns to scale.

Basic Concepts of Market; Monopoly, Perfect Competition, Oligopoly and Monopolistic Competitive Market.

Text Books

1. Riggs, Bedworth and Randhwa, "Engineering Economics", McGraw Hill Education India
2. DevigaVengedasalam "Principles of Economics", Oxford University Press.

ReferenceBooks:

1. William G.Sullivan, ElinM.Wicks, C. PatricKoelling"Engineering Economy", Pearson
2. R. PaneerSelvam, "Engineering Economics", PHI
3. S.P.Gupta, "Macro Economics", TMH.
4. S.B. Gupta,"Monetary Economics", Sultan Chand and Co.
5. Mankiew, N G, "Principles of Microeconomics", Eighth Edition, Cengage Learning, 2016. 6. Sikdar, S, "Principles of Microeconomics", Third Edition, OUP, 2020.

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	1	1	1	2	3	3	2	1	2	2
CO2	3	2	3	3	1	-	2	1	3	3	2	1	2	1
CO3	3	3	2	2	1	-	3	2	3	2	2	1	1	2
CO4	2	2	3	2	1	-	3	2	2	3	2	1	2	2

CAD/CAE LABORATORY

Hours/Week L-T-P :	0-0-3	Credits:	1.5
Course Type :	LC	Course Code:	MS2522

Course Objectives :

1. To introduce the basic principles and user interface of modern CAD software.
2. To develop skills in creating 2D sketches, 3D solid, and surface models using parametric modeling.
3. To enable students to perform feature-based modeling and assembly design.

Course Outcomes (COs):

Upon successful completion of the lab, students will be able to:

CO1: Understand and operate CAD tools for sketching and modeling.

CO2: Develop 3D models of components using solid and surface modeling techniques.

CO3: Perform assembly modeling with constraints and interference checks.

CO4: Create detailed 2D drawings and layout sheets for components and assemblies.

List of Experiments:

1. CAD Introduction.
2. Sketcher
3. Solid modeling – Extrude, Revolve, Sweep and variational sweep, Loft
4. Surface modeling – Extrude, Sweep, Trim and Mesh of curves, Freeform.
5. Feature manipulation – Copy, Edit, Pattern, Suppress, History operations etc.
6. Assembly - Constraints, Exploded Views, Interference check.
7. Drafting - Layouts, Standard & Sectional Views, Detailing & Plotting. Exercises in modeling and drafting of mechanical components-assembly using parametric and feature based packages like PRO-E/SOLIDWORKS /CATIA/NX

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	-	-	-	1	-	-	1	-	3	2	2
CO2	3	2	1	-	-	-	1	-	-	1	-	3	2	2
CO3	3	2	1	-	-	-	1	-	-	1	-	3	2	2
CO4	2	2	1	2	-	1	-	1	3	2	1	2	1	1

Material Testing and Machine Dynamics Laboratory

Hours/Week L-T-P :	0-0-3	Credits:	1.5
Course Type :	LC	Course Code:	MS2524

Course Objectives:

1. To learn about the tensile strength/ compressive strength/ bending strength of materials
2. To learn about the Brinnel, Rockwell and Vickers Hardness strength of materials
3. To study the static and dynamic balancing of machines and various types of governors along with their performance characteristics.
4. To study the principles of gyroscopes.

Course Outcomes:

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

CO1: Determine the tensile strength/ compressive strength/ bending/impact strength of materials.

CO2: Analyze the Brinnel, Rockwell and Vickers Hardness strength and rigidity of materials.

CO3: Analyze mechanisms like governors, Gyroscopes used in machines.

CO4: Carry out static and dynamic balancing of machines and evaluate the moments of inertia of machine parts.

List of Experiments:

1. Determination of tensile strength/ compressive strength/ bending strength of materials by Universal Testing Machine
2. Determination of Impact strength of material (Charpy and Izod)
3. Determination of Hardness strength of materials (Brinnel, Rockwell and Vickers)
4. Determination of Rigidity modulus of material
5. To determine gyroscopic couple on Motorized Gyroscope.
6. To perform experiment on watt and Porter Governors to prepare performance characteristic Curves, and to find stability & sensitivity
7. To perform experiment on Proell Governors to prepare performance characteristic Curves and to find stability & sensitivity.
8. To perform the experiment for static balancing on static balancing machine.
9. To perform the experiment for dynamic balancing on dynamic balancing machine.

10. To determine the moment of inertia of parts like connecting rod by compound pendulum method and tri-flair suspension method.

CO-PO mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	2	1	1	-	1	-	-	2	3	2	1
CO2	3	2	2	2	1	1	-	1	-	-	2	3	2	1
CO3	3	2	2	2	1	1	-	1	-	-	2	3	2	1
CO4	2	2	2	2	1	1	-	1	-	-	2	3	2	1

SOFT COMPUTING LABORATORY			
Hours/Week L-T-P :	0-0-3	Credits:	1.5
Course Type :	LC	Course Code:	MS2530

Course Objectives:

1. To provide hands-on experience in implementing fuzzy logic operations and membership functions.
2. To enable students to simulate and analyze neural network models like Perceptron, McCulloch-Pitts, and associative nets.
3. To develop the ability to apply soft computing techniques using MATLAB for real-world problem solving.

Course Outcomes (COs):

After completing the lab, students will be able to:

CO1: Implement basic fuzzy set operations and visualize membership functions using MATLAB.
CO2: Simulate logical functions using neural networks like McCulloch-Pitts and Perceptron models.
CO3: Develop associative neural networks for pattern recognition tasks.
CO4: Design fuzzy inference systems using tools like FIS Editor in MATLAB.

List of Experiments

1. To write a program in MATLAB to perform Union, Intersection and Complement operations.
2. To write a program in MATLAB to implement De-Morgan’s Law.
3. To write a program in MATLAB to plot various membership functions.
4. To implement FIS Editor.
5. To generate an AND NOT function using the McCulloch-Pitts neural net by a MATLAB program.
6. To write a MATLAB program for a Perceptron net for an AND function with bipolar inputs and targets

7. To write a MATLAB program to calculate the weights for the following patterns using a hetero associative neural net for mapping four input vectors to two output vectors.
8. To write a MATLAB program for an auto-associative net.

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	3	2	3	0	0	0	1	1	1	3	2	2
CO2	3	2	3	2	3	0	0	0	1	2	1	3	3	2
CO3	3	2	3	2	3	0	0	0	1	2	1	3	3	3
CO4	3	2	2	2	3	0	0	0	2	2	1	3	2	3

FLUID THERMAL LABORATORY			
Hours/Week L-T-P :	0-0-3	Credits:	1.5
Course Type :	LC	Course Code:	MS2528

Course Objectives:

1. To identify the behaviour of analytical models introduced in lecture to the actual behaviour of real fluid flows.
2. To explain the standard measurement techniques of fluid mechanics and their applications.
3. To illustrate the students with the components and working principles of the Hydraulic machines different types of Turbines, Pumps, and other miscellaneous hydraulics machines.

Course Outcomes:

Students who successfully complete this course will have demonstrated ability to:

CO1: Describe the measurement techniques of fluid mechanics and its appropriate application.
CO2: Interpret the results obtained in the laboratory for various experiments.
CO3: Compare the results of analytical models introduced in lecture to the actual behavior of real fluid flows and draw correct and sustainable conclusions
CO4: Perform test on centrifugal pump, reciprocating pump, turbines.

List of Experiments:
Any 10 experiments from the following

1. Experiments on flow through pipes and application of Bernoulli's principle
2. Determination of metacentric height and application to stability of floating bodies.
3. Determination of C_v and C_d of orifices.
4. Experiments on impact of jets
5. Experiments on performance of centrifugal pump / reciprocating pump
6. Experiments on performance of IC Engine
7. Experiments on Reynold's Apparatus
8. Study on Pelton / Francis / Kaplan Turbine
9. Study of steam power plant.
10. Study of gas turbine power plant.

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	-	-	-	1	-	-	1	2	3	2	2

CO2	3	2	1	-	-	-	1	-	-	1	2	3	2	2
CO3	3	2	1	-	-	-	1	-	-	1	2	3	2	2
CO4	2	2	1	2	-	1	-	1	3	2	1	2	1	1

School of Mechanical Sciences
Programme: Robotics and Artificial Intelligence

Abbreviation used:

AC	Audit course	LC	Laboratory Course	PA	Practical Assessment
PC	Professional Core	PR	Project/ Practical/ Internship	L	Lecture
PE	Professional Elective	SE	Seminar/ Expert Lecture/ Etc.	T	Tutorial
OE	Open Elective	IA*	Internal Assessment	P	Practical
MC/BS/HS	Mandatory/ Common Course	EA	End-Semester Assessment		
ACC	Advanced Competency Course				
*Internal Assessment Mark (40 marks) consists of (i) Mid Semester (20 marks), (ii) Quiz/ Assignment/Attendance (20 marks)					

5th Semester

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
				L	T	P		IA	EA	PA	Total
1	PC	MS3121	Robot Navigation and Path Planning	3	0	0	3	40	60	-	100
2	PC	MS3123	Design of Manipulators	3	0	0	3	40	60	-	100
3	PC	MS3125	Knowledge Engineering and Expert System	3	0	0	3	40	60	-	100
4	PE-1	MS3221	Mechatronics System Design	3	0	0	3	40	60	-	100
		MS3223	Sensors and Actuators in Robotics	3	0	0	3	40	60	-	100
		MS3225	Applications of Robotics	3	0	0	3	40	60	-	100
5	HS	BH3401/ BH3403	Business Management / Entrepreneurship Development	3	0	0	2	40	60	-	100
6	MC	IP3401/IP3403	Environmental Engineering/ Industrial Safety Engineering	3	0	0	2	40	60	-	100
7	LC	MS3521	Robot Modeling and Simulation Lab	0	0	3	1.5	-	-	100	100
8	LC	MS3523	Advanced Mechatronics Lab	0	0	3	1.5	-	-	100	100
9	LC	MS3525	Sensors and Actuators Lab	0	0	3	1.5	-	-	100	100
10	PSI	MS3701	Seminar on SIRE – I	0	0	3	1.5	-	-	100	100
			Total	**18**	**0**	**12**	**22**	**240**	**360**	**400**	**1000**

Robot Navigation and Path Planning			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	Professional Core	Course Code:	MS3121

Prerequisites

Engineering Mathematics, Engineering Mechanics, Solid Mechanics, Kinematics and Dynamics of Machines.

Course Objective:

1) Designing and implement trajectory plans for robotic manipulators
2) Programming for path plans for mobile robots
3) Carrying out the program robotic systems using the Robot Operating System (ROS) for various automation tasks.
4) Comparing different motion planning strategies for both manipulators and mobile robots.

Course Outcome:

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

CO1: Analyze and apply various trajectory-planning techniques for robotic manipulators.

CO2: Design and implement path planning algorithms for mobile robots in cluttered environments.

CO3: Develop and execute robotic programs using Robot Operating System for various operational tasks.

CO4: Evaluate and compare different motion planning strategies for both manipulators and mobile robots based on specific application requirements.

Module 1: TRAJECTORY PLANNING APPROACHES **(8 Hrs)**

Definitions – Task planning and Trajectory planning – Representation of end-effector: Cartesian and joint space schemes. Workspace Analysis: work envelope of a multi DOF manipulator. Applications: Point to point motion and continuous path motion.

Module 2: TRAJECTORY PLANNING OF MANIPULATOR **(8 Hhrs)**

Joint space techniques – Motion profiles – Cubic polynomial, Linear Segmented Parabolic Blends and cycloidal motion - Cartesian space technique – Straight line and circular trajectories.

Module 3: PATH PLANNING OF MOBILE ROBOT **(15 Hrs)**

Global path planning, local path planning, Path planning algorithm - classical algorithms (artificial potential field, graph search algorithm, and dynamic window approach), bionic algorithms genetic algorithm, ant colony optimization algorithm, particle swarm algorithm, firefly algorithm, and artificial intelligence algorithms fuzzy control algorithms and neural network algorithms. Sensors and actuators required for path planning.

Module 4: ROS PROGRAMMING **(5 Hrs)**

Robot language classification - Introduction to Robot Operating System (ROS) - ROS examples - Introduction to programming using ROS - Industrial ROS - ROS examples - Programming for point to point /continuous – operations - Case Study

Text Books:

1. Niku S B, "Introduction to Robotics, Analysis, Control, Applications", John-Wiley & Sons Inc, 2011.
2. Howie Choset, Kevin Lynch Seth Hutchinson, George Kantor, Wolfram Burgard, 3. Lydia Kavraki, Sebastian Thrun , "Principles of Robot Motion-Theory, Algorithms, and Implementation", MIT Press, Cambridge, 2005

Reference Books:

1. Planning Algorithms by Steve LaValle (Cambridge Univ. Press, New York, 2006).
2. Principles of Robot Motion: Theory, Algorithms, and Implementations (by Howie Choset, Kevin Lynch, Seth Hutchinson, George Kantor, Wolfram Burgard, Lydia Kavraki, and Sebastian Thrun.
3. Robot Motion Planning by J.C. Latombe.
4. Reza N Jazar , "Theory of Applied Robotics", Springer, 2010.
5. Morgan Quigley, Brian Gerkey, William D. Smart, Programming Robots with Ros: A Practical Introduction to the Robot Operating System, First Edition, 2016
6. Articles from the Journals with key words Robot Navigation and Path Planning.

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO 1	PSO 2	PSO 3
CO1	3	3	1	2	-	1	-	-	1	-	1	3	2	1
CO2	3	2	2	2	-	1	1	1	1	1	1	3	2	1
CO3	3	1	2	2	-	1	1	1	1	1	1	3	2	1
CO4	2	2	1	2	-	1	-	-	1	-	1	2	1	1

Design of Manipulators

Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	Professional Core	Course Code:	MS3123

Prerequisites: Robot Kinematics and Dynamics, Mechanics of Solid, CAD, Material Science

Course objectives:

The main objectives of this course is to:

1. Demonstrate the basic knowledge of industrial robots, characteristics, end effectors, actuators and grippers.
2. Inculcate the knowledge of requirements, constraints and conceptual design considerations for designing robotic manipulators.
3. Explain the detail process of design, manufacturing and testing of robotic manipulators.
4. Apply the knowledge of robotics in designing robot manipulators for various applications.

Course Outcomes:

On successful completion of this course, the students should be able to:

CO1: Describe basic knowledge of industrial robots, characteristics, end effectors, actuators and grippers.

CO2: Interpret the requirements, constraints and conceptual design considerations for designing robotic manipulators.

CO3: Design, analyze, manufacture, and test robotic manipulators.

CO4: Apply the concept design considerations in designing manipulators for various applications.

Module 1: Fundamentals of Manipulators **(9 Hours)**

Introductions: Robot, Robotics, Evolution of Robotic Manipulators, Robot Anatomy, Robot Specifications, Classifications, Robotic System Components

Actuators: Types of Actuators, Characteristics and Comparison of Actuating Systems, Electric Motors, Selection of Motors

Grippers: Types of Grippers, Selection of grippers

Module 2: Requirements, Constraints and Conceptual Design Considerations **(9 Hours)**

Requirements, Constraints Considerations: Purpose and Application, Payload Capacity, Degrees of Freedom, Accuracy and Precision, Speed and Velocity, Workspace, Constraints

Conceptual Design Considerations: Arm Configuration, Links, Joint Types, End-Effector, Actuators, Sensors, Control System

Module 3: Design, Manufacturing and Testing **(9 Hours)**

Detailed Design and Analysis:Kinematics, Dynamics, Material Selection and Design Based on Strength and Rigidity, CAD Modeling, Simulation, Analysis

Manufacturing and Assembly: Selection of manufacturing processes (e.g., CNC machining, 3D printing) based on material and design requirements, Assembly of the Components

Testing: Functional Testing, Performance Testing, Optimization

Module 4: Design Considerations for Specific Applications **(9 Hours)**

Design considerations for industrial applications**:** Pick and Place,Welding, Painting, Inspection and Assembly Operations

Design considerations for Medical (Surgical), Space, Marine, Mining, Agricultural Applications, Collaborative Robots, Teleoperated Manipulators

Text Books:

1. S. K. Saha, Introduction to Robotics, TATA McGraw Hills Education, 2014.
2. John J. Craig, Introduction to Robotics, Pearson Education Inc., Asia, 3rd Edition, 2005.

Reference Books:

1. Mittal, R. K., &Nagrath, I. J. (2003). Robotics and control. Tata McGraw-Hill.
2. S. B. Nikku, Introduction to Robotics – Analysis, Control, Applications, 3rd edition, John Wiley & Sons Ltd., 2020.

3. MikellGroover, Mitchell Weiss, Roger N. Nagel, Nicholas Odrey, AshishDutta, Industrial Robotics 2nd edition, SIE, McGraw Hill Education (India) Pvt. Ltd., 2012.
4. Ghosal A. Robotics: fundamental concepts and analysis. Oxford university press; 2006.

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	3	2	2	3	-	-	-	-	2	3	3	-
CO2	3	3	3	3	2	3	1	-	-	-	2	3	3	-
CO3	3	3	3	3	3	3	1	1	1	-	2	3	3	-
CO4	3	3	3	3	3	3	-	-	-	-	2	3	3	-

Knowledge Engineering and Expert System			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	Professional Core	Course Code:	MS3125

Prerequisite : Basic knowledge of artificial intelligence concepts, logic programming, and data structures.

Course Objectives :

1. To understand the fundamental concepts, components, and history of expert systems.
2. To explore knowledge acquisition techniques and inference mechanisms in expert systems.
3. To study knowledge representation methods and reasoning under uncertainty.
4. To examine real-world applications, validation techniques, and future trends in expert systems.

Course Outcomes (COs):

After completing this course, students will be able to:

CO1: Explain the architecture, characteristics, and applications of expert systems across various domains.

CO2: Apply knowledge acquisition and inference techniques such as forward and backward chaining.

CO3: Implement knowledge representation methods and handle uncertainty using probabilistic and fuzzy approaches.

CO4: Evaluate expert systems through real-world case studies and validation techniques.

Module 1: Introduction to Expert Systems **(8 Hrs)**

Definition, need, and history of expert systems,Characteristics and components (knowledge base, inference engine, user interface),Types and applications in medicine, engineering, and finance,Role of knowledge engineers, challenges, advantages and limitations.

Module 2: Architecture, Knowledge Acquisition & Inference **(8 Hrs)**

Expert system architecture and development steps,Knowledge acquisition methods: interviews, protocol analysis, observation,Inference mechanisms: forward and backward chaining, conflict resolution,Explanation facilities in expert systems.

Module 3: knowledge representation & uncertainty **(9 Hrs)**

Representation methods: production rules, semantic networks, frames, ontologies,Reasoning under uncertainty: certainty factors, Bayesian reasoning, fuzzy logic,Tools: CLIPS, JESS, Prolog, expert system shells,Introduction to plausible reasoning techniques

Module 4: Applications, case studies, validation **(10 Hrs)**

Evaluation and validation: performance metrics and testing methods,Meta-reasoning and debugging,Production-rule programming concepts,

Case studies and applications: medical diagnosis, fault diagnosis, decision support

Trends: integration with AI/ML, intelligent agents, future prospects

Text Books:

(i) Davis, R. & Lenat, D. B., "Knowledge-Based Systems in Artificial Intelligence", McGraw-Hill, 1989.

(ii) Hayes-Roth, F., Waterman, D. A. & Lenat, D. B. (eds) Building Expert Systems. Addison-Wesley Publishing Company, Inc., 1984.

Reference Books:

(i) Buchanan, B. B. & Shortliffe, E. H., "Building Expert Systems with Production Rules: The Mycin Experiments", Wesley Publishing Company, 1983.

(ii) Torsun, I. S. Expert Systems: State of the Art, Addison-Wesley Publishing Company, 1983.

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	1	2	1	1	0	1	2	2	3	2	2
CO2	3	2	3	2	3	0	0	0	1	2	2	3	3	3
CO3	3	2	3	2	3	0	0	0	1	2	2	3	3	3
CO4	3	2	2	2	2	1	1	0	2	3	2	3	2	2

Mechatronics System Design			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	Professional Elective I	Course Code:	MS3221

Prerequisite: Basic knowledge of sensors, actuators, control systems, and programming languages like C/C++.

Course Objectives (COs):

1. To provide foundational understanding of mechanical system design with a mechatronics approach.
2. To familiarize students with real-time interfacing for data acquisition and control.
3. To introduce microcontrollers and open-source platforms for embedded system integration.
4. To apply mechatronic concepts through practical case studies in control and automation.

Course Outcomes (COs):

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

CO1: Understand the integrated design process of mechanical systems with ergonomics and safety considerations.

CO2: Demonstrate real-time interfacing using data acquisition systems and I/O hardware.

CO3: Utilize microcontrollers and IoT modules to develop basic embedded applications.

CO4: Analyze and implement case studies for real-world mechatronic systems involving sensing, actuation, and control.

Module 1: Mechanical Systems and Design **(9 Hrs)**

Mechatronics approach – Control program control, adaptive control and distributed systems – Design process – Types of Design – Integrated product design – Mechanisms, load conditions, design and flexibility Structures, load conditions, flexibility and environmental isolation – Man machine interface, industrial design and ergonomics, information transfer from machine from machine to man and man to machine, safety.

Module 2: Real Time Interfacing **(8 Hrs)**

Introduction Elements of data acquisition and control Overview of I/O Process-Installation of I/O card & software – Installation of application software, Over framing.

Module 3: Microcontrollers **(8 Hrs)**

Introduction to use of open source hardware (Arduino & Raspberry Pi); shields/modules for GPS, GPRS/GSM, Bluetooth, RFID, and Xbee, integration with wireless networks, databases and web pages; web and mobile phone apps.

Module 4: Case studies on Data Acquisition **(10 Hrs)**

Transducer calibration system for Automotive Applications Strain Gauge weighing system – Solenoid force – Displacement calibration system – Rotary optical encoder – Inverted pendulum control – Controlling temperature of a hot/cold reservoir -Pick and place robot – Carpark barriers.

Case studies on design of Mechatronics products:Motion control using D.C. Motor, A.C. Motor & Solenoids – Car engine management – Barcode reader.

Text Books:

(iii) Brian Morris, "Automated Manufacturing Systems – Actuators, Controls, Sensors and Robotics", McGraw Hill International Edition, 1995.

(ii) Gopal, "Sensors- A Comprehensive Survey Vol I & Vol VIII", BCH Publisher, 2008.

AICTE Model Curriculum for UG Degree Course in Robotics & Artificial Intelligence Engineering

Reference Books:

(iii) W. Bolton, Mechatronics – Electronic Control systems in Mechanical and Electrical Engineering, 2nd Edition, Addison Wesley Longman Ltd., 1999.

(ii) Bradley, D. Dawson, N.C. Burd and A.J. Loader, "Mechatronics: Electronics in Products and Processes", Chapman and Hall, London, 1991.

(iii) Devdas Shetty, Richard A. Kolk, "Mechatronics System Design", PWS Publishing Company, 1997.

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	3	2	2	2	1	1	2	2	1	3	2	2
CO2	3	3	3	3	3	1	0	0	2	2	2	3	3	3
CO3	3	3	3	2	3	1	0	0	2	3	2	3	3	3
CO4	3	3	3	2	3	1	1	1	3	3	2	3	3	3

Sensors and Actuators in Robotics			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	Professional Elective I	Course Code:	MS3223

Prerequisites: Basic knowledge of mechanics, electrical circuits, sensors, and control systems.

Course Objective:

1. Students will be able to analyze the anatomy of robotic systems
2. Understand the principles of various sensors.
3. Understand the principles of various actuators.
4. To gain knowledge on application of sensors and actuators with intelligent control.

Course Outcomes:

CO1: Identify and classify different types of sensors used in robotics applications.

CO2: Carry out image processing techniques for robot vision sensors.

CO3: Analyze the characteristics and selection criteria for different types of electric actuators used in robotic applications.

CO4: Differentiate between hydraulic and pneumatic actuation systems and evaluate advanced actuator technologies for specific robotic tasks.

Module 1: Anatomy of Robotic System & Sensors **(9hrs)**

Links and joints in robots, types of joints, end effectors, concept of degrees of Freedom and its calculations. Pressure/contact. Resistive position. Infrared. Light. Position Sensors, optical encoders, proximity sensors, Range sensors, Ultrasonic sensors, Touch and Slip sensors. Sensors for motion and position, Force, torque and tactile sensors, Flow sensors, Temperature sensing devices.

Module 2: Vision Sensors & Advanced Sensor Technology **(9hrs)**

Vision System Devices, Image acquisition, Masking, Sampling and quantisation, Image Processing Techniques, Noise reduction methods, Edge detection, Segmentation. Smart sensors, MEMS based sensors, Innovations in sensor technology.

Module 3: Actuators & Electric Actuators **(8hrs)**

Actuators and its selection while designing a robot system. Types of transmission systems. Direct current motor, Permanent magnet stepper motor, Servo Control DC motors, Linear and latching linear actuators, Rotary actuators, Piezoelectric actuators, Actuator parameters and characteristics, Stepper motors, Specifications and characteristics of Stepper Motors Servo Motors.

Module 4: Pneumatic & Hydraulic Actuators **(9hrs)**

Hydraulic and pneumatic power actuation devices: Hydraulic Actuators, selection of linear actuating cylinders, Hydraulic Motors, Pneumatic actuators, design considerations and selection, pneumatic cylinders, pneumatic drive system, Linear & rotary actuators. Advanced actuators – Piezoelectric actuators, elastomer actuators, soft actuators, shape memory alloy based actuators, under actuated robotic hand.

Text Books:

(i) D. Patranabis, Sensors and Transducers, PHI, 2nd Edition 2013.

(ii) Jon S. Wilson, Sensor Technology Handbook, Elsevier, 2005.

Reference Books:

(i) Mc Comb, G. Robot builder's bonanza. 5th ed. New York: McGraw-Hill, 2019. ISBN 9781260135015.

(ii) Braünl, T. Embedded robotics: mobile robot design and applications with embedded systems. 3rd edition Berlin; Heidelberg: Springer, 2008. ISBN 9783540705338.

(iii) Martin, F.G. Robotic explorations: a hands-on introduction to engineering. Upper Saddle River, N.J.: Prentice-Hall, 2001. ISBN 0130895687.

(iv) Gerard C., M. Meijer, Smart Sensors System, Wiley, 2008. AICTE Model Curriculum for UG Degree Course in Robotics & Artificial Intelligence Engineering

(v) Andrzej M. Pawlak, Sensors and Actuators in mechatronics, Taylor & Francis Group, 2007.

(vi) S. R. Ruocco, Robot Sensors & Transducers, Springer, 2013.

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO 1	PSO 2	PSO 3
CO1	3	3	1	2	-	1	-	-	1	-	1	3	2	1
CO2	3	2	2	2	-	1	1	1	1	1	1	3	2	1
CO3	3	1	2	2	-	1	1	1	1	1	1	3	2	1
CO4	2	2	1	2	-	1	-	-	1	-	1	2	1	1

Applications of Robotics			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	Professional Elective I	Course Code:	MS3225

Prerequisites: Basic knowledge of mechanics, automation, and manufacturing systems.

Course Objective:

1. To introduce students to industrial robots and their applications in inspection and material handling.
2. To explore various robotic applications such as welding, painting, and underwater operations, including end effector design

3. To evaluate the selection criteria for robots based on performance, economics, and impact on industry and society.
4. To provide knowledge on conventional and automated material handling systems and technologies.

Course Outcomes:

CO1: Identify and categorize different types of industrial robots and their applications in material handling tasks.

CO2: Explain the principles of robotic vision systems and their application in inspection processes.

CO3: Describe the application of robots in diverse manufacturing processes, including welding, painting, and assembly.

CO4: Analyze and design end effectors for specific robotic tasks and evaluate factors influencing robot selection and the economic impact of robotization.

Module-1 Introduction & Robots for Inspection **(9hrs)**

Types of industrial robots, Load handling capacity, general considerations in Robotic material handling, material transfer, machine loading and unloading, CNC machine tool loading, Robot centered cell. Robotic vision systems, image representation, object recognition and categorization, depth measurement, image data compression, visual inspection, software considerations.

Module-2 Other Applications & End Effectors **(9hrs)**

Application of Robots in continuous arc welding, Spot welding, Spray painting, assembly operation, cleaning, robot for underwater applications. Gripper force analysis and gripper design, design of multiple degrees of freedom, active and passive grippers.

Module-3 Selection of Robot & Advanced Material Handling **(9hrs)**

Factors influencing the choice of a robot, robot performance testing, economics of robotisation, Impact of robot on industry and society. Concepts of material handling, principles and considerations in material handling systems design, conventional material handling systems - industrial trucks, monorails, rail guided vehicles, conveyor systems, cranes and hoists, automated guided vehicle systems, automated storage and retrieval systems(ASRS), bar code technology, radio frequency identification technology.

Module-4 Material Handling Systems **(9hrs)**

Concepts of material handling, principles and considerations in material handling systems design, conventional material handling systems - industrial trucks, monorails, rail guided vehicles, conveyor systems, cranes and hoists, automated guided vehicle systems, automated storage and retrieval systems(ASRS), bar code technology, radio frequency identification technology.

Text Books:

1. Richaerd D Klafter, Thomas Achmielewski and Mickael Negin, “Robotic Engineering – An integrated Approach” Prentice HallIndia, New Delhi, 2001.

2. Mikell P. Groover,”Automation, Production Systems, and Computer Integrated Manufacturing“, 2nd Edition, John Wiley & sons, Inc, 2007

References Books:

1. James A Rehg, “Introduction to Robotics in CIM Systems”, Prentice Hall of India, 2002.

2. Deb S R, "Robotics Technology and Flexible Automation", Tata McGraw Hill, New Delhi, 1994

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	2	3	1	1	1	2	2	1	3	2	2
CO2	3	3	3	2	3	0	0	0	2	2	1	3	3	2
CO3	3	2	3	3	3	1	1	1	3	3	2	3	3	3
CO4	3	2	3	3	3	1	1	0	3	3	2	3	3	3

Business Management			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	HS	Course Code:	BH3401

Prerequisites: Basic understanding of organizational structure, business fundamentals, and communication skills.

Course Objectives:

1. To understand fundamental management principles, roles, functions, and modern approaches.
2. To develop financial literacy by exploring sources of finance, capital structure etc.
3. To equip students with essential human resource management knowledge, focusing on recruitment etc.
4. To impart a comprehensive understanding of marketing concepts, strategies, and tools

Course Outcomes:

1. Comparing and contrasting efficient functional models of business management by integrating the three core areas such as Finance, Human Resource and Marketing Management.
2. Executing the Management principles in all the functional areas of business.
3. Correlating the interrelations and interdependence of the areas of Management in a business organisation.
4. Assessing the functional and managerial practices in business organisations.

MODULE-1: Management Principles **(8 Hours)**

Management Concepts, Nature and Functions, Management Process and Roles ofManagers, Levels of Management and Managerial Skills, Theories of Management – Contributions of F.W.Taylor, Henry

Fayol, Elton Mayo,Line and Staff Relationship, Centralisation and Decentralisation, Delegation of Authority , Management thoughts inModern Trend –Systems Approach

MODULE-2: Financial Management **(8 Hours)**

Concept, Financial function and Role of Financial Managers, Instruments of raising short-term and long-term funds, Capital Structure, Techniques of Project Appraisal, Components of Working Capital, Operating Cycle, Factors affecting requirement of Working Capital.

MODULE-3: Human Resource Management **(7 Hours)**

Nature and Scope of Human Resource Management, Manpower Planning, Recruitment and Selection Methods, Performance Appraisal, Need, Objectives, Modern methods of Appraisals: 720 degree, MBO, Assessment Centre Method, Talent Acquisition, Training Need Analysis, Career Planning, Organisational Citizenship Behaviour.

MODULE- 4: Marketing Management **(7 Hours)**

Concept, Nature, Scope and Importance, Marketing Mix and 7P's of Marketing, Segmentation, Targeting, Positioning, Factors influencing consumer decision-making, e-marketing and Green Marketing

Reference Books:

1- Modern Business Organisation and Management, S.A. Sherlekar, Himalaya Publishing House, 2016.
2- Essentials of Management, Stephen P. Robbins, 6th Edition, Pearson, 2010.
3- Financial Management, Sheeba Kapil, 1st Edition,Pearson, 2013.
4- Human Resource Management Text and Cases,K. Aswathappa, 10th Edition,TMH, 2023
5- Marketing Management, Rajan Saxena, 6th Edition, TMH publishing house, 2022.
6- Principles of Management, Dipak Kumar Bhattacharyya, 1st Edition, Pearson, 2011
7- Mgmt (Principles of Management), Willium& Tripathy, 1st Edition, Cengage Learning, 2016

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	2	3	1	1	1	2	2	1	3	2	2
CO2	3	3	3	2	3	0	0	0	2	2	1	3	3	2
CO3	3	2	3	3	3	1	1	1	3	3	2	3	3	3

CO4	3	2	3	3	3	1	1	0	3	3	2	3	3	3

ENTREPRENEURSHIP DEVELOPMENT			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	HS	Course Code:	BH – 3403

Prerequisites: Basic understanding of economics, business studies, and fundamental financial concepts.

Course Objectives:

1. To introduce students to the foundational concepts of entrepreneurship, including the functions, traits, and motivation of entrepreneurs.
2. To enable students to identify, develop, and evaluate entrepreneurial ideas by conducting feasibility studies and understanding business structures and the startup process.
3. To provide knowledge on various sources of entrepreneurial finance and equip students with basic financial analysis tools
4. To familiarize students with the entrepreneurial ecosystem, including incubators, accelerators etc.

Course Outcomes:

1. Exemplifying the business opportunities, social responsibilities and the support system for setting up an enterprise.
2. Determining stages of Entrepreneurial Process starting from idea generation, developing a business plan and operational aspects of an Enterprise.
3. Appraising the different funding options and Financial Management of an enterprise.
4. Assessing the Start-up management practices like incubation, mentorship and Government initiatives.

MODULE-1: Introduction to Entrepreneurship (8 hours)

Concept, Functions of an Entrepreneur, Entrepreneurial Process, Entrepreneurial Motivation and Barriers, Traits to be a successful Entrepreneur, Creativity and scope of Entrepreneurship in India: Types of new age business (FinTech, EdTech, Healthcare, Agripreneurship, Defence, Drone, Space, IT, Robotics, Digital Transformation, Women-Entrepreneurship, Social Entrepreneurship, Corporate Social Responsibility, Business Ethics – Role of Values in Management.

MODULE-2: Entrepreneurial Idea into Action (8 hours)

Developing a Business Idea; Opportunity, Methods and Creativity, Deciding to set up a start-up, Forms of business organisations (Sole tradership/propreitorship, Partnership, Joint-Stock Company) and MSMEs (Micro, Small and Medium enterprises), Size and Location of the enterprise, Feasibility Study: Market Survey, Techno-economic feasibility and preparing a Project Report.

MODULE-3: Entrepreneurial Finance and Funding (8 hours)

Sources of funding(Bootstrapping, Angel Investors, Venture Capital, Crowdfunding etc.) Project Investment Analysis, Break-Even Analysis, ROI Analysis, Basics of Income Statement and Balance Sheet.

MODULE- 4: Managing an Enterprise (8 hours)

The Start-up ecosystem, Business Incubators, Start-up Accelerators, Mentorship and Networking, Failure and Resilience, Risk Management, Ethical dilemmas and Exit Strategies, Start-up Policy and Initiatives of the Government.

Reference Books:

1. Entrepreneurship: Successfully Launching New Ventures, B.R. Barringer, 6th, Pearson, 2020
2. Fundamentals of Entrepreneurship and Project planning, MadhurimaLall, 1st, Sultan Chand & Sons, 2021
3. Entrepreneurial Development,S.S. Khanka, 1st Edition, S Chand and Company, 1999
4. Entrepreneurship Development and Small business enterprises, P.M. Charantimath, 3rd Edition, Pearson, 2019
5. Entrepreneurship: Theory, Process and Practice, Donald F Kuratco, 11th, Cengage, 2023
6. Entrepreneurship, Robert. D. Hisrich&SabyasachiSinha, 11th Edition, TMH, 2020

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	2	3	1	1	1	2	2	1	3	2	2
CO2	3	3	3	2	3	0	0	0	2	2	1	3	3	2
CO3	3	2	3	3	3	1	1	1	3	3	2	3	3	3
CO4	3	2	3	3	3	1	1	0	3	3	2	3	3	3

ENVIRONMENTAL ENGINEERING			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	MC	Course Code:	IP3401

PREREQUISITES: Basic Physics, Basic Chemistry

COURSE OUTCOMES

At the end of the course a student will be able to

CO1: Understand the multidisciplinary nature of environmental science and ecosystem structure and functions

CO2: Analyze various forms of environmental pollution and assess their impact using scientific parameters

CO3: Demonstrate knowledge of water and wastewater treatment processes and air pollution control technologies

CO4: Evaluate the role of environmental policies, EIA, and sustainable practices in pollution control and resource conservation

Module 1 **(10 hours)**

Fundamentals of Environment and Ecosystem: Multidisciplinary nature of environmental Engineering.

Study of Ecosystem: Definition, Properties, Structure and Function of an ecosystem. Food chains, food webs, Flow of Energy, Ecological Pyramids, Biogeochemical cycles, Types of ecosystems, Bioaccumulation, Bio magnification, ecosystem value, Degradation of Ecosystem.

Concept of Environment and pollution: Atmospheric chemistry, soil chemistry, water quality characteristics, DO, BOD and COD, water pollution, Marine Pollution, soil pollution, thermal pollution, nuclear hazard, Air Pollution: Air Quality, cause and effects of air pollution, Water and air quality standards, and Index, Noisepollution: Introduction, Noise standards, measurement, Ln Concept and control

Module 2 **(8 hours)**

Water treatment process: Pre-treatment of water, conventional process, advanced water treatment process.

Waste water treatment process: Natural Treatment, Engineering Treatment -Pre- treatment, primary and secondary waste water treatment process

Air Pollution Control: The natural self-cleansing properties of Environment, Air pollution meteorology, Atmospheric dispersion, Diffusion equation, ground level emission, plume rise, Effective stack height, Air Pollution control from stationarysources by installing Engineering devices, Flue gas desulphurisation, NOX removal.

Module 3 **(8 hours)**

Solid waste management: Source, classification, separation, storage and transportation of solid wastes, Waste minimization techniques, Benefits of waste minimization, reuse, recycle, thermal and biological treatment, secure land fill technique.

Impact of Environmental pollution and related issues: Global climate change, global warming and greenhouse gases, Acid rain, ozone layer depletion, healthissues.

Module4 **(4 hours)**

Environmental Impact Assessment: EIA procedure, Preparation of an EIS From unsustainable to sustainable development, circular economy, Environmental Protection Act, Air (Prevention and Control of Pollution) Act, Water (Preventionand Control of Pollution) Act, Wildlife Protection Act.

TEXTBOOKS

1. Fundamentals of Ecology, M.C.Dash, Tata McGraw Hill, 2006.
2. Environmental Pollution Control Engineering, C.S. Rao, New Age International Publishers, 2018
3. Environmental Engineering, G. Kiely, TMH, 2007

REFERENCES

1. Environmental Engineering, H.S. Peavy, D.R. Rowe and G. Tchobanoglous,McGraw Hill.
2. Introduction to Environmental Engineering and Science, G.M. Masters, Pearson,2015
3. Integrated Solid Waste Management, G. Tchobanoglous, McGraw Hill, 2014
4. Water Supply Engineering, S.K. Garg; Khanna Publishers, 37th Edition

CO-PO-PSO MAPPING													
COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**
CO1	3	2	1	1	1	2	3	1	1	2	1	2	2	2
CO2	3	3	2	2	2	2	3	1	1	2	1	2	2	2
CO3	3	3	3	2	2	2	3	1	2	2	2	3	3	3
CO4	2	2	2	2	1	3	3	2	2	2	2	3	3	3
Correlation Level 1: Slight 2: Moderate 3: High														

INDUSTRIAL SAFETY ENGINEERING			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	MC	Course Code:	IP3403

PREREQUISITES: NA

COURSE OUTCOMES

At the end of the course a student will be able to

CO1: Apply safety principles in various work environments, especially in construction and machine operations**.**

CO2: Identify safety hazards, implement safety measures,

CO3: Analyse risks to prevent accidents and injuries.

CO4: Understand of safety protocols, policies, and the responsibilities of individuals and organizations in ensuring a safe working environment.

Module 1 **(6 hours)**

Safety Introduction: Need for safety. Safety and productivity. Definitions: Accident, Injury, Unsafe act, Unsafe Condition, Dangerous Occurrence, Reportable accidents. Theories of accident causation. Safety organization- objectives, types, functions, Role of management, supervisors, workmen, unions, government and voluntary agencies in safety. Safety policy. Safety Officer-responsibilities, authority. Safety committee-need, types, advantages.

Module 2 **(7 hours)**

Personal Protection in work environment: Personal protection in the work environment, Types of PPEs, Personal protective equipment- respiratory and non-respiratory equipment. Standards related to PPEs. Monitoring Safety Performance: Frequency rate, severity rate, incidence rate, activity rate. Housekeeping: Responsibility of management and employees. Advantages of good housekeeping. 5 s of housekeeping. Work permit system- objectives, hot work and cold work permits. Typical industrial models and methodology. Entry into confined spaces.

Module 3 **(7 hours)**

Safety issues in Construction: Introduction to construction industry and safety issues in construction Safety in various construction operations – Excavation and filling – Under-water works – Under-pinning & Shoring – Ladders & Scaffolds – Tunneling – Blasting – Demolition – Confined space – Temporary Structures. Familiarization with relevant Indian Standards and the National Building Code provisions on construction safety. Relevance of ergonomics in construction safety. Ergonomics Hazards - Musculoskeletal Disorders and Cumulative Trauma Disorders.

Module4 **(12 hours)**

Safety Hazards in Machines and Hazard identification and analysis: Machinery safeguard-Point-of-Operation, Principle of machine guarding -types of guards and devices.Safetyinturning,andgrinding.WeldingandCutting-SafetyPrecautionsofGas welding and Arc Welding. Material Handling-Classification-safety consideration- manual and mechanical handling. Handling assessments and techniques- lifting, carrying, pulling, pushing, palletizing and stocking. Material Handling equipment-operation & maintenance.

Hazard and risk, Types of hazards –Classification of Fire, Types of Fire extinguishers, fire explosion and toxic gas release, Structure of hazard identification and risk assessment. Identificationofhazards:Inventoryanalysis,Fireandexplosionhazardratingofprocessplants

- The Dow Fire and Explosion Hazard Index, Preliminary hazard analysis, Hazard and Operabilitystudy(HAZOP))–methodology,criticalityanalysis,correctiveactionandfollow-up. Control of Chemical Hazards, Hazardous properties of chemicals, Material Safety Data Sheets (MSDS).

TEXTBOOKS

1. R.K Jain (2000) Industrial Safety, Health and Environment management systems, Khanna Publications.

2. Paul S V (2000), Safety management System and Documentation training Programme handbook, CBS Publication.

3. Krishnan, N.V. (1997).Safety management in Industry. Jaico Publishing House, New Delhi.

REFERENCES

1. John V. Grimaldi and Rollin H.Simonds. (1989) Safety management. All India Traveller Book Seller, Delhi.

2. Ronald P. Blake. (1973). Industrial safety. Prentice Hall, New Delhi.

3. Alan Waring. (1996). Safety management system. Chapman & Hall, England.

4. Vaid, K.N., (1988). Construction safety management. National Institute of Construction Management and Research, Mumbai

CO-PO-PSO MAPPING

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	3	3	2	2	2		3					3	2
CO2	3	3	3	2				3	2				3	2
CO3	3	3	3	2				3					3	2
CO4	2	2	1	2		3		3	2	2			2	2
Correlation Level 1: Slight 2: Moderate 3: High														

Robot Modeling and Simulation Lab			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	Laboratory Course	Course Code:	MS3521

Course Objectives :

1. To understand the fundamentals of robot kinematics, dynamics, and workspace modeling.
2. To simulate and analyze the motion of planar and spatial robotic manipulators.
3. To develop robotic applications through programming and path planning.
4. To expose students to industrial robot tasks like pick-and-place, palletizing, and assembly.

Course Outcomes (COs):

Upon successful completion of this lab, students will be able to:

CO1: Apply kinematic and dynamic modeling techniques to simulate robotic manipulators.

CO2: Analyze and interpret joint-space and Cartesian trajectories using appropriate tools.

CO3: Develop programs for industrial robotic operations such as pick-and-place and palletizing.

CO4: Design and simulate robotic workspaces and end-effector operations with appropriate tools.

Any eight exercises from the following to be performed

1. Simulation of robot motion for various joint configurations using robotic arm models.
2. Forward kinematic analysis of planar (2R) and spatial (6 DoF) robotic manipulators.
3. Inverse kinematic analysis of planar and spatial robots using given end-effector positions.
4. Trajectory generation and visualization for different joint-space and Cartesian paths.
5. Workspace generation for both planar and spatial robots.
6. Modeling of robotic manipulators using Denavit-Hartenberg (DH) parameters.
7. Forward dynamics simulation of a 2R planar robot to study motion under torque inputs.
8. Inverse dynamics analysis for calculating required joint torques for a 2R planar robot.
9. Robot programming for pick-and-place or loading/unloading operations using articulated robots.
10. Palletizing operation simulation using a 6 DoF robotic arm.
11. SCARA robot programming for tasks like conveyor belt operations and assembly.
12. Design and simulation of gripper operations including force analysis for specific tasks.

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3	2	2	-	-	-	2	2	2	3	2	3
CO2	3	3	3	3	3	-	-	-	2	-	2	3	3	3
CO3	3	2	3	2	3	1	1	-	3	2	2	3	3	3
CO4	3	3	3	3	3	-	1	-	2	1	-	3	3	3

Advanced Mechatronics Lab			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	Laboratory Course	Course Code:	MS3523

Course Objective:

1. To provide hands-on experience in interfacing sensors and actuators using LabVIEW and MATLAB/SIMULINK.
2. To understand and analyze various sensor signals and data acquisition techniques.
3. To study control systems for actuators including motors with different control strategies.

Course Outcomes :

CO1: Demonstrate the ability to interface and analyze sensor signals such as IR range finders, accelerometers, ultrasonic, and myoelectric signals using LabVIEW.

CO2: Implement real-time control of actuators including stepper and DC servo motors using LabVIEW and MATLAB-based microcontroller platforms.

CO3: Evaluate the performance of closed-loop control systems (P and PI controllers) using DC servo motor setups integrated with MATLAB/SIMULINK.

CO4: Develop and test wireless sensor systems and light-based object detection systems for remote data acquisition and industrial automation applications.

Any eight exercises from the following to be performed

1. Study the working of IR range finder using LabVIEW
2. Study the working of Accelerometer using LabVIEW
3. Study the working of an ultrasonic sensor using LabVIEW
4. myoelectric signal acquisition using LabVIEW
5. Controlling of stepper motor using LabVIEW
6. Controlling of stepper motor with microcontroller using MATLAB.
7. Study of DC Servomotor Position Controller for P and PI Control with microcontroller using MATLAB/SIMULINK
8. Detection of smaller objects with one-way light barrier and background suppression
9. Development of wireless sensors provide useful information at a distance from the data acquisition system

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3	2	2	-	-	-	2	2	2	3	2	3
CO2	3	3	3	3	3	-	-	-	2	-	2	3	3	3
CO3	3	2	3	2	3	1	1	-	3	2	2	3	3	3
CO4	3	3	3	3	3	-	1	-	2	1	-	3	3	3

Sensors and Actuators Lab			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	Laboratory Course	Course Code:	MS3525

Course Objective:

1. To develop hands-on skills in interfacing and calibrating various sensors and actuators used in intelligent robotic systems.
2. To implement basic control strategies, including PID, for motor control using microcontrollers and simulation tools like MATLAB/SIMULINK.
3. To design and test sensor-based data acquisition and feedback systems for real-time robotic applications.

Course Outcomes (COs):

CO1: Interface and calibrate different types of sensors such as IR, ultrasonic, accelerometer, temperature, and EMG for robotic applications.

CO2: Implement control of actuators including stepper motors and DC servo motors using microcontrollers and simulation tools.

CO3: Develop and evaluate closed-loop control systems using PID controllers in MATLAB/SIMULINK for precise actuator control.

CO4: Design wireless and intelligent sensing systems for real-time robotic data acquisition and object detection tasks.

Any eight exercises from the following to be performed

1. Interface and calibrate an IR distance sensor for proximity detection
2. Implement ultrasonic sensing for obstacle detection and distance measurement
3. Interface an accelerometer to evaluate tilt and orientation of a robotic platform
4. Acquire and analyze temperature and humidity data using DHT11 sensor
5. Acquire and process myoelectric (EMG) signals for human-robot interaction
6. Design a light-based object detection system using photodiodes and background suppression
7. Control a stepper motor using microcontroller for angular positioning tasks
8. Control a DC servo motor using PWM signals and evaluate its speed response
9. Implement PID control for a DC servo motor using MATLAB/SIMULINK
10. Develop a wireless sensor data acquisition system using Bluetooth/ZigBee
11. Design a temperature-based fan control system using sensor-actuator feedback loop
12. Interface a force-sensitive resistor (FSR) to evaluate pressure-based tactile sensing

Course Outcome (CO)	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
CO1:	3	2	2	1	2	-	-	-	-	1	-	-	3	2
CO2:	3	3	3	2	2	-	-	-	-	1	-	-	3	2
CO3:	2	2	3	2	3	-	-	-	1	2	-	-	3	3
CO4:	3	3	3	3	2	-	-	-	-	2	-	-	3	2

6th Semester

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
				L	**T**	**P**		**IA**	**EA**	**PA**	**Total**
1	PC	MS3122	Instrumentation and Control in Robotics	3	0	0	3	40	60	-	100
2	PC	CS3105	Machine Learning	3	0	0	3	40	60	-	100
3	PE-2	MS3222	Drone Technology	3	0	0	3	40	60	-	100
		MS3224	Autonomous Robot	3	0	0	3	40	60	-	100
		MS3226	Mobile Robotics	3	0	0	3	40	60	-	100
4	PE-3	EI3233	Micro Electro Mechanical Systems	3	0	0	3	40	60	-	100
		EI3234	Microcontrollers Architecture and Programming	3	0	0	3	40	60	-	100
		EI3236	Digital Electronics and Microprocessor	3	0	0	3	40	60	-	100
5	HS	BH3401/BH3403	Business Management / Entrepreneurship Development	3	0	0	2	40	60	-	100
6	MC	IP3401/IP3403	Environmental Engineering/ Industrial Safety Engineering	3	0	0	2	40	60	-	100
7	LC	MS3622	Project for Product Development - I	0	0	6	3	-	-	100	100
8	LC		Machine Learning for Robotics Lab	0	0	3	1.5	-	-	100	100
9	LC	EI3503	Microprocessor and Microcontroller Lab	0	0	3	1.5	-	-	100	100
10	Summer Internship and Research Experience (SIRE - II) *										
			Total	**18**	**0**	**12**	**22**	**240**	**360**	**400**	**1000**

Instrumentation and Control in Robotics			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type:	Professional Core	Course Code:	MS3122

Prerequisites: Basic understanding of differential equations, electrical circuits, mechanical systems, and MATLAB fundamentals.

Course Objective:

1. Understand the fundamentals of control engineering and system modeling in the context of robotics.
2. Analyze system behavior in time and frequency domains to evaluate performance and stability.
3. Design and implement controllers, including digital control techniques, for robotic applications.

Course Outcomes:

CO1: Model dynamic systems using transfer functions and analyze their behavior in both electrical and mechanical domains.

CO2: Evaluate the time domain response and stability of linear control systems using established analytical methods.

CO3: Design and implement active control components, such as PID controllers, using root locus analysis and frequency domain specifications to meet desired control objectives.

CO4: Apply the principles of digital control systems, including Z-transforms and discretization techniques.

Module 1: Introduction to Control Engineering & System Modeling **(9 Hrs)**

Introduction to Control Engineering: objectives of control; instrumentation and sensors in robotics; sensor modelling and solution; use of sensors in open and closed loop systems; the control design process; use of MATLAB for modelling and controller design; Laplace transforms; transfer functions; electrical systems; translational systems; rotational systems; electromechanical systems.

Module 2: Time Domain Analysis & Stability **(10 Hrs)**

Time responses: 1st and 2nd order systems; time domain specifications; higher order systems; system zeros; stability: Routh-Hurwitz; Routh array; design via the Routh array; steady state errors; gain and phase margins.

Module 3: Frequency Domain Analysis & Controller Design **(10 Hrs)**

Root locus analysis and sketching rules; design for transient response; design of active control components such as PID controllers to achieve desirable control objectives.

Module 4: Digital Control **(6 Hrs)**

Control Engineering in a robotics context.Z transform and discretisation.

Books:

1. "Robotics: Control, Sensing, Vision, and Intelligence" by K. S. Fu, R. C. Gonzalez, C. S. G. Lee Publisher: McGraw-Hill
2. "Modern Control Engineering" by Katsuhiko Ogata Publisher: Pearson Education

3. "Introduction to Mechatronics and Measurement Systems" by David G. Alciatore, Michael B. Histand Publisher: McGraw-Hill
4. "Sensors and Actuators in Mechatronics: Design and Applications" by Andrzej M Pawlak CRC Press

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	2	3	1	1	1	2	2	1	3	2	2
CO2	3	3	3	2	3	0	0	0	2	2	1	3	3	2
CO3	3	2	3	3	3	1	1	1	3	3	2	3	3	3
CO4	3	2	3	3	3	1	1	0	3	3	2	3	3	3

Machine Learning			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type:	Professional Core	Course Code:	CS3105

Prerequisites:
Mathematics: Linear algebra, probability, and statistics, eigenvalues, eigenvectors, probability distributions, and Bayes' theorem. Basic computer science principles, data structures, and algorithms

COURSE OUTCOME:
At the end of the Course, the student will be able to CO1 Students will be able to
CO1 understand the need for machine learning for various problem solving
CO2 Students will be able to understand a variety algorithm and evaluate models
CO3 Students will be able to understand the features of machine learning to apply on real world problems
CO4 Students will be able design as well as analyse artificial neural networks and deep learning models

Module-I **(8 Hours)**

Introduction to Machine learning
system: Types of machine learning techniques, hypothesis space and inductive bias
Pre-processing: Features: type, measuring the central tendency, dispersion and graphical representation (box plot, scattered plot, and quantile plot), missing and noisy features, Anomaly identification
Dimensional Reduction Techniques: Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA)

Module-II **(10 Hours)**

Supervised learning: Classification: Decision Tree Induction, Classification by artificial neural network (Perceptron, Gradient Descent Algorithm, Stochastic Gradient Descent Algorithm, Backpropagation), Support Vector Machines, Bayes Classification Methods, Lazy Learning vs eager learning, Metrics for Evaluating Classifier Performance

Module-III **(7 Hours)**

Regression Analysis: Linear regression and evaluating regression fit, Logistic regression
Unsupervised Learning: Cluster Analysis: Partitioning Methods, Hierarchical Methods and kNN algorithm

Outlier Detection: Outliers and Outlier Analysis, Outlier Detection Methods

Module-IV **(5 Hours)**

Reinforcement Learning: Introduction to Reinforcement Learning key concepts (agent, environment, reward, policy, value function), Learning Task, Learning Model for Reinforcement – Q Learning, Application of Reinforcement Learning.

Text Books:

1. Machine Learning. Tom Mitchell. First Edition, McGraw-Hill, 1997.
2. Ethem Alpaydin, Introduction to Machine Learning. MIT Press (MA), 2004.

References Books:

1.Baldi, P. and Brunak, S. (2002). Bioinformatics: A Machine Learning Approach. Cambridge, MA: MIT Press.

2. Cohen, P.R. (1999). Empirical Methods in Artificial Intelligence. Cambridge, MA: MIT Press.

CO-PO MAPPING:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	2	3	1	1	1	2	2	1	3	2	2
CO2	3	3	3	2	3	0	0	0	2	2	1	3	3	2
CO3	3	2	3	3	3	1	1	1	3	3	2	3	3	3
CO4	3	2	3	3	3	1	1	0	3	3	2	3	3	3

Drone Technology			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type:	Professional Elective II	Course Code:	MS3222

Prerequisite: Basic knowledge of electronics, programming, and engineering mechanics.

Course Objectives:

1. To impart fundamental understanding of quadcopter flight dynamics and hardware components.
2. To develop skills in assembling, calibrating, and programming drone systems.
3. To familiarize students with maintenance, troubleshooting, and safety procedures for quadcopters.
4. To introduce practical applications and case studies of drones in real-world scenarios.

Course Outcomes (COs):

CO1: Understand the principles of flight, hardware anatomy, and assembly of quadcopters**.**

CO2: Perform calibration, configuration, and testing of drone components and sensors.

CO3: Demonstrate troubleshooting techniques and maintenance practices for drone systems.

CO4: Apply drone technology in practical applications across industries with hands-on experience.

Module 1: Flight Dynamics & Hardware Anatomy of Quadcopters **(9hrs)**

Definitions of Drone, UAV, RPA, Quad copters -Basic Components and Categories – Principles of Flight - Flight Maneuvers – Airframes - Creating a Frame: Materials, Different Frame Shapes – Building Airframes - Flight dynamics - Applications - Future potential - Comparison with other aerial vehicles. Hardware Anatomy of Quadcopter Power Train – Propellers, Motors- Total Lift - Electronic Speed Controllers – Flight Battery – Radio transmitter and receiver – Flight Controller – GPS, Compass, Camera Assembling for Quad copter – Connectors, Mounting of Propellers and Powering up.

Module 2: Testing and Maintenance of Quadcopters **(9hrs)**

Key Flight Safety Rules - Preflight Checklist and Flight Log Information – Flight Instructions - Repair and Maintenance: Crash analysis, Common issues, Voltage testing. Test and troubleshoot Flight Controller Board (FCB), Electronic Speed Controller (ESC), and its associated peripherals. Perform programming and configure the flight control board (FCB). Identify, explore, and test the interconnectivity of different peripherals with FCB. Establish connection of FCB with motor, GPS, ESC, and sensors. Configure, test, and record FCB with battery to monitor battery level and perform return to home operation Perform and carry out drone leveling using IMU sensor. Perform calibration of the compass, Lidar, and gyro sensor. The test communication link between FCB and RF transceiver. Write and upload computer code to FCB to test sensor results. Test and record data of motor connectivity with ESC. Perform motor rotation using FCB and ESC.

Module 3: Testing and Maintenance of Quadcopters & Real World Applications **(9hrs)**

Test signal flow into the drone to test ESC parameters on FCB to check its operation. Write and upload computer code to FCB to ESC working. Real World Applications and Case Studies Beneficial Drones, Aerial Photography, Mapping and Surveying, Precision Agriculture, Search and Rescue, Infrastructure Inspection, and Conservation. Case Studies: Agriculture Weed Classification, Microdrone surveillances.

Module 4: Drone Technology - Practical Applications **(9hrs)**

Drone Technology 1. Familiarization with Drone Parts 2. Assembling of Drone Course Title Course Code Structure (I-P-C) Drone Technology EC571 3 2 4 3. Preparation for Drone for Flight, making flight plan and basic drone flight training 4. Debugging and repairing of the drone 5. Operation of Drone for different Applications.

Text Book(s):

1. Reg Austin "Unmanned Aircraft Systems UAV design, development and deployment", Wiley, 2010.

2. Robert C. Nelson, Flight Stability and Automatic Control, McGraw-Hill, Inc, 1998.

3. Kimon P. Valavanis, "Advances in Unmanned Aerial Vehicles: State of the Art and the Road to Autonomy", Springer, 2007

4. Paul G Fahlstrom, Thomas J Gleason, "Introduction to UAV Systems", UAV Systems, Inc, 1998 5. Dr. Armand J. Chaput, "Design of Unmanned Air Vehicle Systems", Lockheed Martin Aeronautics

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	3	-	3	-	-	-	2	2	1	3	3	2

CO 2	2	2	3	2	3	-	-	-	3	3	1	3	3	2
CO 3	3	3	3	2	3	-	-	-	2	3	2	3	3	3
CO 4	3	2	3	2	3	-	-	-	3	3	2	3	3	3

Autonomous Robot			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type:	Professional Elective II	Course Code:	MS3224

Prerequisite: Basic understanding of robotics, linear algebra, programming (Python/C++), and control systems.

Course Objectives:

1. To introduce students to autonomous robotic systems and middleware integration using ROS/ROS2.
2. To develop understanding of robot kinematics, dynamics, and locomotion models for ground, aerial, and underwater robots.
3. To equip students with techniques in robotic perception, SLAM, and sensor data fusion.
4. To enable students to plan and control autonomous robotic behavior for real-world applications.

Course Outcomes (COs):

CO1: Understand the architecture and middleware of robotic systems including ROS/ROS2 and integrate key robotic components.

CO2: Apply kinematic and dynamic models to simulate and control robotic locomotion in various environments.

CO3: Implement perception algorithms and SLAM techniques for autonomous navigation using sensor data.

CO4: Design path planning and control algorithms for achieving autonomy in UGVs, UAVs, and AUVs.

Module 1: Robotic Systems and Middleware Integration **(9hrs)**

Introduction to autonomous robots: Evolution, applications (UGV/UAV/AUV).ROS and ROS2: Architecture, Nodes, Topics, Services, Bags. Components: Sensors, actuators, computing platforms.

Middleware, sensory fusion, and user interface design for autonomy.

Module 2: Locomotion and Kinematics **(9hrs)**

Kinematic models: 2-DOF/3-DOF (UGVs), 5-DOF/6-DOF (UAVs, AUVs).Dynamics: Thrusters, propellers, advanced locomotion mechanisms. Wheel arrangements, legged mobility, underwater motion physics. Forward and inverse kinematics; motion simulation using ROS/Gazebo.

Module 3: Robotic Perception and SLAM **(9hrs)**

Sensor suite: IMU, GPS, LiDAR, Cameras, Sonars. Visual and inertial navigation: Stereo vision, 3D perception. Object tracking, segmentation, data fusion. SLAM: 2D/3D, visual-inertial SLAM, acoustic SLAM, pose graph optimization.

Module 4: Planning, Control, and Autonomy **(9hrs)**

Path and motion planning: A*, D*, RRT, Dynamic Programming. Kalman Filter, EKF, UKF, and Particle Filters. Model-based and behavior-based planning strategies. Control strategies for UGV/UAV/AUV; summary of applications and real-world autonomy case studies.

TEXTBOOK :

1.Introduction to Robotics: Mechanics and Control By John Craig. ISBN-13: 978-0133489798. Pearson; 4th edition.

Reference:

Probabilistic Robotics By Sebastian Thrun, Wolfram Burgard and Dieter Fox. ISBN-13: 978-0262201629, ISBN-10: 0262201623. Intelligent Robotics and Autonomous Agents series; 1st Edition.

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	3	2	3	-	-	-	-	2	-	3	2	2
CO2	3	3	3	3	3	-	-	-	-	-	-	3	3	3
CO3	3	3	3	3	3	2	1	-	2	2	1	3	3	3
CO4	3	3	3	3	3	2	2	-	2	2	1	3	3	3

Mobile Robotics			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type:	Professional Elective II	Course Code:	MS3226

Prerequisite: Basic knowledge of robotics, kinematics, sensors, and programming.

Course Objectives :

1. To introduce the fundamentals and physical structures of mobile robots, including locomotion and movement mechanisms.
2. To provide an understanding of mobile robot kinematics, motion constraints, and workspace analysis.
3. To explore the integration of sensors, actuators, and AI for perception and control in mobile robotics.
4. To analyze localization, uncertainty handling, and navigation strategies in diverse environments.

Course Outcomes (CO):

CO1: Understand the basic principles of locomotion, types of mobile robot wheels, and robot structures including legged and wheeled robots.

CO2: Apply knowledge of mobile robot kinematics and maneuverability to evaluate motion feasibility and workspace.

CO3: Demonstrate the use of sensors, actuators, and AI techniques in perception and control of mobile robots.

CO4: Analyze and implement localization and navigation strategies for mobile robots in real-world environments.

Module 1: Introduction to the Fundamentals of Mobile Robotics **(9hrs)**

Introduction to the fundamentals of mobile robotics, examining the basic principles of locomotion, kinematics, sensing, perception, and cognition that are key to the development of autonomous mobile robot. Types of robotics wheels used in mobile robotics application, Study of legged mobile robots. Analysis of wheeled mobile robots.

Module 2: Mobile Robots Kinematics and Constraints **(9hrs)**

Mobile robot kinematic and constraints. Mobile robot maneuverability. Mobile robot workspace.

Module 3: Application of AI, Sensors and Actuators for Mobile Robots **(9hrs)**

Use of various sensors and actuators in mobile robotic application, Motion control strategies. Environmental perception by mobile robots using AI Techniques.

Module 4: Navigational Strategies of Mobile Robot **(9hrs)**

Representing uncertainty for mobile robot, Mobile robot localization. The challenge of localization. Application of mobile robot in various sectors, Planning and navigation of mobile robot subjected to various environmental conditions.

Text / Reference Books:

1. R. Siegwart, I. R. Nourbakhsh, "Introduction to Autonomous Mobile Robots", The MIT Press, 2011.
2. Peter Corke , Robotics, Vision and Control: Fundamental Algorithms in MATLAB, Springer Tracts in Advanced Robotics, 2011.
3. S. M. LaValle, "Planning Algorithms", Cambridge University Press, 2006. (Available onlinehttp://planning.cs.uiuc.edu/)Thrun, S., Burgard,W., and Fox, D., Probabilistic Robotics. MIT Press, Cambridge, MA, 2005.Melgar, E. R., Diez, C. C., Arduino and Kinect Projects: Design, Build, Blow Their Minds, 2012.
4. H. Choset, K. M. Lynch, S. Hutchinson, G. Kantor, W. Burgard, L. E. Kavraki, and S. Thrun, Principles of Robot Motion: Theory, Algorithms and Implementations, PHI Ltd., 2005.
5.

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	3	-	3	-	-	-	2	2	2	3	2	2
CO2	3	3	3	-	3	-	-	-	2	-	2	3	3	2
CO3	3	3	3	2	3	-	-	-	2	3	3	3	3	3

CO 4	3	3	3	2	3	-	-	-	2	3	3	3	3	3

Introduction to Micro Electro Mechanical Systems			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type:	Professional Elective III	Course Code:	EI3232

Prerequisite : Basic knowledge of mechanics, electronics, and robotics systems.

Course Objectives :

1. To understand the fundamentals and physics of MEMS, including mechanics, thermals, and scaling laws for robotic systems.
2. To explore various MEMS sensors and actuators such as electrostatic, thermal, and magnetic devices used in robotic components.
3. To apply FEA and microsystem fabrication technologies in designing MEMS for robotics.
4. To analyze advanced MEMS technologies like polymer MEMS, AI-integrated MEMS, and their application in soft robotics and HRI.

Course Outcomes:
At the end of the course, a student will be able to:
CO1: Describe the fundamental principles, working mechanisms, and types of MEMS devices.
CO2: Explain the key processes and techniques used in the fabrication of MEMS and microsystems.
CO3: Analyze the structural, mechanical, and thermal design considerations of MEMS components using theoretical and simulation tools.
CO4: Apply knowledge of micro-sensors, actuators, and embedded systems in the design of robotic, intelligent, and smart systems.

Module I: 8 Hours

Introduction: Overview of MEMS and various devices, Scaling geometry, Rigid Body Dynamics, Forces, Electron transfer, Fluid mechanics and Heat transfer.

Engineering mechanics for Microsystems design: Static Bending of Thin plates, Mechanical vibration, Resonant vibration, Design theory of Accelerometers and Thermal analysis, Thermal effects on Mechanical strength of Materials, Creep formation. Material selection criteria for robotic components using MEMS, Application of MEMS in robotic mobility and manipulation

Module II: 8 Hours

Electrostatic Sensing and Actuation: Introduction to Electrostatic Sensors and Actuators, Parallel-Plate Capacitors, Applications of Parallel Plate Capacitors, Inter digitised Finger Capacitors, Applications of Comb Drive Devices. Thermal Sensing and Actuation: Introduction, Sensors and Actuators Based on Thermal Expansion, Thermal Couples, Thermal Resistors, Magnetic Actuation, Embedded sensors and actuators in robotic arms, drones. Sensors and actuators in autonomous robots.

Module III: 8 Hours

Finite Element Analysis: Concept of FEA, Comparison with other methods, Formulation from the governing Differential equations, Formulation based on stationary total potential, 1-D Finite Element Analysis.

Overview of Micro - Scale fabrication: Microsystem fabrication process- Lithography, Dry and wet etching, thin film deposition- PVD, CVD, LIGA, Micro molding, Electro-deposition. Linking FEA simulations with robotic part design, CAD/CAE tools used in robotic MEMS design.

Module IV: **6 Hours**

Polymer MEMS: Applications-Acceleration Sensors, Pressure Sensors, Flow Sensors, Tactile Sensors. Emerging Trends: Flexible MEMS, AI-MEMS Integration, Smart Wearables. MEMS in soft robotics and human-robot interaction (HRI), Edge AI integration for real-time decision-making in robotics

Total lecture hours: 30 Hours

Text Book:

1. Tai-ran Hsu, MEMS and microsystems design and manufacture, Nanoscale Engineering, TMGH, 2008.
2. Chang Liu, Foundations of MEMS, Pearson Education Inc., 2012.
3. Sergey Edward Lyshevski, MEMS and NEMS: Systems, Devices, and Structures, CRC, 2002
4. Mohamed Gad-el Hak, MEMS and Applications, The MEMS Handbook, 2nd Edition, CRC Press, 2005.

Reference Book:

1. Stephen D Senturia, Microsystem Design, Springer Publication, 2000.
2. P.Seshu, Text Book of Finite Element Analysis, PHI,2006
3. James J. (Jim) Madou, Fundamentals of Microfabrication and Nanotechnology, CRC Press, 2002.
4. G. K. Ananthasuresh, K. J. Vinoy, S. Gopalakrishnan, K. N. Bhat & V. K. Aatre, Micro and Smart Systems, Wiley-India, 2010

CO-PO-PSO MAPPING

Micro Electro Mechanical Systems													
Course outcome	Program Outcomes										Program Specific Outcomes		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PSO 1	PSO 2	PSO 3
CO1	3	2	2	1	1	1	1	–	–	–	2	3	2	1
CO2	3	2	2	2	2	–	1	–	–	–	2	3	3	1
CO3	3	3	3	2	3	–	–	–	–	–	2	3	3	2
CO4	3	3	3	2	3	2	2	1	2	2	3	3	3	2

Microcontrollers Architecture and Programming			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type:	Professional Elective III	Course Code:	EI3234

Prerequisite : Basic knowledge of digital electronics and C programming.

Course Objectives :

1. To introduce microcontrollers and differentiate them from microprocessors, highlighting their architecture and applications.

2. To provide in-depth knowledge of the 8051 microcontroller architecture, instruction set, and programming in Assembly and C.
3. To explore ARM Cortex-M series microcontrollers and their interfacing capabilities.
4. To develop practical skills in interfacing sensors, actuators, and communication peripherals with microcontrollers.

Course Outcomes:

At the end of the course, a student will be able to:

CO1: Understand microcontroller architectures and compare microcontrollers with microprocessors.

CO2: Write and execute assembly and C programs for 8051 microcontroller applications.

CO3: Explain ARM Cortex-M architecture and interface peripherals in real-time systems.

CO4: Interface sensors, actuators, and communication modules in embedded systems

Module I: Introduction to Microcontrollers 7 Hours

Definition of microcontroller and comparison with microprocessors, Basic components: CPU, memory, I/O ports, and buses, Harvard vs. Von Neumann architecture, Overview of popular microcontroller families: 8051, AVR, ARM, Criteria for selecting microcontrollers for various applications

Module II: 8051 Microcontroller Architecture and Programming 8 Hours

8051 architectures: pin diagram, memory organization, and SFRs, Instruction set: data transfer, arithmetic, logic, branching, and bit manipulation, Addressing modes: direct, indirect, register.

Assembly language programming: I/O operations, delay generation, arithmetic, logic C programming for 8051: port access, timers, and peripheral control, Interrupt handling: external and internal interrupts, Timers/counters: waveform generation, delay, event counting, Serial communication (UART): basics and applications

Module III: ARM Cortex-M Microcontrollers 8 Hours

Introduction and evolution of ARM processors, Architecture of ARM Cortex-M series, Programmer's model: core registers, memory model, Instruction set overview: data manipulation and control flow, Interfacing GPIOs, timers, ADCs with ARM-based boards, Introduction to Real-Time Operating System (RTOS) concepts

Module IV: Interfacing Techniques and Applications 7 Hours

Memory interfacing: external RAM and ROM, I/O interfacing: LEDs, switches, LCDs, keypads, Sensor interfacing: temperature, LDR, pressure, ultrasonic, Motor control: DC, stepper, and servo motor interfacing, Communication interfaces: UART, SPI, I2C, Case studies: building basic embedded systems combining hardware and software

Total lecture hours: 30 Hours

Text Book:

1. Muhammad Ali Mazidi et al., The 8051 Microcontroller and Embedded Systems, Pearson.

2. Jonathan Valvano, Embedded Systems: Introduction to ARM Cortex-M Microcontrollers, CreateSpace.

3. Raj Kamal, Microcontrollers: Architecture, Programming, Interfacing and System Design, Pearson.

4. Shibu K. V., Introduction to Embedded Systems, McGraw-Hill.

Reference Book:

1. John Morton, The AVR Microcontroller and Embedded Systems, Pearson.

2. Yifeng Zhu, Embedded Systems with ARM Cortex-M Microcontrollers, E-Man Press LLC.

3. Han-Way Huang, 8051 and Embedded Systems Using Assembly and C for ATMEL, Cengage.

4. Steven Barrett & Daniel Pack, Embedded Systems with the MSP432 Microcontroller, Morgan & Claypool.

CO-PO-PSO MAPPING

Microcontrollers Architecture and Programming													
Course outcome	**Program Outcomes**										**Program Specific Outcomes**		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PSO 1	PSO 2	PSO 3
CO1	3	2	1	1	2	1	1	1	1	1	1	3	2	1
CO2	3	3	2	2	3	1	1	1	2	2	1	3	3	1
CO3	3	3	3	2	3	1	1	1	2	2	2	3	3	2
CO4	2	2	3	2	3	2	1	1	2	2	2	3	3	2

Digital Electronics and Microprocessors			
Hours/Week L-T-P :	**3-0-0**	**Credits:**	**3**
Course Type:	Professional Elective III	**Course Code:**	**EI3236**

Prerequisite: Basic understanding of binary number systems and introductory electronics.

Course Objectives :

1. To understand number systems, Boolean algebra, and simplification techniques in logic design.
2. To design and analyze combinational and sequential digital circuits.
3. To introduce the architecture and functioning of the 8085 microprocessor.
4. To develop skills in 8085 assembly language programming and interfacing peripheral devices.

Course Outcomes:

At the end of the course, a student will be able to:

CO1: Apply number system conversions, logic codes, and binary arithmetic in digital logic design.

CO2: Design and analyze combinational and sequential circuits using Boolean algebra and memory elements.

CO3: Explain microprocessor architecture and develop basic assembly programs.

CO4: Implement microprocessor-based memory and I/O interfacing for embedded and robotic applications.

Module I: Digital Fundamentals and Logic Design 7 Hours

Number Systems—Decimal, Binary, Octal, Hexadecimal, 1's and 2's Complements, Binary Codes – BCD, Excess-3, Gray, Boolean algebra and Logic Gates, Universal gates, Sum of products and product of sums, Minterms, Maxterms, Karnaugh Map (K-Map) Minimization (up to 4 variables).

Module II: Combinational and Synchronous Sequential Circuits 8 Hours

Adders and Subtractors (Half and Full), Multiplexers, Demultiplexers, Encoders, Decoders, SR, JK, D, T Flip-Flops, Shift Registers, Synchronous Counters & Asynchronous Counters (MOD-N).

Module III: Microprocessor Basics 8 Hours

Introduction to Microprocessors (8085) - Architecture, Register Organization, Signal descriptions, timing diagrams, Stacks and Subroutines, Interrupts.

Module IV: Programming & Interfacing 7 Hours

Interfacing with microprocessors (8085)- Addressing modes, Instruction sets, Assembly language programing, Address maps, Memory and I/O interfacing, Interfacing using 8255 PPI.

Total lecture hours: 30 Hours

Text Book:

1. Morris Mano and Michael D. Ciletti, "Digital Design", 5th Ed., Pearson Education, 2013.

2. R.P. Jain, "Modern digital Electronics", Tata McGraw Hill, 4th edition, 2009.

3. R. S. Gaonkar, Microprocessor Architecture: Programming and Applications with the 8085/ 8080A, Penram International Publishing, 1996.

4. K M Burchandi and A K Ray, "Advanced Microprocessors and Peripherals," 3rd edition, Tata McGraw-Hill Education, 2012, ISBN: 9781259006135.

Reference Book:

1. C.H. Roth, "Fundamentals of Logic Design", 5th Ed. Cengage Learning, 2004.

2. John F. Wakerly, "Digital Design-Principles and Practices", Pearson Publication, 5th Edition

3. Douglas V. Hall, Microprocessors and Interfacing: Programming and Hardware, 2nd Edition, McGraw-Hill Education, 2006, ISBN: 9780070600181.

4. Krishna Kant, Microprocessors and Microcontrollers: Architecture, Programming and System Design, PHI Learning, 2nd Edition, 2010, ISBN: 9788120340817.

CO-PO-PSO MAPPING

Digital Electronics and Microprocessor														
Course outcome	Program Outcomes											Program Specific Outcomes		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PSO 1	PSO 2	PSO 3

CO1	3	2	2	1	2	–	–	–	–	–	2	3	2	–
CO2	3	3	3	2	3	–	–	–	–	–	2	3	3	–
CO3	3	2	2	2	3	–	–	–	1	1	2	3	3	1
CO4	3	3	3	3	3	1	1	1	2	2	3	3	3	2

Business Management			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	HS	Course Code:	BH3401

Prerequisites: Basic understanding of organizational structure, business fundamentals, and communication skills.

Course Objectives:

1. To understand fundamental management principles, roles, functions, and modern approaches.
2. To develop financial literacy by exploring sources of finance, capital structure etc.
3. To equip students with essential human resource management knowledge, focusing on recruitment etc.
4. To impart a comprehensive understanding of marketing concepts, strategies, and tools

Course Outcomes:

1. Comparing and contrasting efficient functional models of business management by integrating the three core areas such as Finance, Human Resource and Marketing Management.
2. Executing the Management principles in all the functional areas of business.
3. Correlating the interrelations and interdependence of the areas of Management in a business organisation.
4. Assessing the functional and managerial practices in business organisations.

MODULE-1: Management Principles **(8 Hours)**

Management Concepts, Nature and Functions, Management Process and Roles ofManagers, Levels of Management and Managerial Skills, Theories of Management – Contributions of F.W.Taylor, Henry Fayol, Elton Mayo,Line and Staff Relationship, Centralisation and Decentralisation, Delegation of Authority , Management thoughts inModern Trend –Systems Approach

MODULE-2: Financial Management **(8 Hours)**

Concept, Financial function and Role of Financial Managers, Instruments of raising short-term and long-term funds, Capital Structure, Techniques of Project Appraisal, Components of Working Capital, Operating Cycle, Factors affecting requirement of Working Capital.

MODULE-3: Human Resource Management **(7 Hours)**

Nature and Scope of Human Resource Management, Manpower Planning, Recruitment and Selection Methods, Performance Appraisal, Need, Objectives, Modern methods of Appraisals: 720 degree, MBO, Assessment Centre Method, Talent Acquisition, Training Need Analysis, Career Planning, Organisational Citizenship Behaviour.

MODULE- 4: Marketing Management **(7 Hours)**

Concept, Nature, Scope and Importance, Marketing Mix and 7P’s of Marketing, Segmentation, Targeting, Positioning, Factors influencing consumer decision-making, e-marketing and Green Marketing

Reference Books:

1- Modern Business Organisation and Management, S.A. Sherlekar, Himalaya Publishing House, 2016.
2- Essentials of Management, Stephen P. Robbins, 6th Edition, Pearson, 2010.
3- Financial Management, Sheeba Kapil, 1st Edition,Pearson, 2013.
4- Human Resource Management Text and Cases,K. Aswathappa, 10th Edition,TMH, 2023
5- Marketing Management, Rajan Saxena, 6th Edition, TMH publishing house, 2022.
6- Principles of Management, Dipak Kumar Bhattacharyya, 1st Edition, Pearson, 2011
7- Mgmt (Principles of Management), Willium& Tripathy, 1st Edition, Cengage Learning, 2016

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	2	3	1	1	1	2	2	1	3	2	2
CO2	3	3	3	2	3	0	0	0	2	2	1	3	3	2
CO3	3	2	3	3	3	1	1	1	3	3	2	3	3	3
CO4	3	2	3	3	3	1	1	0	3	3	2	3	3	3

ENTREPRENEURSHIP DEVELOPMENT			
Hours/Week L-T-P :	3-0-0	Credits:	3

Course Type :	HS	Course Code:	BH – 3403

Prerequisites: Basic understanding of economics, business studies, and fundamental financial concepts.

Course Objectives:

1. To introduce students to the foundational concepts of entrepreneurship, including the functions, traits, and motivation of entrepreneurs.
2. To enable students to identify, develop, and evaluate entrepreneurial ideas by conducting feasibility studies and understanding business structures and the startup process.
3. To provide knowledge on various sources of entrepreneurial finance and equip students with basic financial analysis tools
4. To familiarize students with the entrepreneurial ecosystem, including incubators, accelerators etc.

Course Outcomes:

1. Exemplifying the business opportunities, social responsibilities and the support system for setting up an enterprise.
2. Determining stages of Entrepreneurial Process starting from idea generation, developing a business plan and operational aspects of an Enterprise.
3. Appraising the different funding options and Financial Management of an enterprise.
4. Assessing the Start-up management practices like incubation, mentorship and Government initiatives.

MODULE-1: Introduction to Entrepreneurship (8 hours)

Concept, Functions of an Entrepreneur, Entrepreneurial Process, Entrepreneurial Motivation and Barriers, Traits to be a successful Entrepreneur, Creativity and scope of Entrepreneurship in India: Types of new age business (FinTech, EdTech, Healthcare, Agripreneurship, Defence, Drone, Space, IT, Robotics, Digital Transformation, Women-Entrepreneurship, Social Entrepreneurship, Corporate Social Responsibility, Business Ethics – Role of Values in Management.

MODULE-2: Entrepreneurial Idea into Action (8 hours)

Developing a Business Idea; Opportunity, Methods and Creativity, Deciding to set up a start-up, Forms of business organisations (Sole tradership/propreitorship, Partnership, Joint-Stock Company) and MSMEs (Micro, Small and Medium enterprises), Size and Location of the enterprise, Feasibility Study: Market Survey, Techno-economic feasibility and preparing a Project Report.

MODULE-3: Entrepreneurial Finance and Funding (8 hours)

Sources of funding(Bootstrapping, Angel Investors, Venture Capital, Crowdfunding etc.) Project Investment Analysis, Break-Even Analysis, ROI Analysis, Basics of Income Statement and Balance Sheet.

MODULE- 4: Managing an Enterprise (8 hours)

The Start-up ecosystem, Business Incubators, Start-up Accelerators, Mentorship and Networking, Failure and Resilience, Risk Management, Ethical dilemmas and Exit Strategies, Start-up Policy and Initiatives of the Government.

Reference Books:

1. Entrepreneurship: Successfully Launching New Ventures, B.R. Barringer, 6th, Pearson, 2020
2. Fundamentals of Entrepreneurship and Project planning, MadhurimaLall, 1st, Sultan Chand & Sons, 2021
3. Entrepreneurial Development,S.S. Khanka, 1st Edition, S Chand and Company, 1999
4. Entrepreneurship Development and Small business enterprises, P.M. Charantimath, 3rd Edition, Pearson, 2019
5. Entrepreneurship: Theory, Process and Practice, Donald F Kuratco, 11th, Cengage, 2023
6. Entrepreneurship, Robert. D. Hisrich&SabyasachiSinha, 11th Edition, TMH, 2020

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	2	3	1	1	1	2	2	1	3	2	2
CO2	3	3	3	2	3	0	0	0	2	2	1	3	3	2
CO3	3	2	3	3	3	1	1	1	3	3	2	3	3	3
CO4	3	2	3	3	3	1	1	0	3	3	2	3	3	3

ENVIRONMENTAL ENGINEERING			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	MC	Course Code:	IP3401

PREREQUISITES: Basic Physics, Basic Chemistry

COURSE OUTCOMES

At the end of the course a student will be able to

CO1: Understand the multidisciplinary nature of environmental science and ecosystem structure and functions

CO2: Analyze various forms of environmental pollution and assess their impact using scientific parameters

CO3: Demonstrate knowledge of water and wastewater treatment processes and air pollution control technologies

CO4: Evaluate the role of environmental policies, EIA, and sustainable practices in pollution control and resource conservation

Module 1 **(10 hours)**

Fundamentals of Environment and Ecosystem: Multidisciplinary nature of environmental Engineering.

Study of Ecosystem: Definition, Properties, Structure and Function of an ecosystem. Food chains, food webs, Flow of Energy, Ecological Pyramids, Biogeochemical cycles, Types of ecosystems, Bioaccumulation, Bio magnification, ecosystem value, Degradation of Ecosystem.

Concept of Environment and pollution: Atmospheric chemistry, soil chemistry, water quality characteristics, DO, BOD and COD, water pollution, Marine Pollution, soil pollution, thermal pollution, nuclear hazard, Air Pollution: Air Quality, cause and effects of air pollution, Water and air quality standards, and Index, Noisepollution: Introduction, Noise standards, measurement, Ln Concept and control

Module 2 **(8 hours)**

Water treatment process: Pre-treatment of water, conventional process, advanced water treatment process.

Waste water treatment process: Natural Treatment, Engineering Treatment -Pre- treatment, primary and secondary waste water treatment process

Air Pollution Control: The natural self-cleansing properties of Environment, Air pollution meteorology, Atmospheric dispersion, Diffusion equation, ground level emission, plume rise, Effective stack height, Air Pollution control from stationarysources by installing Engineering devices, Flue gas desulphurisation, NOX removal.

Module 3 **(8 hours)**

Solid waste management: Source, classification, separation, storage and transportation of solid wastes, Waste minimization techniques, Benefits of waste minimization, reuse, recycle, thermal and biological treatment, secure land fill technique.

Impact of Environmental pollution and related issues: Global climate change, global warming and greenhouse gases, Acid rain, ozone layer depletion, healthissues.

Module4 **(4 hours)**

Environmental Impact Assessment: EIA procedure, Preparation of an EIS From unsustainable to sustainable development, circular economy, Environmental Protection Act, Air (Prevention and Control of Pollution) Act, Water (Preventionand Control of Pollution) Act, Wildlife Protection Act.

TEXTBOOKS

4. Fundamentals of Ecology, M.C.Dash, Tata McGraw Hill, 2006.
5. Environmental Pollution Control Engineering, C.S. Rao, New Age International Publishers, 2018
6. Environmental Engineering, G. Kiely, TMH, 2007

REFERENCES

5. Environmental Engineering, H.S. Peavy, D.R. Rowe and G. Tchobanoglous,McGraw Hill.
6. Introduction to Environmental Engineering and Science, G.M. Masters, Pearson,2015
7. Integrated Solid Waste Management, G. Tchobanoglous, McGraw Hill, 2014
8. Water Supply Engineering, S.K. Garg; Khanna Publishers, 37th Edition

CO-PO-PSO MAPPING														
COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	2	1	1	1	2	3	1	1	2	1	2	2	2
CO2	3	3	2	2	2	2	3	1	1	2	1	2	2	2
CO3	3	3	3	2	2	2	3	1	2	2	2	3	3	3
CO4	2	2	2	2	1	3	3	2	2	2	2	3	3	3
Correlation Level 1: Slight 2: Moderate 3: High														

INDUSTRIAL SAFETY ENGINEERING			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	MC	Course Code:	IP3403

PREREQUISITES: NA

COURSE OUTCOMES

At the end of the course a student will be able to

CO1: Apply safety principles in various work environments, especially in construction and machine operations**.**

CO2: Identify safety hazards, implement safety measures,

CO3: Analyse risks to prevent accidents and injuries.

CO4: Understand of safety protocols, policies, and the responsibilities of individuals and organizations in ensuring a safe working environment.

Module 1 **(6 hours)**

Safety Introduction: Need for safety. Safety and productivity. Definitions: Accident, Injury, Unsafe act, Unsafe Condition, Dangerous Occurrence, Reportable accidents. Theories of accident causation. Safety organization- objectives, types, functions, Role of management, supervisors, workmen, unions, government and voluntary agencies in safety. Safety policy. Safety Officer-responsibilities, authority. Safety committee-need, types, advantages.

Module 2 **(7 hours)**

Personal Protection in work environment:Personal protection in the work environment, Types of PPEs, Personal protective equipment- respiratory and non-respiratory equipment. Standards related to PPEs. Monitoring Safety Performance: Frequency rate, severity rate, incidence rate, activity rate. Housekeeping: Responsibility of management and employees. Advantages of good housekeeping. 5 s of housekeeping. Work permit system- objectives, hot work and cold work permits. Typical industrial models and methodology. Entry into confined spaces.

Module 3 **(7 hours)**

Safety issues in Construction: Introduction to construction industry and safety issues in construction Safety in various construction operations – Excavation and filling – Under-water works – Under-pinning & Shoring – Ladders & Scaffolds – Tunneling – Blasting – Demolition – Confined space – Temporary Structures. Familiarization with relevant Indian Standards and the National Building Code provisions on construction safety. Relevance of ergonomics in construction safety. Ergonomics Hazards - Musculoskeletal Disorders and Cumulative Trauma Disorders.

Module4 **(12 hours)**

Safety Hazards in Machines and Hazard identification and analysis: Machinery safeguard-Point-of-Operation, Principle of machine guarding -types of guards and devices.Safetyinturning,andgrinding.WeldingandCutting-SafetyPrecautionsofGas welding and Arc Welding. Material Handling-Classification-safety consideration- manual and mechanical handling. Handling assessments and techniques- lifting, carrying, pulling, pushing, palletizing and stocking. Material Handling equipment-operation & maintenance.

Hazard and risk, Types of hazards –Classification of Fire, Types of Fire extinguishers, fire explosion and toxic gas release, Structure of hazard identification and risk assessment. Identificationofhazards:Inventoryanalysis,Fireandexplosionhazardratingofprocessplants

- The Dow Fire and Explosion Hazard Index, Preliminary hazard analysis, Hazard and Operabilitystudy(HAZOP))–methodology,criticalityanalysis,correctiveactionandfollow-up. Control of Chemical Hazards, Hazardous properties of chemicals, Material Safety Data Sheets (MSDS).

TEXTBOOKS

1. R.K Jain (2000) Industrial Safety, Health and Environment management systems, Khanna Publications.

2. Paul S V (2000), Safety management System and Documentation training Programme handbook, CBS Publication.

3. Krishnan, N.V. (1997).Safety management in Industry. Jaico Publishing House, New Delhi.

REFERENCES

1. John V. Grimaldi and Rollin H.Simonds. (1989) Safety management. All India Traveller Book Seller, Delhi.

2. Ronald P. Blake. (1973). Industrial safety. Prentice Hall, New Delhi.

3. Alan Waring. (1996). Safety management system. Chapman & Hall, England.

4. Vaid, K.N., (1988). Construction safety management. National Institute of Construction Management and Research, Mumbai

CO-PO-PSO MAPPING														
COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**
CO1	3	3	3	2	2	2		3					3	2
CO2	3	3	3	2				3	2				3	2
CO3	3	3	3	2				3					3	2
CO4	2	2	1	2		3		3	2	2			2	2

Project for Product Development – I			
Hours/Week L-T-P :	3-0-0	Credits:	1.5
Course Type	Laboratory Course	Course Code:	MS3622

Course Objectives:

1. To foster innovation by enabling students to identify real-world problems and ideate potential robotic product solutions using design thinking methodologies.
2. To equip students with hands-on experience in rapid prototyping, system integration, and testing using tools available in the AICTE IDEA Lab.
3. To develop entrepreneurial competencies such as user validation, business model creation, and product pitching for transforming ideas into market-ready products.

Course Outcomes (COs):

CO1: Identify and define real-world robotics-related problems by applying innovation frameworks and design thinking principles.

CO2: Develop functional prototypes of robotic solutions using tools and technologies available in the AICTE IDEA Lab.

CO3: Collaborate in multidisciplinary teams to manage product development cycles, including planning, fabrication, testing, and iteration.

CO4: Present and pitch the developed robotic product ideas effectively, demonstrating both technical feasibility and entrepreneurial viability.

1. Design Thinking & Ideation Workshops
   Use the IDEA Lab's innovation spaces to conduct structured workshops on problem identification and solution design.
2. CAD Modelling and Simulation
   Utilize CAD tools and simulation software available in the lab for mechanical and system design of robots.
3. Rapid Prototyping with 3D Printing
   Develop robotic chassis, joints, and custom components using 3D printers.
4. Embedded Systems Development
   Use microcontrollers (Arduino, ESP32, Raspberry Pi) and available development kits to build control units.
5. Sensor Integration Projects
   Integrate IR, ultrasonic, LIDAR, and IMU sensors for environment sensing and robot navigation.
6. IoT-enabled Robotics Applications
   Build IoT-based robots for applications like smart farming, surveillance, or automation.
7. AI & Computer Vision Experiments
   Use AI tools and kits (like Jetson Nano) for object detection, facial recognition, and autonomous decision-making.
8. Mobile Robot Development
   Develop differential drive, tracked, or omnidirectional mobile robots with autonomous capabilities.

9. Entrepreneurship & IP Sessions
   Organize startup mentoring, IP filing workshops, and product commercialization seminars in the IDEA Lab.
10. Tech Expo / Demo Day
   Showcase student projects and startups emerging from the lab through a structured Demo Day.

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	2	3	1	1	1	2	2	1	3	2	2
CO2	3	3	3	2	3	0	0	0	2	2	1	3	3	2
CO3	3	2	3	3	3	1	1	1	3	3	2	3	3	3
CO4	3	2	3	3	3	1	1	0	3	3	2	3	3	3

Machine Learning for Robotics Lab			
Hours/Week L-T-P :	3-0-0	Credits:	1.5
Course Type	Laboratory Course	Course Code:	

Prerequisites: Python programming, Basic data structures, linear algebra, probability, statistics

Libraries like NumPy, Pandas, and scikit-learn is recommended. Basic knowledge of algorithm design and data analysis concepts is also required.

Course Outcomes:

CO1 Implement supervised learning algorithms like regression, classification, and decision trees.

CO2 Apply unsupervised learning techniques such as clustering and dimensionality reduction.

CO3 Build and evaluate neural networks and reinforcement learning models.

CO4 Design and develop ML solutions using appropriate tools and techniques.

Detailed Syllabus

1. Data cleaning: Filling in missing values, cleaning and filling missing data, drop missing values, smoothing noisy data
2. Dimensionality reduction using PCA and LDA
3. Build a decision tree classifier on a dataset
4. Implementation of Perceptron learning for binary classification.
5. Implementation of ANN with backpropagation for binary classification.
6. Performance evaluation of SVM for multi-class classification.
7. Implement a Naive Bayes classifier for text classification.
8. Statistical relation between two variables and scatter plots using linear regression.

9. Clustering of sample data points using k-Means algorithm and agglomerative algorithm.

10. Implement of a simple Q-Learning algorithm for a grid-world problem.

Text Books:

1. Introduction to Machine Learning with Python" by Andreas C. Müller and Sarah Guido.

2. "Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow" by AurélienGéron

Reference Books:

1. "Pattern Recognition and Machine Learning" by Christopher M. Bishop

2. "Machine Learning" by Tom M. Mitchell

CO-PO Mapping: ***(1: Low, 2: Medium, 3: High)***

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	2	3	1	1	1	2	2	1	3	2	2
CO2	3	3	3	2	3	0	0	0	2	2	1	3	3	2
CO3	3	2	3	3	3	1	1	1	3	3	2	3	3	3
CO4	3	2	3	3	3	1	1	0	3	3	2	3	3	3

MICROPROCESSOR & MICROCONTROLLERS LABORATORY			
Hours/Week L-T-P :	3-0-0	Credits:	1.5
Course Type	Laboratory Course	Course Code:	EI3503

Prerequisite: Digital Electronics, Basic Programming Skills

Course Outcomes:

At the end of the course, a student will be able to:

CO1: Execute assembly language programs for 8085, 8086, and 8051.

CO2: Interface microprocessors/microcontrollers with peripherals such as LEDs, stepper motors, ADC/DAC, and traffic control modules.

CO3: Simulate and implement simple microcontroller-based designs using Keil, Proteus, or equivalent.

CO4: Design simple systems using Advanced processors.

List of Experiments: (At least 10 experiments excluding Mini project should be done)

EXP 1: Write an assembly language program to perform arithmetic and logical operations using 8085/8086/8051.

EXP 2: Write an assembly language program to calculate the sum of a finite series of numbers.

EXP 3: Write an assembly language program to find the largest and smallest numbers from: (a) two given numbers (b) a set of N numbers.

EXP 4: Sort an array of numbers in ascending and descending order using assembly language.

EXP 5: Write an assembly language program to compute (a) Fibonacci series (b) Factorial of a given number.

EXP 6: Interface LEDs with 8051 and display rolling/flashing LED patterns.

EXP 7: Interface and control a stepper motor to rotate in forward and reverse directions.

EXP 8: Perform Analog-to-Digital (ADC) and Digital-to-Analog (DAC) conversions using interfacing circuits.

EXP 9: Simulate and implement a traffic light controller with different delays using 8085/ 8051.

EXP 10: Interface 8255 Programmable Peripheral Interface (PPI) to perform port configuration and data transfer.

EXP 11: Display data on an alphanumeric LCD using 8051 microcontrollers.

EXP 12: Use Keil or Proteus to simulate applications such as temperature sensing, IR sensors, or motor control.

EXP 13: Perform interrupt programming and timer control using 8051/ARM.

MP: Mini-project using 8051MC /ARM/ PIC/ AVR etc.

Text Book:

1. R. S. Gaonkar, Microprocessor Architecture, Programming and Applications with the 8085, 6th ed. Stamford, CT, USA: Cengage Learning, 2013.

2. M. A. Mazidi, J. G. Mazidi, and R. D. McKinlay, The 8051 Microcontroller and Embedded Systems: Using Assembly and C, 2nd ed. Upper Saddle River, NJ, USA: Pearson, 2008.

Reference Book:

1. N. Sloss, D. Symes, and C. Wright, ARM System Developer’s Guide: Designing and Optimizing System Software, 1st ed. San Francisco, CA, USA: Morgan Kaufmann, 2004.

CO-PO-PSO MAPPING

MICROPROCESSOR & MICROCONTROLLERS LABORATORY														
Course outcome	**Program Outcomes**											**Program Specific Outcomes**		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO11	PS O1	PS O2	PS O3
CO1	3	3	3	3	3	1	1	1	3	3	1	3	3	3

CO2	3	3	3	3	3	2	2	1	3	3	1	3	3	3
CO3	3	3	3	3	3	3	2	2	3	3	2	3	3	3
CO4	3	3	3	3	3	3	3	3	3	3	3	3	3	3

FOURTH YEAR (SEVENTH SEMESTER)

Sl. No.	**Subject Type**	**Subject Code**	**Subject Name**	**Teaching Hours**			**Credit**	**Maximum Marks**			
				L	**T**	**P**		**IA**	**EA**	**PA**	**Total**
1	PE-4	MS4221	Field and Service Robotics	3	0	0	3	40	60	-	100
		MS4223	Bio Inspired Robotics	3	0	0	3	40	60	-	100
		MS4225	Medical Robotics	3	0	0	3	40	60	-	100
2	PE-5		Computer Vision & Image Processing	3	0	0	3	40	60	-	100
			Deep Learning	3	0	0	3	40	60	-	100
			Data Modeling and Visualization	3	0	0	3	40	60	-	100
3	OE-1	MS4301 MS4303 MS4305	Open Elective – I 4. Decision Modelling 5. Soft Computing Techniques 6. Statistical Methods for Engineers	3	0	0	2	40	60	-	100
4	PC (ACC)		Virtual Reality	3	0	0	2	40	60	-	100
5	LC	MS4701	Seminar on SIRE - II	0	0	6	1	-	-	100	100
6	LC	MS4601/ MS4603	Project for Product Development – II / Internship Project - I	0	0	6	3	-	-	100	100
			Total	**12**	**0**	**12**	**15**	**160**	**240**	**400**	**1000**

Field and Service Robotics			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type	Professional Elective IV	Course Code:	MS4221

Prerequisite : Basic knowledge of robotics, control systems, and programming fundamentals.

Course Objectives :

1. To provide an understanding of the evolution, types, and applications of service and field robots.
2. To explore localization techniques and challenges in robotic navigation.
3. To develop knowledge of path planning and navigation strategies for autonomous robots.
4. To examine design, operation, and application aspects of field robots and humanoids.

Course Outcomes (COs):

CO1: Explain the classifications, specifications, and applications of service and field robots.

CO2: Analyze various localization techniques used in mobile robotics.

CO3: Apply different planning and navigation algorithms in robot movement and obstacle avoidance.

CO4: Evaluate technologies and applications related to humanoids and field robots across various sectors.

Module-1 **(9hrs)**
INTRODUCTION
History of service robotics – Present status and future trends – Need for service robots - applications-examples and Specifications of service and field Robots. Nonconventional Industrial robots.
Module-2 **(9hrs)**
LOCALIZATION
Introduction-Challenges of Localization- Map Representation- Probabilistic Map based Localization-Monte carlo localization- Landmark based navigation- Globally unique localization- Positioning beacon systems- Route based localization.
Module-3 **(8hrs)**
PLANNING AND NAVIGATION
Introduction-Path planning overview- Road map path planning- Cell decomposition path planning-Potential field path planning- Obstacle avoidance - Case studies: tiered robot architectures.
Module-4 **(10hrs)**
FIELD ROBOTS , HUMANOIDS
Ariel robots- Collision avoidance- Robots for agriculture, mining, exploration, underwater, civilian and military applications, nuclear applications, Space applications. Wheeled and legged, Legged locomotion and balance, Arm movement, Gaze and auditory orientation control, Facial expression, Hands and manipulation, Sound and speech generation, Motion capture/Learning from demonstration, Human activity recognition using vision, touch, sound, Vision, Tactile Sensing, Models of emotion and motivation. Performance, Interaction, Safety and robustness, Applications, Case studies.

TEXT BOOKS:

1. Roland Siegwart, Illah Reza Nourbakhsh, Davide Scaramuzza, 'Introduction to Autonomous Mobile Robots", Bradford Company Scituate, USA, 2004.
2. Riadh Siaer, 'The future of Humanoid Robots- Research and applications', Intech Publications,2012.

REFERENCES :

1. Richard D Klafter, Thomas A Chmielewski, Michael Negin, "Robotics Engineering – An Integrated Approach", Eastern Economy Edition, Prentice Hall of India P Ltd., 2006.
2. Kelly, Alonzo; IagnModule 1: Foundations and Design Principles

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	-	1	1	-	-	-	1	-	2	2	2
CO2	3	3	2	2	2	-	-	-	-	-	-	3	2	2
CO3	3	3	3	2	3	-	-	-	-	-	-	3	3	2
CO4	3	2	2	2	2	1	2	-	2	1	-	3	3	2

Bio Inspired Robotics			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type:	Professional Elective IV	Course Code:	MS4223

Prerequisite : Basic understanding of robotics, control systems, sensors, and human anatomy.
Course Objectives :

1. To introduce biologically inspired robotic systems and distinguish between biomimetics and biorobotic modeling.
2. To explore bio-actuation, sensing technologies, and their applications in micro/nanorobotics.
3. To examine real-world examples of bio-inspired robots and their functional roles.
4. To understand modeling, control strategies, and biomedical applications of bio-inspired robotics.

Course Outcomes (COs)

CO1: Demonstrate understanding of biomimetics and biorobotic modeling, mapping biological functions into robotic design.

CO2: Design and analyze bio-inspired actuation and sensing systems at macro and micro scales.

CO3: Critically evaluate real-world bio-robotic systems (e.g., snakebots, robotic fish, humanoids, rehab robots).

CO4: Model and implement biologically inspired control systems and algorithms for robotic applications in environmental monitoring, healthcare, and human–robot interaction.

Module 1: **(9hrs)**

history of biologically inspired robotics, distinguishing biomimetics (design inspired by nature) from biorobotic modeling (using robots to study biology) , biomimetic robot design and control, translate biological mechanisms—like muscle-skeleton interaction—into robotic architectures. Central Pattern Generator (CPG)-based control, exemplified by snake‑like robots, and analysis of bio-inspired systems such as jaguar-inspired fitness cycles

Module 2:(9hrs)

Bio‑actuation, Sensing, and Micro/Nanorobotics, soft actuators that mimic muscle behavior, magnetorheological fluid-based assistive braces, and systems for single-cell manipulation with optical tweezers ,noninvasive bio-sensing techniques like hybrid brain scanning and EMG-based hand-motion recognition, the crossover between robotics and biomedical engineering

Module 3: **(9hrs)**

real-world bio-inspired robots and their functionalities.serpentine robots for search‑and‑rescue, robotic fish for pollution detection, humanoid neck mechanisms for expressive interactions, and rehabilitation systems for paralytic patients

Module 4: Modeling, Control, and Applications **(9hrs)**

brain circuitry simulations, neural control of movement, and robotic environments designed to measure human-likeness (e.g., eye movement behavior) , capsule endoscopy detection, EMG signal classification, and wire-driven robotic-hand rehabilitation.

Textbook:

1.Biologically Inspired Robotics,Edited by Yunhui Liu and Dong Sun,CRC Press, 2014,ISBN: 9781439854884

Reference Books:

1.Autonomous Robots: From Biological Inspiration to Implementation and Control,George A. Bekey,MIT Press, 2005,ISBN: 9780262025782

2.Biomimicry: Innovation Inspired by Nature,Janine M. Benyus,Harper Perennial, 2002,ISBN: 9780060533229

3.Amphibionics: Build Your Own Biologically Inspired Reptilian Robot,Karl Williams,McGraw-Hill/TAB Electronics, 2003,ISBN: 9780071413640

4.Biomimetic Robotics: Mechanisms and Control,Yoseph Bar-Cohen,SPIE Press, 2005,ISBN: 9780819452978

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	-	2	-	1	-	-	1	-	3	2	2
CO2	3	3	3	2	3	-	1	-	-	-	-	3	3	2
CO3	3	3	2	2	2	1	-	-	1	2	-	3	2	3
CO4	3	3	3	3	3	2	-	-	2	2	1	3	3	3

Medical robotics			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type:	Professional Elective IV	Course Code:	MS4225

Prerequisite : Basic knowledge of robotics, anatomy, and medical imaging systems.

Course Objectives (COBs):

1. To provide an overview of medical robotics and their integration into healthcare systems.
2. To understand the technologies behind localization and tracking used in medical procedure
3. To analyze surgical robotics applications across different medical domains.
4. To explore rehabilitation and assistive robotic systems for improved patient care.

Course Outcomes (COs):

CO1: Classify various types of medical robots and describe their applications in navigation, motion replication, imaging, and rehabilitation.

CO2: Analyze different localization and tracking technologies used in medical robotic systems, including sensor types and hybrid systems.

CO3: Explain the structure, control strategies, and clinical applications of surgical robotic systems in minimally invasive and specialty surgeries.

CO4: Evaluate the role of robots in rehabilitation and assistive care, including brain-machine interfaces, steerable needles, and physiotherapy systems.

Module 1: **(9hrs)**

Introduction to Medical Robotics and Healthcare Systems, Types of medical robots, Navigation, Motion replication, Imaging, Rehabilitation and prosthetics, State-of-the-art robotics in healthcare, DICOM (Digital Imaging and Communications in Medicine)

Module 2: **(9hrs)**

Localization and Tracking Technologies, Position sensor requirements, Tracking methods, Mechanical linkages, Optical tracking, Sound-based tracking, Electromagnetic tracking, Impedance-based tracking In-bore MRI tracking, Video matching, Fiber optic tracking systems, Hybrid tracking systems

Module 3: **(9hrs)**

Surgical Robotics, Minimally invasive surgery and robotic integration, Surgical robotic subsystems

Synergistic control, Control modes in surgical robots, Radiosurgery, Orthopedic surgery, Urologic surgery and robotic imaging, Cardiac surgery, Neurosurgery, Case studies

Module 4: **(9hrs)**

1.Robots in Rehabilitation and Assistive Care, Rehabilitation for limbs, Brain-Machine Interfaces (BMI)

Steerable needles, Assistive robots, Robots in physiotherapy, Case studies

Text book:

Jaydev P Desai, Rajni V Patel, Antoine Ferreira; Sunil Kumar Agrawal, "The Encyclopedia of Medical

Reference Books:

1.Robotics", World Scientific Publishing Co. Pvt. Ltd, 2019.

2.Jocelyne Troccaz , "Medical Robotics", John Wiley & Sons Incorporated, 2013.

3.VanjaBonzovic , "Medical Robotics", I-tech Education publishing, Austria, 2008.

4.FaridGharagozloo "Robotic Surgery", Springer, 2022.

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PSO 1	PSO 2	PSO 3
CO 1	3	2	2	-	2	1	-	-	-	1	1	3	2	2
CO 2	3	3	3	2	3	-	-	-	-	-	2	3	3	2
CO 3	3	3	3	3	3	2	1	-	2	2	2	3	3	3
CO 4	3	3	2	3	2	2	1	-	2	2	1	3	3	3

Computer Vision and image processing			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type:	Professional Elective V	Course Code:	

Prerequisites Digital Signal Processing (DSP),Basic Image Processing, Programming Skills, Mathematics, Data Structure and Algorithms

Course Outcomes:

CO1 Apply transforms like Fourier, DCT, and Wavelet for image representation and analysis

CO2 Perform image pre processing using smoothing, edge, and corner detection.

CO3 Implement segmentation and recognition using SIFT, RANSAC, and Random Forests.

CO4 Analyze 3D scenes using projective geometry and epipolar constraints.

Module-I **(8 Hours)**

The Image, its representation and properties, The image, its mathematical and physical background: 1D Fourier Transform, 2D Fourier Transform, Sampling and the Shannon constraint, Discrete Cosine Transform, Wavelet Transform,**Data Structures for Image Analysis:** Traditional Image Data Structure, Matrices; Hierarchical data structures, Quad trees, **Image Pre processing:** Local Pre-processing, Image Smoothing, Edge Detectors, Parametric Edge Models, Edges in multi-spectral images, Detection of corners

Module-II **(8 Hours)**

Segmentation: Segmentation: Edge based Segmentation, Border Tracing, Border Detection as graph searching, Border Detection as dynamic programming, Hough transforms Region Based Segmentation: Splitting and merging, Matching: Template Matching **Image Understanding:** Hierarchical control, Bottom-up control, Model-based control, SIFT, RANSAC, Image Understanding using Random Forests, Semantic image segmentation and understanding, Semantic Region Growing, Genetic image interpretation

Module-III **(7 Hours)**

3D Geometry, correspondence, 3D from intensities: Basics of projective geometry, Points and Hyper planes in projective space, A single perspective camera, Scene reconstruction from multiple views, Triangulation, projective reconstruction, Two camera, stereopsis, Epipolar geometry; Fundamental matrix

Module-IV **(7 Hours)**

Texture: Statistical texture description, methods based on spatial frequencies, Co-occurrence matrices, Local Binary Patterns, Fractal texture description, Multi scale texture description, Other statistical methods of texture description **Motion Analysis:** Optical flow, Optical flow computation, Global and local optimal flow estimation

Text Books:

1. Image Processing, Analysis & Machine Vision, Milan Sonka, Vaclav Hlavac, Roger Boyle, Cengage Learning, 2017.
2. Richard Szeliski, Computer Vision: Algorithms and Applications, Springer Verlag, London Limited 2011.

References Books:

1. R. C. Gonzalez and R.E. Woods, Digital Image Processing, Addison- Weslay, 1999.
2. Richard Hartley and Andrew Zisserman, Multiple View Geometry in Computer Vision, Second Edition, Cambridge University Press, March 2004.

CO-PO Mapping:*(1:Low, 2:Medium, 3:High)*

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	-	2	1	-	-	-	1	1	3	2	2
CO2	3	3	3	2	3	-	-	-	-	-	2	3	3	2
CO3	3	3	3	3	3	2	1	-	2	2	2	3	3	3
CO4	3	3	2	3	2	2	1	-	2	2	1	3	3	3

Deep Learning			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type:	Professional Elective V	Course Code:	

Prerequisites A foundational understanding of programming, mathematics, and machine learning

Course Outcomes:

CO1 Understand the fundamentals of deep learning and the main research activities in this field.

CO2 Remember architectures and optimization methods for deep neural network training.

CO3 Implement, apply and test relevant learning algorithms in TensorFlow.

CO4 Critically evaluate the method's applicability in new contexts and construct new applications

Module-I **(8 Hours)**

History of Deep Learning, McCulloch Pitts Neuron, Multilayer Perceptrons (MLPs), Representation Power of MLPs, Sigmoid Neurons, Feed Forward Neural Networks, Back propagation

Module-II **(6 Hours)**

Gradient Descent (GD), Momentum Based GD, Nesterov Accelerated GD, Stochastic GD, Principal Component Analysis and its interpretations, Singular Value Decomposition, Parameters v/s Hyper-parameters

Module-III **(8 Hours)**

Auto encoders and relation to PCA, Regularization in auto encoders, Denoising auto encoders, Sparse auto encoders, Regularization: Bias Variance Tradeoff, L2 regularization, Early stopping, Dataset augmentation, Encoder Decoder Models, Attention Mechanism, Attention over images, Batch Normalization

Module-IV **(8 Hours)**

Introduction to CNNs, Architecture, Convolution/pooling layers, CNN Applications, LeNet, AlexNet, ZF-Net, VGGNet, GoogLeNet, ResNet. Introduction to RNNs, Back propagation through time (BPTT), Vanishing and Exploding Gradients, Truncated BPTT, GRU, LSTMs

Text Books:

1. Ian Goodfellow, YoshuaBengio, Aaron Courville. Deep Learning, the MIT press, 2016
2. Bengio, Yoshua. " Learning deep architectures for AI." Foundations and trends in Machine Learning 2.1, Now Publishers, 2009

References Books:

3. Deep Learning, Rajiv Chopra, Khanna Book Publishing, Delhi 2020.
4. C++: The Complete Reference- Schildt, McGraw-Hill Education(India)

CO-PO Mapping: ***(1: Low, 2: Medium, 3: High)***

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	-	2	1	-	-	-	1	1	3	2	2
CO2	3	3	3	2	3	-	-	-	-	-	2	3	3	2
CO3	3	3	3	3	3	2	1	-	2	2	2	3	3	3
CO4	3	3	2	3	2	2	1	-	2	2	1	3	3	3

Data modeling and visualisation			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type:	Professional Elective V	Course Code:	

Prerequisite : Basic understanding of databases, statistics, and programming fundamentals.

Course Objectives :

1. To introduce fundamental concepts of data modeling using ER and relational models.
2. To provide an overview of data visualization principles and abstraction methods.
3. To explore various visualization techniques for scalar, vector, and multivariate data.
4. To familiarize students with modern data visualization tools and practical dashboard creation.

Course Outcomes (COs):

CO1: Apply data modeling techniques including ER models and relational schema mapping.
CO2: Explain data visualization principles, task abstraction, and validation levels.
CO3: Utilize appropriate visualization techniques for different data types and analytical needs.
CO4: Create interactive dashboards using tools like Tableau and R for real-world domains.

Module 1: Introduction Data Modeling: **(7 Hours)**
Entity Relationship Model: Types of Attributes, Relationship, Structural Constraints – Relational Model, Relational model Constraints - Mapping ER model to a relational schema – Integrity constraint.

Module 2: Introduction to Data Visualization: **(7 Hours)**
Overview of data visualization - Data Abstraction -Analysis: Four Levels for Validation- Task Abstraction - Analysis: Four Levels for Validation.

Module 3: Visualization Techniques: **(10 Hours)**
Scalar and point techniques Color Maps Contouring Height Plots – Vector visualization techniques Vector Properties Vector Glyphs Vector Color Coding Stream Objects.
Visual Analytics:
Visual Variables- Networks and Trees - Map Color and Other Channels- Manipulate View Arrange Tables Geo Spatial Data Reduce Items and Attributes.
Types of Visual Analysis:
Time- Series data visualization -Text data visualization- Multivariate data visualization and case studies.

Module 4: Visualization Tools and Techniques: **(9 Hours)**
Introduction to data visualization tools- Tableau - Visualization using R- Dashboard creation using visualization tools for the use cases: Finance-marketing-insurance- healthcare etc.

Text Books:

(i) Tamara Munzer, Visualization Analysis and Design, CRC Press 2014 Alexandru Telea, Data Visualization Principles and Practice CRC Press 2014.
(ii) Paul J. Deitel, Harvey Deitel, Java SE8 for Programmers (Deitel Developer Series) 3rd Edition, 2014.

Reference Books:

(i) Y. Daniel Liang, Introduction to Java programming-comprehensive version- Tenth Edition, Pearson Ltd. 2015.
(ii) Paul Deitel Harvey Deitel, Java, How to Program, Prentice Hall; 9th edition, 2011.
(iii) Cay Horstmann BIG JAVA, 4th edition, John Wiley Sons, 2009.
(iv) Nicholas S. Williams, Professional Java for Web Applications, Wrox Press, 2014.

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	-	2	1	-	-	-	1	1	3	2	2
CO2	3	3	3	2	3	-	-	-	-	-	2	3	3	2
CO3	3	3	3	3	3	2	1	-	2	2	2	3	3	3
CO4	3	3	2	3	2	2	1	-	2	2	1	3	3	3

Virtual reality			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type:	ACC(PC)	Course Code:	

Prerequisite : Basic knowledge of computer graphics, human-computer interaction, and programming in C++/Python.

Course Objectives :

1. To introduce the fundamental concepts, components, and architecture of Virtual and Augmented Reality systems.
2. To understand the modeling techniques used in VR systems including geometric, physical, and behavioral models.
3. To explore user interaction strategies and evaluate design principles for 3D user interfaces.
4. To apply human-centered design for developing practical VR/AR applications using open-source tools.

Course Outcomes (COs):

CO1: Describe the components and functionalities of VR/AR systems and interfaces.
CO2: Apply modeling and interaction techniques for building effective virtual environments.
CO3: Design and evaluate user-centered 3D interaction strategies in VR/AR systems.
CO4: Develop and implement a basic VR/AR application using industry-standard open-source toolkits.

Module 1: **(9 Hours)**

Introduction, Components of a VR system, 3D User Interface Input and Output devices, 3D viewing, Designing & Building VR Systems, Introduction to Augmented Reality (AR),

Module 2: **(9 Hours)**
VR Modeling: Geometric modeling, Kinematic, Physical and Behavior modeling; Selection and Manipulation during 3D Interaction,

Module 3: **(9 Hours)**
Travel and Wayfinding in Virtual Environments, Strategies for Designing and Developing 3D UIs, Evaluation of 3D User Interfaces, Traditional and Emerging VR/AR applications

Module 4: **(9 Hours)**
Human Factors in Virtual Reality, Case study on Construction of Geographic Virtual World. Group assignments on implementation of a Virtual/ Augmented Reality Application using open-source toolkits/ libraries such as OpenSceneGraph, Vega, VRML etc.

Text/ Reference Books:

1. G.C. Burdea & P. Coiffet, “Virtual reality Technology, Second Ed.”, Wiley-India.
2. GJ Kim, “Designing VR Systems: The Structured Approach”, Springer.
3. D.A. Bowman et al., “3D User Interfaces: Theory and Practice”, Addison Wesley.
4. John Vince, “Virtual Reality Systems”, Pearson Ed.
5. Rick Parent, “Computer Animation: Algorithms & Techniques”, Morgan Kaufmann.

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	-	2	1	-	-	-	1	1	3	2	2
CO2	3	3	3	2	3	-	-	-	-	-	2	3	3	2
CO3	3	3	3	3	3	2	1	-	2	2	2	3	3	3
CO4	3	3	2	3	2	2	1	-	2	2	1	3	3	3

Decision Modelling

Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	OE	Course Code:	MS

Course Objective:

1. To understand the differences between traditional decision making and structured decision making methods of selection process.
2. To learn the theory of decision making and their applications in traditional and modern business firms.
3. To improve the skills of using the MCDM tools and techniques, in critical thinking especially in appropriate decision making in manufacturing systems.
4. To demonstrate ability to identify and define issues in decision making with multiple criteria and understanding its root causes.

Course Outcomes:

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

CO1: Understand the basic principles of structured decision making approaches

CO2: Analyze the various types of decision making scenarios and application of appropriate decision making methods on situations

CO3: Develop a continuous decision making process for sustainable business practices results

CO4: Apply methods/steps adequate enough to make the right group decisions in the new age business firms

Module-1 **9hrs**

Introduction to Structured Decision Making, Estimation of Weights: Normalization methods; Rating methods; Entropy method; Analytical Hierarchy Process Compromise Programming Methods of Classification: ELECTRETRI; Kohonen Neural Networks; Cluster validity indices

Module- 2 **9hrs**

Distance based MCDM methods: TOPSIS; Composite Programming, Outranking based MCDM methods: PROMETHEE-2; ELECTRE-3; ELECTRE-4 Utility Based MCDM Method: Multi-Attribute Utility Theory.

Module- 3 **9**

Data Envelopment Analysis Multi Criterion Q-Analysis-2; EXPROM2; STOPROM-2 ,

Module- 4

Fuzzy Logic-Based Discrete MCDM Fuzzy TOPSIS ,Fuzzy Programming Methods in MCDM Correlation Coefficient and Group Decision Making

Text Books:

1. Multi criterion Analysis in Engineering and Management Raju K.S., Nagesh Kumar D, (2014), Prentice Hall of India (PHI) Learning Pvt. Ltd, New Delhi.
2. Multiple Criteria Decision Making and Aiding: Cases on Models and Methods with Computer Implementations (International Series in Operations Research & Management Science Book 274) 1st ed. 2019 Edition, Kindle Edition by Sandra Huber (Editor), Martin Josef Geiger (Editor), Adiel Teixeira de Almeida (Editor) Format: Kindle Edition
3. Socially Reponsible Investment. A Multi-Criteria Decision Making Approach. E. Ballestero, B. Pérez-Gladish, A. García- Bernabeu (Eds.) International Series in Operations Research and Management Science. Springer, Cham, 2015.
4. Multicriteria and Multi objective Models for Risk, Reliability and Maintenance Decision Analysis. A. T. de Almeida, C. A. V. Cavalcante, M. H. Alencar, R. J. P. Ferreira, A.T. de Almeida-Filho, T.V. Garcez, International Series in Operations Research and Management Science. Springer, 2015.

Reference Books:

1. Decision Making in Manufacturing Environment Using Graph Theory and Fuzzy Multiple Attribute Decision Making Methods. R. R. Venkata, Springer Series in Advanced Manufacturing.
2. Multi-criteria Decision Analysis for Supporting the Selection of Engineering Materials in Product Design. A. Jahan, K. L. Edwards, Butterworth-Heinemann.
3. TOPSIS Algorithms for Multiple Objectives Decision Making: Large Scale Programming Approach. Abou-El-Enien T LAP Lambert Academic Publishing.

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	2	2	1	-	2	2	1	2	2
CO2	3	2	1	1	1	2	3	1	-	2	3	1	2	2
CO3	3	2	1	1	1	2	2	1	-	2	2	1	2	2
CO4	3	2	1	1	1	2	3	1	-	2	3	1	2	2

Soft Computing Technique

Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type:	OE	Course Code:	MS2124

Prerequisite: Basic knowledge of linear algebra, probability, calculus, and fundamentals of artificial intelligence or machine learning.

Course Objectives:

1. To introduce the fundamental concepts of soft computing and its components such as fuzzy logic, neural networks, and genetic algorithms.
2. To enable students to design and apply fuzzy systems for reasoning and inference under uncertainty.
3. To develop an understanding of supervised and unsupervised neural network architectures and their applications.
4. To familiarize students with hybrid soft computing techniques like Neuro-Fuzzy systems and genetic algorithms for problem-solving.

Course Outcomes (COs):

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

CO1: Apply fuzzy logic concepts to solve problems involving uncertainty and vagueness.

CO2: Analyze and design neural networks for classification and pattern recognition tasks.

CO3: Implement genetic algorithms for optimization problems in engineering domains.

CO4: Develop and evaluate Neuro-Fuzzy models for real-time intelligent systems.

Module -1

INTRODUCTION TO SOFT COMPUTING AND FUZZY LOGIC **(8 Hours)**

Introduction - Fuzzy Logic - Fuzzy Sets, Fuzzy Membership Functions, Operations on Fuzzy Sets, Fuzzy Relations, Operations on Fuzzy Relations, Fuzzy Rules and Fuzzy Reasoning, Fuzzy Inference Systems

Module -2

NEURAL NETWORKS **(8 Hours)**

Supervised Learning Neural Networks – Perceptrons - Backpropagation -Multilayer Perceptrons –Unsupervised Learning Neural Networks – Kohonen Self-Organizing Networks

Module -3

GENETIC ALGORITHMS **(8 Hours)**

Chromosome Encoding Schemes -Population initialization and selection methods – Evaluation function - Genetic operators- Cross over – Mutation - Fitness Function – Maximizing function.

Module -4

NEURO FUZZY MODELING **(8 Hours)**

ANFIS architecture – hybrid learning – ANFIS as universal approximator – Coactive Neuro fuzzymodeling – Framework – Neuron functions for adaptive networks – Neuro fuzzy spectrum – Analysisof Adaptive Learning Capability

Text Books:

1. J.S.R.Jang, C.T. Sun and E.Mizutani, “Neuro-Fuzzy and Soft Computing”, PHI / Pearson Education 2004.
2. S.N.Sivanandam and S.N.Deepa, "Principles of Soft Computing", Wiley India Pvt Ltd,

2011.

Reference Book:
1. S.Rajasekaran and G.A.VijayalakshmiPai, "Neural Networks, Fuzzy Logic and Genetic Algorithm: Synthesis & Applications", Prentice-Hall of India Pvt. Ltd., 2006.
2. George J. Klir, Ute St. Clair, Bo Yuan, "Fuzzy Set Theory: Foundations and Applications" Prentice Hall, 1997.
3. David E. Goldberg, "Genetic Algorithm in Search Optimization and Machine Learning" Pearson Education India, 2013.
4. James A. Freeman, David M. Skapura, "Neural Networks Algorithms, Applications, and Programming Techniques, Pearson Education India, 1991.
5. Simon Haykin, "Neural Networks Comprehensive Foundation" Second Edition, Pearson Education, 2005

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	2	3	1	1	1	1	2	1	3	2	2
CO2	3	2	3	2	3	1	1	1	2	2	1	3	2	2
CO3	3	3	3	3	3	1	1	1	2	2	1	3	2	2
CO4	3	2	3	3	3	1	1	1	2	2	2	3	3	2

Statistical Methods for Engineers

Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	OE	Course Code:	MS4305

Course Objectives:
1. To provide the solid foundation on topics in various statistical methods
2. To address the issues and the principles of estimation theory, testing of hypothesis, correlation and regression
3. To introduce the basics of design of experiments.
4. To emphasis the importance of multivariate analysis

Course Outcomes (COs):
CO1: Select and apply probability distributions (e.g., Normal, Weibull) to model engineering system variability and reliability.
CO2: Construct confidence intervals and conduct hypothesis tests (t, χ^2, ANOVA) to validate engineering designs and processes.
CO3: Build and diagnose regression models (linear/multiple) to analyze experimental data and forecast engineering outcomes.
CO4: Design control charts (X-bar, p-chart) and reliability tests (Weibull analysis) to optimize manufacturing processes and product lifespan.

Module 1 **9 Hours**

Estimators: Unbiasedness, Consistency, Efficiency and sufficiency – Maximum likelihood estimation – Method of moments.

Sampling distributions - small and large samples -Tests based on Normal, t, Chi square, and F distributions for testing of means, variance and proportions – Analysis of r x c tables – Goodness of fit.

Module 2 **9 Hours**

Multiple and partial correlation – Method of least squares – Plane of regression – Properties of residuals – Coefficient of multiple correlation – Coefficient of partial correlation – Multiple correlation with total and partial correlations – Regression and partial correlations in terms of lower order co - efficient

Module 3 **9 Hours**

Analysis of variance – One way and two way classifications – Completely randomized design – Randomized block design – Latin square design - 2 2 Factorial design.

Module 4 **9 Hours**

Random vectors and matrices – Mean vectors and covariance matrices – Multivariate normal density and its properties – Principal components: Population principal components – Principal components from standardized variables.

Text Books:

1. Gupta S.C., and Kapoor, V.K., “Fundamentals of Mathematical Statistics”, 12th Edition, Sultan Chand and Sons, 2020.
2. Jay L. Devore, “Probability and statistics for Engineering and the Sciences”, 8th Edition, Cengage Learning, 2014.

Reference Books:

1. Johnson, R.A., Miller, I and Freund J., "Miller and Freund’s Probability and Statistics for Engineers", 9th Edition, Pearson Education, Asia, 2016.
2. Johnson, R.A. and Wichern, D. W. “Applied Multivariate Statistical Analysis”, 6th Edition, Pearson Education, Asia, 2012.
3. Rice, J.A. "Mathematical Statistics and Data Analysis", 3rd Edition, Cengage Learning, 2015.

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	3	-	2	2	-	-	-	-	-	2	3	-	-
CO2	2	3	-	3	2	-	1	-	2	-	2	-	3	-
CO3	2	1	-	3	3	-	-	1	2	-	2	2	3	-
CO4	2	1	-	2	3	-	1	-	1	-	1	3	-	2

FOURTH YEAR (EIGHTH SEMESTER)

Sl. No.	Course Code	Subject	Contact Hrs. L-T-P	Credit
1	MS4302 MS4304 MS4306	Open Elective – II 4. Design of Experiment 5. Introduction to Robotics 6. Automobile Engineering	3-0-0	3
2	MS4308 MS4310 MS4312	Open Elective – III 4. Refrigeration and Air Conditioning system 5. Power Generation Technologies 6. Solar Technology	3-0-0	3
3	MS4314 MS4316 MS4318	Open Elective – IV 4. Digital Manufacturing 5. Sensors and Actuators 6. Production and Operations Management	3-0-0	3
Sessional				
4	MS4702	Seminar on Project	0-0-6	3
5	MS4602/MS4604	Projectfor Product Development – III / Internship Project - II	0-0-12	6
Total			**6-0-18**	**15**

***Project / Seminar / Internship**

Design of Experiments			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	Open Elective-II	Course Code:	MS4302

Prerequisite: Probability and statistics

Course Objectives:

The objective of this course is to

1. Impart students a holistic view of the fundamentals of experimental designs
2. Learn analysis tools and techniques, interpretation and applications.

Course Outcomes:

At the end of the course the students would be able to

CO1: Understand the basic concepts of experimentation analysis like selection of random variables.

CO2: Construct mathematical model for random phenomena like Null Hypothesis and Alternative Hypothesis.

CO3: Obtain engineering solutions based on statistical analysis like Factorial Design and Taguchi Method.

CO4: Analyze the variance like one-way ANOVA, two ways ANOVA, numerical on ANOVA, Z-test and T test

Module-1 **(6 Hrs)**

INTRODUCTION

Brief introduction of optimization techniques, Strategy of experimentation, Basic principles of Design, Terminology used in Design of Experiment, Guidelines for designing experiments, Basic statistical concepts: Types of Data, Graphical representation of Data, Measures of Central Tendency and Dispersion, Skewness.

Module-2 **(8 Hrs)**

SIMPLE COMPARATIVE EXPERIMENTS

Sampling and sampling Distribution, Test of significance for single mean and for difference of means of two samples, Inferences about the Differences in means: randomized designs, Inferences about the Differences in means: Paired comparison Designs, Inferences about the Variances of Normal Distributions. Test of significance based on t, F and Chi square distribution.

Module-3 **(8 Hrs)**

FITTING REGRESSION MODELS

Introduction, Linear regression models, Estimate of parameters in linear regression models, The method of least square, Hypothesis testing : Null Hypothesis, Alternative Hypothesis, Prediction of new response observations, Testing for lack of fit.

Module-4 **(10 Hrs)**

FACTORIAL DESIGN

Basic definition and principles, Advantages of factorials, Types of factorial design: Full factor factorial design and fraction factorial design, Design Matrix, Development of mathematical model, Regression model diagnostics.

ANALYSIS OF VARIANCE (ANOVA)

Introduction, One way ANOVA process, Two way ANOVA process, Degrees of freedom, Case studies on Factorial design, Taguchi Method and ANOVA.

Text books

1. Design and Analysis of Experiments, Douglas C Montgomery, John Wiley
2. Statistical Design and Analysis of Experiments, John P.W.M., Macmillan,
3. Introduction to Linear Regression Analysis, Montgomery D.C., Runger G. C.

Reference Books

1. Introduction to Quality Engineering, Taguchi, G., Asian Productivity Organisation, UNIPUB, White Plains, New York.
2. Statistical Methods for Engineering and Sciences, Taneja HC, IK International Publishing house Pvt Ltd.
3. Statistical Analysis for Engineers and Scientists, J. Wesley Barnes, McGraw Hill Inc.

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	2	2	1	-	2	2	1	2	2
CO2	3	2	1	1	1	2	3	1	-	2	3	1	2	2
CO3	3	2	1	1	1	2	2	1	-	2	2	1	2	2
CO4	3	2	1	1	1	2	3	1	-	2	3	1	2	2

Introduction to Robotics			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	Professional Core	Course Code:	MS2121

Prerequisites: Basic understanding of physics, mathematics (geometry and vectors), and fundamentals of mechanics is required.

Course Objectives :

5. Introduce the fundamentals, components, classifications, and societal impacts of robotics.
6. Explain robot anatomy, configurations, degrees of freedom, and basic kinematics.
7. Describe robot drive systems, end effectors, and control methods used in robotics.
8. Illustrate various robotic applications in industries, healthcare, agriculture, and unmanned systems.

Course Outcome :

CO1: Understand the significance, social impact and future prospects of robotics and automation in various engineering applications.

CO2: Identify and describe the components and anatomy of robotic system.

CO3: Know about various path planning techniques and analyze different motions of robotics system

CO4: Use the suitable drives and end-effectors for a given robotics application

Module 1: Introduction To Robotics **(8 Hours)**

Introduction to Robotics and Automation, laws of robot, brief history of robotics, basic components of robot, robot specifications, classification of robots, human system and robotics, safety measures in robotics, social impact, Robotics market and the future prospects, advantages and disadvantages of robots.

Module 2: Robot Anatomy And Motion Analysis **(10 Hours)**

Anatomy of a Robot, Robot configurations: polar, cylindrical,Cartesian, and jointed arm configurations, Robot links and joints, Degrees of freedom: types of movements,vertical, radial and rotational traverse, roll, pitch and yaw, Wok volume/envelope, Robot kinematics: Introduction to direct and inverse kinematics, transformations and rotation matrix.

Module 3: Robot Drives And End Effectors **(8 Hours)**

Robot drive systems: Hydraulic, Pneumatic and Electric drive systems, classification of end effectors, mechanical grippers, vacuum grippers, magnetic grippers, adhesive gripper, gripper force analysis and gripper design, 1 DoF, 2 DoF, multiple degrees of freedom robot hand, tools as end effectors, Robot control types: limited sequence control, point-to-point control, playback with continuous path control, and intelligent control.

Module 4: Robotics Applications **(8 Hours)**

Material Handling: pick and place, palletizing and depalletizing, machining loading and unloading, welding & assembly, Medical, agricultural and space applications, unmanned vehicles: ground, Ariel and underwater applications, robotic for computer integrated manufacturing. Types of robots:Manipulator, Legged robot, wheeled robot, aerial robots, Industrial robots, Humanoids, Robots, Autonomous robots, and Swarm robots.

Text Books:

1. S.R. Deb, Robotics Technology and flexible automation, Tata McGraw-Hill Education, 2009.

2. Mikell P. Grooveret. al., "Industrial Robots - Technology, Programming and Applications",

McGraw Hill, Special Edition, (2012).

3. Ganesh S Hegde, "A textbook on Industrial Robotics", University science press, 3rdedition, 2017.

Reference Books:

1. Richard D Klafter, Thomas A Chmielewski, Michael Negin, "Robotics Engineering – An Integrated

Approach", Eastern Economy Edition, Prentice Hall of India Pvt. Ltd., 2006.

2. Fu K S, Gonzalez R C, Lee C.S.G, "Robotics: Control, Sensing, Vision and Intelligence",McGrawHill, 1987. https://www.robots.com/applications.

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3	3	1	1	1	-	-	-	3	3	3	3
CO2	3	2	3	2	1	-	2	-	-	-	3	3	3	1
CO3	3	3	3	2	1	-	3	-	-	-	3	3	3	2
CO4	2	2	3	2	1	-	3	-	-	-	-	3	3	3

Automobile Engineering			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	Open Elective-II	Course Code:	MS4306

Course Objectives:
1. To study basics of principles of actual automobile systems.
2. To study importance and features of different systems like axle, differential, brakes, Steering, suspension, and balancing etc
3. To study working of various Automobile Systems.
4. To know some modern trends in Automotive Vehicles.

Course Outcomes:
Course objectives are to be fulfilled. Students learn and become familiar with
1. UnderstandtheConstruction,workingandotherdetailsaboutInternalCombustionEnginesused in automobiles
2. Identify Construction, working, preventive maintenance, trouble shooting and diagnosis of various Automobile Systems.
3. Understand importance and features of different systems like axle, differential, brakes, steering,

suspension, and balancing etc.
4. Identify Modern technology and safety measures used in Automotive Vehicles
Course Content:

Module 1: 8 Hours

Classification of automobiles, chassis, body, layout types, Sub-systems of automobile Power Unit:- Functions and locations power for propulsion, Engine parts-types, construction and functions, multiple cylinder engines. General considerations of engine balance vibration, firing order road performance curves.

Module 2: 8 Hours

Fuel feed systems: - fuel feed systems for petrol engines. Fuel pumps, Basic principles of MPFI and CRDI. Multipoint Fuel Injection Systems (MPFI), Common Rail Diesel Injection Systems (CRDI), Cooling system: purpose, types of cooling system, troubles and remedies of cooling system. Lubrication: - Types of lubricants, multi viscosity oils, chassis lubrication. Engine lubrication:-types of lubricating systems, crankcase ventilation, and Engine lubrication troubles and remedies.

Module 3: 8 Hours

Transmission system: - Construction, transmission, requirements of single plate friction clutch and multiplateclutch,clutchadjustments,clutchtroublesandremedies.GearBoxes:-Slidingmesh,constant meshandsynchromeshgearbox,functionofoverdrives,troubleshootingandremedies.Propellershaft, Hotchkiss drive torque tube drive, differential, Final drives Types of rea raxles.

Module 4: 8 Hours

Brakingsystem:-Mechanical,hydraulicbrakes,powerbrakes,airbrakesandvacuumbrakesFault findingandmaintenanceofbrakes,Steeringsystem:-Function,typesoflinkages,Steeringgears, steering gear ratio. Wheel alignment, steering geometry, & their
effects, Introduction of power steering.
Suspensions: - Types of Rigid, axle and independent suspension system, shock absorbers.

CO-PO mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	3	-	-	-	-	1	-	-	2	3	2	2
CO2	2	2	3	-	-	-	1	1	1	-	2	3	2	2
CO3	2	2	3	-	-	-	1	1	1	-	2	3	2	2
CO4	2	2	3	-	-	-	-	1	-	-	2	3	2	2

Refrigeration and Air Conditioning system			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	Open Elective-III	Course Code:	MS4308

Course Objectives:

To impart knowledge on principles of operations in different Refrigeration & Air conditioning systems and components.

Course Outcomes:

CO1: Analyse different kids of refrigeration and air conditioning systems
CO2: Be familiar with the fundamentals of psychrometry and applied psychometrics
CO3: Acquire the skills required to model, analyze and design different refrigeration as well as air conditioning processes and components
CO4: Learn heat load calculations for designing air-conditioning systems for all seasons

Syllabus:

Module 1 **7 Hrs**

Introduction to Refrigeration - Unit of Refrigeration and C.O.P.– Ideal cycles- Refrigerants Desirable properties – Classification - Nomenclature – Ozone Depletion Potential and Global Warming Potential.

Module 2 **11 Hrs**

Vapor compression cycle: p-h and T-s diagrams - deviations from theoretical cycle – subcooling and super heating- effects of condenser and evaporator pressure on COP- multi pressure system –low temperature refrigeration - Cascade systems – problems. Equipments: Type of Compressors, Condensers, Expansion devices, Evaporators.

Working principles of Vapor absorption systems and adsorption cooling systems – Steam jet refrigeration- Ejector refrigeration systems- Thermoelectric refrigeration- Air refrigeration - Magnetic Vortex and Pulse tube refrigeration systems.

Module 3 **8 Hrs**

PSYCHROMETRIC PROPERTIES AND PROCESSES: Properties of moist Air-Gibbs Dalton law, Specific humidity, Dew point temperature, Degree of saturation, Relative humidity, Enthalpy, Humid specific heat, Wet bulb temperature Thermodynamic wet bulb temperature, Psychrometric chart; Psychrometric of air- conditioning processes, mixing of air streams.

Module 4 **6 Hrs**

AIR CONDITIONING SYSTEMS AND LOAD ESTIMATION: Air conditioning loads: Outside and inside design conditions; Heat transfer through structure, Solar radiation, Electrical appliances, Infiltration and ventilation, internal heat load; Apparatus selection; fresh air load, human comfort & IAQ principles, effective temperature & chart, calculation of summer & winter air conditioning load; Classifications, Layout of plants; Air distribution system.

Text Books:

1. Refrigeration and Air conditioning by C.P. Arora, Tata Mc Graw Hill.
2. Refrigeration and Air Conditioning by R.C. Arora, PHI Publication

Reference Books:

1. Refrigeration and Air conditioning by P.L. Ballaney, Khanna Publishers.
2. Refrigeration and Air conditioning by Manohar Prasad, New Age International publishers
3. Refrigeration and Air Conditioning by S.C. Arora and S. Domkundwar, Dhanpat Rai &Sons.
4. Refrigeration and Air Conditioning Data book by Manohar Prasad

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	-	-	-		-	1	-	1	3	-	2
CO2	3	2	1	-	-	-		-	1	-	1	3	-	2
CO3	2	3	2	-	1	-	2	-	2	-	1	3	1	2
CO4	3	2	1	-	-	-	1	-	1	-	1	3	-	2

Power Generation Technologies			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	Open Elective-III	Course Code:	MS4310

Course Objectives:

- Understand the global and Indian energy scenario and explain the components, layout, and classification of hydro power plants.

- Gain insights into the layout, components, and working of modern coal, oil, and gas turbine-based power plants.

- Understand the functioning, types, and safety mechanisms of nuclear power plants and explore various renewable and hybrid power plant technologies.

- Develop the ability to analyze the economics of power generation systems including tariffs, load curves, and cost estimation.

Course Outcomes:

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

CO1: Illustrate the working of a hydro-electric powerplant appropriate turbine
CO2: Analyze the operational subsystems and layouts of coal-based, oil, diesel, and gas turbine power plants with modern technologies.
CO3: Enumerate components of nuclear power plants and renewable energy systems
CO4: Apply cost analysis techniques to evaluate the economic performance of various power plants using load curves, tariff systems, and fixed/variable costs.

Module 1 **4 Hrs**

HYDRO POWER PLANTS: Energy scenario–Global and National. Hydro Power Plants-Essential elements and classification, Layout-Selection of turbines–small hydropower plants-Pumped storage plants.

Module 2 **10 Hrs**

COAL, OIL AND GAS TURBINE POWER PLANTS: Cycle analysis-Layout of modern coal-based power plant. Super Critical Boilers- FBC Boilers. Subsystems–Water and Steam, Fuel and ash handling, Air and Gas, Draught system.

Diesel and Gas Turbine Power Plants-Layout and Functioning.

Module 3 **10 Hrs**

NUCLEAR AND RENEWABLE ENERGY POWERPLANTS: Nuclear Power Plant Layout and Subsystems. Fuels and Nuclear reactions. Boiling Water Reactor, Pressurized Water Reactor, Fast Breeder Reactor, Gas Cooled and Liquid Metal Cooled Reactors – working and Comparison. Safety measures

Solar power plants – Photovoltaic and Thermal. Wind power plants – Vertical and Horizontal axis. Biomass power plants – Gasification and Combustion. Tidal, OTEC and Wave Power plants. Geothermal plants. Fuel cell–Types. Hybrid Power Plants–Wind and Solar.

Module 4 **6 Hrs**

ECONOMICS OF POWER GENERATION: Load and load duration curves. Electricity billing – Tariff structures. Wheeling and Banking. Economics of power plant–Fixed and variable costs–computation of per unit cost of electricity.

TextBooks:

1. P.K. Nag,"Power Plant Engineering", Tata McGraw-Hill, 5^{th}Edn. 2021.
2. M.M.El.Wakil,"Power PlantT echnology", Tata McGraw-Hill, 2010.

Reference Books:

1. Blackand Veatch, "Power Plant Engineering", Indian edition,CBSPublishersandDistributors,Delhi,2005.
2. K. Rajput,"Power Plant Engineering", Laxmi Publications,2016.
3. Janet Wood, "Nuclear Power", The Institution of Engineering and Technology,2007.
4. B H Khan, Non-Conventional Energy Resources,3rd Edition, McGraw-Hill,2017
5. Paul Breeze,"PowerGenerationTechnologies", Elsevier.,2019.

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	1	0	0	1	0	1	0	0	3	2	1
CO2	3	3	3	2	2	1	1	1	2	1	0	3	2	2
CO3	2	2	3	2	2	2	3	2	2	1	2	3	3	2
CO4	3	2	2	3	1	2	1	3	2	2	2	2	2	3

SOLAR TECHNOLOGY			
Hours/Week L-T-P:	3-0-0	Credits:	3
Course Type:	PC	Course Code:	MS4312

Course Objectives

1. To introduce the fundamentals of solar radiation, photovoltaic principles, and various solar cell technologies.
2. To provide knowledge on solar thermal systems including collectors, energy storage, and thermal performance analysis.
3. To familiarize students with applications of solar energy technologies in residential, agricultural, and industrial sectors.
4. To develop an understanding of the economic aspects of solar power generation and tariff systems.

Course Outcomes:

On successful completion of this course, the students should be able to:

CO1: Analyze the characteristics and performance parameters of photovoltaic systems and solar cell technologies

CO2: Evaluate the design and thermal performance of various solar thermal collectors and storage systems.

CO3: Identify and assess the suitability of solar PV and thermal systems for various real-world applications.

CO4: Perform cost and tariff analysis for solar-based power systems and assess their economic feasibility.

MODULE-1 **10 Hrs**

Solar Photovoltaic (SPV) Systems:

Source of radiation – solar constant– solar charts – Measurement of diffuse, global and direct solar radiation, Photovoltaic Effect, Multi-junction solar cell, Quantum well solar cell, thin film solar cells, Equivalent Circuit of the Solar Cell, Analysis of PV Cells: Dark and illumination characteristics, Figure of merits of solar cell, Efficiency limits, Variation of efficiency with band-gap and temperature, Efficiency measurements, Solar array, Voltage regulation, Maximum tracking**.**

MODULE-2 **10 Hrs**

Solar Thermal Systems:

Flat Plate Collectors, Energy balance principle, Overall Heat Loss Coefficient, heat transfer between Parallel surfaces , Heat capacity effect, Types of Flat Plate Collectors: Liquid Flat Plate Collectors, Air flat-plate Collectors-Thermal analysis, Evacuated tubular collectors, Solar Energy Storage, Collector tracking systems, Concentrators, Thermal Caluclations

MODULE-3 **06 Hrs**

Applications of Solar PV and Solar Thermal Systems:

Centralized and decentralized SPV systems, stand-alone, hybrid, and grid-connected SPV systems.

Solar Passive Heating and Cooling, Solar Thermal Power Plant, Solar Desalination, Solar Drying, Solar Cooking, Solar Greenhouse technology, Application of solar thermal energy in agriculture and space heating.

MODULE-4 **04 Hrs**

Economics of power generation:

Load and load duration curves. Electricity billing – Tariff structures. Wheeling and Banking.Economics of power plant–Fixed and variable costs–computation of per unit cost of electricity. Economics of Solar Thermal systems

Texts Books

1. SP Sukhatme, *Solar Energy: Principles of Thermal Collection and Storage*, Tata McGraw-Hill,1984
2. J. Twidell and T. Weir, Renewable Energy Resources, E & F N Spon Ltd, London, 1986.
3. JA Duffie and WA Beckman, *Solar Engineering of Thermal Processes,* John Wiley, 1991

Reference Books

1. AL Fahrenbruch and RH Bube, *Fundamentals of Solar Cells: PV Solar Energy Conversion*, Academic Press, New York, 1983

2. T Bhattacharya, *Terrestrial Solar Photovoltaic*, Narosa Publishers Ltd, New Delhi LD Partain (ed), *Solar Cells and their Applications*, John Wiley and Sons, Inc, New York, 1995

3. Garg HP, J Prakash, *Solar Energy: Fundamentals and Applications*, Tata McGraw Hill, New Delhi, 1997

4. DY Goswami, F Kreith and JF Kreider, *Principles of Solar Engineering*,Taylor and Francis

5. GN Tiwari, S Suneja, *Solar Thermal Engineering System*, Narosa Publishing House, New Delhi, 1997

6. Gilbert M. Masters, Renewable and Efficient Electric Power Systems, A John Wiley & Sons, Inc., Publication

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	0	00	2	0	0	0	0	0	2	3	2	0
CO2	3	3	3	2	0	2	0	0	0	0	0	3	3	0
CO3	0	0	2	0	0	3	2	2	2	0	0	2	3	2
CO4	0	0	0	0	0	2	0	0	0	3	3	1	2	3

Digital Manufacturing

Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	Open Elective-IV	Course Code:	MS4314

Course Objectives:

To study the various aspects of digital manufacturing, importance of DM in Product Life-cycle Management and Supply Chain Management in the digital work environment.

Course Outcomes:

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

CO1: Impart knowledge to use various elements in the digital manufacturing.
CO2: Differentiate the concepts involved in digital product development life cycle process and supply chain management in digital environment.
CO3: Select the proper procedure of validating practical work through digital validation in Factories.
CO4: Implementation the concepts of IoT and its role in digital manufacturing.

Module -I Introduction *8 Hours*

Need – Overview of Digital Manufacturing and the Past – Aspects of Digital Manufacturing: Product life cycle, Smart factory, and value chain management – Practical Benefits of Digital Manufacturing – The Future of Digital Manufacturing.

Module -II Digital Life Cycle & Supply Chain Management: 12 Hours

Collaborative Product Development, Mapping Requirements to specifications – Part Numbering, Engineering Vaulting, and Product reuse – Engineering Change Management, Bill of Material and Process Consistency – Digital Mock up and Prototype development – Virtual testing and collateral. Overview of Digital Supply Chain - Scope& Challenges in Digital SC - Effective Digital Transformation - Future Practices in SCM.

Smart Factory – Levels of Smart Factories – Benefits – Technologies used in Smart Factory – Smart Factory in IoT- Key Principles of a Smart Factory – Creating a Smart Factory – Smart Factories and Cybersecurity.

Module -III Industry 4.0: *8 Hours*

Introduction – Industry 4.0 –Internet of Things – Industrial Internet of Things – Framework: Connectivity devices and services – Intelligent networks of manufacturing – Cloud computing – Data analytics –Cyber physical systems –Machine-to-Machine communication – Case Studies.

Module -IV Study of Digital Twin: Basic Concepts *8 Hours*

– Features and Implementation – Digital Twin: Digital Thread and Digital Shadow- Building Blocks – Types – Characteristics of a Good Digital Twin Platform – Benefits, Impact & Challenges – Future of Digital Twins.

Text Books:

1. Zude Zhou, Shane (Shengquan) Xie and Dejun Chen, Fundamentals of Digital Manufacturing Science, Springer-Verlag London Limited, 2012.

2. Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things", A press, 2016.

Reference Books:

1. Lihui Wang and Andrew Yeh Ching Nee, Collaborative Design and Planning for Digital Manufacturing, Springer-Verlag London Limited, 2009

2. Andrew Yeh Chris Nee, Fei Tao, and Meng Zhang, "Digital Twin Driven Smart Manufacturing", Elsevier Science., United States, 2019.

3. Alp Ustundag and Emre Cevikcan, "Industry 4.0: Managing The Digital Transformation", Springer Series in Advanced Manufacturing., Switzerland, 2017

4. Ronald R. Yager and Jordan Pascual Espada, "New Advances in the Internet of Things", Springer., Switzerland, 2018.

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	1	1	3	3	-	1	2	2	2	2	2	1
CO2	3	2	3	1	3	3	2	2	2	2	2	2	2	3
CO3	3	-	3	1	3	3	2	-	3	2	2	2	2	3
CO4	3	2	2	2	3	3	2	2	2	2	2	2	2	3

Sensors and Actuators			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	Open Elective-IV	Course Code:	MS4316

Course Objective

Upon successful completion of this course, students will be able to analyze the anatomy of robotic systems, understand the principles and applications of various sensors and actuators, and select appropriate components for robotic design.

Course Outcomes

CO1: Identify and describe the fundamental components of a robotic system, including various types of joints, end effectors, and degrees of freedom.

CO2: Explain the working principles of diverse robotic sensors and apply image processing techniques for robot vision systems.

CO3: Analyze the characteristics and selection criteria for different types of electric actuators used in robotic applications.

CO4: Differentiate between hydraulic and pneumatic actuation systems and evaluate advanced actuator technologies for specific robotic tasks.

Module 1: Anatomy of Robotic System & Sensors **(9hrs)**

Links and joints in robots, types of joints, end effectors, concept of degrees of Freedom and its calculations. Pressure/contact. Resistive position. Infrared. Light. Position Sensors, optical encoders, proximity sensors, Range sensors, Ultrasonic sensors, Touch and Slip sensors. Sensors for motion and position, Force, torque and tactile sensors, Flow sensors, Temperature sensing devices.

Module 2: Vision Sensors & Advanced Sensor Technology **(9hrs)**

Vision System Devices, Image acquisition, Masking, Sampling and quantisation, Image Processing Techniques, Noise reduction methods, Edge detection, Segmentation. Smart sensors, MEMS based sensors, Innovations in sensor technology.

Module 3: Actuators & Electric Actuators **(8hrs)**

Actuators and its selection while designing a robot system. Types of transmission systems. Direct current motor, Permanent magnet stepper motor, Servo Control DC motors, Linear and latching linear actuators, Rotary actuators, Piezoelectric actuators, Actuator parameters and characteristics, Stepper motors, Specifications and characteristics of Stepper Motors Servo Motors.

Module 4: Pneumatic & Hydraulic Actuators **(9hrs)**

Hydraulic and pneumatic power actuation devices: Hydraulic Actuators, selection of linear actuating cylinders, Hydraulic Motors, Pneumatic actuators, design considerations and selection, pneumatic cylinders, pneumatic drive system, Linear & rotary actuators. Advanced actuators – Piezoelectric actuators, elastomer actuators, soft actuators, shape memory alloy based actuators, under actuated robotic hand.

Text Books:

(i) D. Patranabis, Sensors and Transducers, PHI, 2nd Edition 2013.

(ii) Jon S. Wilson, Sensor Technology Handbook, Elsevier, 2005.

Reference Books:

(i) Mc Comb, G. Robot builder's bonanza. 5th ed. New York: McGraw-Hill, 2019. ISBN 9781260135015.

(ii) Braünl, T. Embedded robotics: mobile robot design and applications with embedded systems. 3rd edition Berlin; Heidelberg: Springer, 2008. ISBN 9783540705338.

(iii) Martin, F.G. Robotic explorations: a hands-on introduction to engineering. Upper Saddle River, N.J.: Prentice-Hall, 2001. ISBN 0130895687.

(iv) Gerard C., M. Meijer, Smart Sensors System, Wiley, 2008. AICTE Model Curriculum for UG Degree Course in Robotics & Artificial Intelligence Engineering

(v) Andrzej M. Pawlak, Sensors and Actuators in mechatronics, Taylor & Francis Group, 2007.

(vi) S. R. Ruocco, Robot Sensors & Transducers, Springer, 2013.

Production and Operation Management			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	OE	Course Code:	MS4318

Course Objectives:

By the end of this course, students will:

1. Analyze how operations decisions impact organizational performance.
2. Apply quantitative models (e.g., breakeven analysis, forecasting techniques) to solve facility location, layout, and demand planning problems.
3. Design efficient production schedules using methods like Johnson's Rule and aggregate planning.
4. Construct PERT/CPM networks to manage projects, including resource allocation and crashing.

Course Outcomes (COs):

CO1: Explain the strategic role of operations management in manufacturing and service sectors, and evaluate facility location decisions using qualitative and quantitative.

CO2: Design optimal facility layouts and apply forecasting techniques to predict demand and minimize errors.

CO3: Develop aggregate production plans and scheduling strategies to enhance operational efficiency in resource-constrained environments.

CO4: Apply PERT/CPM techniques for project scheduling and crashing, and optimize inventory systems using EOQ and ABC analysis to balance cost and service levels.

Module 1 **9 Hours**

Objectives of Operations Management, Scope of Operations Management, Relationship of Operations with other Functional areas, Manufacturing Vs Service sector, Operations Decision making, Phases in Product Design and Development.

Facility location: Factor influencing plant & warehouse location, impact of location on cost & revenue. Facility location procedure & models; qualitative models, Breakeven analysis, Single facility location model, Minimax location.

Module 2 **9 Hours**

Layout Planning: Layout Types: Process Layout, Product Layout, Fixed Position Layout Planning, line balancing, computerized layout planning- overview. CRAFT, ALDEP Algorithm.
Forecasting: Principles & methods, moving average, double moving average, Regression methods, exponential smoothing, double exponential smoothing, Forecasting error analysis.

Module 3 **9 Hours**

Role of aggregate Product planning, Managerial inputs to aggregate planning, Pure and Mixed strategies. Master production scheduling, Material requirement planning.
Sequencing and Scheduling: Single Machine Sequencing: Basics and Performance Evaluation Criteria, Methods for Minimizing Mean Flow Time, Parallel Machines: Minimization of Make span, Flow shop sequencing: 2 and 3 machines cases: Johnson's Rule and Job shop Scheduling: Priority dispatching Rules.

Module 4 **9 Hours**

Project management: Project management through PERT/CPM. Network construction, CPM, Network Calculation, crashing of project network, project scheduling with limited resources, line of balance.

Inventory Management, EOQ, ELS, Discount Model, ABC Analysis

Text Books:

1. Production systems: planning analysis and control- J.L. Riggs, John Wiley.
2. Modern Production and Operations Management by Elwood S. Buffa.
3. Production and Operations Management- R. Panneerselvam, PHI.

Reference Books:

1. Production and Operation Management- E.E.Adam and R.J.Ebert, PHI
2. Production and Operations Management- S.N.Chary, Tata McGraw Hill.
3. Gaither & Frazier - Operations Management, Cengage Publication

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	1	1	3	3	-	-	-	1	2	2	2	1
CO2	3	2	3	1	3	3	2	2	2	-	2	2	2	3
CO3	3	-	3	1	3	3	2	-	3	2	2	2	2	3
CO4	3	2	2	2	3	3	2	1	-	1	2	2	2	3

Honors in Design and Dynamics

Sl. No.	Subject Type	Subject Code	Subject Name	Semester	Teaching Hours			Credit
					L	T	P	
1	Theory	MS3173	Robotic Materials	5^{th}	3	0	0	3
2	Theory	MS3174	Analysis & Synthesis of Mechanism	6^{th}	3	0	0	3
3	Theory	MS4175	Design of Robotics Components	7^{th}	3	0	0	3
4	Theory	MS4177	Mechanical Vibration	7^{th}	3	0	0	3
5	Theory	MS4174	Human Robot Interaction	8^{th}	3	0	0	3
6	Laboratory Course	MS3574	Innovation and Entrepreneurship Lab	6^{th}	0	0	3	1.5
7	Laboratory Course	MS4573	KDM and Design Lab	7^{th}	0	0	3	1.5
			Total		**15**	**0**	**6**	**18**

Robotic Materials			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	Professional Core	Course Code:	MS3173

Pre-requisites: Engineering Materials, Mechanics of Materials, Introduction to Robotics, Basics of Sensors/Actuators

Course Objectives:

1. To introduce the concept, evolution, and functional characteristics of robotic materials inspired by biological systems.
2. To explore smart materials and their integration for sensing, actuation, and computation in robotics.
3. To understand fabrication techniques and integration challenges associated with robotic materials.

4. To analyze emerging applications and trends through case studies of advanced robotic materials.

Course Outcomes:

At the end of the course, the student will be able to,

CO1: Identify and explain the properties of robotic and smart materials

CO2: Select suitable materials for robotic sensing and actuation & Integrate computation and logic into material systems

CO3: Design and propose robotic skins or soft actuation systems

CO4: Analyze fabrication techniques and future potential of robotic materials

Module 1 **8hrs**

Introduction to Robotic Materials

Definition and characteristics of robotic materials, Historical evolution: from passive to active and intelligent materials, Requirements: sensing, actuation, computation, and communication, Inspiration from nature: muscle, skin, and nervous tissue analogies, Applications in soft robotics, wearables, and intelligent environments

Smart and Multifunctional Materials

Piezoelectric materials and shape memory alloys (SMAs), Magnetostrictive and electroactive polymers, Thermo-responsive and hydrogel-based materials, Phase change materials, Material selection criteria for robotic use

Module 2 **8hrs**

Embedded Sensing and Actuation

Integration of sensors into materials: strain, temperature, proximity, pressure, Material-based actuation: ionic, pneumatic, thermal, magnetic, Design of soft actuators and distributed actuating systems, Printed/flexible electronics and electronic textiles (e-textiles), Energy harvesting materials and embedded power

Material Intelligence and Computation

Neuromorphic computing and materials-as-processors, Material-embedded logic circuits and simple decision-making, Signal processing within the material network, Distributed sensing and local actuation control, Challenges in embedding computation at material level

Module 3 **8hrs**

Fabrication and Integration Techniques

Additive manufacturing and 3D printing of robotic materials, Layer-by-layer deposition, soft lithography, microfabrication, Stretchable circuits and hybrid composites, Challenges in durability, repeatability, and maintenance, Interfacing robotic materials with traditional systems

Module 4 **8hrs**

Case Studies and Emerging Trends

Robotic skins and artificial muscles, Self-healing and self-sensing materials, Adaptive camouflage materials, Biohybrid and living robotic materials, Research challenges and future directions

Text Books:

1. Nikolaus Correll (ed.) – Robotic Materials, [open-source course material or eBooks]
2. Yoseph Bar-Cohen – Electroactive Polymer (EAP) Actuators as Artificial Muscles
3. Mel Schwartz – Smart Materials (CRC Press)

Reference Books:

1. IEEE/ASME Transactions on Mechatronics and Smart Materials
2. Research journals: *Advanced Materials*, *Nature Materials*, *Soft Robotics (SoRo)*
3. MIT/CMU/ETH Zurich HRI and robotic materials lab publications
4. Online lectures from Stanford/MIT on Robotic Materials and Soft Robotics

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	3	3	3	-	-	-	3	-	3	2	3	2
CO2	3	2	3	2	3	-	-	-	3	-	3	2	3	2
CO3	3	3	2	2	1	-	-	-	3	-	1	2	3	2
CO4	3	3	2	2	1	-	-	-	3	-	3	2	3	2

Analysis & Synthesis of Mechanism			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	Core	Course Code:	MS3174

Pre-requisites: Kinematics and Dynamics of Machines

Course Objectives:

1. To understand the fundamentals of kinematics, mechanisms, and motion synthesis principles.
2. To apply graphical and analytical methods for the design of planar and spatial mechanisms.
3. To analyze and synthesize linkages for path, motion, and function generation.
4. To perform velocity and acceleration analysis in complex mechanical systems.

Course Outcomes:

At the end of the course, the student will be able to,

CO1: Explain fundamental concepts of kinematics, types of mechanisms, kinematic chains, Chebyshev’s accuracy points, and mobility criteria

CO2: Apply graphical and analytical methods to design planar mechanisms for path generation, motion coordination, and function generation

CO3: Analyze four-bar linkages, coupler curves, and curvature principles using Robert’s Law, Euler–Savary equation, and polode curvature concepts.

CO4: Evaluate velocity and acceleration characteristics of complex mechanisms to determine performance in real-world motion scenarios.

Module 1 **8hrs**

Basic concepts of kinematics and mechanisms-type, type, kinematic pairs, chains and inversions, Number and Dimension synthesis, Movability criteria, accuracy point, Chebyshev's polynomials Chebyshev accuracy points

Module 2 **8hrs**

Planer and spatial problems, graphical and analytical methods, finite displacements, analytical design of 4-bar mechanisms for coordinated motion, Synthesis of coordinated positions, synthesis of mechanism to trace a curve or path generation, synthesis for function generation, method of approach and optimization of a solution, Error analysis

Module 3 **8hrs**

Equivalent and conjugate linkages, four bar chains, coupler curves, Robert's Law, Path curvature Euler -Savary equation, Polode curvature

Module 4 **8hrs**

Velocity and Acceleration analysis of different complex mechanism, gross motion in the 4-bar mechanisms

Text Books:

1. Ghosh & A.K. Mallik,, Theory of Mechanism And Machines, Affiliated East-West Press , Edition 2009, Reprint 2021.
2. L R Norton, Kinematic and Dynamics of Mechinery, Pearson , Edition 2017, Reprint 2020.

Reference Books:

1. Uicker, Pennock and Shigley, Theory of Machines and Mechanisms, Oxford International , Edition 2014
2. J S Rao, RV Dukkipati, Mechanism and Machine Theory, Newage publishers , Edition 2020

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	3	3	3	-	-	-	3	-	3	2	3	2
CO2	3	2	3	2	3	-	-	-	3	-	3	2	3	2
CO3	3	3	2	2	1	-	-	-	3	-	1	2	3	2
CO4	3	3	2	2	1	-	-	-	3	-	3	2	3	2

Design of Robotic Components			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	Core	Course Code:	MS4175

Pre-requisites: Basics of Mechanics, Strength of Materials, Engineering Design, Introduction to Robotics

Course Objectives:

1. To provide a comprehensive understanding of the structural and mechanical design requirements of robotic systems.
2. To develop the ability to select and design joints, actuators, and transmission elements suited for robotic applications.
3. To introduce the principles and practices involved in designing effective and safe end-effectors and grippers.
4. To equip students with CAD/CAE tools for simulating, integrating, and optimizing robotic components and subsystems**.**

Course Outcomes:

At the end of the course, the student will be able to,

CO1: Identify design requirements for various robotic components,

CO2: Design and analyze structural elements like links and joints

CO3: Select and integrate appropriate actuators, Design efficient and adaptive end-effectors

CO4: Use CAD tools for robotic component modeling and simulation

Module 1 **8hrs**

Overview of Robotic Systems and Design Requirements

Structure of robotic manipulators: links, joints, actuators, end-effectors, Degrees of Freedom (DOF), workspace, payload, precision, and repeatability, Kinematic and dynamic considerations in component design, Load paths and stress concentration zones in robotic structure, Design for manufacturability, modularity, and lightweight

Design of Links and Structural Members

Material selection (aluminum alloys, carbon fiber, high-strength plastics), Cross-sectional shape optimization, Bending and torsion in robotic arms, Buckling and vibration issues in long robotic arms, Finite Element Modeling (introductory)

Module 2 **8hrs**

Design of Joints and Motion Transmission

Revolute, prismatic, spherical, and passive joints, Bearings, shafts, couplings, and backlash minimization, Harmonic drive, planetary gear systems, cable-pulley transmission, Compliance, stiffness, and joint failure analysis, Compact joint designs and integration challenges

Actuators for Robotic Components

Actuator types: electric (DC, BLDC, servo, stepper), pneumatic, hydraulic, Sizing of actuators based on torque-speed-load curves, Torque amplification using gears and linkages, Design for energy efficiency and thermal considerations, Integration of encoders and feedback mechanisms

Module 3 **8hrs**

End-Effector and Gripper Design

Types of end effectors: mechanical, vacuum, electromagnetic, adhesive, Design for object grasping and manipulation, Force closure and form closure concepts, Adaptive and compliant gripper design, Safety considerations in end-effector design

Module 4 **8hrs**

System Integration and CAD-Based Design

Packaging and mounting of robotic components, Cable routing and joint wiring issues, Introduction to CAD/CAE tools for component design (e.g., SolidWorks, Fusion 360), Simulating motion and stress in robotic subsystems, Case studies on design failures and improvements.

Text Books:

1. John J. Craig – Introduction to Robotics: Mechanics and Control, Pearson
2. Siegwart, Nourbakhsh, Scaramuzza – Autonomous Mobile Robots, MIT Press
3. Groover, M.P. – Industrial Robotics, McGraw-Hill

Reference Books:

1. Spong, M.W. – Robot Modeling and Control
2. Mark Rosheim – Robot Builder's Bonanza
3. B. Siciliano et al. – Springer Handbook of Robotics

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	3	3	3	-	-	-	3	-	3	2	3	2
CO2	3	2	3	2	3	-	-	-	3	-	3	2	3	2

CO3	3	3	2	2	1	-	-	-	3	-	1	2	3	2
CO4	3	3	2	2	1	-	-	-	3	-	3	2	3	2

Mechanical Vibration			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	Core	Course Code:	MS 3102

Pre-requisites: Engineering Mechanics, Kinematics and Dynamics of Machine, Mechanics of Solids, Engineering Mathematics

Course objectives:

1. To enable the students to understand the theoretical principles of vibration and vibration analysis techniques for the practical solution of vibration problems.
2. To enable the students to understand the importance of vibrations in mechanical design of machine parts subject to vibrations
3. To enable the students to analyse free and forced (harmonic, periodic, non-periodic) vibration of single and multi- degree of freedom linear systems.
4. To enable the students to write the differential equation of motion for vibratory systems and their solutions for vibratory response with physical interpretations.

Course Outcomes

After studying the course, the students will be able to:

CO1: *Explain* the basic concepts of mechanical vibrations, including types of vibrations, simple harmonic motion, degrees of freedom, and damping characteristics.

CO2: *Apply* analytical methods (differential equations, energy methods, Rayleigh's method) to determine natural frequency and response of single-degree-of-freedom (SDOF) systems under free and forced vibration.

CO3: *Analyze* two-degree-of-freedom systems and evaluate their dynamic response using concepts of coupled motion, influence coefficients, and vibration absorbers.

CO4: *Evaluate* normal mode vibrations of multi-degree and continuous systems using modal analysis techniques such as matrix iteration, Holzer's and Stodola methods.

Module 1 **8hrs**

Types of Vibration, Simple Harmonic Motion (S.H.M.), Principle of superposition applied to S.H.M., Beats, Fourier Analysis, Concept of degree of freedom for different vibrating systems.

UNDAMPED FREE VIBRATION OF SINGLE DEGREE FREEDOM SYSTEMS: Modeling of Vibrating Systems, Evaluation of natural frequency – differential equation, Energy & Rayleigh's methods, Equivalent systems.

DAMPED FREE VIBRATION OF SINGLE DEGREE FREEDOM SYSTEMS: Different types of damping, Equivalent viscous damping, structural damping, Evaluation of damping using free and forced Vibration technique, Concept of critical damping and its importance, study of vibration response of viscous damped systems for cases of under damping, critical damping and over damping, Logarithmic decrement.

Module 2 **8hrs**

FORCED VIBRATION OF SINGLE DEGREE FREEDOM SYSTEMS: Steady state solution with viscous damping due to harmonic force, reciprocating and rotating unbalance mass, vibration isolation and transmissibility due to harmonic force excitation and support motion. Vibration measuring instruments – vibrometer and accelerometer. Whirling of shaft with single disc and without damping, Concept of critical speed and its effect on the rotating shaft.

Module 3 **8hrs**

UNDAMPED VIBRATION OF TWO DEGREE FREEDOM SYSTEMS: Free vibration of spring coupled and mass coupled systems, Longitudinal, Torsional and transverse vibration of two-degree freedom systems, influence coefficient technique, Un-damped vibration Absorber.

Module 4 **8hrs**

Normal mode vibration, Co-ordinate coupling-close coupled and far coupled systems, Orthogonality of mode shapes, Methods of matrix iteration, Holzer's method and Stodola method. Torsinal vibration of two, three and multi-rotor systems. Dunkerley's lower bound approximate method.

CONTINOUS SYSTEMS: Vibration of strings, longitudinal vibration of rods, torsional vibration of rods, transverse vibration of Euler-beams.

Text Books:

1. Theory of vibration with Applications: W.T. Thomson and Marie Dillon Dahleh, Pearson Education.

2. Introductory Course on theory and Practice of Mechanical Vibrations. J.S. Rao & K. Gupta, New Age International Publication, New Delhi.

Reference Books:

1. Mechanical Vibrations: S.S. Rao, Prarson Education Inc
2. Mechanical Vibrations: Theory and Applications, Tse, Morse and Hinle, CBS Publishers
3. Mechanical Vibrations: S. Graham Kelly, Schaum's outline series, Tata McGraw Hill
4. Mechanical Vibrations: V.P. Singh, Dhanpat Rai & company
5. Elements of vibration Analysis: Leonard Meirovitch, Tata McGraw Hill
6. Mechanical Vibration: Analysis, Uncertainties, and Control, Haym Benaroya, CRC Press

CO-PO mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	3	2	1	1	-	2	-	-	2	2	3	2
CO2	3	3	3	2	1	1	-	2	-	-	2	2	3	2
CO3	3	3	3	3	1	1	-	2	-	-	2	2	3	2
CO4	3	3	3	3	1	1	-	2	-	-	2	2	3	2

Human Robot Interaction			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	Professional Core	Course Code:	MS4174

Pre-requisites: Introduction to Robotics, Control Systems, Basic Programming, Sensors & Actuators

Course Objectives:

1. To introduce the fundamental concepts, classifications, and applications of Human-Robot Interaction (HRI).
2. To explore human-centered design principles and multimodal communication techniques for interactive robots.
3. To understand sensing, perception, and control strategies that enable effective and safe human-robot collaboration.
4. To evaluate HRI systems using appropriate metrics, methodologies, and to address ethical, social, and technological challenges in HRI.

Course Outcomes:

At the end of the course, the student will be able to,

CO1: Understand the fundamental principles of HRI and its applications

CO2: Analyze and design effective human-robot interfaces

CO3: Evaluate HRI systems using appropriate metrics and human factors, Apply ethical, safety, and usability considerations in HRI

CO4: Develop and test interactive robot systems for real-world scenarios

Module 1 **8hrs**

Introduction to HRI

Definitions and scope of HRI, Types of human-robot interaction: teleoperation, supervisory control, peer collaboration, Levels of autonomy and robot roles in interaction, Applications: industrial, assistive, medical, military, domestic, social robots, Overview of current HRI research and trends

Human-Centered Design of Interactive Robots

Principles of human-centered design, Anthropomorphism, embodiment, proxemics, and affordances in robot design, Cognitive models of human interaction, Multimodal interaction: voice, gesture, facial expressions, haptics, User experience (UX) design in robotics

Module 2 **8hrs**

Perception and Sensing in HRI

Human detection and tracking (vision-based, IR, depth sensors), Speech recognition and natural language processing (NLP) basics, Gesture and facial emotion recognition, Touch and force sensing in collaborative tasks, Sensor fusion for robust interaction

Interaction Control and Behavior Modeling

Shared control and intent inference, Motion planning and adaptive response during interaction, Behavioral models and social cues in robot behaviour, Human-in-the-loop control systems, Learning from demonstration (LfD) and imitation learning

Module 3 **8hrs**

Evaluation Metrics and Experimental Design

Usability, effectiveness, safety, and trust metrics, Quantitative vs qualitative evaluation methods, User studies, questionnaires (e.g., NASA-TLX, SUS), Task performance analysis, Human factors and ergonomics in HRI

Module 4 **8hrs**

Ethics, Privacy and Future Directions

Ethical considerations in HRI: transparency, consent, data privacy, Robot acceptance models (e.g., TAM, UTAUT), Bias and fairness in interactive systems, Emerging technologies: affective robotics, empathic robots, brain-robot interfaces, Future of symbiotic human-robot teams

Text Books:

1. ***Goodrich, M.A., Schultz, A.C.*** *– Human-Robot Interaction: A Survey, Foundations and Trends in HCI*
2. ***Christoph Bartneck et al.*** *– Human-Robot Interaction: An Introduction, Cambridge University Press*
3. ***Julie A. Adams*** *– Foundations of Human-Robot Interaction, MIT Press (recommended)*

Reference Books:

1. IEEE Transactions on HRI and Robotics
2. Articles from ASME and other reputed journals
3. ROS Tutorials for HRI applications

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	3	3	3	-	-	-	3	-	3	2	3	2
CO2	3	2	3	2	3	-	-	-	3	-	3	2	3	2
CO3	3	3	2	2	1	-	-	-	3	-	1	2	3	2
CO4	3	3	2	2	1	-	-	-	3	-	3	2	3	2

Innovation and Entrepreneurship Lab			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	Laboratory Course	Course Code:	MS3574

Course Objectives :

1. To foster innovation skills by engaging students in hands-on, real-world problem-solving using robotics and to encourage entrepreneurship by developing business models around robotic solutions.
2. To cultivate interdisciplinary collaboration and startup-oriented thinking.
3. To impart foundational knowledge on intellectual property rights, funding, and product-market fit.

Course Outcomes (COs):

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

CO1 Identify real-world problems and propose innovative robotic solutions

CO2 Design and prototype functional robotic systems using low-cost or rapid tools

CO4 Demonstrate teamwork, leadership, and project management skills

CO5 Apply concepts of IP, funding strategies, and commercialization in robotics

Development of Mini Projects

1. Idea Generation & Problem Identification Workshops. Conduct sessions to identify real-world problems in agriculture, healthcare, logistics, etc.
2. Rapid Prototyping with Low-Cost Robotics Kits. Use Arduino/Raspberry Pi with 3D-printed parts to quickly prototype robotic arms, mobile bots, or grippers.
3. Business Model Canvas for Robotics Startups, Develop business plans using tools like Lean Canvas, Focus on market need, unique value proposition, customer segment, and revenue model.
4. Robotics Product Pitching & Demo Day, Host a "Shark Tank"-style event where students pitch their robot-based startup idea. Include working prototypes or MVPs (Minimum Viable Products).
5. Hands-on IoT + Robotics Projects, Smart robotic systems for homes, industries, or agriculture. Example: IoT-enabled irrigation robot, security drone, or warehouse inventory bot.
6. Innovation Challenge: Frugal Engineering, Build a robot with limited budget (e.g., ₹1000-₹2000).
Objective: solve a problem using recycled/e-waste materials.
7. Entrepreneurial Robotics Case Study Analysis Analyze Indian/Global robotics startups like Grey Orange, Asimov Robotics, or Boston Dynamics. Extract lessons on innovation, funding, and market fit.
8. Intellectual Property (IP) Awareness Sessions, Basics of patents, design rights, copyrights for robotics innovation. Guide students on filing provisional patents for their ideas.
9. Customer Validation and Field Testing, Take prototypes into real environments (labs, farms, hospitals) for feedback. Develop user-centric design habits and improve product-market fit.
10. Interdisciplinary Team Collaboration Projects. Form student teams from different branches (Mech, ECE, CSE) to build robotic systems. Focus on collaborative problem-solving and soft skills development.

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO 1	PSO 2	PSO 3
CO1	2	2	2	2	2	2	3	2	–	–	2	3	2	2
CO2	2	2	3	2	2	2	3	3	2	2	3	3	2	2
CO3	3	2	3	2	3	–	–	–	2	–	2	3	3	3
CO4	2	1	2	–	2	2	2	2	3	3	3	2	3	2

KDM and Design Lab			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	Laboratory Course	Course Code:	MS4573

Course Outcomes:

After successful completion, students will be able to:

CO1: Analyse velocity, acceleration, and dynamic forces in mechanisms
CO2: Conduct experiments related to vibration and balancing
CO3: Perform basic mechanical design calculations & Create CAD models and drawings of mechanical components
CO4: Use design data books and software tools for real-world applications

A. Kinematics and Dynamics (KDM) Experiments

1. Study of Mechanisms: Slider-crank, Four-bar, Quick return, Geneva mechanism
2. Velocity and Acceleration Analysis using graphical or simulation methods
3. Gyroscope Apparatus – verification of gyroscopic couple and effect
4. Motorized Governor Apparatus – Characteristics of Porter, Proell, or Watt governor

5. Vibration Analysis – Natural frequency of spring-mass system (undamped/damped)

B. Design Experiments (Computer-Aided + Manual)

1. Design of Riveted and Welded Joints using design data book
2. Design of Shaft, Keys, and Couplings – Analytical and CAD-based
3. Design of Spur Gears – Strength and wear criteria
4. CAD Modeling of Machine Elements: Gear, cam, crank, or bracket
5. Introduction to Finite Element Analysis (FEA) using ANSYS/SolidWorks Simulation

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO 1	PSO 2	PSO 3
CO1	3	3	2	2	2	–	–	–	–	–	2	3	2	2
CO2	3	3	2	2	2	–	–	–	2	–	2	3	2	2
CO3	2	2	3	2	3	–	–	–	2	–	2	3	3	3
CO4	2	2	3	2	3	–	–	–	–	–	2	3	3	3

Minor in Robotics

Sl. No.	Subject Type	Subject Code	Subject Name	Semester	Teaching Hours			Credit
					L	T	P	
1	Theory	MS3263	Introduction to Robotics and AI	5th	3	0	0	3
2	Theory	MS3264	Intelligent Manufacturing	6th	3	0	0	3
3	Theory	MS4265	Robot Dynamics and Control	7th	3	0	0	3
4	Theory	MS4264	Robot Navigation and Path Planning	8th	3	0	0	3
5	Theory	MS4267	Automation Engineering	7th	3	0	0	3
6	Laboratory Course	MS3564	Artificial Intelligence Lab	6th	0	0	3	1.5
7	Laboratory Course	MS4563	Robotics Programming Lab	7th	0	0	3	1.5
Total					**15**	**0**	**6**	**18**

Introduction to Robotics and AI			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :		Course Code:	MS3263

Prerequisite :

Basic knowledge of engineering mechanics, matrix algebra, and programming fundamentals is required. Familiarity with control systems and introductory concepts of sensors and actuators will be beneficial.

Course Objectives:

1. To provide a foundational understanding of industrial robots, their classifications, components, and application-based selection.
2. To explain the working principles, selection criteria, and integration of sensors, drives, controllers, and grippers in robotic systems.

3. To introduce robotic kinematics and transformations essential for manipulator motion analysis and control.
4. To explore the fundamentals of Artificial Intelligence and its applications in robotics through various problem-solving and reasoning techniques**.**

Course outcome:

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

CO1: Getting acquainted with different types of robots and robot grippers.

CO2: Apply basic principles of AI in solutions that require problem solving, inference, perception, knowledge representation and learning.

CO3: Understand AI, its current scope and limitations, and societal implications.

CO4: Analyze forces in links and joints of a robot.

Module 1: Introduction: 6 Hours

Introduction to Robotics-classification with respect to geometrical configuration (Anatomy), Industrial robots' specifications. Selection based on the Application. Controlled system & chain type: Serial manipulator & Parallel Manipulator. Components and characteristics of Industrial robots.

Module 2: Sensors, Drives and Grippers 6 Hours

Sensors: Characteristics of sensing devices, Criterion for selections of sensors, Classification, & applications of sensors. Internal sensors: Position sensors, & Velocity sensors, External sensors: Proximity sensors, Tactile Sensors, & Force or Torque sensors. **Drives**: Basic types of drives. Advantages and Disadvantages of each type. Selection / suitability of drives for Robotic application. Controllers, Types of Controller and introduction to close loop controller Grippers, Mechanical Gripper-Grasping force, mechanisms for actuation, Magnetic gripper vacuum cup gripper considerations in gripper selection & design.

Module 3: Transformation and Kinematics of Manipulators: 8 Hours

Kinematics-Manipulators Kinematics, Rotation Matrix, Homogeneous Transformation Matrix, D-H transformation matrix, D-H method of assignment of frames. Direct and Inverse Kinematics for industrial robots. Differential Kinematics for planar serial robots

Module 4: Introduction to Artificial Intelligence: 14 Hours

Overview: Approaches of AI. Intelligent agents, Artificial Intelligence programming techniques.

Knowledge Representation and Reasoning: Ontology, predicate logic, situation calculus, description logics, reasoning with defaults, reasoning about knowledge, sample applications.

Problem-solving through Search: forward and backward, state-space, blind, heuristic, problem reduction, alpha-beta pruning, mini max, constraint propagation, neural, stochastic, and evolutionary search algorithms, sample applications.

Applications of AI (vision/robotics etc.)

Text Books:

1. John J. Craig, Introduction to Robotics, Pearson Education Inc., Asia, 3rd Edition, 2005.
2. S. K. Saha, Introduction to Robotics, TATA McGraw Hills Education, 2014.
3. Russell, Stuart and Norvig, Peter, Artificial Intelligence: A Modern Approach" Prentice Hall, 2003.

Reference Books:

1. Mittal, R. K., & Nagrath, I. J. (2003). *Robotics and control*. Tata McGraw-Hill.
2. S. B. Nikku, Introduction to Robotics – Analysis, Control, Applications, 3rd edition, John Wiley & Sons Ltd., 2020.
3. Mikell Groover, Mitchell Weiss, Roger N. Nagel, Nicholas Odrey, Ashish Dutta, Industrial Robotics 2nd edition, SIE, McGraw Hill Education (India) Pvt. Ltd., 2012.
4. R. D. Klafter, Thomas A. Chmielewski and Michael Negin, Robotic Engineering – An Integrated Approach, EEE, Prentice Hall India, Pearson Education Inc., 2009.
5. Aleksander, Igor and Burnett, Piers, Thinking Machines Oxford, 1987.
6. Bench-Capon, T. J. M., Knowledge Representation: An approach to artificial intelligence Academic Press, 1990.
7. Genesereth, Michael R. and Nilsson, Nils J, Logical Foundations of Artificial Intelligence Morgan Kaufmann, 1987.
8. Michael Negnevitsky, Artificial Intelligence: A Guide to Intelligent Systems (3rd Edition), 2011.

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	3	2	1	–	2	–	–	–	3	3	3	2
CO2	3	3	3	3	2	–	2	1	–	–	3	3	3	3
CO3	2	1	2	1	–	2	3	3	–	–	2	2	2	2
CO4	3	3	3	2	1	–	1	–	–	–	3	3	2	2

INTELLIGENT MANUFACTURING			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	ACC	Course Code:	MS2130

Prerequisite: Basic knowledge of Manufacturing Processes, CAD/CAM, and Industrial Automation.

Course Objectives:

5. To provide knowledge about CIM system structure and its components such as CAD, CAM, CAPP, and CAQC.
6. To understand the principles and techniques of automated process planning and expert systems.
7. To apply group technology methods and algorithms to manufacturing systems.
8. To explore knowledge-based and AI-based approaches for industrial decision-making and planning.

Course Outcomes (COs):

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

CO1: Explain the structure and components of a CIM system and their roles in integrated manufacturing.
CO2: Apply automated and knowledge-based process planning methods to real-world manufacturing problems.
CO3: Utilize group technology algorithms for efficient part classification and layout planning.
CO4: Analyze and implement AI-based strategies in manufacturing decision-making and planning tasks.

Module-1 **(8 Hours)**

Computer Integrated Manufacturing Systems Structure and functional areas of CIM system,- CAD, CAPP, CAM, CAQC, ASRS. Advantages of CIM. Manufacturing Communication Systems - MAP/TOP, OSI Model, Data Redundancy, Top- down and Bottom-up Approach, Volume of Information. Intelligent Manufacturing System Components, System Architecture and Data Flow, System Operation.

Module-2 **(8 Hours)**

Automated Process Planning - Variant Approach, Generative Approach, Expert Systems for Process Planning, Feature Recognition, Phases of Process planning. Knowledge Based System for Equipment Selection (KBSES) - Manufacturing system design. Equipment Selection Problem, Modeling the Manufacturing Equipment Selection Problem, Problem Solving approach in KBSES, Structure of the KRSES.

Module-3 **(8 Hours)**

Group Technology: Models and Algorithms Visual Method, Coding Method, Cluster Analysis Method, Matrix Formation-Similarity Co efficient Method, Sorting-based Algorithms, Bond Energy Algorithm, Cost Based method, Cluster Identification Method, Extended CI Method.

Knowledge Based Group Technology - Group Technology in Automated Manufacturing System. Structure of Knowledge based system for group technology (KBSC IT) — Data Base, Knowledge Base, Clustering Algorithm.

Module-4 **(8 Hours)**

Application of AI to Industrial Planning and Decision Making, Speicial Purpose Resource, Design in Planning to Make More Efficient Plans.

Text Books:

3. Andrew Kusiak, "Intelligent Manufacturing Systems",PrenticeHall, 1990.
4. Mikell P. Groover, "Automation, Production Systems and Computer integrated Manufacturing", 8th edition, PHI,2008

Reference Books:

3. Mohammad Jamshidi,"Design and Implementation of Intelligent Manufacturing Systems: From Expert Systems, Neural Networks to Fuzzy Logic", 1st Edition, 1995.
4. Lucia Knapčíková, Michal Balog," Industry 4.0:Trends in Management of Intelligent ManufacturingSystems",Springer,2019835441

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	1	2	1	0	0	1	2	1	3	2	1
CO2	3	3	3	2	3	1	0	0	1	2	2	3	3	2
CO3	3	2	3	2	3	1	0	0	2	2	2	3	3	2
CO4	3	3	3	3	3	1	0	0	2	2	2	3	3	2

ROBOT DYNAMICS AND CONTROL			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	PC	Course Code:	MS2122

Prerequisites: Basic knowledge of engineering mechanics, linear algebra, differential equations, control systems, and introductory robotics.

Course Objectives :

5. To understand the kinematic structure and velocity relationships of robotic manipulators using Jacobians.
6. To analyze the dynamic behavior of robotic systems using Lagrangian and Newton-Euler formulations.
7. To study force control strategies applicable to constrained tasks and industrial applications.
8. To design and evaluate control techniques for precise and compliant motion of robotic joints.

Course Outcomes (COs):

CO1: Apply forward and inverse kinematics, velocity propagation, and Jacobian matrices to analyze robot motion.

CO2: Formulate dynamic models of manipulators using Lagrange and Newton-Euler methods and analyze static forces.

CO3: Implement hybrid position/force control strategies for manipulators in partially constrained environments.

CO4: Design and tune control laws such as PD, PID, and impedance control for joint motion and force compliance.

Module-1 Jacobians: Velocities Analysis **(10 Hours)**

Forward Kinematics. (DH parameter) Inverse Kinematics Workspace, Differential kinematics , notation for time-varying position and orientation, linear and rotational velocity of rigid bodies, more on angular velocity, motion of the links of a robot, velocity "propagation" from link to link, jacobians, singularities.

Module-2 Dynamics analysis and static forces **(10 Hours)**

Jacobian derivation Manipulability , Lagrange equation of motion Kinetic and Potential energyInertia tensor Reflected/ effective moment of inertia, Manipulator Equation Examples and properties Forward and inverse dynamics, Newton-Euler algorithm. Static Force analysis of robot, Transformations of forces and moments between co-ordinate frames.

Module-3 Force control of manipulators **(10 Hours)**

Application of industrial robots to assembly tasks, a framework for control in partially constrained tasks, the hybrid position/force control problem, force control of a mass—spring system, the hybrid position/force control scheme. Feedback control of single link manipulator.

Module-4 Robot Control **(10 Hours)**

Joint PD control Selecting gains Practical considerations, Joint PID control Feedforward control PD control feedforward, Stiffness and compliance Impedance control

TEXT BOOKS:

3. John J. Craig, "Introduction to Robotics – Mechanics and control", 3rd edition, Prentice hall, 2022.
4. Groover. M.P., Weis. M., Nagel. R.N. and Odrey.N.G. "Industrial Robotics Technology, Programming and Applications", Mc Graw-Hill, Int., 2012.

REFERENCES:

4. K.S.Fu, Gonzalez, R.C. and Lee, C.S.G. "Robotics Control, Sensing, Vision and Intelligence", McGraw Hill, 1987.
5. Saeed B. Niku, "Introduction to Robotics: Analysis, Control, Applications", 2nd edition, John Wiley & sons, Inc., 2020
6. Klafter. R.D., Chmielewski, T.A. and Negin. M. "Robotics Engineering – An Integrated Approach", Prentice-Hall of India Pvt. Ltd., 2006.

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	3	2	1	1	1	1	1	1	3	2	2
CO2	3	3	3	3	2	1	1	1	1	1	1	3	3	2
CO3	3	2	2	3	3	1	1	1	1	1	1	2	3	2
CO4	3	3	3	3	3	1	1	1	1	1	1	3	3	3

Robot Navigation and Path Planning			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :	Professional Core	Course Code:	MS3121

Prerequisites
Engineering Mathematics, Engineering Mechanics, Solid Mechanics, Kinematics and Dynamics of Machines.

Course Objective:

1) Designing and implement trajectory plans for robotic manipulators
2) Programming for path plans for mobile robots
3) Carrying out the program robotic systems using the Robot Operating System (ROS) for various automation tasks.
4) Comparing different motion planning strategies for both manipulators and mobile robots.

Course Outcome:

Upon successful completion of this course, students will be able to
CO1: Analyze and apply various trajectory-planning techniques for robotic manipulators.
CO2: Design and implement path planning algorithms for mobile robots in cluttered environments.
CO3: Develop and execute robotic programs using Robot Operating System for various operational tasks.
CO4: Evaluate and compare different motion planning strategies for both manipulators and mobile robots based on specific application requirements.

Module 1: TRAJECTORY PLANNING APPROACHES **(8 Hrs)**

Definitions – Task planning and Trajectory planning – Representation of end-effector: Cartesian and joint space schemes. Workspace Analysis: work envelope of a multi DOF manipulator. Applications: Point to point motion and continuous path motion.

Module 2: TRAJECTORY PLANNING OF MANIPULATOR **(8 Hhrs)**

Joint space techniques – Motion profiles – Cubic polynomial, Linear Segmented Parabolic Blends and cycloidal motion - Cartesian space technique – Straight line and circular trajectories.

Module 3: PATH PLANNING OF MOBILE ROBOT **(15 Hrs)**

Global path planning, local path planning, Path planning algorithm - classical algorithms (artificial potential field, graph search algorithm, and dynamic window approach), bionic algorithms genetic algorithm, ant colony optimization algorithm, particle swarm algorithm, firefly algorithm, and artificial intelligence algorithms fuzzy control algorithms and neural network algorithms. Sensors and actuators required for path planning.

Module 4: ROS PROGRAMMING **(5 Hrs)**

Robot language classification - Introduction to Robot Operating System (ROS) - ROS examples - Introduction to programming using ROS - Industrial ROS - ROS examples - Programming for point to point /continuous – operations - Case Study

Text Books:

1. Niku S B, "Introduction to Robotics, Analysis, Control, Applications", John-Wiley & Sons Inc, 2011.
2. Howie Choset, Kevin Lynch Seth Hutchinson, George Kantor, Wolfram Burgard, 3. Lydia Kavraki, Sebastian Thrun , "Principles of Robot Motion-Theory, Algorithms, and Implementation", MIT Press, Cambridge, 2005

Reference Books:

1. Planning Algorithms by Steve LaValle (Cambridge Univ. Press, New York, 2006).
2. Principles of Robot Motion: Theory, Algorithms, and Implementations (by Howie Choset, Kevin Lynch, Seth Hutchinson, George Kantor, Wolfram Burgard, Lydia Kavraki, and Sebastian Thrun.
3. Robot Motion Planning by J.C. Latombe.
4. Reza N Jazar , "Theory of Applied Robotics", Springer, 2010.
5. Morgan Quigley, Brian Gerkey, William D. Smart, Programming Robots with Ros: A Practical Introduction to the Robot Operating System, First Edition, 2016
6. Articles from the Journals with key words Robot Navigation and Path Planning.

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO 1	PSO 2	PSO 3
CO1	3	3	1	2	-	1	-	-	1	-	1	3	2	1
CO2	3	2	2	2	-	1	1	1	1	1	1	3	2	1
CO3	3	1	2	2	-	1	1	1	1	1	1	3	2	1
CO4	2	2	1	2	-	1	-	-	1	-	1	2	1	1

Automation Engineering			
Hours/Week L-T-P :	3-0-0	Credits:	3
Course Type :		Course Code:	MS4267

Pre-requisite:
Basic understanding of manufacturing processes, industrial automation, and control systems.

Course Objective :

To introduce the fundamentals, strategies, and hierarchical levels of automation in manufacturing systems. To develop analytical and design skills for implementing automated production, material handling, and inspection systems.

Course Outcomes:

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

CO1: Explain the structure and levels of automation in modern production systems and identify the components of an automated system.

CO2: Analyze and evaluate Detroit-type automation systems including automated flow lines and work-part transfer methods.

CO3: Design and analyze material handling systems such as conveyor systems, AGVs, and automated storage systems.

CO4: Apply principles of automated inspection and testing using contact, optical, and machine vision techniques; understand their integration using control instructions.

Module-1: Introduction **(8 hours)**

Automation in Production System, Principles and Strategies of Automation, Basic Elements of an Automated System, Advanced Automation Functions, Levels of Automations.

Module-2: Detroit-Type Automation **(8 hours)**

Automated Flow lines, Methods of Work-part Transport, Transfer Mechanism, Buffer Storage, Control Functions, and Automation for Machining Operations, Design and Fabrication Considerations.
Analysis of Automated Flow Lines: General Terminology and Analysis, Analysis of Transfer Lines Without Storage, Partial Automation, Automated Flow Lines with Storage Buffers, Computer Simulation of Automated Flow Lines.

Module-3: Material handling and Identification Technologies **(8 hours)**

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, Interfacing Handling and Storage with

Manufacturing. Product identification system: Barcode, RFID etc. Automated Assembly Systems: Design for Automated Assembly, Types of Automated, Assembly Systems, Part Feeding Devices, Analysis of Multi station Assembly Machines, Analysis of a Single Station Assembly Machine.

Module-4: Automated Inspection and Testing **(8 hours)**

Inspection and testing, Statistical Quality Control, Automated Inspection Principles and Methods, Sensor Technologies for Automated Inspection, Coordinate Measuring Machines, Other Contact Inspection Methods, Machine Vision, Other optical Inspection Methods. Instructions, Comparison & Data Handling Instructions, Sequencing Instructions, Mask Data Representation.

Text Books:

1. "Automation, Production Systems and Computer Integrated Manufacturing"- M.P.

Grover, Pearson Education.

Reference Books:

1. "Computer Based Industrial Control" – Krishna Kant, EEE-PHI

2. Principles and Applications of PLC – Webb John, Mcmillan 1992

3. "An Introduction to Automated Process Planning Systems" – Tiess Chiu Chang & Richard A. Wysk

4. "Anatomy of Automation" – Amber G.H & P.S. Amber, PrenticeHall.

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	2	2	–	–	–	–	–	2	3	2	1
CO2	3	3	3	3	2	–	–	–	–	–	2	3	3	2
CO3	3	3	3	3	3	–	–	–	–	–	2	3	3	3
CO4	3	3	2	2	3	–	–	–	–	–	2	3	3	3

Artificial intelligence laboratory			
Hours/Week L-T-P :	0-0-3	Credits:	1.5
Course Type :	Laboratory Course	Course Code:	MS2523

Course Objectives (COs):

4. To develop logical thinking and coding skills using Python for solving basic computational problems.
5. To implement classical AI and search algorithms for solving problem-based tasks.
6. To build simple applications and games to understand real-time interaction, data

Course Outcomes (COs):

CO1: Apply fundamental programming constructs like loops, conditionals, and functions to solve basic computational problems.

CO2: Implement search and AI algorithms such as BFS, DFS, A*, and hill climbing in Python.

CO3: Develop small-scale applications such as calculators, chatbots, and games using logical programming techniques.

CO4: Design and analyze algorithmic solutions for classical problems like Towers of Hanoi and the Water Jug Problem. processing, and decision-making.

List of Experiments

1. To write a program to print the multiplication table for the given number.
2. To write a program to find the factorial of a number.
3. To write a program to check whether the given number is prime or not.
4. To write a program to implement a simple calculator program.
5. To write a program to generate a calendar for the given month and year.
6. To write a program to illustrate different set operations?
7. To write a program to implement simple chat bot.
8. To write a program to remove punctuations from the given string
9. To write a program to sort the sentence in alphabetical order.

10. To write a program to implement of towers of hanoi problem.
11. To write a program to implement breadth first search.
12. To write a program to implement depth first search.
13. To write a program to implement hill climbing algorithm.
14. To write a program to implement a* algorithm.
15. To write a program to implement tic-tac-toe game.
16. To write a program to implement water jug problem.

Course Outcome (CO)	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
CO1:	3	2	2	1	2	-	-	-	-	1	-	-	3	2
CO2:	3	3	3	2	2	-	-	-	-	1	-	-	3	2
CO3:	2	2	3	2	3	-	-	-	1	2	-	-	3	3
CO4:	3	3	3	3	2	-	-	-	-	2	-	-	3	2

Robot programming laboratory			
Hours/Week L-T-P :	0-0-3	Credits:	1.5
Course Type :	Laboratory Course	Course Code:	MS2525

course Objectives:

1. Understand the operation and safety protocols of industrial robotic systems and their controllers.
2. Develop and debug robot programs using teach pendants and advanced logic structures.
3. Configure and manage robotic system inputs, outputs, coordinate systems, and recovery processes.

Course Outcomes (CO):

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

CO1: Safely operate and initialize industrial robots using controller interfaces and teach pendants.

CO2: Write and troubleshoot basic to advanced robot programs involving logic commands and signal assignments.

CO3: Configure robotic coordinate systems, home positions, and user-defined functions for task automation.

CO4: Perform system recovery, backup, and maintenance operations including mastering and program conversion.

List of experiments:

Any 10 experiments from the following

1. Safely power up the robot and controller from a fully shutdown position.
2. Understand general robotic safety within working envelopes.
3. Know the purpose and operation of the teach pendant.
4. Basic programming overview, refresher.
5. Definition and theory of harmonious programming.
6. Input and Output signal assignment.
7. System Mastering (robot and external axis.)
8. Advanced logic commands and program structure.
9. Total system recovery/tool shift for program correction.
10. Advanced Input/Output programming for system allocation.
11. Teach pendant layout and customization.

12. System back-up and program data.
13. How to set-up and use user coordinate systems.
14. How to set-up and use home position fields.
15. How to create and use function grouping.
16. Use and manipulate program conversion functions.

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	2	3	1	1	2	1	1	1	3	2	2
CO2	3	2	1	2	3	1	1	2	3	2	1	2	2	2
CO3	3	2	2	2	3	2	1	2	2	1	1	2	2	1
CO4	3	2	1	2	3	2	1	1	2	2	1	2	2	1