Savitribai Phule Pune University

Faculty of Science & Technology

Curriculum for

Third Year
Robotics & Automation

(2019 Course)

Savitribai Phule Pune University, Pune

Syllabus for

Third Year Robotic & Automation (2019 Course)

Course	Teaching Scheme (Hrs/week)			Examination Scheme						Credit	
	Theory	Practical	Seminar /Internship	Paper		TW	OR	PR	Total	TH/TW /TUT	PR/ OR
				Insem	Endsem						
SEM-I											
Statistics and Numerical Methods	3			30	70				100	3	
Hydraulics and Pneumatics	3			30	70				100	3	
Robot Kinematics and Dynamics	3			30	70				100	3	
Sensors Technology	3			30	70				100	3	
Robot Drive Systems	3			30	70				100	3	
Statistics and Numerical Methods Lab		2						50	50		1
Hydraulics and Pneumatics Lab		2				25			25		1
Robot Kinematics and Dynamics Lab		2				25			25		1
Sensors Technology LAB		2					25		25		1
Robot Drive Systems Lab		2					25		25		1
Seminar			1			50			50		1
Total	15	10	1	150	350	100	50	50	700	15	6
									Total credits =	**21**	

Abbreviations:

TW: Term Work
TH: Theory
OR: Oral
TUT: Tutorial
PR: Practical

Course	Teaching Scheme (Hrs/week)			Examination Scheme						Credit	
	Theory	Practical	Seminar / Internship	Paper		TW	OR	PR	Total	TH/TW /TUT	PR/ OR
				Insem	Endsem						
SEM-II											
Robot Programming	3			30	70				100	3	
Artificial Intelligence for Robotics	3			30	70				100	3	
Flexible Manufacturing Systems	3			30	70				100	3	
Computer Integrated Manufacturing System	3			30	70				100	3	
Robot Programming Lab		2						50	50		1
Artificial Intelligence for Robotics LAB		2					50		50		1
Computer Integrated Manufacturing System Lab		2					25		25		1
Flexible Manufacturing Systems Lab		2					25		25		1
Internship			4			50			50		2
Seminar / Communication Skills			1			50			50		1
Fabrication Lab		2				25			25		1
Software Lab		2				25			25		1
Total	12	12	5	120	280	150	100	50	700	12	9
									Total credits	**21**	

Abbreviations:

TW: Term Work
TH: Theory
OR: Oral
TUT: Tutorial
PR: Practical

Statistics and Numerical Methods

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures: 03 hours / week	Theory: 03	In-Sem: 30 Marks End-Sem: 70 Marks

Prerequisites: Engineering Mathematics III

Course Outcomes:

Students will be able to

1. Understand the sampling and concept of hypothesis
2. Design the experiments based on the processes parameters.
3. Make use of numerical method to solve the simultaneous equations.
4. Able to establish the co-relation between input factors and performance measure using regression analysis and interpolation methods
5. Make use of numerical & iterative methods for solving complex algebraic & transcendental equation, simultaneous equations, curve fitting, interpolation , optimization , integration & differentiation

Unit I: Testing of Hypothesis

Sampling distributions - Estimation of parameters - Statistical hypothesis - Large sample tests based on Normal distribution for single mean and difference of means -Tests based on t, Chi-square and F distributions for mean, variance and proportion - Contingency table (test for independent) - Goodness of fit.

Unit II: Design of Experiments

One way and two way classifications - Completely randomized design – Randomized block design – Latin square design - 22 factorial design.

Unit III: Solution of Equations and Eigenvalue Problems

Solution of algebraic and transcendental equations - Fixed point iteration method – Newton Raphson method - Solution of linear system of equations - Gauss elimination method – Pivoting - Gauss Jordan method – Iterative methods of Gauss Jacobi and Gauss Seidel - Eigenvalues of a matrix by Power method and Jacobi's method for symmetric matrices.

Unit IV: Interpolation, Numerical Differentiation and Numerical Integration

Lagrange's and Newton's divided difference interpolations – Newton's forward and backward difference interpolation – Approximation of derivates using interpolation polynomials – Numerical single and double integrations using Trapezoidal and Simpson's 1/3 rules.

Unit V: Numerical Solution of Ordinary Differential Equations

Single step methods : Taylor's series method - Euler's method - Modified Euler's method - Fourth order Runge-Kutta method for solving first order equations - Multi step methods : Milne's and Adams - Bash forth predictor corrector methods for solving first order equations.

Unit VI: Curve Fitting

Mathematical background, Least squares linear and polynomial regression, Lagrange interpolating Polynomials. Splineinterpolation, Case studies.

Reference:

Text Books:

1. Silberschatz, Korth H F, Sudarshan, —Database System Concepts, McGraw Hill Intl., 4th Edition, 2002, ISBN 0071005293.
2. A.M. Muzumdar and P. Bhattacharya, —Database management System, Tata McGraw Hill Publication, New Delhi, ISBN 0074622390.
3. Turban, Rainer & Potter-John, —Introduction to Information Technology, Wiley & Sons, 2000, ISBN 8126509686.
4. Ivan Bayross, —SQL. PL/SQL – The programming language of oracle BPB publication, New Delhi, ISBN 81-7656-964-X. .

Reference Books:

1. Rajashekhar Sundarraman, —Oracle91 Programming: Primer, A Pearson Education, 2004, ISBN 8129703629.
2. Dr. Sadhu Singh, —Computer aided Design and Manufacturingll, Khanna Publication, New Delhi.
3. Y. Kanetkar, —Let Us Cll, BPB Publications, 4th revised edition 2002, ISBN 8176566217.
4. B.S. Gottfried, —Programming with Cll, McGraw Hill Intl., Schaum's Outline Series, ISBN 00071006214.
5. S.C. Chapra, R.P. Canale, —Numerical Methods for engineers with programming and software applicationsll, Tata McGraw Hill Co. Ltd, New Delhi, ISBN 0071158952.

Hydraulics and Pneumatics

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures: 03 hours / week	Theory: 03	In-Sem: 30 Marks End-Sem: 70 Marks

Pre-requisites: Systems in Mechanical Engineering

Course outcomes:

Student will be able to:
1. Exemplify the basic principles of Industrial fluid power.
2. Select and specify various components for hydraulic and pneumatic systems.
3. Execute PLC program for electro-hydraulic circuit applications
4. Organize hydraulic and pneumatic circuits for given application
5. Evaluate the hydraulic and pneumatic systems based on various evaluation criteria

Unit I: Introduction to fluid power and automation

Introduction to oil hydraulics and pneumatics, their structure, advantages and limitations. Properties of fluids, Fluids for hydraulic systems, governing laws.

Unit II: Hydraulic pumps and actuators

Pumps Classification of pumps, Pumping theory of positive displacement pumps, construction and working of Gear pumps, Vane pumps, Piston pumps, fixed and variable displacement pumps, Pump performance characteristics, pump Selection factors, problems on pumps. Design of reservoir capacity.
Classification cylinder and hydraulic motors, Linear Hydraulic Actuators [cylinders], single and double acting cylinder, Mechanics of Hydraulic Cylinder Loading, mounting arrangements, cushioning, special types of cylinders, problems on cylinders, construction and working of rotary actuators such as gear, vane, piston motors, Hydraulic Motor Theoretical Torque, Power and Flow Rate, Hydraulic Motor Performance, problems, symbolic representation of hydraulic actuators (cylinders and motors).

Unit III: Control Components in hydraulic system

Classification of control valves, Directional Control Valves- Symbolic representation, constructional features of poppet, sliding spool, rotary type valves solenoid and pilot operated DCV, shuttle valve, check valves, Pressure control valves - types, direct operated types and pilot operated types. Flow Control Valves -compensated and non-compensated FCV, needle valve, temperature compensated, pressure compensated, pressure and temperature compensated FCV, symbolic representation.

Unit IV: Hydraulic Circuit Design and Analysis

Control of Single and Double -Acting Hydraulic Cylinder, Regenerative circuit, Pump Unloading Circuit, Counter balance Valve Application, Hydraulic Cylinder Sequencing Circuits, Automatic cylinder reciprocating system, Speed Control of Hydraulic Cylinder and motors, Safety circuit, Accumulators, types, construction and applications with circuits, Intensifier circuits and their applications, Proportional control valves and servo valves..

Unit V: Introduction to Pneumatic system

Introduction to Pneumatic Control: Definition of pneumatic system, advantages, limitations, applications, Choice of working medium. Characteristic of compressed air. Structure of Pneumatic control System, fluid conditioners and FRL unit. Pneumatic Actuators: Linear cylinder - Types, Cascade design of Pneumatic circuit, Use of Logic gates - OR and AND gates in pneumatic applications.

Unit VI: Electro-hydraulics and electro-pneumatic systems

PLC based electro-hydraulic systems, PLC programming using ladder logic for automation and robotics applications, Electro- Pneumatic Control: Principles - signal input and out put, pilot assisted solenoid control of directional control valves, Use of relay and contactors. Control circuitry for simple applications.

References:

1) Mujumdar S.R., Pneumatic Systems, Tata McGraw Hill, 2002 Edition. ISBN: 9780074602317
2) Bolton W., Mechatronics Electronic Control Systems in Mechanical and Electrical Engineering, Pearson, Education (Singapore) Pvt Ltd., ISBN 81-7808-339-6.
3) Industrial hydraulics manual by Vickers, Inc.
4) Fluid Power: Generation, Transmission and Control, Wiley, 2018, ISBN: 9788126539543
5) Peter Rohner, Industrial hydraulic control, Hydrauluc Supermarket, 2005, ISBN 978-0958149310

Robot Kinematics and Dynamics

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures: 03 hours / week	Theory: 03	In-Sem: 30 Marks End-Sem: 70 Marks

Pre-requisites: Engineering Mechanics, Strength of Materials, Design of Machine Elements

Course outcomes:

Student will be able to:
1. Select the type of mechanism for the robotic applications
2. Perform kinematic analysis, synthesis of mechanisms.
3. Perform forward and inverse kinematics of robots
4. Apply design procedure for mechanical grippers depending upon their types and mechanism
5. Design of robot manipulators based on dynamic analysis

Unit I: Robot Mechanisms

kinematic Link ,Types of links, Kinematics pair, Types of constrained motion, Classification of Kinematics pairs, Kinematics chain, Degrees of freedom of mechanisms, Inversion of mechanism, Analysis of mechanisms such as Gear trains, cams and followers, belt drives, four bar mechanism, slider crank mechanism etc. Computer aided analysis and synthesis of coupler curves for four bar/five bar mechanism and slider crank mechanisms,

Unit II: Forward Kinematics

Robot kinematics-Types- 2D, 3D Transformation, D-H Representation, Displacement Matrices for Standard Configurations, Forward kinematics of manipulators up to 6 degrees of freedom

Unit III: Inverse kinematics

Inverse kinematics analysis of robot with standard configurations, methods for solution of non-linear simultaneous equations, use of meta-heuristics for inverse kinematic solutions

Unit IV: Robot end effectors:

Types of end effectors, mechanical grippers, vacuum grippers, magnetic grippers, adhesive grippers, tools. force analysis, the robot end effectors interface, considerations in gripper selection and design.

Unit V: Robot Arm Dynamics

Robot dynamics – Rigid body dynamics, Newton-Euler formation, Lagrange-Euler, formation, generalized D'Alembert equations of motion.

Unit VI: Balancing and Vibrations

Static and Dynamic balancing, Balancing of revolving and reciprocating masses, Balancing machines, free vibrations, Equations of motion, natural Frequency, Damped Vibration, bending critical speed of simple shaft.

References:

1. Hartenberg and Denavit, "Kinematics and Synthesis of Linkages", McGraw Hill Book Co.
2. J. E. Shigley and J.J.Uicker Jr., Theory of Machines and Mechanism, McGraw Hill [ISBN019515598X]
3. G K Grover', "Mechanical Vibration", Nemchand and brothers. [ISBN8185240752]
4. S.S.Ratan , Theory of Machines, Tata McGraw Hill [ISBN0070591202]
5. Deb S.R., ―Robotics‖, Tata McGraw Hill Publications, New Delhi.
6. YoramKoren, "Robotics for Engineers", McGraw Hill Book Co.
7. Groover M.P., Weiss M., Nagel R.N., Odrey N.G., "Industrial Robotics Technology-Programming and Applications", McGraw Hill Book Co.

Sensor Technology

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures: 3 hours / week	Theory: 03	In-Sem: 30 Marks End-Sem: 70 Marks

Pre-requisites: Applied Electronics Engineering, control system Engineering

Course Outcomes:

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

1. Choose sensor for a particular application
2. Check the performance of the sensor under test.
3. Design signal conditioning circuitry for a sensor
4. Analyze the specifications of various types of sensors
5. Understand the principals of advance sensors

Unit I: Sensor Fundamentals

Sensor Performance Characteristics, Types of Sensors Sensor Signal Conditioning, Conditioning Bridge Circuits, Amplifying and Linearizing Bridge Outputs, Amplifiers for Signal Conditioning, Precision Op Amp Characteristics, Instrumentation Amplifiers. Data-Acquisition Systems: Hardware and Software of Data Aquisition System (DAS)

Unit II: Mechanical Transducers

Transduction methods, accelerometers, gyroscopes, pressure sensors, MEMS microphones, mechanical structures, actuators. Chemical and Biological Transducers: basic concepts of cellular biology, chemical sensors, molecule-based biosensors, cell-based biosensors, chemical actuators, biological transducers.

Unit III: Thermal Sensors

Definition of Temperature: Thermal Energy, absolute and relative Temperature, Metal resistance versus temperature devices: Resistance versus Temperature Approximations, Resistance-Temperature Detectors (RTD), Thermistors, Semiconductor Resistance versus Temperature, Thermistor Characteristics, thermocouples, Thermoelectric Effects, Thermocouple, Characteristics, Thermocouple Sensors, Other thermal sensor: Bimetal Strips, Gas Thermometers.– Touch sensors-Tactile sensor – Proximity and range sensors Robotic vision sensor

Unit IV: Displacement, Location, or Position Sensors

Resistive, Capacitive, and Inductive Sensors, Variable-Reluctance Sensors, LVDT, Level Sensors, Acceleration, Shock and Vibration Sensors: Piezoelectric Accelerometer, Piezo resistive Accelerometers, Applicable Standards, Interfacing and Designs, Latest Developments

Unit V: Force, Load and Weight Sensors

Quartz Sensors, sensor types, Applicable Standards Strain Gage Sensors, types, Applicable Standards, Metal Strain Gauges and Semiconductor Strain Gauges (SGs), Load CellsPressure sensors

Unit VI: Optical and Radiation Sensors

Photo sensors, Thermal Detectors, Phototransistor, Position and Motion Sensors. Introduction to Nanotechnology-Enabled Sensors, Bio Sensors

Text Books:

1. John Wilson: Sensor Technology Handbook.
2. “Process Control Instrumentation Technology, 6th Edition”, Author: Curtis D. Johnson, Publisher: Prentice Hall International Edition, ISBN: 0-13-978-200-3

Reference Books:

1. Springer Handbook of Nanotechnology ISBN: 978-3-540-35172-6
2. J. Norberto Pires, Altino Loureiro and Gunnar Bölmsjo, _Welding Robots -Technology,System Issues and Applications_, Springer-Verlag 2006, ISBN-10:1852339535
3. Ben-Zion Sandler, _Robotics: Designing the Mechanisms for Automated Machinery_, 2nded. 1999 by Academic Press, ISBN 0-12-618520-4

Robot Drive Systems

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures: 3 hours / week	Theory: 03	In-Sem: 30 Marks End-Sem: 70 Marks

Pre-requisites: Control system Engineering

Course Outcomes:

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

1. Understand the different drive system
2. Understand the hydraulic and pneumatic drive system
3. Design the hydraulic drive system
4. Design the Pneumatic drive system
5. Understand electrical drive system for robot application
6. Understand the troubleshooting of the robot drive system

Unit I: Introduction to drive system

Introduction of drive system, structure of drive system, Necessity of drive system, different types of drive system, Robot Actuators: types of actuators, Actuators Quality, Characteristics of Actuating Systems, design consideration of drive system, Advantages and limitations of drive system.

Unit II: Introduction to Hydraulic and Pneumatic Systems

Power Sources, Accumulators and Intensifiers, Directional Control valves, Flow control valves, , Air control valves

Unit III: Hydraulic Drives

Linear hydraulic actuators, Types of hydraulic cylinders, Single acting, Double acting special cylinders like tandem, Rod less, Telescopic, Cushioning mechanism, Construction of double acting cylinder, Rotary actuators – Fluid motors, Gear, Vane and Piston motors, Motor performance, Filtration systems and maintenance of system.

Unit IV: Pneumatic Drive system

Pneumatic Components: Properties of air, Compressor, Filter, Regulator, and Lubricator Unit, Compressed Air distribution system, Pneumatic actuators- Linear and Rotary, Tie rod cylinders, Rodless actuators with magnetic linkage or rotary cylinders, Rodless actuators with mechanical linkage, Pneumatic artificial muscles, Vane Motors, Speciality actuators that combine rotary and linear motion—frequently used for clamping operations, Vacuum generators

Unit V: Electrical Actuation System

Solid State Switches, Solenoids, D.C. motors, A.C. motors, Stepper motors, Servomotorsstepper motors; ac servomotors, dc servomotors,

Unit No VI: Troubleshooting of the drive system

Troubleshooting of drive systems Identifying root cause, suggest remedies, steps to be followed in troubleshooting.

Reference Books:

1. Anthony Esposito, “Fluid Power with Applications”, Pearson Education, 7th Edition,2014.
2. Johnson, James L., Introduction To Fluid Power, Delmar Publishers, 2003
3. Harry L. Stewart D.B, “Practical guide to fluid power”, Taraoeala Sons and Port Ltd.
4. Michael J, Prinches and Ashby J. G, “Power Hydraulics”, Prentice Hall.
5. Dudelyt, A. Pease and John T. Pippenger, “Basic Fluid Power”, Prentice Hall.
6. Hasebrink J.P., and Kobler R., “Fundamentals of Pneumatics/electropneumatics”, FESTO Didactic Publication No. 7301, Esslingen Germany.
7. Majumdar S.R., “Pneumatic systems – Principles and Maintenance”, Tata McGraw-Hill.
8. Joji P., “Pneumatic Controls”, John Wiley & Sons, 2008.

Statistical and Numerical Method Lab

Teaching Scheme	Credit Scheme	Examination Scheme
Practical: 02hours / week	Practical: 01	PR:50 Marks

List of Practical

1. Design of Experiments using software package.
2. C / Matlab program for Solution of linear system of equations
3. C / Matlab program for interpolations
4. C / Matlab program Numerical Integration
5. C / Matlab program for Ordinary Differential Equations.
6. C / Matlab program for Curve fitting

Hydraulics and Pneumatics Lab

Teaching Scheme	Credit Scheme	Examination Scheme
Practical: 02 hours / week	Practical: 02	Practical: 50 Marks

The term work shall consist of assignments based on the following topics. Evaluation of practical will be based on practical examination.

Practical Work:

1. Experiment on measurement of hydraulic pump efficiency.
2. Experiment on design of speed control hydraulic circuits.
3. Experiment on design of regenerative circuits
4. Experiment on design of electro-hydraulic sequencing circuits
5. Experiment on pneumatic circuits by demonstrating logic gates.
6. Experiment on electro-pneumatic circuits
7. Experiment on programmable logic controllers: Ladder logic programming
8. Microprocessor programming for basic operations.
9. Industrial visit report on automation in any Industry.

Robot Kinematics and Dynamics Lab

Teaching Scheme	Credit Scheme	Examination Scheme
Practical: 02 hours / week	Practical: 01	Term Work: 50 Marks

Term Work

Term work will be based on following practical/design assignments

1. Computer program for analysis and synthesis of any mechanism and test it.
2. Determination of holding torque in epicyclic gear train.
3. Design of cams and followers
4. Experiment on Robot forward kinematic analysis
5. Experiment on Robot inverse kinematic analysis
6. Determination of mass moment of inertia and radius of gyration of robotic links.
7. Experiment on balancing of mass.

Sensor Technology Lab

Teaching Scheme	Credit Scheme	Examination Scheme
Practical: 02 hours / week	Practical: 01	OR: 25 Marks

List of Experiments:

1. Design of instrumentation amplifier
2. Measurement of temperature using thermistor (whetstone Bridge)
3. Measurement and Analysis of temperature using various sensors.
4. Measurement of Displacement using LVDT.
5. Measurement and Analysis of Displacement using various sensors.
6. Measurement of load using strain gauge.
7. Measurement and Analysis of load using various sensors.
8. Study of photo sensors.

.

Robot Drive System Lab

Teaching Scheme	Credit Scheme	Examination Scheme
Practical: 02 hours / week	Practical: 01	OR: 25 Marks

The term work shall consist of the following Experiments:

1. Study of different drive system used in robot
2. Demonstration of hydraulic actuators, accumulators and intensifiers.
3. Demonstration of Pneumatic Actuators
4. Design report of a hydraulic or pneumatic drive system using manufacturer's catalogue.
5. Study and demonstration of different types of electrical actuation system
6. Application of simple electrical drive systems
7. Industrial visit to study robot drive system by means of hydraulic/ pneumatics/ electrical for industrial robots.

Seminar and Technical Communication

Teaching Scheme	Credit Scheme	Examination Scheme
Seminar:1 hours / week	Pr/Or: 01	Term work: 50 Marks

1. The objective of Seminar is to test the student on his/her ability for self-study and his/her ability to communicate - Written and oral.

2. Seminar will be in the form of a report submitted by the student:

a) On topic of his/her choice based on literature survey/ a case study wherever applicable/possible, and approved by the staff- in- charge.

b) A report with 20-25 pages of A-4 size paper, 1.5 spaced typed material, and appropriately bound.

c) Title font/figures/graphs shall be black and white.

Robot Programming

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures: 03 hours / week	Theory: 03	In-Sem: 30 Marks End-Sem: 70 Marks

Pre-requisites: Sensors Technology, Robot Drive Systems.

Course outcomes:

Student will be able to:
1. Explain robot programming methods
2. Understand the components of robot programming
3. Develop simple programmes to simulate robot movements
4. Develop robot programmes for specific application
5. Describe the safety rules in robot handling

UNIT I: Introduction to Robot Programming
Robot programming-Introduction-Types- Flex Pendant- Lead through programming, Coordinate systems of Robot, Robot controller- major components, functions-Wrist Mechanism-Interpolation-Interlock commands- Operating mode of robot, Jogging-Types, Robot specifications- Motion commands, end effectors and sensors commands.

UNIT II: VAL Language
Robot Languages-Classifications, Structures- VAL language commands motion control, hand control, program control, pick and place applications, palletizing applications using VAL, Robot welding application using VAL program-WAIT, SIGNAL and DELAY command for communications using simple applications.

UNIT III: VAL-II
VAL-II programming-basic commands, applications- Simple problem using conditional statements-Simple pick and place applications-Production rate calculations using robot.

UNIT IV: RAPID Language
RAPID language basic commands- Motion Instructions-Pick and place operation using Industrial robot-manual mode, automatic mode, subroutine command based programming. Move master command language-Introduction, syntax, simple problems.

UNIT V: AML Language
AML Language - General description, elements and functions, Statements, constants and variables-Program control statements-Operating systems, Motion, Sensor commands-Data processing.

UNIT VI: Practical Study of Virtual Robot
Robot cycle time analysis-Multiple robot and machine Interference-Process chart-Simple problems-Virtual robotics, Robot studio online software- Introduction, Jogging, components, work planning, program modules, input and output signals-Singularities-Collision detection-Repeatability measurement of robot-Robot economics. AML Language-General description, elements and functions, Statements, constants and variables-Program control statements-Operating systems, Motion, Sensor commands-Data processing.

Reference Books:

1) Cameron Hughes Tracey Hughes, Robot Programming: A Guide to Controlling Autonomous Robots, 1/e First Edition, 2016, ISBN: 9789332577442
2) S. R. Deb, Robotics Technology and Flexible Automation, 2010. McGraw Hill ISBN: 9780070077911
3) Mikell. P. Groover, Industrial Robotics: Technology, Programming, and Applications 2nd Edition, McGraw Higher Ed. 2012, ISBN: 9781259006210,
4) Industrial Robotics Technology, Programming and Applications, McGraw Hill Co, 1995.
5) Robotics Lab manual, 2007.

Artificial Intelligence for Robotics

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures: 03 hours / week	Theory: 03	In-Sem: 30 Marks End-Sem: 70 Marks

Pre-requisites: Engineering mathematics-III, statistics and Numerical Methods, Sensors Technology

Course outcomes:

Student will be able to:

1. Select appropriate artificial intelligence method/algorithm to handle various issues in robotics
2. Demonstrate various algorithms used in artificial intelligence
3. Apply artificial intelligence algorithms to robotics problems
4. Compare the performance of AI algorithms
5. Build solution methodology to solve complex problems in flexible automation

Unit I: Introduction to artificial intelligent techniques

Goals of AI in manufacturing, tools for AI such as Search algorithm, Mathematical optimization, Evolutionary computation, fuzzy logic, Probabilistic methods for uncertain reasoning such as Bayesian network, Hidden Markov model, Kalman filter, Decision theory and Utility theory, statistical learning methods, support vector machines, neural networks, expert systems

Unit II: Handling uncertainty and learning:

Non-monotonic reasoning, probabilistic reasoning, use of certainty factors, fuzzy logic, Concept of learning, learning automation, genetic algorithm, learning by inductions, neural network, Unsupervised learning- K-Means clustering, Boltzmann machine, Supervised learning-classification algorithms, support vector machine.

UNIT III: Search algorithms in AI:

Algorithms for uninformed and informed search, Heuristics search: hill climbing, branch and bound, best first search, Metaheuristics: Simulated annealing, Tabu search, ant colony optimization, real coded genetic algorithm.

Unit IV: Machine vision in robotics:

Machine vision algorithms, Imaging based automatic sorting and inspection, image processing, imaging based robot guidance,

Unit V: Intelligent robotic systems

Applications of intelligent systems for mobile Robot Motion Planning, Path Planning Robot Control in DynamicEnvironments, Task Based Hybrid Closure Grasping Optimization for Autonomous Robot Hand. Accurate Motion

Control of Fast Mobile Robots, obstacle avoidance.

Unit VI: Artificial intelligence in flexible automation

Applications of various intelligent systems for FMS functional segmentation schemes including control, real time scheduling, tool management, process planning, route optimization for AS/RS systems.

References:

1) Steger, Carsten, Markus Ulrich, Christian Wiedemann. Machine Vision Algorithms and Applications (2nd ed.). Wiley, 2018. ISBN 978-3-527-41365-2.
2) Mikell P Groover, Automation, Production System and Computer Integrated Manufacturing, Prentice Hall, Publications, 2016. ISBN 9789332549814
3) Bhattacharya S., Artificial Intelligence, Laxmi Publications, Ltd., 2008, ISBN9788131804896
4) Chopra Rajiv, Artificial Intelligence, S. Chand Publishing, 2012, ISBN9788121939485
5) Pawar P. J., Evolutionary Computations for Manufacturing, Studium Press, 2019, ISBN: 978-93-85046-52-0
6) Jain N, Artificial Intelligence: making a system intelligent, 2018, ISBN: 9788126579945

Flexible Manufacturing Systems

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures: 03 hours / week	Theory: 03	In-Sem: 30 Marks End-Sem: 70 Marks

Pre-requisites: Industrial Engineering and Management, Manufacturing Technology

Course outcomes:
Students should be able to:

1. Understand FMS and its applications.
2. Apply cell formation techniques.
3. Differentiate Turning & Machining Centres.
4. Measure dimensional accuracy using CMM.
5. Understand various types of AGVS
6. Understand basics of Tool Management System.

Unit I: FMS Introduction and Description

limitations with conventional manufacturing, Need for FMS Introduction, Definition, Basic Component of FMS, Significance of FMS, General layout and configuration of FMS, Principle Objectives of FMS, Benefits and limitations of FMS, Area of Application of a FMS in Industry, Various Hardware and Software required for an FMS, CIM Technology, Hierarchy of CIM, FMS Justification

Unit II : Manufacturing Cell

Introduction, Description and Classifications of Cell, Unattended Machining, Cellular versus Flexible Manufacturing.

Group Technology

Introduction, Definition, Reasons for Adopting Group Technology, Benefits of Group Technology Affecting Many Areas of a Company, Obstacles to Application of GT 5

Unit III: Turning and Machining Centres

Introduction, Types ,Construction and Operation Performed on Turning enter, Automated Features and Capabilities of Turning Centres, General Advantages and Disadvantages of Vertical and Horizontal Machining Centres, Pallet and Part Loading and Programming Options in Machining Centres, Automated features and capabilities of a Machining Centres 6

Unit IV: Cleaning and Deburring Equipment

Introduction, Wash Station and Operation Description, Deburring Station and Operation Description, Importance of Cleaning and Deburring in Automated Manufacturing 4

Coordinate Measuring Machines

Introduction, Types, Construction and General Functions of CMM, Operational Cycle Description, CMM Applications, Importance to Flexible Cells and Systems

Unit V: Automated Material Movement and Storage System

Introduction, Types of AGV and Their principle of working, Advantages, Limitation and General AGV Guide path, Robots, Benefits of using Industrial Robots, Basic components and benefits of Automated Storage and Retrieval Systems, Conveyors and Pallet Flotation System, Queuing Carrousels and Automatic Work Changers, Coolant and Chip Disposal and Recovery system. 6

Unit VI: Automated Systems

Automated Assembly Systems: System Configurations, Parts Delivery at Workstations, Applications, Quantitative Analysis of Assembly Systems- Parts Delivery System at Workstations, Multi-station Assembly machines, Single Station Assembly Machines, Partial Automation

Automatic Material Handling and Storage systems: Design Considerations in Material Handling, Material Transport Equipment-Industrial Trucks, Automated Guided Vehicles, Monorails and Other Rail-Guided Vehicles, Conveyors, Cranes and Hoists, Analysis of Vehicle Based Systems, Conveyor Analysis. Automated Storage/Retrieval Systems, Carousel Storage Systems, Engineering Analysis of AS/RS and Carousel Systems

References:

1. H. K. Shivanand, M. M. Benal, Flexible Manufacturing System, V. Koti, New Age Pub. ISBN:9386070227
2. Automation, Production Systems and Computer Integrated Manufacturing, Groover M.P, Prentice Hall of India, ISBN: 9789332572492
3. CAD/CAM, Groover M.P, Zimmers E.W, Prentice Hall of India, ISBN: 9780132440813
4. Approach to Computer Integrated Design and Manufacturing, Nanua Singh, John Wiley and Sons, ISBN:9780471585176
5. Principles of CIM, Vajpayee, PHI, ISBN: 9788120314764
6. Flexible Manufacturing Cells and Systems, Luggen, PHI, ISBN: 9780133217384

Computer Integrated Manufacturing System

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures: 03 hours / week	Theory: 03	In-Sem: 30 Marks End-Sem: 70 Marks

Pre-requisites: Engineering Mathematics-III, Manufacturing Technology

Course Outcomes:

Student will be able to:

1. Apply geometric modeling principles to design a component
2. Use different transformation methods to solve problems in CAD
3. Appreciate the role of computers in manufacturing process and apply it in operation.
4. Combine different concepts to describe computer integrated manufacturing
5. Group similar parts and design FMS process

Unit I: Computer Graphics

CAD cycle for product design, CAD workstations - data communications - input/output devices, display technology, CAD software. Transformation- Introduction, Formulation, Translation, Rotation, Scaling, Reflection, Homogenous Representation, Concatenated Transformation, Mapping of Geometric Models, Inverse Transformations.

Unit II: Geometric Modelling

Requirements of geometric modeling, geometric models, Wireframe modeling, Surface modeling, geometric construction methods, constraint based modeling, Representation of curves and surfaces. Analytic curves- Lines, circles, circular arcs, ellipse, parabola, hyperbola etc. Synthetic curves - cubic splines, bezier curves, B-spline curve etc., Surface modeling –Representation of surfaces, analytical and synthetic surfaces. Solid modeling – Solid entities, methods of solid modeling

Unit III: Computer Aided Manufacturing (CAM)

Concepts and features of NC, CNC & DNC - feed back devices ,Interpolators., Point-to-point and contouring systems –Interchangeable tooling system – preset& qualified tools – ISO specification – Machining center – Turning center,

CNC Programming:- Machine Tool Co-ordinate System, Machine zero, Job zero, Cutter Programming, Tool Offsets, Manual part programming – steps involved – G-codes and M-codes, sample program in lathe & milling. CAM package – canned cycles - Programming.

Unit IV: Computer Integrated Manufacturing (CIM) and Rapid Prototyping

Computer application in manufacturing automation, Computer aided inspection and quality control. Computer integrated production management system, inventory, material requirement planning, manufacturing resource planning, enterprise resource planning. Rapid Product Development and Manufacture, Extended Enterprises. Methods of rapid prototyping: steriolithography, Laminated Object Manufacturing (LOM), Fused Deposition Modeling (FDM), selective laser sintering, solid ground curing, 3D Printing system, Thermo jet Process, Ballistic Particle Manufacturing. Application of rapid tooling methods to press tool manufacture

Unit V: Computer Applications in Engineering Analysis

Introduction, steps in FEA, Boundary conditions Co-ordinates and shape functions, Potential Energy Approach, Galerkin Approach, Assembly of Global Stiffness Matrix and Load Vector, Finite Element equations. Truss problems: Plane trusses, Three-dimensional trusses, Two dimensional problems: Finite element modeling, constant strain triangle, One Dimensional Problem and Two dimensional Problems and Boundary conditions.

Unit VI: Cutting Tools and Tool Management

Introduction, Control of Cutting Tools, Tool Management, Tool Strategies, Tool Preset, Identification and Data Transfer, Tool Monitoring and Fault Detection

FMS Installation and Implementation: FMS Installation, FMS implementation.

References:

1) Mikell P. Groover, “Automation, Production System and CIM & quot;, Prentice-Hall of India, 2016. ISBN: 978-93-325-7249-2.
2) 2) Mikell P. Groover, “Computer Aided Design and Manufacturing”, Prentice Hall of India, 2008. ISBN: 0-87692-402-10.
3) S. Kant Vajpayee, “Principles of Computer Integrated Manufacturing”, Prentice Hall of India, 1999.
4) Zeid Ibrahim, —CAD - CAM Theory and Practicell, Tata McGraw Hill Publishing Co. Ltd New Delhi.(2000), ISBN:0-07-463991-4.
5) Kundra T.K., Rao P.N., Tiwari N.K., —Numerical control and Computer aided manufacturingll, Tata McGraw Hill New Delhi, ISBN: 9780074517406.
6) Rao P.N.,—CAD - CAM Principles and Practicell, Tata McGraw Hill Publishing Co. Ltd New Delhi.(2000), ISBN:0-07-044530-3.
7) Radhakrishnan. P, Subramanyan S., “CAD/CAM/CIM”, New Age International publishers. ISBN: 81-224-1248-3.
8) David Bedworth, "Computer Integrated Design and Manufacturing", TMH, New Delhi, I Edition1999.
9) James A.Retrg and Henry W. Kraebher, —Computer Integrated Manufacturingll, Pearson Education, Asia, 2001
10) Viswamathan N. and NarahariY., —Performance Modelling of Automated Manufacturing Systemll, Prentice Hall of India Private Limited, ISBN:978-81-203-0870-1.
11) Chandrupatla T.R., Belegundu A.D., —Introduction to Finite Elements in Engineering, Prentice Hall of India 2003.ISBN:13:9780130615916.

Robot Programming Lab

Teaching Scheme	Credit Scheme	Examination Scheme
Lectures: 02 hours / week	Practical: 01	Practical Exam: 50 Marks

Term Work

Term work will be based on following practical/design assignments

1. Programming on VAL Language
2. Programming on VAL-II Language
3. Programming on RAPID Language
4. Programming on AML Language
5. Programming the robot for pick and place operation using any robot
6. Robot Programming for Colour identification/shape identification/path tracking
7. Industrial visit and its report on industrial applications of robots

Artificial Intelligence for Robotics Lab

Teaching Scheme	Credit Scheme	Examination Scheme
Practical: 02 hours / week	Practical: 01	OR: 50 marks

List of practical:

1. Programming in C or Matlab to implement fuzzy logic application for autonomous robot system.
2. Programming in C/Matlab to implement simulated annealing/genetic algorithm for solving inverse kinematic problems
3. Programming in C/Matlab to solve traveling salesman problem using ant colony optimization algorithm
4. Write program using Visual Prolog to create an expert system
5. Write program for obstacle avoidance in mobile robots using any one algorithm
6. Implement A* algorithm to Solve 8-puzzle problem using. Assume any initial configuration and define goal configuration clearly
7. Define the operators for controlling domestic robot; use these operators to plan an activity to be executed by the robot. For example, transferring two/three objects one over the other from one place to another. Use Means-Ends analysis with all the steps revealed.
8. Solving real time planning and scheduling problems using software like Witness/Pro-model

Computer Integrated Manufacturing System Lab

Teaching Scheme	Credit Scheme	Examination Scheme
Practical: 02 hours / week	Practical: 01	Oral - 25 Marks

Oral will be based on Assignment submitted on the topic and following practical work (Any 4)

1. Construction of parametric solid model of any machine elements using software package.
2. Programming on CNC Lathe/Milling (student must perform one job in group of 5 students)
3. Stress–strain analysis of any machine component consisting of 1-D, 2-D elements using FEA software
4. Simulation of a simple mechanical system
5. Rapid prototyping of component

Internship

Teaching Scheme	Credit Scheme	Examination Scheme
Practical: 04hours / week	Practical: 02	Oral - 50 Marks

The student will undergo internship in industry to study the practical applications and implementation of various aspects of robotics such as robot programming, design of end effectors, robot kinematics and dynamics, robot control systems and drives, AI applications in robotics etc.

Seminar / Communication Skill

Teaching Scheme	Credit Scheme	Examination Scheme
Seminar:1 hours / week	Pr/Or: 01	Term work: 50 Marks

1. The objective of Seminar is to test the student on his/her ability for self-study and his/her ability to communicate - Written and oral.

2. Seminar will be in the form of a report submitted by the student:

a) On topic of his/her choice based on literature survey/ a case study wherever applicable/possible, and approved by the staff- in- charge.

b) A report with 20-25 pages of A-4 size paper, 1.5 spaced typed material, and appropriately bound.

c) Title font/figures/graphs shall be black and white.

3. The Oral examination will be based on the report submitted and (orally) presented.

Fabrication Lab

Teaching Scheme	Credit Scheme	Examination Scheme
Practical: 02 hours / week	Practical: 01	TW - 25 Marks

The practical will be based on:

1. Manual and Robotic welding
2. CNC/VMC Processes and applications
3. Plasma arc cutting for any profile shape.
4. Laser beam cutting for any profile shape.
5. Additive manufacturing processes and applications
6. Meal Casting

Software Lab

Teaching Scheme	Credit Scheme	Examination Scheme
Practical: 02 hours / week	Practical: 02	TW: 25 Marks

List of Practical

1. Solid modeling using any CAD software
2. Tool path generation and Part programming using any CAM software
3. Stress and deflection analysis using FEA software
4. Robot Kinematics and dynamics using software such as Robo Analyser
5. Robot path planning using ROS
6. Robot route planning with obstacle avoidance
7. SCADA simulation and HMI visualization Software