Industrial Track				
Minor in Industrial Automation & Robotics				
Eligibility: All branches				

Subject Code	Subject Name	No of Hours		
		Lecture	Tutorial	Practical
ARMR1	Robotic Engineering	4	-	-
ARMR2	Mechatronics and Microcontrollers	4	-	-
ARMR3	Industrial Automation	4	-	-
ARMR4	Computer integrated Manufacturing	4	-	-
ARMR5	Fluidics and Control Systems	4	-	-
ARMR6	Mechanics of Robots	3	1	-
ARMR7	3D Printing	4	-	-

ARMR1	Robotic Engineering	L	T	P	C	Int	Ext
		4	-	-	4	30	70
	Minors: Industrial Automation & Robotics						

Course Objective:

This course aims to familiarize students with basic terminologies of the robotics sciences and essential knowledge required to get started in the field of Robotics.

Course Outcomes:

After completion of course, students would be able to:

1. Express his views as per terminologies related to Robotics technology.
2. Demonstrate logic for selection of robotic sub systems and systems.
3. Determine basics of principals of robot system integration.
4. Identify ways to update knowledge in the required area of robotic technology.

Course Contents:

UNIT 1: **[CO-1][12]**

Introduction to robotics: Brief History, Basic Concepts of Robotics such as Definition, Three laws, Elements of Robotic Systems i.e. Robot anatomy, DOF, Misunderstood devices etc., Classification of Robotic systems on the basis of various parameters such as work volume, type of drive, etc., Associated parameters i.e. resolution, accuracy, repeatability, Introduction to of Automation, Types of Automations, Need of automation, Industrial applications of robot.

UNIT 2: **[CO-2][12]**

Grippers and Actuators for Robotics: Grippers for Robotics - Types of Grippers, Guidelines for design for robotic gripper,

Actuators - Types of Actuators- Hydraulic, Pneumatic and Electric Actuators – AC Motors, DC Motors and stepper motors.

UNIT 3: **[CO-3][12]**

Sensors for Robotics: Sensors for Robots - Types of Sensors used in Robotics, Classification and applications of sensors, Characteristics of sensing devices, Selections of sensors. Need for sensors and vision system in the working and control of a robot.

UNIT 4: **[CO-4][12]**

Programming and Languages for Robotics: Robot Programming: Methods of robot programming, Languages: Generations of Robotic Languages, Introduction to various types such as VAL, RAIL, AML, Python, ROS etc.,.WAIT, SIGNAL and DELAY commands, small Programs.

Transformations of Robotics: Spatial Descriptions: positions, orientations, and frame, mappings: changing description from frame to frame, Operators: translations, rotations and transformations, transformation arithmetic, compound Transformations, inverting a transform, transform equations, Euler Angle representation, Fixed Angle representation.

Text Books/References:

1. S. K. Saha, Introduction to Robotics 2e, TATA McGraw Hills Education (2014)
2. Dilip Kumar Pratihar, Fundamentals of Robotics, Narosa Publishing House, (2019)
3. R. K. Mittal, I. J. Nagrath, Robotics and Control, TATA McGraw Hill Publishing Co Ltd, New Delhi (2003)
4. S. B. Niku, Introduction to Robotics - Analysis, Control, Applications, 3rd edition, John Wiley & Sons Ltd., (2020)
5. Mikell P Groover, Mitchell Weiss, Roger N. Nagel, Nicholas Odrey, Ashish Dutta, Industrial Robotics 2nd edition, SIE, McGraw **Hill** Education (India) Pvt Ltd (2012)
6. R. D. Klafter, Thomas A. Chmielewski, and Mechael Negin, Robotic Engineering - An Integrated Approach, EEE, Prentice Hall India, Pearson Education I nc. (2009)

Alternative SWAYAM/NPTEL Course:

NPTEL Course Name	Instructor	Host Institute
Introduction to robotics	Dr. Krishna Vasudevan, Dr. Balaraman Ravindran, Dr. T Asokan	IIT Madras
Sensors and Actuators	Prof. Hardik Jeetendra Pandya	IISc Bangalore

ARMR2	Mechatronics and Microcontrollers	L	T	P	C	Int	Ext
		4	-	-	4	30	70
	Minors: Industrial Automation & Robotics						

COURSE OBJECTIVES:

1. Able to design Mechatronics systems by applying underlying mathematical principles for model preparation and analysis.
2. Able to exposed he methods of signal processing and conversion
3. Understand the concepts of intercepts and interfacing details of 8051
4. Able to design plc based system for process control.

COURSE OUTCOMES:

At the end of the course the students should be able to:

CO1 Develop simulation model for simple physical systems and Mechatronics design process

CO2 Describe the concept of signal conditioning, know about data acquisition system and get an exposure to digital condition through the knowledge of Analog to Digital converters

C03 Review architecture and working of 8051, functions of constituting components and their applications

C04 Describe the concept of plc system and ladder programming, and significance of PLC systems in different applications

Course Content:

UNIT 1 [CO1] 12

Introduction: Integrated Design issues in Mechatronics, Mechatronics Design process, Mechatronics Key Elements, Applications in Mechatronics.

Modeling and simulation of physical systems: Electrical systems, Mechanical systems translational & rotational systems, fluid systems.

UNIT 2 [CO2] 12

Signal Conditioning and Real Time Interfacing: Signal conditioning process, Elements of a Data Acquisition, transducers and signal conditioning, Data Conversion Process: Analog to Digital Conversion and types.

UNIT 3 [CO3] 12

8051 Microcontroller: Microprocessor Vs Microcontroller, 8051 Architecture- Registers, Pin diagram, I/O ports functions, Internal Memory organization. External Memory (ROM & RAM) interfacing, Addressing modes, 8051 Instruction Set. Interfacing and Applications: Interfacing of 8051 to Keyboard and LCD.

UNIT 4 [CO4] 12

PLC: Programmable Logic Controllers, Architecture, Ladder programming, Logic functions, timer and counters, comparison and data handling, sequencing.

Learning Resources:

Text Books:

1. Bolton.W ,"Mechatronics – Electronics Control Systems in Mechanical and Electrical Engineering" Addison Wesley Longman,1999

2. The 8051 Microcontroller and Embedded Systems – using assembly and C -, Muhammad Ali Mazidi and Janice Gillespie Mazidi and Rollin D. McKinlay; PHI, 2006 / Pearson, 2006

Reference books:

1. Michael B.Histand and David G. Alciatore, "Introduction to Mechatronics and Measurement Systems",McGraw Hill International Editions,1999
2. Bradley, D.A.,. Dawspn, D, Buru, N.C. and Loader, AJ., “Mechatronics”, Chapman and Hall,1993
3. Ayala, Kenneth J, The 8051 Microcontroller: Architecture, Programming, and Application, 2008.

Alternative SWAYAM/NPTEL Course:

NPTEL Course Name	Instructor	Host Institute
Mechatronics	Prof. Pushparaj Mani Pathak	IIT Roorkee
Micropocessors and Micro Controllers	Prof. Santanu Chattopadhyay	IIT Kharagpur

ARMR3	INDUSTRIAL AUTOMATION	L	T	P	C	Int	Ext
		4	-	-	4	30	70
	Minors: Industrial Automation & Robotics						

COURSE OBJECTIVES:

1. Understanding Automation technologies and identify and solve industrial problems using automation technologies.
2. To introduce the importance of automation techniques manufacturing and process industries

COURSE OUTCOMES:

At the end of the course the students should be able to:

CO1 Identify the need of automation
CO2 Classify various types of automated transmission lines and components of Automation
C03 List various material handling systems.
C04 Design various types of automated assembly systems and automatic inspection systems

Course Content:

UNIT-1	CO1 12
Automation in .Production System, Principles and Strategies of Automation, Basic Elements of an Automated System, Advanced Automation Functions, Levels of Automations. **Production Economics:** Methods of Evaluating Investment Alternatives, Costs in Manufacturing, Break- Even Analysis, Unit cost of production, Cost of Manufacturing Lead time and Work-in process.	
UNIT-2	**CO2 12**
Detroit type Automation: Automated Flow lines, Methods of Work-part Transport, Transfer Mechanism,Buffer Storage, Control Functions, and Automation for Machining Operations, Design and Fabrication Considerations	
UNIT-3	**C03 12**
Material handling and Identification Technologies: The material handling function, Types of Material Handling Equipment, Analysis for Material Handling Systems, Design of the System, Conveyor Systems Automated Guided Vehicle Systems. Automated Storage Systems: Storage System Performance, Automated Storage/Retrieval Systems, Work-in-process Storage, Interfacing Handling and Storage with Manufacturing. Product identification system: Barcode, RFID etc.	
UNIT-4	**C04 12**
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. **Automated Inspection and Testing:** Automated Inspection Principles and Methods, Sensor Technologies for Automated Inspection, Coordinate Measuring Machines, Other Contact Inspection Methods.	

Learning resources:

Text Book:

1. Automation, Production systems and Computer Integrated Manufacturing by M.P.Groover, Pearson Education / PHI.

Reference Book:

1. " An Introduction to Automated process planning systems" – Tiess Chiu Chang & Richard A. Wysk.
2. " Computer Based Industrial Control", Krishna Kant. EEE -PHI

Alternative SWAYAM/NPTEL Course:

NPTEL Course Name	Instructor	Host Institute
Manufacturing Automation	Prof. Sounak Kumar Choudhury	IIT Kanpur

ARMR4	COMPUTER INTEGRATED MANUFACTURING	L	T	P	C	Int	Ext
		4	0	0	4	30	70
	Minors: Industrial Automation & Robotics						

COURSE OBJECTIVES:

1. Able to understand the concepts of CAD/CAM/CIM
2. Able to learn various concepts of part process planning.
3. To understanding the concepts of general manufacturing systems and more insights on cellular manufacturing systems.
4. To understand the concepts of applications of FMS

COURSE OUTCOMES:

At the end of the course the students should be able to:

1. Recognize scope of CAD/CAM/CIM
2. Apply performance analysis techniques.
3. Describe CAPP and its general architecture as well as types and related concepts
4. Demonstrate concept of Group technology and cellular manufacturing for formation of cells as well as arrangement of machines with in a cell.
5. Perform planning scheduling and control of FMS

UNIT-1	CO1, CO2	12
Introduction: Brief introduction to CAD and CAM - Manufacturing Planning, Manufacturing control- Introduction to CAD/CAM - Concurrent Engineering-CIM concepts - Computerized elements of CIM system -Types of production - Manufacturing models and Metrics - mathematical models of Production Performance - Simple problems - Manufacturing Control - Simple Problems - Basic Elements of an Automated system - Levels of Automation - Lean Production and Just-In-Time Production.		
UNIT-2	**CO3**	**12**
Computerized Process Planning: Computer Aided Process Planning (CAPP) - Logical steps in Computer Aided Process Planning - Aggregate Production Planning and the Master Production Schedule - Material Requirement planning - Capacity Planning- Control System s- Shop Floor Control- Inventory Control - Brief on Manufacturing Resource Planning-II (MRP-11) & Enterprise Resource Planning (ERP) - Simple Problems.		
UNIT-3	**C04**	**12**
Cellular Manufacturing: Group Technology(GT), Part Families - Parts Classification and coding - Simple Problems in Opitz Part Coding system - Production flow Analysis - Cellular Manufacturing - Composite part concept - Machine cell design and layout - Quantitative analysis in Cellular Manufacturing - Rank Order Clustering Method - Arranging Machines in a GT cell – Simple problems.		
UNIT-4	**C05**	**12**
Flexible Manufacturing System (FMS): Components of an FMS, types of system, where to apply FMS technology, FMS work stations. Material handling and storage system: Functions of the handling system, FMS layout configuration, analysis method for FMS, application and benefits.		

Learning resources:

Text Book:

1. Automation, Production systems and Computer Integrated Manufacturing by M.P.Groover, Pearson Education / PHI.

Reference Book:

1. " An Introduction to Automated process planning systems" – Tiess Chiu Chang & Richard A. Wysk.
2. " Computer Based Industrial Control", Krishna Kant. EEE -PHI

Alternative SWAYAM/NPTEL Course:

NPTEL Course Name	Instructor	Host Institute
Computer Integrated Manufacturing	Prof. J. Ramkumar Prof. Amandeep Singh	IIT Kanpur

ARMR5	FLUIDICS AND CONTROL SYSTEMS	L	T	P	C	Int	Ext
		3	0	2	4	30	70
	Minors: Industrial Automation & Robotics						

COURSE OBJECTIVES:

1. To identify the elements of hydraulic systems. To Explain the working of various pumps and actuators
2. To understand various control elements of hydraulic systems
3. To know the variety of industrial circuits
4. To understand the common methods of designing logic circuits

COURSE OUTCOMES:

After successful completion of the course, the students are able to

1. Recognize various elements of hydraulic systems. To have good knowledge on working principles of various pumps and actuators
2. Explain various control elements of hydraulic systems.
3. Design various logic circuits
4. Determine proper industrial circuits for given application

COURSE CONTENT:

UNIT-1	CO1	12
Hydraulic Pumps & Pressure Regulation: Pressure regulation, pump types: Gear Pump, Vane Pump, Piston Pump, and Combination Pumps. Selection and specification of pumps pump characteristics. **Hydraulic & Pneumatic Actuators:** Linear and Rotary Actuators-Selection, Specification and Characteristics, Hydraulic and pneumatic accessories		
UNIT-2	**CO2**	**12**
Control and Regulation elements: Press ure-direction and flow control valves, relief valves, non- return valves and safety valves. Actuation systems. Application circuits.		
UNIT-3	**CO3**	**12**
Hydraulic Circuits: Reciprocation, quick return, sequencing synchronizing circuits-accumulator circuits, industrial circuits-press circuits.		
UNIT-4	**CO4**	**12**
Pneumatic Systems and Circuits: Pneumatic fundamentals, Control elements, Sequential circuits, Cascade methods, Mapping Methods, Step counter method, Compound circuit design, Combination circuit design.		

LEARNING RESOURCES:

TEXT BOOK:

Andrew Parr, "Hydraulics and Pneumatics", (HB), Jaico Publishing House, 1999.

REFERENCE BOOK(s):

1. Antony Espossito, "Fluid power with Applications", Prentice Hall, 1980
2. Dudleyt A.Pease and John J.Pippenger, "Basic Fluid Power", Prentice Hall, 1987.

Alternative SWAYAM/NPTEL Course:

NPTEL Course Name	Instructor	Host Institute
Fluid Power Control	PROF. Jagadeesha T	IIT Madras

ARMR6	MECHANICS OF ROBOTS	L	T	P	C	Int	Ext
		3	1	-	4	30	70
	Minors: Industrial Automation & Robotics						

Course Objective:

This course aims to inculcate thorough understanding about basic knowledge of mathematics, kinematics and dynamics required for understanding motion programming and operational/ control functionality in robotics.

Course Outcomes:

At the end of the course the students should be able to:

1. Demonstrate and ability to solve inverse kinematics of simple robot manipulators.
2. Formulate the Jacobian matrix and use it to identify singularities.
3. Describe the concepts and formulations of Robot Dynamics
4. Explain different trajectories for motion planning.

Course Content:

UNIT I **CO1 12**

Robot Kinematics: Manipulator Kinematics, Link Description, Link to reference frame connections, Denavit-Hartenberg Approach, D-H Parameters, Position Representations, Homogeneous Transformation Matrix, Forward Kinematics. Inverse Kinematics, Geometric and analytical approach.

UNIT II **CO2 12**

Velocities & Statics: Cross Product Operator for kinematics, Jacobians - Direct Differentiation, Basic Jacobian, , Jacobian Jv / Jw, Jacobian in a Frame, Jacobian in Frame {O}, Kinematic Singularity, Kinematics redundancy, Force balance equation, Forces, Velocity /Force Duality, Virtual Work , Force ellipsoid, Jacobian, Kinematic Singularity, Kinematics red undancy , Mechanical Design of robot linkages,

UNIT III **CO3 12**

Robot Dynamics: Introduction to Dynamics, Velocity Kinematics, Acceleration of rigid body, mass distribution Newton's equation, Euler's equation, Iterative Newton - Euler's dynamic formulation, closed dynamic, Lagrangian formulation of manipulator dynamics, dynamic simulation, computational consideration.

UNIT IV **CO4 12**

Trajectory Planning: Trajectory Interpolators, Basic Structure of Trajectory, Interpolators, Cubic Joint Trajectories. General Design Consideration on Trajectories

LEARNING RESOURCES:

Text Books/References:

1. S. K. Saha, Introduction to Robotics 2e, TATA McGraw Hills Education (2014).
2. M. Spong, M. Vidyasagar, S. Hutchinson, Robot Modeling and Control, Wiley & Sons, (2005).

3. J. J. Craig, "Introduction to Robotics: Mechanics and Control", 3 rd edition , Addison-Wesley (2003).
4. S. B. Niku, Introduction to Robotics - Analysis, Control, Applications, 3rd edition, John Wiley & Sons Ltd., (2020)

Alternative SWAYAM/NPTEL Course:

NPTEL Course Name	Instructor	Host Institute
Robotics	Prof. Dilip Kumar Pratihar	IIT Kharagpur
Robotics	Prof. P. Seshu, Prof. P.S. Gandhi, Pro f. K. Kurien Issac, Prof. B. Seth, Prof. C. Amarnath	IIT Bombay

ARMR7	3D Printing	L	T	P	C	Int	Ext
		4	0	-	4	30	70
	Minors: Industrial Automation & Robotics						

Course Objectives:

The objectives of this course are to:

- Understand the fundamentals of various Additive Manufacturing Technologies for application to various industrial needs.
- Able to convert part file into STL format.
- Able to understand the method of manufacturing of liquid based, powder based and solid based techniques.
- Understand the manufacturing procedure of a prototype using FDM technique.

Course Outcomes:

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

1. Identify the fundamentals of Additive Manufacturing Technologies for engineering applications.
2. Distinguish different Liquid Based Additive Manufacturing System
3. Illustrate the Solid Based Additive Manufacturing System
4. Summarize the working principles of Powder Based Additive Manufacturing System

Course Content:

Unit-I **[CO-1] [12]**

Introduction, Prototyping fundamentals, Historical development, Advantages of AMT, Commonly used terms, process chain, 3D modelling, Data Conversion, and transmission, Checking and preparing, Building, Post processing, RP data formats, Classification of AMT process, Applications to various fields

Unit-II **[CO-2] [12]**

Liquid based systems: Stereo lithography apparatus (SLA): Models and specifications, process, working principle, photopolymers, photo polymerization, layering technology, laser and laser scanning, applications, advantages and disadvantages, case studies. Solid ground curing (SGC): Models and specifications, process, working ,principle, applications, advantages and disadvantages, case studies.

UNIT III **[CO-3] [12]**

Solid based systems: Laminated object manufacturing(LOM): Models and specifications, Process, Working principle, Applications, Advantages and disadvantages, Case studies. Fused Deposition Modeling (FDM): Models and specifications, Process, Working principle, Applications, Advantages and disadvantages, Case studies, practical demonstration

Unit-IV **[CO-4] [12]**

Powder Based Systems: Selective laser sintering (SLS): Models and specifications, process, working principle, applications, advantages and disadvantages, case studies. Three dimensional printing (3DP): Models and specification, process, working principle, applications, advantages and disadvantages, case studies.

Learning Resources:

1. Chua C.K., Leong K.F. and LIM C.S Rapid prototyping: Principles an Applications, World Scientific publications, 3rdEd., 2010
2. D.T. Pham and S.S. Dimov, “Rapid Manufacturing”, Springer, 2001
3. Terry Wohlers, “ Wholers Report 2000”, Wohlers Associates, 2000
4. Paul F. Jacobs, “ Rapid Prototyping and Manufacturing”–, ASME Press, 1996
5. Ian Gibson, Davin Rosen, Brent Stucker “Additive Manufacturing Technologies, Springer, 2nd Ed, 2014.

Alternative SWAYAM/NPTEL Course:

NPTEL Course Name	Instructor	Host Institute
Fundamentals Of Additive Manufacturing Technologies	PROF. SAJAN KAPIL	IIT Guwahati