INDUSTRIAL ROBOTICS **Course Code : 315364**

Programme Name/s : Mechatronics
Programme Code : MK
Semester : Fifth
Course Title : INDUSTRIAL ROBOTICS
Course Code : 315364

I. RATIONALE

Industrial robots are widely used in many industrial applications, to make industries more competitive and efficient. The most obvious impact of industrial robots is that they eliminate many dull, dirty, dear, difficult and dangerous tasks. The use of robot helpful in hazardous and challenging environments. The purpose of industrial robotics course is to provide skilled workforce to the industry.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

Operate industrial robot for the given industrial applications.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Select robot for given application.
- CO2 - Select end effectors, actuators and sensors for given robotic applications.
- CO3 - Apply robot vision system for given application.
- CO4 - Develop robot program for given applications.
- CO5 - Indentify future technologies to integrate with industrial applications.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
315364	INDUSTRIAL ROBOTICS	IRO	DSC	5	-	4	-	9	3	3	30	70	100	40	25	10	25#	10	-	-	150

Total IKS Hrs for Sem. : 0 Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 10 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Explain fundamental terminology in robotics. TLO 1.2 Select robot configuration for the given application. TLO 1.3 Explain basic elements of robotic system. TLO 1.4 Select robot specification for the given application. TLO 1.5 Choose robot motions for the given application. TLO 1.6 Simulate different joints used in robotic systems.	**Unit - I Components of Robotics System** 1.1 Fundamentals of robotics: Introduction, definition, need, brief history, laws of robot. 1.2 Robot configurations: Polar (Spherical), Cylindrical, Cartesian coordinate, Jointed arm (Articuted), SCARA (Selective Compliance Assembly Robot Arm). 1.3 Elements of robot system (Robot Anatomy): Base, Manipulator arm, End Effectors, Sensors and transducers, Actuators and Drives, Control systems. 1.4 Robot specification: Degree of Freedom, Work envelope, Load carrying capacity, Speed of movement, Accuracy, Repeatability, Control Resolution, Spatial resolution. 1.5 Robot motions: Vertical motions, Radial motions, Rotational motions, Pitch motions, Roll motions, Yaw motions. 1.6 Types mechanical joints used in robotics system: Linear Joint, Orthogonal joint, Rotational Joint, Twisting Joint, Revolving Joint (Symbols, Notations).	Lecture Using Chalk-Board PPT Demonstrations Video Flipped Classroom

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Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
2	TLO 2.1 Select end effector for the given application. TLO 2.2 Compare different actuators for robotic system. TLO 2.3 Select robot sensor for the given application.	**Unit - II Robot - Gripper, Actuators and Sensors** 2.1 Robots End Effectors: Types of End Effectors - Gripper and Tools, Grippers- Mechanical, Pneumatic, Magnetic, Vacuum, adhesive, Considerations in gripper selection. 2.2 Actuators and drives: Pneumatic, Hydraulic, Electric. 2.3 Robotic Sensors: Introduction to Sensors in robotics, classification of Sensors – Tactile Sensors, Touch sensors, Force sensors, Force sensing wrist, Joint sensing, Tactile array sensors, Proximity and Range Sensors, Miscellaneous Sensors and Sensor based Systems, Uses of Sensors in Robotics. 2.4 Desirable features of sensors in Robotics.	Lecture Using Chalk-Board PPT Video Case study
3	TLO 3.1 Construct flowchart of robot vision system. TLO 3.2 Describe role of image processing in robot vision system. TLO 3.3 Use of robot vision system for the given application.	**Unit - III Robot Vision System** 3.1 Robot Vision: Introduction, The Sensing and Digitizing Function - Imaging devices, Lighting techniques, Analog to Digital signal conversions (Sampling, Encoding, Image storage). 3.2 Image Processing and Analysis: Image Data reduction, Segmentation, Thresholding, Region growing, Edge detection, Feature extraction, Object Recognition. 3.3 Industrial application of vision controlled Robotic system.	Lecture Using Chalk-Board PPT Video
4	TLO 4.1 Use of different robotic commands for programming robot. TLO 4.2 Describe Robot language structure. TLO 4.3 Select robot programming method for the given application. TLO 4.4 Develop Robot programs for the given industrial application.	**Unit - IV Introduction to Robot Languages & Programming** 4.1 Introduction to Robot Languages: The Textual Robot Languages, Generations of Robot Programming Languages, Robot Language Structure, Constant, Variables and other Data Objects, Motion Commands, End Effecter and Sensor Commands, Computations and Operations, Program Control and Sub-routines, Communications and Data Processing, Monitor Mode Commands. 4.2 Introduction to Robot Programming: Methods of Programming a Robot, Lead through Programming Methods, Robot Programme as a Path in Space, Motion Interpolation, WAIT, SIGNAL and DELAY Commands, Branching, Capabilities and Limitations of Lead through Methods. 4.3 Introduction to Teach Pendant. 4.4 Simple Program for Pick and place activity. 4.5 Simple Program to Palletize the object. 4.6 Simple Program for Inspection (Bolt, PCB, Bearing etc.).	Lecture Using Chalk-Board PPT Video Demonstration

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
5	TLO 5.1 Indentify type of robot used for the given industrial applications. TLO 5.2 Identify future technology in robotics for the given industrial applications. TLO 5.3 Explain future use of robots in various application.	**Unit - V Robot Applications & Future Technology** 5.1 Robots in material handling. 5.2 Robots in processing operations - Spot welding, Continuous arc welding, Plastic spray coating, Die-casting, molding, Forging operation. 5.3 Robots in automated assemblies & inspections. 5.4 Future technology in robotics: Introduction, Robot intelligence, Advanced sensor capabilities (3D Vision), Telepresence and related technologies, Mechanical design features (Direct Drive robot, Multiple arm coordinate robot), Mobility, locomotion and navigation, Universal hand, System integration and network. 5.5 Future applications of Robots: Military operations, Fire-fighting operations, under sea operations, Space operations, Industry 4.0, AI in industrial robotics.	Lecture Using Chalk-Board PPT Video Case study Field Visit

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Identify different robotic components and its working for the given system.	1	*Robotic components and its working.	2	CO1
LLO 2.1 Simulate the robot configuration with 3 DoF for planer robot.	2	*Robot motion simulation of Cartesian Robot using software.	2	CO1
LLO 3.1 Simulate the robot configuration with 4 DoF for spatial robot.	3	Robot motion simulation of SCARA Robot using software.	2	CO1
LLO 4.1 Simulate the robot configuration with 6 DoF for spatial robot.	4	Robot motion simulation of Articulated Robot (6 DoF) using software.	2	CO1
LLO 5.1 Use end effector for the given application.	5	*End effector interfacing with robotic system.	2	CO2
LLO 6.1 Use sensors for the given robotic system.	6	Sensor interfacing with robotic system.	2	CO2
LLO 7.1 Operate robot with different motion commands for the given situation.	7	*Robot simulation by using motion commands.	2	CO4
LLO 8.1 Operate robot with different end effector commands for the given application.	8	Robot simulation by using end effector commands.	2	CO4
LLO 9.1 Develop program for path movement. LLO 9.2 Operate robot for the given path movement.	9	Program for specific path movement of robot.	2	CO4
LLO 10.1 Develop program for pick and place activity. LLO 10.2 Operate robot for pick and place activity.	10	Program for pick and place activity.	2	CO4

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 11.1 Develop program for palletizing the object. LLO 11.2 Operate robot for palletizing the object.	11	*Program for palletizing the object.	2	CO4
LLO 12.1 Calibrate the vision system with robot coordinate system.	12	Calibration of robot vision system	2	CO3
LLO 13.1 Develop program for inspection of the object. LLO 13.2 Use robot vision system for inspection.	13	*Program for inspection. (Bolt, PCB, Bearing etc.)	2	CO3 CO4
LLO 14.1 Interface PLC with robotic system for the given application.	14	*PLC interfacing with robotic system as per standard procedure.	2	CO4
LLO 15.1 Use robot vision system for sorting the given objects on shape basis.	15	Program for sorting objects as per shape (square, cicle etc).	2	CO3 CO4 CO5
LLO 16.1 Develop program for spot/ arc welding operation. LLO 16.2 Operate robot for welding application.	16	*Program for spot/ arc welding operation.	2	CO4 CO5
LLO 17.1 Develop program for spot painting operation. LLO 17.2 Operate robot for painting application.	17	Program for painting operation.	2	CO4 CO5
LLO 18.1 Develop program for tightening and loosing the fasteners with torque gun. LLO 18.2 Operate robot for assembly work with torque gun.	18	*Program for tightening and loosing the fasteners with torque gun.	2	CO4 CO5
LLO 19.1 Operate robot to write the given word.	19	*Program robot for writing name of your institute.	2	CO4 CO5
LLO 20.1 Interface conveyer with robotic system. LLO 20.2 Operate conveyer with robotic system.	20	Program for interfacing of conveyer.	2	CO4 CO5

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING) : NOT APPLICABLE

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	PLC (Min 8 input/output)	1,16

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
2	Programmable Robot Trainer Kit with standalone servo controller as well as compatible PLC interface with following features: 1) Minimum 3 linkages 2) Minimum 4 degree of freedom (4DoF) 3) Various sensors 4) Compatible Robot vision system for inspection.	1,4,5,6,7,8,9,10,11,12,13,14,16
3	End effector - Grippers – Minimum two (Mechanical, Pneumatic, Vacuum, Magnetic etc.)	1,5,8,10,11,12
4	End effector - Tools – Weld gun, spray gun, torque gun, Pen Holder etc.	1,5,8,10,11,16,17,18,14,15,19
5	Robot offline simulation software	2,3
6	Computers with internet connectivity (Minimum Core i5 Processor, 8GB RAM, 500GB HDD)	2,3,9,10,11,12,13,14

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Components of Robotics System	CO1	11	4	4	6	14
2	II	Robot - Gripper, Actuators and Sensors	CO2	12	2	6	8	16
3	III	Robot Vision System	CO3	8	2	4	6	12
4	IV	Introduction to Robot Languages & Programming	CO4	12	2	4	12	18
5	V	Robot Applications & Future Technology	CO5	7	2	4	4	10
Grand Total				**50**	**12**	**22**	**36**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- For laboratory learning Maximum 25 Marks and Minimum 10 Marks.
- Two-Class Tests of 30 marks and average of Two-Class Tests out of 30.

Summative Assessment (Assessment of Learning)

- • End Semester External Assessment of Maximum 25 Marks and Minimum 10 Marks for laboratory learning.
- • End Semester Assessment of 70 marks for theory learning.

XI. SUGGESTED COS - POS MATRIX FORM

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Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	3	3	3	2	-	1	1			
CO2	3	3	3	2	-	1	1			
CO3	3	3	3	3	-	1	1			
CO4	3	3	3	3	-	1	1			
CO5	3	1	1	1	-	1	2			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Mikell P. Groover, Michell Weiss, Roger N. Nagel, Nicholas G. Odrey & Ashish Dutta	Industrial Robotics	McGraw Hill Education (India) Pvt. Ltd., Chennai, 2012, ISBN: 9781259006210
2	Ramchandran Nagarajan	Introduction to Industrial Robotics	Pearson Education India, New Delhi, 2016, ISBN: 9789332544802
3	R. K. Rajput	Robotics and Industrial Automation	S. Chand limited, 2014, ISBN: 9788121929974
4	R. K. Mittal & I. J. Nagrath	Robotics and Control	McGraw Hill education India Pvt. Ltd. New Delhi, 2010, ISBN: 9780070482937
5	Ganesh S. Hegde	A Textbook on Industrial Robotics	University Science Press, New Delhi, 2015, ISBN: 9788131805183
6	D. J. Todd	Fundamentals of Robot Technology	British library Cataloguing in Publication Data, 2012, ISBN: 9789401167703
7	Ghosal, Ashitava	Robotics – Fundamental Concepts and Analysis	Oxford University Press, 2006, ISBN: 978019567391

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://nptel.ac.in/courses/112105319	NPTEL Course - Industrial Robotics: Theories for Implementation
2	https://nptel.ac.in/courses/112105249	NPTEL Course - Robotics
3	http://www.mechanalyzer.com/downloads-roboanalyzer.html	Simulation Software- Robo analyzer (Download)
4	http://www.roboanalyzer.com/tutorials.html	Simulation Software - tutorials
5	https://www.youtube.com/watch?v=l1gRr_NI4BU	Introduction to Industrial Robot

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Sr.No	Link / Portal	Description
6	https://www.youtube.com/watch?v=X7iBT5l599c	Industrial Robot Manipulator
7	https://www.youtube.com/watch?v=_canCYWZPsc&t=227s	Animation of Work Envelope
8	http://vlabs.iitkgp.ernet.in/mr/exp0/index.html#	Virtual Lab – IIT Kharagpur

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students