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INDUSTRIAL ROBOTICS AND APPLICATIONS **Course Code : 316343**

Programme Name/s : **Automation and Robotics**
Programme Code : **AO**
Semester : **Sixth**
Course Title : **INDUSTRIAL ROBOTICS AND APPLICATIONS**
Course Code : **316343**

I. RATIONALE

Industrial robots are widely utilized in manufacturing sectors to boost productivity, competitiveness, and operational efficiency. They are particularly valuable for performing tasks that are dirty, monotonous, or hazardous, thereby improving workplace safety and reducing human labor. This course is specifically designed to provide students with the essential knowledge and practical skills needed to meet the growing demands of the manufacturing as well as processing industries. This course covers a range of applications, including robotic systems used in welding, automobile production, medical device manufacturing, and material handling, preparing students for the diverse challenges they will encounter as the 21st-century workforce.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to attain the following industry/ employer expected outcome through various teaching learning experiences:
Use robotic systems for various 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 - Interpret the use of robot vision system for relevant application.
- CO2 - Develop VAL program for various robotic applications.
- CO3 - Apply the fundamentals of Robot Operating System (ROS) in programming.
- CO4 - Troubleshoot robot for basic applications.
- CO5 - Recognize the various emerging robot technologies.

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		
316343	INDUSTRIAL ROBOTICS AND APPLICATIONS	ARS	DSC	4	-	4	2	10	5	3	30	70	100	40	25	10	-	-	25	10	150	

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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.* 15 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 Describe the block diagram of robot vision system. TLO 1.2 Compare different lighting techniques. TLO 1.3 Explain the concept of segmentation and their types. TLO 1.4 List industrial applications of vision controlled robotic systems.	**Unit - I Robot Vision System** 1.1 Robot vision - Overview, sensing and digitizing function for image devices, lighting techniques, analog to digital signal conversions (sampling, encoding, image storage) 1.2 Image processing and analysis for image data reduction, segmentation, thresholding, region drawing, edge detecting, feature extraction, object recognition 1.3 Overview of industrial applications of vision controlled robotic systems	Model Demonstration Video Demonstrations Hands-on Collaborative learning Presentations
2	TLO 2.1 Enlist different robot languages. TLO 2.2 List various generations of programming languages. TLO 2.3 State capabilities and limitations of lead through programming methods. TLO 2.4 Develop programs to perform simple robotic operations. TLO 2.5 State capabilities and limitations of lead through programming method.	**Unit - II Robot Languages & Programming** 2.1 Textual robot languages, generations of robot programming languages, robot language structure, constant, variables and other data objects, motion, end-effector and sensor commands, computations and operations , program control and sub- routines, communications and data processing, monitor mode commands 2.2 Robot programming: Methods of programming a robot, lead through programming methods, robot program as a path in space, motion Interpolation, WAIT , SIGNAL and DELAY commands, branching, capabilities and limitations of lead through methods 2.3 Functioning modes of teach pendant 2.4 Simple program for pick and place activity 2.5 Simple program to palletize the object 2.6 Simple program for Insertion (Bolt, Bearing, etc.)	Model Demonstration Video Demonstrations Presentations Collaborative learning Hands-on

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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.
3	TLO 3.1 Describe the need for a robot operating system. TLO 3.2 Differentiate between operating system & robot operating system. TLO 3.3 List different platforms of robot operating systems. TLO 3.4 Explain ROS architecture. TLO 3.5 Enlist advantages of the robot operating system.	**Unit - III Robot Programming using ROS 2** 3.1 Overview, need of robot operating system, history 3.2 Difference between OS, ROS 1 and ROS 2 3.3 ROS 2 supporting libraries, basic ROS equation 3.4 ROS 2 computing platforms, ROS 2 architecture and concepts, design goals of ROS, nomenclature, advantages of ROS	Model Demonstration Video Demonstrations Case Study Hands-on Collaborative learning
4	TLO 4.1 Describe the use of robots in material handling. TLO 4.2 Explain use of robots in automated assemblies. TLO 4.3 Enlist the steps regarding robot maintenance. TLO 4.4 Compare predictive and preventive maintenance. TLO 4.5 List different safety norms in robot handling. TLO 4.6 Explain the concept of interlocking in robotic systems. TLO 4.7 Suggest the remedies for common troubles encountered in robots	**Unit - IV Robot Applications and Maintenance** 4.1 Robot in material handling - Pick and place robot, robot in palletizing and related operations 4.2 Robot in processing operations - Spot welding, continuous arc welding , spray coating, die- casting, plastic molding, forging operation 4.3 Robot in automated assemblies 4.4 Robot in automated inspections 4.5 Robot maintenance - Need and types of maintenance 4.6 Common troubles and remedies in robot operation 4.7 General safety norms, robot handling aspects and their precautions 4.8 Overview of interlocking robots	Educational Video Video Demonstrations Site/Industry Visit Collaborative learning Demonstration 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.
5	TLO 5.1 Interpret the concept of robot intelligence. TLO 5.2 Explain the functionalities of telepresence. TLO 5.3 Explain system integration and network approach. TLO 5.4 Enlist the emerging applications of robots. TLO 5.5 Describe briefly applications of robots like military operations, fire-fighting operations, space operations, etc. TLO 5.6 Describe the working principle and applications of humanoid robots.	**Unit - V Emerging Robotic Technologies** 5.1 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 5.2 Emerging applications of robots - Military operations, fire-fighting operations, under sea operations, space operations, humanoid robots, swarm robotics, soft robotics, micro-robots, nano-robots and Cobalt robots	Model Demonstration Educational Video Case Study Collaborative learning Demonstration Flipped Classroom

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 key components of an industrial vision system, such as cameras, lenses, and lighting sources. LLO 1.2 Explain the function of each component in capturing and processing images for robotic applications.	1	*Identification of industrial machine vision components (industrial camera, lens, light source, etc.)	2	CO1
LLO 2.1 Implement an OpenCV-based program to capture and display images from a camera. LLO 2.2 Modify camera settings in order to optimize image capture for different lighting conditions.	2	*Implementation of image display using OpenCV	2	CO1
LLO 3.1 Apply edge detection techniques to highlight object boundaries. LLO 3.2 Analyze the different threshold values that affect the accuracy of edge detection.	3	*Edge detection of an object in an image using OpenCV	2	CO1
LLO 4.1 Use contour detection to identify and classify geometric shapes in an image. LLO 4.2 Apply image thresholding to improve shape detection accuracy.	4	Shape detection of an object in an image using contours	2	CO1
LLO 5.1 Extract object coordinates from an image using bounding boxes and centroid calculation. LLO 5.2 Implement real-time tracking of objects based on their detected position.	5	*Object location detection in an image	2	CO1

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Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 6.1 Implement HSV color filtering to segment objects of a specific color in an image. LLO 6.2 Apply masking techniques to highlight detected color regions.	6	Segmentation using color detection of an object in an image	2	CO1
LLO 7.1 Integrate computer vision data with robotic motion commands for automated control. LLO 7.2 Develop a real-time object recognition and response system for a robotic arm.	7	Vision system interfacing with robot programming	2	CO1
LLO 8.1 Apply image processing techniques to detect manufacturing defects in industrial components. LLO 8.2 Evaluate the effectiveness of vision-based quality control systems in automation.	8	Image processing techniques for industrial applications using OpenCV	2	CO1
LLO 9.1 Execute an assembly language program for inserting a bolt or bearing using an industrial robot. LLO 9.2 Troubleshoot programs to optimize insertion accuracy and efficiency.	9	Insertion program for bolt or bearing	2	CO2
LLO 10.1 Execute an assembly language program for a robot to follow a specific path using precise motion control. LLO 10.2 Optimize the robot's path planning to ensure smooth and accurate movement while avoiding obstacles.	10	Program for specific path movement for a robot	2	CO2
LLO 11.1 Develop a robot program for automated palletizing, ensuring efficient object stacking using any assembly language. LLO 11.2 Apply kinematic principles to optimize the robot’s pick-and-place movements for palletizing.	11	*Program for palletizing the objects	2	CO2
LLO 12.1 Analyze interrupted welding lines using sensor-based data collection for robotic path adjustments. LLO 12.2 Evaluate the effectiveness of real-time path correction algorithms for maintaining welding precision.	12	*Identification of sensing strategy and robot path for interrupted welding lines	2	CO2
LLO 13.1 Implement a robot painting program that ensures uniform paint application over a surface. LLO 13.2 Design an optimal path planning strategy for robotic arms to cover complex shapes with minimal overspray.	13	Development of robot program for painting operation	2	CO2

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Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 14.1 Develop a robotic spot welding program that ensures accurate positioning and heat application. LLO 14.2 Apply motion control algorithms to synchronize robot movement with welding sequences.	14	*Development of robot program for spot welding operation	2	CO2
LLO 15.1 Set up a ROS 2 environment for configuration on Linux-based system. LLO 15.2 Execute basic Linux commands essential for ROS 2 operation (e.g., sourcing setup files, navigating directories).	15	*Use basic ROS 2 commands and tools	2	CO3
LLO 16.1 Use Linux terminal commands to run and manage ROS 2 nodes . LLO 16.2 Analyze node communication through topics and messages. LLO 16.3 Use Linux-based ROS 2 CLI tools to inspect, debug, and interact with nodes.	16	*Use of ROS 2 commands and CLI tools	2	CO3
LLO 17.1 Install Turtlesim to simulate basic robot movement in ROS 2. LLO 17.2 Verify the execution of Turtlesim by listing active nodes and topics in ROS 2.	17	*Installation of open source ROS simulator - Turtlesim	2	CO3
LLO 18.1 Publish velocity commands to the Turtlesim robot using ROS 2 topics. LLO 18.2 Analyze the effect of different twist message parameters on turtle movement.	18	Turtle movemenr using ROS 2	2	CO3
LLO 19.1 Execute a ROS 2 teleop node to control the turtle’s movement using keyboard inputs. LLO 19.2 Demonstrate interactive control of a simulated robot using ROS 2 command-line tools.	19	Control of Turtle using the keyboard	2	CO3
LLO 20.1 Call ROS 2 services to reset and teleport the turtle to a specific position. LLO 20.2 Evaluate the differences between ROS 2 services and topics in handling robot actions.	20	*Use of ROS 2 services to reset and teleport the Turtle	2	CO3
LLO 21.1 Develop a custom ROS 2 Python node that publishes velocity commands to move the turtle in a circular motion. LLO 21.2 Implement ROS 2 publisher-subscriber communication within a Python script.	21	*Development of a custom ROS 2 python node to move the Turtle in a circle	2	CO3
LLO 22.1 Create a ROS 2 launch file to start multiple nodes simultaneously. LLO 22.2 Evaluate the effectiveness of launch files in managing complex robotic applications in ROS 2.	22	Development of ROS 2 launch file to start multiple nodes	2	CO3

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Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 23.1 Use preventive maintenance techniques to inspect and maintain robotic components, including joints, actuators, and sensors. LLO 23.2 Evaluate the impact of regular maintenance on robot performance, longevity, and failure prevention.	23	*Preventive maintenance techniques for a robot	2	CO4
LLO 24.1 Identify common robot faults such as misalignment, sensor failures, and communication errors. LLO 24.2 Analyze error logs and system diagnostics. LLO 24.3 Troubleshoot robotic malfunctions effectively.	24	*Troubleshooting common robot faults	2	CO4
LLO 25.1 Apply safety inspection protocols to verify emergency stop buttons, interlocks, and sensor-based safety features. LLO 25.2 Evaluate the effectiveness of robotic safety measures in preventing accidents and ensuring compliance with industrial safety standards.	25	Implementation of safety checks in robot operation	2	CO4
LLO 26.1 Analyze the role of AI and machine learning in improving robot intelligence and decision-making. LLO 26.2 Evaluate the differences between AI-powered autonomous robots and traditional pre-programmed robots.	26	Case study on evaluation of robot intelligence in an AI-powered robot	2	CO5
LLO 27.1 Analyze the role of autonomous robots like Mars rovers in space exploration and extraterrestrial research. LLO 27.2 Design a conceptual AI-driven robotic system for future deep-space exploration missions.	27	*Case study on robots in space exploration – Mars rovers & beyond	2	CO5
LLO 28.1 Identify the challenges of deep-sea exploration. LLO 28.2 Analyze the role of sonar, LiDAR, and AI-driven mapping in underwater robotic navigation.	28	*Case study on deep-sea exploration robots for ocean research	2	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)

Micro project

- Autonomous turtle navigation with obstacle avoidance in ROS 2.
- Vision-based quality inspection system for industrial components.
- Gesture-controlled robot using OpenCV and ROS 2.
- Smart painting robot for industrial applications using ROS 2.
- Battery performance and power consumption analysis in robots.
- Recalibration and accuracy testing of a robot after a fault.
- Robot safety audit and risk assessment.

Student Activity

- Perform a survey and prepare a detailed report on robots used in manufacturing industries, such as welding, painting, die-casting, etc.
- Prepare a detailed report on the case study for robots used in military operations like logistics, firefighting, surveillance, rescue operations, etc.
- Prepare a detailed report on the case study for robots used in the healthcare sector.
- Prepare a comparative chart on NASA's Perseverance rover and CHANDRAYAN 2 spacecraft (Vikram).

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Light source: Luminous Colour = White Illumination = 40,000 lux Brightness = Continuously Adjustable, (Range:0~100%), Colour Temperature Constant	1,2,3,4,5,6,7,8
2	Focus lens: Focal length = 16mm Aperture = F1.4-F16C Focus Point = 0.3m-Inf	1,2,3,4,5,6,7,8
3	4 axis robotic arm manipulator and programming software Payload - Minimum 500g Maximum reach - 320mm	1,2,3,4,5,6,7,8,9,10,11,12,13,14,23,24,25
4	Vision camera: Effective Pixel = 3 million Hue = Colour Frame Rate/ Resolution =12 @2048x1536	1,2,3,4,5,6,8
5	Any open source software like OpenCV	2,3,4,5,6,7,8

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Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
6	Color sensor: Input = 20~150mm Detectable = non-glowing object Embedded controllable white LED	5,6,8
7	Open source robot simulation software like VAL/ RT tool box/ RoboDK or any other suitable software	9,10,11,13,14
8	Personal Computer : 8GB RAM, 500 GB HDD, I3 or higher processor Linux operating system like Ubuntu (Windows 10 only, Linux-Ubuntu 18.04 recommended, macOS — Sierra (10.12.x)	All

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	Robot Vision System	CO1	14	4	4	8	16
2	II	Robot Languages & Programming	CO2	14	4	6	6	16
3	III	Robot Programming using ROS 2	CO3	10	2	4	6	12
4	IV	Robot Applications and Maintenance	CO4	12	2	6	6	14
5	V	Emerging Robotic Technologies	CO5	10	2	4	6	12
Grand Total				**60**	**14**	**24**	**32**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Two offline unit tests of 30 marks and average of two unit test marks will be considered for out of 30 marks.

For formative assessment of laboratory learning 25 marks.
Each practical will be assessed considering 60% weightage to process, 40% weightage to product.

Summative Assessment (Assessment of Learning)

- End semester assessment of 70 marks.

XI. SUGGESTED COS - POS MATRIX FORM

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	2	2	3	2	-	2			

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CO2	3	3	2	2	2	2	2			
CO3	3	3	2	2	1	2	2			
CO4	3	2	1	1	2	-	2			
CO5	3	2	1	-	2	-	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	S. K. Saha	Introduction to Robotics	McGraw Hill 3rd Edition ISBN: 978-9355326461
2	Mikell P. Groover, Nicholas Odrey, Mitchell Weiss	Industrial Robotics -Technology ,Programming and Applications	McGraw Hill Education 2nd Edition ISBN: 978-1259006210
3	Lentin Joseph	Robot Operating System (ROS) for Absolute Beginners	Apress 1st Edition ISBN: 978-1484234044
4	Ganesh S. Hegde	Industrial Robotics	Laxmi Publications 2nd Edition ISBN: 978-8131805183
5	Ramachandran Nagarajan	Introduction to Industrial Robotics	Pearson Education 1st Edition ISBN: 978-9332544802
6	K. S. Fu, Ralph Gonzalez, C.S.G. Lee	Robotics: Control, Sensing, Vision and Intelligence	McGraw Hill Education 1st Edition ISBN: 978-0070226258

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://www.ros.org/	Robot Operating System (ROS) official website
2	https://mr-iitkgp.vlabs.ac.in/exp/val-programming/	Robot Teaching Using VAL Programming (Vlabs)
3	https://opencv.org/	OpenCV official website
4	https://docs.ros.org/en/eloquent/Tutorials/Turtlesim/Introducing-Turtlesim.html	Introducing turtlesim and rqt - ROS 2 Documentation: Eloquent documentation

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Sr.No	Link / Portal	Description

Note :

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

MSBTE Approval Dt. 04/09/2025 **Semester - 6, K Scheme**