GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2023 (COGC-2023)
Semester-VI

Course Title: Robotics and Industrial Automation
(Course Code: 4361906)

Diploma programmer in which this course is offered	Semester in which offered
Diploma Mechanical Engineering	6th Semester

1. RATIONALE

In near future, robots will be used widely in the fields of manufacturing, medicine, search and rescue, service, and entertainment. So, it is very much important to teach robotics as the synergistic integration of mechanics, electronics, controls and computer science. This subject is intended to make students aware with basics of robot sensors, controls, transformations along with essential kinematics and dynamics, robot programming language and Industrial automation system & Industry 4.0.

2. COMPETENCY

The purpose of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- Able to select types of robots, its end effectors and sensor.
- Able to understand concept of robot kinematics.
- Able to calculate the robot position and orientation.
- Able to understand various industrial automation system & Industry 4.0.

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with this competency are to be developed in the student to display the following COs:

CO1	Classify types of robots and identify its subsystems.
CO2	Select an actuator, its gripper/s and sensor for a robot based on given application
CO3	Calculate robot position and orientation.
CO4	Identification of robot programming language.
CO5	Explain Industrial automation system & Industry 4.0

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
3	0	2	4	70	30	25	25	100

(*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessing the attainment of the cognitive domain UOs required for the attainment of the COs.

***Legends: L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **CA** - Continuous Assessment; **ESE** - End Semester Examination.*

5. SUGGESTED PRACTICAL EXERCISES

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	**Demonstration:** Students would: a. Demonstrate working of following: i. Robot-anyone. b. Sketch following. i. Configuration sketch of robot demonstrated.	1	2 Hrs
2	**Demonstration:** Students would: a. Demonstrate working of following: i. Sensors-each one from unit IV. b. Sketch following. i. Working sketch of sensors demonstrated.	4	2 Hrs
3	Demonstrate various types of grippers used in robotics.	2	4 Hrs
4	Demonstrate block diagram of actuator system.	2	4 Hrs
5	Prepare a report/Case study on various types of motors used in robotics	2	2 Hrs
6	Prepare a report/Case study on classification of robots based on coordinate system and Conversion of coordinates form one system to other.	3	2 Hrs
7	Calculate position of a given point in Cartesian coordinate system.	3	2 Hrs
8	Develop a program of Robert in any available software (like V-REP, RoboDK etc.) for given activity.	5	4 Hrs
9	Prepare a report/Case study on Industrial Automation and process control system.	6	2 Hrs
10	Prepare a report/Case study on Industry 4.0	6	2 Hrs
11	Industrial visit ,report and presentation: Students would: Visit any one advanced manufacturing system/CAD-CAM/ Robotics/Additive manufacturing based industry/Centre of excellence/Exhibition and prepare brief report.	1 to 6	2 Hrs

Note: *More* ***Practical Exercises*** *can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.*

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

This major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to usher in uniformity of practical in all institutions across the state.

Sr. No.	Equipment Name	Broad Specifications	PrO. No.
1	Any available software (like V-REP, RoboDK etc.)	Robot programming and simulation software	8
2	Robotic arm	6 axis robotic arm	1,
3	Sensors, Grippers and Actuators	Various sensors, grippers and actuators	2,3,4

7. AFFECTIVE DOMAIN OUTCOMES

The following ***sample*** Affective Domain Outcomes (ADOs) are embedded in many of the above-mentioned COs and PrOs. More could be added to fulfil the development of this competency.

a) Work as a leader/a team member for Micro project.
b) Follow safety practices and procedure in Lab.
c) Realize the importance of engineering for societal development.
d) Develop gradually the engineering mindset in day-to-day observation.

8. UNDERPINNING THEORY:

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
Unit-I Introduction to Robotics	1a. Understand evolution of robotics over time. 1b. Define robot. 1c. Explain advantages and disadvantages of robots. 1d. Explain terminology of robot 1e. Explain components the component of robot. 1f. Classification of robots based on coordinate system they use, power source they use, control method used by them and programming method. 1g.Explain safety measures to be followed while working with and around robots.	1.1: Brief History of robotics. 1.2: Definition of a ROBOT 1.3: Laws of robotics. 1.4: Advantages and Disadvantages of robots 1.5: Component of an Industrial Robot 1.6: Robot Terminology 1.7: Robotic Joints 1.8: Classification of Robots 1.8.1 : Based on Coordinate Systems 1.8.2 : Based on Power Source 1.8.3 : Based on Method of Control 1.8.4 : Based on programming Method 1.9: Industrial Applications of Robot. 1.10: Safety practices with robots
Unit-II Actuators and Grippers	2a. Explain robotic actuators and its components. 2b. Classify robotics actuators and explain their working. 2c. Explain factors affecting selection of actuators. 2d. Explain robotic grippers. 2e. Classify robotic grippers.	2.1: Introduction to robotic actuators: 2.1.1: Block Diagram of an actuator system 2.1.2: Subsystems of actuator system: 2.1.2.1: Power supply, 2.1.2.2: Power amplifier, 2.1.2.3: Servomotor, and 2.1.2.4: Transmission system. 2.2: Classification of actuators: 2.2.1: Pneumatic actuators, 2.2.2: Hydraulic actuators, 2.2.3: Electric actuators: 2.2.3.1: DC motor. 2.2.3.2: AC motor. 2.2.3.3: Induction motor. 2.2.3.4: Stepper motors. 2.2.3.5: Linear actuators. 2.3: Factors affecting selection of actuators. 2.4: Introduction to Grippers. 2.5: Classification of grippers: 2.5.1: Mechanical grippers. 2.5.2: Magnetic grippers. 2.5.3: Vacuum grippers.

	2f. Explain factors affecting design and selection of grippers.	2.5.4: Adhesive grippers. 2.5.5: Tools as grippers. 2.6: Factors affecting design and Selection of grippers.
Unit-III Robot Kinematics	3a. Introduction to kinematics. 3b. types of links in kinematics. 3c. Explain kinematic constrains. 3d. Explain types of joints used in robots. 3e. Explain Chain in kinematics. 3f. Explain and calculate Degree of freedom for given body. 3g. Explain and calculate position and orientation of rigid body in space. 3h. Identification of position of a point and vector in given coordinate system.	3.1: What is kinematics? 3.2: Types of kinematic links: 3.2.1: Rigid link. 3.2.2: Flexible link. 3.2.3: Floating link. 3.3: Kinematic pair/constrains. 3.3.1: Types of constrains 3.3.2: Classification of kinematic pairs. 3.4: Common types of robotic joints 3.5: Kinematic chain: 3.5.1: Closed chain mechanism. 3.5.2: Open chain mechanism. 3.6: Degree of freedom (DOF) 3.7: Position and orientation of rigid body in space. 3.7.1: Configuration space 3.7.2: Coordinate systems 3.7.2.1: Cartesian coordinate system 3.7.2.2: Cylindrical coordinate system 3.7.2.3: Spherical Coordinate system 3.8: Representation of points and vectors in coordinate systems.
Unit-IV Robotic Sensors	4a. Categorize various robotic sensors 4b. List various Internal and External sensors used in Robotic Application 4c. List various Contact and Non-Contact sensors used in Robotic Application 4d. Describe the general working principles of given sensor 4e. Explain Construction and Working of given Robotic sensor with neat sketch 4f. Discuss some applications of given sensor	4.1: Types of Sensors in Robots 4.1.1: Internal Sensors 4.1.2: External Sensors 4.1.3: Contact sensors 4.1.4: Non-contact sensors 4.2: Position and Displacement Sensor 4.2.1: Potentiometers 4.2.2: Optical Encoders 4.2.2.1: Absolute 4.2.2.2: Incremental 4.2.2.3: LVDT 4.3: Touch or Tactile Sensor 4.3.1: Binary Sensor 4.3.2: Analog Sensor 4.4: Proximity Sensor 4.4.1: Contact Proximity 4.4.2: Non-Contact Proximity 4.4.3: Optical 4.4.4: Ultrasonic 4.4.5: Eddy Current 4.4.6: Inductive 4.4.7: Hall Effective 4.4.8: Capacitive 4.5: Procedure to choose right sensor for particular Application

	4g. Write procedure to choose right sensor for particular Application	
Unit-V Robot Programming	4a. Describe the requirement of robot language 4a. Explain languages and its structure used for robot programming. 4b. Explain methods used for programming a robot.	5.0: Introduction 5.1: Requirement for robot language 5.2: Structure of robot language 5.3: Different Robot languages 5.4: Robot Programming Techniques: 5.4.1: Manual Programming Method 5.4.2: Walk through Programming method 5.4.3: Teach pendant or lead through programming method 5.4.4: Off-line programming method
Unit-VI Industrial Automation	6a. List advantages and limitations of Automation 6b. Explain application of Automation 6c. List elements of automation 6d. Differentiate Mechanization vs Automation 6e. Explain types of Automation. 6f. Explain assembly automation equipment. 6g. Explain Automated Guided Vehicles. 6h. Explain Automated Storage system. 6h.Explain Flexible Manufacturing System. 6i.Describe various components of Flexible Manufacturing System. 6i. Explain Importance of Group technology 6j. Determine part family of given parts based on part design	6.1: Introduction 6.2: Advantages and Limitations of Automation 6.3: Application of Automation 6.4: Elements of Automation 6.5: Mechanization vs Automation 6.6: Types of Automation 6.6.1: Fixed (or Hard) Automation 6.6.2: Programmable Automation 6.6.3: Flexible (or soft) Automation 6.7: Assembly automation equipment: 6.7.1: Material handling System 6.7.1.1: Classification of Material handling system 6.7.2: Transportation System : 6.7.2.1: Transfer Systems 6.7.2.2: Transfer Machines 6.7.2.3: Transfer Devices 6.7.3: Feed System 6.7.3.1: Introduction 6.7.3.2: Characteristics of Feeder 6.7.3.3: Types of Feeders 6.7.5: Automated Guided Vehicles (AGV's) 6.7.6: Automated Storage Systems : 6.7.6.1: Introduction 6.7.6.2: Automated storage/ Retrieval Systems 6.8: Flexible Manufacturing System (FMS) 6.8.1: Introduction 6.8.2: Flexible Manufacturing Cell and FMS 6.8.3: Components of FMS 6.8.4: Requirement of FMS 6.8.5: Advantages and limitations of FMS 6.9: Group Technology 6.9.1: Introduction 6.9.2: Advantages and limitations of Group Technology 6.9.3: Part Families 6.9.4: Formation and establishment of component family

	attribute and part manufacturing attribute. 6j. Explain Computer Aided Process Planning 6k. Explain Computer integrated Manufacturing 6l. Industry 4.0	6.9.5: Collection of production data 6.10: Computer Aided Process planning system 6.11: Computer Integrated Manufacturing (CIM) 6.12: Industry 4.0

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN:

Unit No.	Unit Title	Teaching Hours	Distribution of Theory marks			
			R Level	U Level	A Level	Total Marks
1	Introduction to Robotics	4	2	4	0	06
2	Actuators and Grippers	8	5	5	4	14
3	Robot Kinematics	8	6	4	4	14
4	Robotic Sensors	8	6	4	4	14
5	Robot Programming	6	2	3	3	08
6	Industrial Automation	8	6	6	2	14
	Total	**42**	**27**	**26**	**17**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)*
Note*: This specification table provides general guidelines to assist student for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions assess the attainment of the UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary slightly from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related co-curricular activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a) Prepare models of 2 DOF and 3 DOF robotic arms.
b) Give seminar on drones and its controls.
c) Undertake a market survey of different types of robots used in industries.
d) Give seminar on advancement in robotics with development of AI.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

Following Sample strategies teacher can use to accelerate the attainment of the various outcomes in this course:

a) Inspire Student to read books on development and evolution of robotics, instruct them to take notes in form of summary
b) Prepare a short note on applications of robot in defense industry.
c) Guide students to make presentation on various applications of robotics in medical field in small groups.
d) List out various programming languages used in robotics along with their advantages and limitations.
e) Make a model for 3D Cartesian coordinate system and explain calculation of position of point, vector and plane in it.

12. SUGGESTED PROJECT LIST

The micro-project could be industry application based, internet-based, workshop based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain a dated work diary consisting of individual contributions in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than 16 (sixteen) student engagement hours during the course. The student ought to submit a micro-project by the end of the semester to develop the industry oriented COs. A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

1) *Prepare a model of 2DOF robotic arm.*
2) *Prepare a model of 3DOF robotic arm.*
3) *Prepare a model of pick and place robot.*
4) *Prepare a model for demonstration of hydraulics.*
5) *Prepare a model for demonstration of Gripper mechanism.*
6) *Prepare a model for demonstration of rigid links.*
7) *Prepare a model for demonstration of flexible links.*
8) *Prepare a model for demonstration of floating links.*
9) *Prepare model for demonstration on flexible Manufacturing System.*
10) *Prepare a model using robotic sensors.*

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
1	Robotics and Industrial Automation	R.K.Rajput	S.Chand and Company ISBN (13): 978-8121929974 ISBN (10): 8121929970
2	Industrial Automation and Robotics	A.K.Gupta S.K.Arora	University of Science Press (An imprint of Laxmi Publication Private Limited) ISBN: 978-1-938549-30-4
3	Introduction to robotics	Prof. Subair kumar Shah	McGraw Hill Education (India) Private Limited ISBN (13): 978-93-3290-280-0 ISBN (10): 93-3290-280-1
4	Robotics Simplified	Dr. Jisu Elsa Jacob Manjunath N	BPB Publications India ISBN: 978-93-91030-26-1
5	Fundamentals of Robotics	Prof. Dilip Kumar Pratihar	Narosa Publication House Pvt. Ltd., New Delhi, ISBN (13): 978-8184875775 ISBN (10): 8184875770
6	Fundamentals of Robot Technology	D J Todd	Kogan Page Ltd 120 Pentonville Road, London Nl 9JN ISBN-13: 978-94-011-6770-3 e- ISBN-13: 978-94-011-6768-0

14. SOFTWARE/LEARNING WEBSITES

Various link of free demo robotics software

1. https://downloads.intelitek.com/PLTW/ROBOCELL/
2. https://intelitek.com/
3. https://convergent-it.com/robot-programming-demo/
4. https://cyberbotics.com/
5. https://www.robocamp.eu/en/lessons/demo/
6. https://instrumentationtools.com/download-free-robotics-software/
7. https://www.kuka.com/en-in/products/robotics-systems/software/simulation-planning-optimization/kuka_sim

15. PO-COMPETENCY-CO MAPPING:

Semester VI	Robotics and Industrial Automation (Course Code:4361906)						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/ development of solutions	PO 4 Engineering Tools, Experimentation &Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning
Classify types of robots and identify its subsystems.	3	2	-	-	-	-	2
Select an actuator, its gripper/s and sensor for a robot based on given application	3	2	2	2	-	-	2
Calculate robot position and orientation.	3	3	3	3	-	-	3
Identification of robot programming language.	3	2	3	3	2	-	3
Explain Industrial automation system.	3	2	2	-	-	2	3

*Legend: '**3**' for high, '**2**' for medium, **'1'** for low and **'-'** for no correlation of each CO with PO.*

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

Sr. No.	Name and Designation	Institute	Contact No.	Email
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