

GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)
Competency-focused Outcome-based Green Curriculum-2023 (COGC-2023)
Semester - IV
Course Title : Robotic Simulation Practices
(Course Code : 4344107)

Diploma programme in which this course is offered	Semester in which offered
AUTOMATION AND ROBOTICS	FOURTH

1. RATIONALE

This course has been designed for diploma students through which they can learn the basics of how to create virtual environments that mimic real-world scenarios, students can rigorously simulate and refine robotic systems without the constraints and expenses associated with physical prototypes. This approach mitigates risks by identifying potential issues before deployment, ensuring the safety and reliability of robots in diverse applications. Simulation enables iterative design simulation and rapid prototyping, accelerating the development cycle and fostering innovation. It promotes accessibility to a broader audience, allowing students and enthusiasts to experiment with robotics without the need for specialized hardware. Furthermore, simulations facilitate scalability testing, environmental exploration, and the generation of large datasets for training different models.

2. COMPETENCY

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

- ✓ **Understand and implement basic simulation model of different robotic system.**

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills should be taught to acquire different learning outcomes in cognitive, psychomotor and affective domain for the achievement of the following CO's:

- CO1: Illustrate concept of robotic simulation system
- CO2: Demonstrate Proficiency in Robotic Simulation Tools
- CO3: Apply programming functions to create robot system model
- CO4: Implement algorithms in robotic simulation environment
- CO5: Experiment with hardware and software interaction for robotic simulation

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				Total Marks
L	T	P		Theory Marks		Practical Marks		
			C	CA	ESE	CA	ESE	
0	0	4	2	0	0	25	25	50

(*): 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

The following practical outcomes (PrOs) are the subcomponents of the Course Outcomes (Cos). Some of the **PrOs** marked ‘*’ are compulsory, as they are crucial for that particular CO at the ‘Precision Level’ of Dave’s Taxonomy related to ‘Psychomotor Domain’.

Sr. No.	Practical Outcomes (PrOs)	Approx. Hrs. Required
1	Install and set up a robotic simulation environment, such as ROS, Gazebo, or V-REP.	2
2	Design a basic robot model using the simulation software's modeling tools.	4
3	Simulate the basic motion of a robot, including forward and inverse kinematics	2
4	Integrate sensors (e.g., cameras, lidars) into the robot model and simulate their data output.	2
5	Implement a simple path planning algorithm (e.g., A* algorithm) for the robot to navigate through a predefined environment.	2
6	Introduce dynamic elements to the simulation, such as moving obstacles.	2
7	Implement collision detection mechanisms and avoidance. Strategies within the simulation	2
8	Simulate multiple robots working collaboratively on a task or navigating a shared environment.	2
9	Implement a PID controller for controlling the robot's movement and tune the controller parameters	2
10	Design and simulate a robotic arm performing manipulation tasks	2
11	Connect simulated robots to real-world hardware (e.g., microcontrollers) and observe the interaction.	4

Sr. No.	Practical Outcomes (PrOs)	Approx. Hrs. Required
12	Create a simulation where a robot picks an object from one location and places it in another	2
13	Simulate a robot that can avoid obstacles in its environment using sensors.	2
14	Design and simulate different types of grippers for a robotic arm.	2
15	Model and simulate a robotic welding process with accuracy and precision.	4
16	Develop a simulation of a soccer game where robots act as players.	2
17	Implement a teleoperation system where a robot is controlled remotely.	2

Note

i. 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.

ii. The following are some **sample** ‘Process’ and ‘Product’ related skills (more may be added / deleted depending on the course) that occur in the above listed **Practical Exercises** of this course required which are embedded in the COs and ultimately the competency.

Sr. No.	Sample Performance Indicators for the PrOs	Weightage in % *
1	Conceptual clarity.	20
2	Experimental setup, Procedure and conduction by following safety practices.	50
3	Interpretation of Results and Ethical values.	30
Total		100

* Weightage of particular PrO may vary as per experiments.

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

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

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
1	Computer system with latest operating system.	All
2	Robotic Arm Kit	9, 10, 11, 12, 14, 15

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 fulfill the development of this course competency.

- a. Work as a leader/a team member (while doing a micro-project).
- b. Follow safety practices while using D.C. and AC supply and electrical equipment.
- c. Work as a group member (while performing experiments and taking readings)
- d. Practice environmentally friendly methods and processes. (Environment related)

The ADOs are best developed through the laboratory/field-based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- a. 'Valuing Level' in 1st year.
- b. 'Organization Level' in 2nd year.
- c. 'Characterization Level' in 3rd year.

8. 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 perform following activities in group (or individual) and prepare reports of about 5 pages for each activity. They should also collect/record physical evidence for their (student's) portfolio which may be useful for their placement interviews:

- a. Present seminar on various topics from course content
- b. Undertake micro-projects in teams
- c. Mini project for industrial robotic application
- d. Students are encouraged to register themselves in various MOOCs such as: Swayam, edx, Coursera, Udemy etc to further enhance their learning
- e. Encourage students to participate in different competitions like hackathon, online competitions on codechef etc

9. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

- a) Massive open online courses (*MOOCs*) may be used to teach various topics/subtopics.
- b) Guide student(s) in undertaking micro-projects.
- c) Show animation/ video related to course content.
- d) Co-relating the importance of content of this course with other practical applications.
- e) Industrial visit for practical exposure.
- f) Quiz competition across intercollege branch students.
- g) Organize a workshop on Robotic System by experts from industry.
- h) Guide students on how to address issues on environment and sustainability

10. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-projects are group-based (group of 3 to 5). However, **in the fifth and sixth semesters**, the number of students in the group should *not exceed three*.

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 duration of the micro project should be about **12-14 (fourteen to sixteen) student engagement hours** during the course. The students ought to submit 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:**

- a) Simulate the movement of a robotic arm using forward and inverse kinematics.
- b) Create a simulation where a robot picks an object from one location and places it in another
- c) Implement a path planning algorithm for a robot to navigate through obstacles.
- d) Develop a simulation where a robot uses computer vision to recognize objects
- e) Simulate the navigation of a mobile robot in an indoor environment.
- f) Implement collision detection algorithms to prevent robot collisions with objects.
- g) Integrate a simulated robot with the Robot Operating System (ROS).
- h) Simulate a swarm of robots cooperating to achieve a common goal.
- i) Optimize the trajectory of a robotic arm to achieve faster and smoother movements.

11. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
1	Robotics, Vision, and Control: Fundamental Algorithms in MATLAB	Peter Corke	Springer
2	Introduction to Robotics: Mechanics and Control	John Craig	Pearson
3	Modern Robotics Mechanics, Planning, and Control	Kevin M. Lynch, Frank C. Park	Amazon
4	Introduction to autonomous mobile robots	Roland Siegwart, Illah Reza Nourbakhsh, Davide Scaramuzza.	MIT Press

12. SOFTWARE/LEARNING WEBSITES

- a) <http://www.kronotech.com/>
- b) <http://www.ros.org/>
- c) <http://gazebosim.org/>
- d) <http://www.coppeliarobotics.com/>
- e) <https://cyberbotics.com/>

- f) <https://morse-simulator.github.io/>
- g) <https://www.mathworks.com/products/robotics.html>
- h) <https://pybullet.org/wordpress/>
- i) <https://gym.openai.com/>
- j) <http://vlabs.iitkgp.ernet.in/mr/>

13. PO-COMPETENCY-CO MAPPING:

SEMESTER IV	ROBOTIC SIMULATION PRACTICES (COURSE CODE: 4344107)						
	POs						
Competency & Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7
	Basic & Discipline specific knowledge	Problem Analysis	Design/ development of solution	Engineering Tools, Experimentation & Testing	Engineering practices for society, sustainability & environment	Project Management	Life-long learning
CO1	2	-	-	1	1	-	1
CO2	2	1	2	1	1	-	1
CO3	2	2	2	2	2	1	2
CO4	2	2	2	2	2	1	2
CO5	2	2	3	2	3	2	3

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

14. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Member – Board of Studies (GTU), Electrical and Allied branches

Prof. Suresh Z. Shyara, IC Engineering, AVPTI, Rajkot.

Prof. Mahesh J. Vadhvaniya, IC Engineering, Government Polytechnic, Palanpur.

Prof. Urvish P. Soni, IC Engineering, Government Polytechnic, Ahmedabad

Prof. Parth S. Thaker, IC Engineering, Government Polytechnic, Gandhinagar

Prof. Zankhana D. Mehta, IC Engineering, Government Polytechnic, Ahmedabad

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