Shri Vile Parle Kelavani Mandal's

Dwarkadas J. Sanghvi College of Engineering

(Autonomous College Affiliated to the University of Mumbai)

Scheme and detailed Syllabus (DJS23)

of

Honours Degree Program

in

Robotics

Revision: 1 (2024)

With effect from the Academic Year: 2024-2025

Scheme for Honors in Robotics
(Academic Year 2024-2025)

Sr. No.	Course Code	Course	Teaching Scheme (hrs.)				Continuous Assessment (A) (Marks)			Semester End Assessment (B) (marks)					(A+B)	Total Credits
			Th	P	T	Credits	Th	T/W	Total CA (A)	Th/ Cb	O	P	P&O	Total SEA (B)		
Semester III																
1	DJS23MEHN2C1	Introduction to Robotics and Its Applications	4	--	--	4	40	--	40	60	--	--	--	60	100	4
Semester IV																
2	DJS23MEHN2L1	Basic Robotics Laboratory	--	4	--	2	--	25	25	--	25	--	--	25	50	2
Semester V																
2	DJS23MEHN2C2	Modelling and Design of Robotics	3	--	--	3	40	--	40	60	--	--	--	60	100	3
3	DJS23MEHN2L2	Robotics Laboratory 2	--	2	--	1	--	25	25	--	--	--	--	--	25	1
Semester VI																
4	DJS23MEHN2C3	Advance Robotics	3	--	--	3	40	--	40	60	--	--	--	60	100	3
5	DJS23MEHN2L2	Robotics Laboratory 3	--	2	--	1	--	25	25	--	--	--	--	--	25	1
Semester VII																
6	DJS23MEHN2C4	AI and ML for Robotics	4	--	--	4	40	--	40	60	--	--	--	60	100	4
			14	8	--	18	160	75	235	240	25	--	--	265	500	18

Program: Mechanical Engineering	S.Y. B.Tech.	Semester: III
Course: Introduction to Robotics & Its Applications (DJS23MEHN2C1)		

Pre-requisites:

1. Knowledge of basic elements of mechanical engineering
2. Knowledge of electrical engineering like motors & drives
3. Knowledge of instrumentation related topics like sensors & applications

Basic knowledge of control systems engineering

Course Objectives:

1. To impart knowledge of the fundamental concepts of robotics in the modern-day world from the olden days.
2. Make the student know the anatomical structure of the fixed & mobile robots with actuating systems.
3. To develop the student's knowledge in various types of sensors & its applications.
4. Making the robotic system to know how to do robotic manipulation using different types of end-effectors, viz., the tools & grippers.
5. To introduce the basic principles, techniques, state of art techniques in robot programming with control strategies.
6. Make the learner know about the different types of applications of robots in the modern-day world.

Course Outcomes: On completion of the course, the learner will be able to …

1. Remember the basic structure of robots with their mathematical interpretations in the 3-dimensional analysis.
2. Understand the kinematic analysis while doing the PNPO.
3. Apply the knowledge of mathematics in developing all possible solutions to the inverse kinematic analysis while doing the PNPO.
4. Analyze the area in which the robot can do the effective PNPO with a well-defined optimized shortest path trajectory.
5. Evaluate the performance of difference learning schemes used for solving a typical robotic application using AI concepts.
6. Create a typical robotic application to solve any type of automated works without human intervention.

Introduction to Robotics & Its Applications (DJS23MEHN2C1**)**		
Unit	**Description**	**Duration**
1	**Introduction to Robotics :** to automation & its types, History & evolution of robotics, Definition of robots, Robotic manipulators, Types of robots, Generations of robots, Laws of robotics, Classification of robots & its applications in engineering sector, Difference human hand & robot hands, Robot joints and links, Serial chain & closed chain manipulators, Need for robots in the modern-day world, Specifications of robots.	8
2	**Robot Anatomy :** Anatomy of robots, Drive systems, Actuators and Power Transmission systems, Types of drives & its applications, Hydraulic drives, Pneumatic drives, Electric drives, Hybrid drives, Basic control system design for actuations, Robot activation & feedback components, Types of actuators, Applications of drives in robotics, Types of control for robot movements, Types of motion & its interpretations.	8
3	**Sensors in robotics :** Touch Sensors, Tactile Sensors, Proximity & Range Sensors, Sensor Based Systems, Force Sensors, Light sensors, Pressure sensors, Ultrasonic sensors, Infra-red sensors, Pots, Encoders, Position & Velocity Sensors, Vision systems and Equipments, Introduction to Machine vision & Computer vision for robotic systems, Interoceptive sensors & Exteroceptive sensors, Sensor integration, calibrations & its performance, Applications of each sensor, A case study for sensory feedback design for a particular application.	8
4	**Articulated Mechanical System:** Materials used for robot design & its properties, Transmission devices in robots & its types, End effectors, Types of end effectors, Tools & Grippers, Classification of tools & grippers, Types of tool & gripper actuations, Gripper selection for particular application, Gripper design, Robot wrist mechanisms, Spherical wrists & non spherical wrists, Purpose & need for grippers, A case study for gripper design for a particular application.	8
5	**Robot Controllers & Programming :** Robot brain, Controller & its types, Need for controller in robots, Robot simulation, Robot software, Robot Programming & the Languages, Types of robot programming, Industrial robot programming, Job scenario in industrial robot programming, Motion commands in some languages, On-line & Off-line programming of robots, A case study of a typical robot programming for a particular application (Say, Python or Matlab or Simulink or any other language)	8
6	**Robot Applications :** Industrial applications of robots, Medical, Household, Entertainment, Space, Underwater, Defense, Rehabilitation, Disaster management, Microbots and Nanorobots, Social, Environmental & economic issues in robot applications, Advantages & Disadvantages of Robotization, Use of IoT application in Robotics & Automation, Future Applications & Trends in Robotics.	8
	Total	48

Text-Books Recommended:

1. Dr. T.C. Manjunath, “Fundamentals of Robotics”, Nandu Publishers, 5th Edn., India, 2005.
2. Elaine Rich & Kevin Knight, “Artificial Intelligence”, Mac Graw Hill, Singapore, 3rd Edn., 2017.
3. Dr. T.C. Manjunath, “Fast Track to Robotics”, Nandu Publishers, 2nd Edn., Mumbai, Maharashtra, India, 2005.
4. K.S. Fu, R.C. Gonzalez, C.S.G. Lee, “Robotics: Control Sensing Vision & Intelligence”, Mac Graw Hill, USA, 5th Edition, 2010.
5. Robin R. Murphy, “Introduction to AI and Robotics”, MIT Press, Second Edition, 648 pp., Oct. 2019.

Reference Books:

1. Industrial Robotics, Technology, Programming & Applications, Grover, Weiss, Nagel, Ordey,Mc Graw Hill.
2. Robotic technology & Flexible Automation, S R Deb. TMH.
3. Robotics for Engineers, Yoram Koren, Mc Graw hill.
4. Fundamentals of Robotics, Larry Health.
5. Robot Analysis & Control, H Asada, JJE Slotine.
6. Robot Technology, Ed. A Pugh, Peter Peregrinus Ltd. IEE, UK. 8. Handbook of Industrial Robotics, Ed. Shimon. John Wiley
7. Roland Siegwart, Illah Reza Nourbakhsh, and Davide Scaramuzza, “Introduction to Autonomous Mobile Robots”, Bradford Company Scituate, US
8. Fundamentals of Robotics – Analysis & Controls, Robert Schilling, Prentice Hall Inc, India.
9. Robotics – Amitaabh Bhattacharya
10. P.A. Janaki Raman, "Robotics and Image Processing an Introduction", Tata McGraw Hill Publishing company Ltd., 1995.

Prepared by **Checked by** **Head of the Department** **Principal**

Program: Mechanical Engineering	S.Y. B. Tech.	Semester: IV
Course: Basic Robotics Laboratory (DJS23MEHN2L1)		

Pre-requisites :

1. Knowledge of Python Programming Basics
2. Knowledge of Matlab Programming & Simulink in Matlab
3. Knowledge of C/C++, Java, LabVIEW

Course Objectives :

1. To know the basic programming skills to develop simulations for workspace of a robot arm.
2. To know the basic programming skills to develop simulations for pick & place applications.
3. To know the basic programming skills to develop simulations to develop the graphical representation of the robot arm.
4. To know the basic programming skills to develop simulations for simulating the different types of robot work envelopes.
5. To equip students with the skills to graphically simulate and analyze various types of robotic arms (Planar Articulated, Cylindrical, Rectangular, Polar, and SCARA) in both 2D and 3D views, providing a strong foundation in understanding robotic kinematics and workspaces.
6. To enable students to implement and simulate practical robotic operations such as pick-and-place tasks and screw transformations.

Course Outcomes :

On completion of the course, the learner will be able to …

1. simulate and analyze the kinematic behavior of various robotic arm configurations (Planar Articulated, Cylindrical, Rectangular, Polar, SCARA) in both 2D and 3D views.
2. gain the ability to graphically and numerically determine the workspace of different robotic arms, enhancing their understanding of reach and motion capabilities.
3. develop proficiency in simulating robotic control systems using Simulink, enabling them to observe and evaluate the dynamic response of robots to control inputs.
4. acquire practical skills in programming and executing pick-and-place operations with Planar Articulated and SCARA robotic arms, demonstrating their application in real-world scenarios.
5. learn to implement screw transformations, threading, and unthreading operations, deepening their comprehension of complex robotic motions and transformations.
6. gain hands-on experience with graphical simulation software, reinforcing theoretical concepts through practical applications and enhancing their problem-solving skills in robotics.

Basic Robotics Laboratory (Simulation only)		
Expt	**Particulars of the experiment**	**Hrs**
1.	Orientation to the laboratory course – Programming skills & concepts	2
2.	Program-1 : Graphical simulation of a 3-axis planar articulated robot arm (PARA) (2D & 3D View)	2
3.	Program-2 : Graphical simulation of 3-axis cylindrical coordinate robot arm & its work space of cylindrical robot (2D & 3D View)	2
4.	Program-3 : Graphical representation of a 3-axis Rectangular Coordinate Robot arm (2D & 3D View)	2
5.	Program-4 : Graphical representation of a 3-axis Polar Coordinate Robot arm (2D & 3D View)	2
6.	Program-5 : Graphical representation of a 4-axis SCARA Robot arm (2D & 3D View)	
7.	Program-6 : Pick & place operation using a 3-axis planar articulated robot arm	2
8.	Program-7 : Pick & place operation using a 4-axis SCARA Robot arm	
9.	Program-8 : Determination of horizontal & Vertical reach of cylindrical coordinate robot with graphical & numerical simulations.	2
10.	Program-9 : Program to develop Screw Transformations (ST), threading of a screw & unthreading of a screw	2
11.	Program-10 : Simulation of a control system of a robot to see its response using Simulink	2
12.	Program-11 : Program to study the work space of a 3-axis Planar Articulated robot arm	2
13.	Program-12 : Program to study the work space of a 3-axis Rectangular Articulated robot arm	2
14.	Program-13 : Program to study the work space of a 3-axis Cylindrical Coordinate Articulated robot arm	2
15.	Program-14 : Program to study the work space of a 3-axis Polar-Spherical Coordinate Articulated robot arm	2
16.	Program-15 : Program to study the work space of a 3-axis SCARA robot arm	2
17.	Revision & Repetition of the missed experiments if any	2
18.	Internal test	2
	Total any 10 expts + Orientation + Repetition class + Internal test …. 13 sessions of 2 hrs	26

10 experiments from the above-suggested list or any other experiments based on syllabus can be included to be performed in 10 weeks with the first week orientation, the last week internal test & the repetitions, which would take 13 weeks & which would help the learner to apply the concept learnt. Assignments based on syllabus, Mini project or case study/literature-based seminar/presentation relevant to the subject may be included, which would help the learner to apply the concept learnt.

Open ended experiment:

Students should make a robot model bringing components from outside with motors, wheels, Arduino board, battery (power supply), wheels, ultrasonic sensors (obstacle detection & avoidance), connecting wires, links, screws, gripper, etc… to make the student know the practical aspects of how a robot looks like (similar to doing any type of mini-project)

Text Books Recommended:

1. Dr. T.C. Manjunath, "Fundamentals of Robotics", Nandu Publishers, 5th Edn., India, 2005 (Programming with CD/DVD)
2. Kenneth Lambert – "Fundamentals of Python_ Data Structures", Cengage Learning PTR (2013).
3. Gowrishankar S, Veena A, "Introduction to Python Programming", 1st Edition, CRC Press/Taylor & Francis, 2018. ISBN-13: 978-0815394372.
4. http://do1.drchuck.com/pythonlearn/EN_us/pythonlearn.pdf
5. Allen B. Downey, "Think Python: How to Think Like a Computer Scientist", 2nd Edition, Green Tea Press, 2015. (http://greenteapress.com/thinkpython2/thinkpython2.pdf)
6. Kernigan & Ritche, Fundamentals of C/C++.
7. Bal Guruswamy, Fundamentals of C Programming.
8. Stephen J. Chapman, MATLAB Programming for Engineers MATLAB Programming for Engineers

On-Line Materials & Resources (NPTEL courses / Video lectures / You-tube Videos / Power points / On-line notes / web-links:

a. https://nptel.ac.in/courses/106/106/106106182/
b. https://nptel.ac.in/courses/115/104/115104095/
c. https://www.edx.org/learn/python
d. https://www.coursera.org/courses?query=python
e. https://www.udemy.com/topic/python/
f. https://online-learning.harvard.edu/subject/python
g. https://www.codecademy.com/learn/learn-python
h. https://www.geeksforgeeks.org/python-programming-language/
i. https://www.lynda.com/Python-training-tutorials/415-0.html
j. https://www.python.org/
k. https://www.mathworks.com/