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 (2025)

With effect from the Academic Year: 2025-2026

Prepared by Checked by Head of the Department Principal

Scheme for Honours in Robotics

(DJS23)

Sr. No.	Course Code	Course Title	Teaching Scheme (hrs.)				Semester End Examination (SEE) - A						Continuous Assessment (CA) - B						A+B	Total Credits
			Th. (Hrs)	P (Hrs)	T (Hrs)	Credits	Duration (Hrs)	Th	O	P	O&P	SEE Total (A)	TT1	TT2	TT3	TT Total	T/W	CA Total (B)		
Semester III																				
1	DJS23MH2201	Introduction to Robotics and Its Applications	4	--	--	4	4	60	--	--	--	60	15	15	10	40	--	40	100	**4**
Semester IV																				
2	DJS23MH2251L	Robotics Laboratory I	--	4	--	2	2	--	25	--	--	25	--	--	--	--	25	25	50	**2**
Semester V																				
3	DJS23MH2301	Modelling and Design of Robotics	3	--	--	3	3	60	--	--	--	60	15	15	10	40	--	40	100	**3**
4	DJS23MH2301L	Robotics Laboratory II	--	2	--	1	--	--	--	--	--	--	--	--	--	--	25	25	25	**1**
Semester VI																				
5	DJS23MH2351	Advanced Robotics	3	--	--	3	3	60	--	--	--	60	15	15	10	40	--	40	100	**3**
6	DJS23MH2351L	Robotics Laboratory III	--	2	--	1	--	--	--	--	--	-	--	--	--	--	25	25	25	**1**
Semester VIII																				
7	DJS23MH2451	AI and ML for Robotics	4	--	--	4	4	60	--	--	--	60	15	15	10	40	--	40	100	**4**
			14	8	--	18	16	240	25	--	--	265	60	60	40	160	75	235	**500**	**18**

Th: Theory; P: Practical; T: Tutorial; O: Oral; P: Practical; O&P: Oral and Practical; TT1: Term Test 1; TT2: Term Test 2; TT3: Term Test 3; TT: Term Test; T/W: Term Work

Prepared by Checked by Head of the Department Principal

Honors in Robotics	**S.Y. B.Tech**	**Semester: III**
Program: Mechanical Engineering		
Course: Introduction to Robotics and Its Applications (DJS23MH2201)		

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
4. 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 and Its Applications (DJS23MH2201)		
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,	9

	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.	
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.	9
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, Interceptive sensors & Exteroceptive sensors, Sensor integration, calibrations & its performance, Applications of each sensor, A case study for sensory feedback design for a particular application.	10
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.	10
5	**Robot Controllers and 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)	9
6	**Robot Applications:** Industrial applications of robots, Medical, Household, Entertainment, Space, Underwater, Defence, 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.	9
	Total	56

Books Recommended:

Text-Books:

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

Reference Books:

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

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 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.

Expt.	Robotics Laboratory I (DJS23MH2251L)
	Study-Type Experiments (Theoretical and Conceptual Learning)
1.	Orientation to the laboratory course – Programming skills & concepts
2.	Study of Drive Systems and Motion Control
3.	Sensor Integration and Feedback Control Design
4.	Kinematic Analysis of Robotic Manipulators
5.	Robot Gripper Design and Application
	Simulation and Analysis Experiments (Python/ MATLAB/ Simulink, etc.)

6.	Program-1: Graphical simulation of a 3-axis planar articulated robot arm (PARA) (2D & 3D View)
7.	Program-2: Graphical simulation of 3-axis cylindrical coordinate robot arm & its work space of cylindrical robot (2D & 3D View)
8.	Program-3: Graphical representation of a 3-axis Rectangular Coordinate Robot arm (2D & 3D View)
9.	Program-4: Graphical representation of a 3-axis Polar Coordinate Robot arm (2D & 3D View)
10.	Program-5: Graphical representation of a 4-axis SCARA Robot arm (2D & 3D View)
11.	Program-6: Pick & place operation using a 3-axis planar articulated robot arm
12.	Program-7: Pick & place operation using a 4-axis SCARA Robot arm
13.	Program-8: Determination of horizontal & Vertical reach of cylindrical coordinate robot with graphical & numerical simulations.
14.	Program-9: Program to develop Screw Transformations (ST), threading of a screw & unthreading of a screw

8 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. Allen B. Downey, "Think Python: How to Think Like a Computer Scientist", 2nd Edition, Green Tea Press, 2015.

Web Resources:

1. https://nptel.ac.in/courses/106/106/106106182/
2. https://nptel.ac.in/courses/115/104/115104095/
3. https://www.edx.org/learn/python
4. https://www.coursera.org/courses?query=python

Course: Modelling and Design of Robotics (DJS23MH2301)

Pre-requisites:

1. Knowledge of basics of mechanics like kinematics
2. Knowledge of basics knowledge of mathematics like vector algebra
3. Knowledge of basics knowledge of mathematics like vector matrices

Objectives:

1. To impart knowledge of the fundamental concepts of robotics & its mathematical interpretations in 3- dimensional analysis.
2. Make the student to develop the direct kinematic & inverse kinematic model for successful robotic manipulation
3. Make the student to develop the inverse kinematic model for successful robotic manipulation to do a PNP operation.
4. To develop the student's knowledge in various robot structures to work effectively in its workspace.
5. Making the robotic system to follow a well-defined trajectory from source to destination during manipulation.

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

1. Demonstrate a clear understanding of the fundamental concepts of robotics, including the ability to mathematically interpret robotic motions in three-dimensional space.
2. Construct direct kinematic models and analyze them to describe the motion of robotic systems accurately.
3. Design and implement inverse kinematic models to achieve successful robotic manipulation for tasks such as pick-and-place (PNP) operations.
4. Evaluate and compare various robotic structures and configurations to optimize their performance within specified workspaces.
5. Design and implement robotic systems capable of following well-defined trajectories from source to destination during manipulation tasks.

Modelling and Design of Robots (DJS23MH2301)		
Unit	**Description**	**Duration**
1	**Modeling of robots**: An introduction (Kinematic & dynamical models), Design of Robots – An introduction (Kinematic & dynamical design), Mathematical Notations & Symbols, Coordinate Frames & their different types of Transformations with matrices, Coordinate Transformations, Rotations & Translations.	**8**
2	**Robot Direct / Forward Kinematics Modelling & Design**: Introduction to robot arm direct kinematics, Kinematic model, Kinematic parameters (Joint & Link parameters), General Link Coordinate Transformation matrix, Kinematic Parameter Table (KPT), DH Algorithm, Direct Kinematic model of 1-axis robot, Direct Kinematic model of 2-axis robot.	**9**
3	**Robot Inverse / Backward Kinematics Modelling & Design**: Introduction to robot	**9**

	inverse kinematics problems, Definition of IK, Inverse kinematic model, Tool Configuration Vector (TCV), Inverse Kinematic model of 1-axis robot, Inverse Kinematic model of 2-axis robot.	
4	**Robot Work Space Analysis Modelling & Design**: Work space, Definition, Work space envelope, Definition, Types of work envelopes, Types of work space envelopes, Joint space work envelope design, Total work envelope design, Dexterous work envelope design, Work space analysis of 1 axis robot, Work space analysis of 2 axis.	**8**
5	**Robot Trajectory Planning Modelling & Design**: Robot Path, Robot Trajectory, Shape of trajectory, Speed Distribution Functions (SDF), Types of robot motions, Pick & Place trajectory design, Point to Point trajectory design, Interpolated trajectory design, Piecewise linear interpolated trajectory design, Cubic polynomial path & trajectory.	**8**
	Total	**42**

Books Recommended:

Text Books:

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

Reference Books:

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

Pre-requisites:

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

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 solve direct kinematics problems.
4. To know the basic programming skills to develop simulations for solving inverse solution problems.
5. To know the basic programming skills to develop simulations for finding the routes form source to destination by searching paths in the 2D environment.
6. To know the basic programming skills to develop simulations for simulating the different types of robot work envelopes.

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

1. Design and simulate the workspace of a robotic arm, visualizing its reach and operational limits in a 3D environment.
2. Program and execute pick-and-place operations in a simulated environment, ensuring smooth and accurate object handling.
3. Demonstrate the ability to simulate and solve direct kinematics problems, determining the end-effector position from given joint parameters.
4. Compute inverse kinematics, enabling the determination of joint configurations for specific end-effector positions
5. Simulate robotic path planning in 2D environments and visualizing various robot work envelopes for optimized task execution.
6. Design and implement simulations that effectively utilize path-planning algorithms to identify optimal routes from a source to a destination in a 2D environment, ensuring obstacle avoidance and efficient navigation.

Robotics Laboratory II (DJS23MH2301L)	
Exp.	**Study-Type Experiments (Theoretical and Conceptual Learning)**
1	Program to study the work space of a 3-axis Cylindrical Coordinate Articulated robot arm
2	Program to study the work space of a 3-axis Planar Articulated robot arm
3	Program to study the work space of a 3-axis Rectangular Articulated robot arm
4	Program to study the work space of a 3-axis Polar-Spherical Coordinate Articulated robot arm
5	Program to study the work space of a 3-axis SCARA robot arm
	Simulation and Analysis Experiments (Python/ MATLAB/ Simulink, etc.)

1	Work-space analysis of a 4-axis SCARA robot arm
2	Direct Kinematic Analysis of a 4-axis SCARA robot arm
3	Inverse Kinematic Analysis of a 4-axis SCARA robot arm
4	Graphical simulation of a cylindrical coordinate robot arm (2D & 3D View)
5	Graphical simulation of any one type of robot arm (2D & 3D View), either a rectangular or cylindrical or polar or articulated robot arm.
6	Work Space Envelope of 3-axis Cartesian coordinate robot
7	Work Space Envelope of 3-axis Polar coordinate robot.
8	Robot Path Planning using General Voronoi Diagram (GVD) methods – generation of path from source to goal (2D)
9	Trajectory-planning (linear interpolation) from source to goal.
10	Development of a program to show Bounded Deviation Algorithm for achieving straight line motion in the TCS.

A minimum of 8 experiments from the above-suggested list or any other experiment based on syllabus may be included, which would help the learner to apply the concept learnt. A case study or seminar report relevant to the topics may be included, which would help the learner to apply the concept learnt.

Books Recommended:

Text Books:

- T. C. Manjunath, "Fundamentals of Robotics", Nandu Publishers, 5th Edn., India, 2005.
- Kenneth Lambert, "Fundamentals of Python: Data Structures", Cengage Learning PTR (2013).
- Gowrishankar S, Veena A, "Introduction to Python Programming", 1st Edition, CRC Press/ Taylor & Francis, 2018. ISBN-13: 978-0815394372.
- Allen B. Downey, "Think Python: How to Think Like a Computer Scientist", 2nd Edition, Green Tea Press, 2015.

Web Resources

1. https://nptel.ac.in/courses/106/106/106106182/
2. https://nptel.ac.in/courses/115/104/115104095/
3. https://www.edx.org/learn/python
4. https://www.coursera.org/courses?query=python

Pre-requisites:

1. Knowledge of basics of mechanics like kinematics
2. Knowledge of basics knowledge of mathematics like vector algebra
3. Knowledge of basics knowledge of mathematics like matrix theory & algebra
4. Knowledge of integration, differentiation & numerical methods

Objectives:

1. To impart knowledge of the fundamental concepts of machine-to-machine interactions.
2. Make the student to develop the knowledge in flexible manufacturing systems.
3. To develop the student's knowledge in developing various types of robot structures w.r.t. handicapped persons.
4. Making the robotic system to know the behaviour of robots in the external environments.
5. Objective of this module is to introduce the basic principles, techniques, state of art techniques in the development of microbots & nanobots. 6. Learn the different replicas of humans w.r.t. the 2-legged walking mechanism and their working natures.

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

1. Demonstrate an understanding of the fundamental principles and technologies underlying machine-to-machine interactions in robotic systems.
2. Analyze and develop strategies for implementing flexible manufacturing systems to optimize production efficiency and adaptability.
3. Design and develop robotic structures tailored to assist handicapped individuals, addressing diverse needs and functionalities.
4. Evaluate and model the behaviour of robotic systems in external and dynamic environments, ensuring adaptability and precision in diverse scenarios.
5. Apply advanced principles to the design and functioning of microbots and nanobots, as well as develop and analyze robotic replicas of humans, focusing on two-legged walking mechanisms and their working dynamics.

Advance Robotics (DJS23MH2351)		
Unit	**Description**	**Duration**
1	Large-scale machine-to-machine communication (M2M), Factory automation, Industry 4.0, Automated robotic drones, Healthcare robots, Autonomous cars, Robots in educational sectors, Robotics in public & national security, Speaking robots, Surveillance machines, Cybernetics, Human-robot interactions, micro aerial vehicles.	8
2	FMS definition and classification of flexible manufacturing systems, automated production cycle, Need of flexibility, Concept of flexibility, Types of flexibilities and its measurement, FMS Equipments, Why FMS, Factors responsible for the growth of FMS, FMS types and applications, Economic justification for FMS.	9

3	Cognitive robotics, Robotic exoskeletons, Artificial Legs & Limbs, Remote Surgery, Orthesis, Telethesis, Surgical robots doing surgery, Robots working together, Interactive robotics, Co-operative robotics, Farming robots for agricultural applications, IoT & Robotics for different applications	9
4	Interaction of manipulator with the environment, Flexibots & Flexible Robotics, CAD CAM & CIM, Human centered robotics, complex robotic systems, Soccer robotics, Advanced perceptions for intelligent robots, Composite Materials for Robotic Applications, Case study.	8
5	Microbots & Nanobots, Applications, Surgical Applications in Medicine, Modelling of a typical Microbots & Nanobots, Parameters for nanorobot design, Simulation tools for designing nanorobots, Cancer treatment cure using nanobots, Corona detection using nanorobots, Micro-surgical tools, Drug delivery pellets, Nano sensors.	8
	Total	42

Books Recommended:

Textbooks:

- T. C. Manjunath, "Fundamentals of Robotics", Nandu Publishers, 5th Edn., India, 2005.
- K.S. Fu, R.C. Gonzalez, C.S.G. Lee, "Robotics: Control, Sensing, Vision & Intelligence", McGraw-Hill, USA, 5th Edition, 2010.
- T. C. Manjunath, "Fast Track to Robotics", Nandu Publishers, 2nd Edn., Mumbai, Maharashtra, India, 2005.
- Robin R. Murphy, "Introduction to AI and Robotics", MIT Press, Second Edition, 648 pp., Oct. 2019.
- Robert Schilling, "Fundamentals of Robotics – Analysis & Controls", Prentice Hall Inc, India.

Reference Books:

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

Honors in Robotics	**T.Y. B.Tech**	**Semester: VI**
Program: Mechanical Engineering		
Course: Robotics Laboratory III (DJS23MH2351L)		

Pre-requisite:

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

Objectives:

1. To understand the principles and applications of machine-to-machine (M2M) communication in Industry 5.0 and its role in enhancing industrial automation and efficiency.
2. To analyze the concept of flexibility in Flexible Manufacturing Systems (FMS) and explore its impact on adaptability and efficiency in modern production systems.
3. To study the integration of sensors, materials, and technologies in advanced robotics, with a focus on healthcare robotics and micro/nanobots for specialized applications.
4. To know the basic programming skills to develop simulations for solving inverse solution problems.
5. To know the basic programming skills to develop simulations for finding the routes form source to destination by searching paths in the 2D environment.
6. To know the basic programming skills to develop simulations for simulating the different types of robot work envelopes.

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

1. Evaluate the significance of M2M communication in Industry 4.0 and propose its applications for improving real-time connectivity and decision-making in smart factories.
2. Gain insights into the classification and measurement of flexibility in FMS, understanding its role in reducing production time and increasing customization capabilities.
3. Develop a theoretical understanding of sensor integration, material properties, and design principles in advanced robotic systems, including healthcare robotics and nanobots, to address practical challenges and innovations in the field.
4. Create simulations to compute inverse kinematics, enabling the determination of joint configurations for specific end-effector positions
5. Develop simulations for robotic path planning in 2D environments and visualizing various robot work envelopes for optimized task execution.
6. Design and implement simulations that effectively utilize path-planning algorithms to identify optimal routes from a source to a destination in a 2D environment, ensuring obstacle avoidance and efficient navigation.

Robotics Laboratory III (DJS23MH2351L)	
Exp.	**Suggested experiments**
	Study-Type Experiments (Theoretical and Conceptual Learning)
1	Comparative Study of M2M Communication in Industry 5.0
2	Analysis of Flexibility in Flexible Manufacturing Systems (FMS)

3	Study of Sensors and Materials in Advanced Robotics
4	Case Study on Healthcare Robotics
5	Theoretical Design and Analysis of Microbots and Nanobots
	Simulation and Analysis Experiments (Python/ MATLAB/ Simulink, etc.)
1	To develop the work-space model, trajectory planning & a pick-place operation of a four axis SCARA robot arm.
2	To do the DK & IK of a four axis SCARA robot arm.
3	To develop the work-space model, trajectory planning & a pick-place operation of a three-axis planar articulated robot arm.
4	To do the DK & IK of a three-axis planar articulated robot arm.
5	To develop the work-space model, trajectory planning & a pick-place operation of a two-axis planar articulated robot arm.
6	To do the DK & IK of a two-axis planar articulated robot arm.
7	Graphical simulation of any one type of robot arm (2D & 3D View), either a rectangular or cylindrical or polar or articulated robot arm.
8	Design a Robot Path Planning, i.e., the generation of path from source to goal (2D) using configuration space method, General Voronoi Method, Dijkstra's methods.
9	Design a robotic path, i.e., do the Interpolation using parabolic blends & Trajectory-planning (linear interpolation) from source to goal for the movement of the robot.
10	Write a program to find the coordinates of the point p w.r.t. F frame given the coordinates of the point p w.r.t. M frame with both rotations & translations, i.e., both.
11	Write a program to develop the graphical display of the link coordinate diagram (LCD) of a 2-axis PARA, 3-axis PARA & a 4-axis SCARA robot arm.
12	Develop a program to develop Screw Transformations (ST) & to show the navigation through obstacles using Shortest Path from source to goal along with the Bounded Deviation Algorithm for achieving straight line motion in the TCS.

A minimum of six experiments from the above-suggested list or any other experiment based on syllabus may be included, which would help the learner to apply the concept learnt. A case study or seminar report relevant to the topics may be included, which would help the learner to apply the concept learnt.

Books Recommended:

Text Books:

- T. C. Manjunath, "Fundamentals of Robotics", Nandu Publishers, 5th Edn., India, 2005.
- Kenneth Lambert, "Fundamentals of Python: Data Structures", Cengage Learning PTR (2013).
- Gowrishankar S, Veena A, "Introduction to Python Programming", 1st Edition, CRC Press/Taylor & Francis, 2018. ISBN-13: 978-0815394372.
- Allen B. Downey, "Think Python: How to Think Like a Computer Scientist", 2nd Edition, Green Tea Press, 2015.

Web Resources:

1. https://nptel.ac.in/courses/106/106/106106182/
2. https://nptel.ac.in/courses/115/104/115104095/

Pre-requisites:
1. Knowledge of basics of image processing
2. Some basic ideas about the cameras & its operations
3. Knowledge of basics knowledge of AI & ML
4. Knowledge of logical thinking for solving simple problems.

Objectives:
1. To impart knowledge of the use of Artificial Intelligence in solving robotic problems.
2. Make the student understand different types of machine learning approaches in robotics.
3. To develop the different types of motion planning techniques to find the paths in the space.
4. Making the robotic system know how to solve the given task using task planners.
5. To introduce the student to know the fundamental concepts lying under the robotic vision.

Outcomes: On completion of the course, the learner will be able to:
1. Demonstrate the ability to utilize Artificial Intelligence techniques to address and solve complex robotic problems effectively.
2. Analyze and differentiate between various machine learning approaches and apply them in the context of robotics for enhanced decision-making and autonomy.
3. Design and implement motion planning algorithms to determine efficient paths for robotic systems in three-dimensional space.
4. Apply task planning methodologies to enable robotic systems to autonomously solve given tasks with precision and adaptability.
5. Apply knowledge of the foundational principles of robotic vision, enabling robots to interpret and interact with their environments.

AI and ML for Robotics (DJS23MH2451)		
Unit	**Description**	**Duration**
1	**AI in Robotics:** Human Intelligence, Artificial Intelligence, Definition, Types of Artificial Intelligence, Goals of AI, Tenets of AI, Applications of AI, Problem representation in AI, Knowledge representation & Reasoning, Intelligent Agents, Swarm Intelligence, Distributed Intelligence, Imitation learning, Multi agent learning, Project based learning, Artificial Neural Networks, Convolution Neural Networks, Recurrent Neural Networks, Natural Language Processing, Speech Recognition, Cognitive Sciences, Expert Systems, AI based programming languages, Future research trends in AI, A case study to solve a typical robotic problem using AI, Problems.	11
2	**Machine Learning in Robotics:** Supervised learning, Unsupervised learning, Reinforcement learning, Deep learning, Automated Machine Learning, Convergence of IoT & ML, ML algorithms, Classification, Clustering, Prediction, Motion Heuristics, Types, State space search techniques, Graph theory techniques, AND/OR	12

	graphs, Breadth first search techniques, Hill Climbing, Best first search techniques, Semantic networks and petri-nets, Dijkstra's algorithm, Wide Path Motion Heuristics Method of Path Planning, Sophisticated Motion Heuristics, A case study to solve a typical robotic problem using ML, Problems.	
3	**AI based Robot Task Planning - 1:** Task Planners, Automatic Program Generators, Uncertainty – Introduction, Illustration of Uncertainty Using an Example, Robot Motion Planning Techniques, Methods, Gross Motion Planning, Configuration space method & the GVD method, Fine motion planning, Guarded & Compliant motion, Grasp planning, Safe grasp planning, Secured grasp planning, Reachable grasp planning.	11
4	**AI based Robot Task Planning - 2 :** Computation of Sector Boundaries, Peg in a Hole Problem, Simulation of Planar Motion, Polygon Penetration Algorithm, A Task Planning Simulation Problem – Introduction, Source and Goal Scenes, Task Planning Sub-Problems, Scene analysis & Part ordering, Autonomous vehicles, Application to Chandrayan, Mars Rovers, Problems	11
5	**Introduction to Robotic Vision:** Features of Robotic Vision, Image Representation & Analysis, Digitization of Images, Sampling - Quantization - Coding of Images, Digital, Black-White & Gray Scale Image, Template Matching, Performance Index, Normalized Cross-Correlation, Comparison, Explanation Using an Example, Polyhedral Objects (Edge Detection and Corner Point Detection Algorithms), Selection of the Edge Threshold, Corner Point Detection, Principle of CP Detection & its Algorithm, Perspective & Inverse Perspective Transformations, Camera Calibration, Illumination Techniques, Case study of Robot Vision in Engineering-1, Problems.	11
	Total	**56**

Books Recommended:

Text books:

- Pavithra, T. C. Manjunath, et.al., "Playing Smart – Artificial Intelligence", Notion Publishers, India, 2022
- Stuart J. Russell and Peter Norvig, "Artificial Intelligence a Modern Approach", Second Edition, Pearson Education.
- Elaine Rich and Kevin Knight, "Artificial Intelligence", Third Edition, Tata McGraw-Hill Education Pvt. Ltd., 2008.
- George F Luger "Artificial Intelligence" Low Price Edition, Pearson Education, Fourth edition.
- Deepak Khemani, "A first course in Artificial Intelligence", Mc Graw Hill.

Reference Books:

- Robin R. Murphy, "Introduction to AI and Robotics", MIT Press, Second Edition,
- T. C. Manjunath, "Fundamentals of Robotics", Nandu Publishers, 5th Edn., India, 2005.
- T. C. Manjunath, "Fast Track to Robotics", Nandu Publishers, 2nd Edn., Mumbai, Maharashtra, India, 2005.
- Robert Schilling, "Fundamentals of Robotics: Analysis & Controls", Prentice Hall Inc, India.
- Pavithra, et.al., "Machine Learning for Web Applications", Notion Publishers, India, 2021

- Pavithra, et.al., "Computer Vision Techniques", Notion Publishers, India, 2022
- Pavithra, et.al., "Deep Learning & its Techniques", Notion Publishers, India, 2021
- T. C. Manjunath, et.al., "Computational Intelligence", Notion Publishers, India, 2021