NITTE (Deemed to be University) | NMAM INSTITUTE OF TECHNOLOGY

Scheme & Syllabus for Minor Degree in

Robot Technology

Offered by

B. Tech. (Robotics & Artificial Intelligence)

DEPARTMENT OF ROBOTICS & ARTIFICIAL INTELLIGENCE

2023-24

REGULATIONS FOR OBTAINING A MINOR DEGREE

1.1.1 Minor Degree

i. Students have to earn a min of 18 additional credits from the courses focused on discipline other than his/her major program discipline entitles a student to get a 'Minor' credential.

ii. Students have to pay additional fees for all the courses registered for 'Minor'.

iii. Students with a minimum of 5.0 CGPA and no backlog at the end of the 3rd semester will only qualify for registering for the course under the 'Minor' credential.

iv. Students shall register for 'Minor' degree courses from the 4th semester onwards.

v. All Departments will offer 'Minors' in their varied disciplines and will prescribe what set of courses and/or projects is necessary for earning a minor in that discipline.

vi. Students should register for additional courses and plan to take courses that are prescribed under that 'Minors' list as per 'pre-requisite' courses to earn the 'Minor' credential

vii. If any of the courses listed under the 'minor' option is a course listed under his/her curriculum as PCC then the student cannot opt for that 'Minor', since all minor courses need to be earned as additional courses to his/her program curriculum and depts decision is final and binding

viii. Students who wish to acquire a 'Minor' can register for 'Minor' courses along with their regular semester course registration.

ix. Also, the student should have a minimum **CGPA of 5.0 in the 'Minor' courses registered to become eligible for the Minor credentia**l. This fact will also be reflected in the Consolidated Grade Sheet under a separate heading 'Minor in (specialization)'.

x. If the course requirements for a particular 'Minor' are met within the prescribed minimum time limit of the program, the minor will be awarded along with the degree, and it will be mentioned in the **Degree Certificate as "Bachelor of Technology in (Major discipline) with Minor in (specialization)."**

xi. In case a student withdraws from the 'Minor', the 'Minor' courses completed, will be converted to 'Audit' courses and indicated accordingly in subsequent Grade Sheets and Consolidated Grade Sheets.

xii. The grades obtained in the courses credited towards the 'Minor' award are not counted and shall not influence the GPA/ CGPA of the program the student has registered for.

1.1.2 Additional norms for Minors

i. Students shall register for additional courses to earn Minors in consultation with their Class Advisor from the list of courses suggested by the DUGC.

ii. DUGC may recommend Massive Open Online Courses (MOOCs)/SWAYAM/NPTEL courses to students who wish to register for Minors after justifying and establishing the equivalence of the curriculum. The decision of DUGC should be communicated to the Dean of Academics and Controller of Examinations for seeking approval.

iii. A maximum of 40% credits prescribed for Minors may be earned through MOOCs/SWAYAM/NPTEL

iv. Students may choose to take up additional course work, from the MOOCs courses list suggested by various departments (which can be from SWAYAM/NPTEL) with proctored examinations as approved by the University and complete the same before the last working day of the VIII semester with a final score (online assignments: 25 % + Proctored examination: 75 %) leading to the following certificates: Completed the course (40-59)– ELITE (60 to 75 %) or ELITE + SILVER (76 to 89 %) or ELITE + GOLD (≥ 90 %)

v. In case, in MOOCs (ex: Coursera), there is no proctored examination, the University will conduct a SEE as deemed to be fit for the award of Credits

vi. The Credit equivalence for online courses shall be as follows –

- 4 weeks of online course duration – 1 credit (approx. 13-14 hours)
- 8 weeks of online course duration – 2 credits (approx. 26-28 hours) and
- 12 weeks of online course duration – 3 credits (approx. 39-42 Hours)

Minor Degree in Robot Technology

Sl. No.	Course and Course code		Course Title	Teaching Dept.	Teaching Hours/Week				Examination				Credits
					Theory Lecture	Tutorial	Practical/ Drawing	PBL	Duration in hr	CIE Marks	SEE Marks	Total Marks	
					L	T	P	J					
1.	IPCC	RI2009-1	Fundamentals of Robotics	RI	3	0	2	0	03	50	50	100	04
2.	PCC	RI2606-1	Automation using PLC Lab	RI	0	0	2	0	03	50	50	100	01
3.	IPCC	RI2010-1	Robot Motion Analysis	RI	3	0	2	0	03	50	50	100	04
4.	PCC	RI2112-1	Wheeled Mobile Robots	RI	2	0	2	0	03	50	50	100	03
5.	PCC	RI2607-1	Robot Programming Lab	RI	0	0	2	0	03	50	50	100	01
6.	IPCC	RI2011-1	Micro Aerial Vehicles	RI	3	0	2	0	03	50	50	100	04
7.	PCC	RI2608-1	Control System Lab for Robotics	RI	0	0	2	0	03	50	50	100	01
TOTAL					**11**	**0**	**14**	**-**	**21**	**350**	**350**	**700**	**18**

Fundamentals of Robotics

Course Code:	**RI2009-1**	**Course Type:**	**IPCC**
Teaching Hours/Week (L: T: P: S):	**(3:0:2:0)**	**Credits:**	**04**
Total Teaching Hours:	**40+0+26**	**CIE + SEE Marks:**	**50+50**
Prerequisite	**MA1001-1**		

Teaching Department: Robotics & AI Engineering

Course Objectives:

1.	Familiarize with the Anatomy of robot and 3D homogeneous transformations.
2.	To study the different sensors and actuators used in robotics
3.	Study the application of robot technology in wheeled mobile robots, medical robots, unmanned aerial vehicles, service robots, underwater robots
4.	To study the linear and rotary motion control using sensors and actuators
5.	To understand the robot programming and 3D homogeneous transformations applied to robotics

Unit-I

Definitions- Robots, Robotics; Types of Robots- Manipulators, Mobile Robots-wheeled & Legged Robots, Aerial Robots; Anatomy of a robotic manipulator-links, joints, actuators, sensors, controller; open kinematic vs closed kinematic chain; degrees of freedom; Robot considerations for an application- number of axes, work volume, capacity & speed, stroke &reach, Repeatability, Precision and Accuracy, Operating environment, point to point control or continuous path control. **Robotic configurations and end effectors, Human factors in Robotics.**

Robot configurations-PPP, RPP, RRP, RRR; features of SCARA, PUMA Robots; Classification of robots based on motion control methods and drive technologies; 3R wrist.

Classification of End effectors - mechanical grippers, special tools, Magnetic grippers, Vacuum grippers, adhesive grippers, Active and passive grippers, selection, and design considerations of grippers in robot.

3D Homogeneous transformations: 3D homogeneous rotation Matrix, 3D Homogeneous translation Matrix, Composite rotation Matrix, Rotation Matrix about an Arbitrary Axis, Application of 3D homogeneous transformations in robotics, numerical Problems **15 Hours**

Unit- II

Sensors for Robots

Sensor classification- Proprioceptive and Exteroceptive sensors, active and passive sensors, characteristics of sensors, touch, force, range, proximity, vision sensors. **Internal sensors**-Linear and rotary position sensors, velocity sensors, acceleration sensors, Force sensors; **External sensors**-contact type, noncontact type; Vision - Elements of vision sensor, image acquisition, image processing; Selection of sensors.

Actuators for Robots: classification-Electric, Hydraulic, Pneumatic actuators; their advantages and disadvantages; Electric actuators- Stepper motors, DC motors, DC servo motors and their drivers, AC motors, Linear actuators, selection of motors; Hydraulic actuators- Components and typical circuit, advantages, and disadvantages; Pneumatic Actuators- Components and typical circuit, advantages and disadvantages. **15 Hours**

Unit-III

Application of Robot: Industrial Robots, aerial robots-Fixed wing unmanned aerial vehicle, helicopters, Multi rotor UAV, Flapping wing/Bio inspired UAV, wheeled mobile robots, smarm robots, Legged robots, medical/healthcare robots-Surgical Robot, Exoskeleton robot, Rehabilitation robot, hospital robot, space robots, service robots, Underwater and floating robots, Military Robots.

10 Hours

Suggested List of Experiments

1. Experiments on:
   i. Linear and rotary displacement sensors
   ii. Proximity Sensors
   iii. Range Sensors-Ultrasonic, IR and laser range sensors
   iv. Force and Torque sensors
   v. Vision Sensors
2. Experiments on:
   i. Stepper motor controlled linear slide
   ii. Servo motor controlled linear slide
3. Experiments on sequence control using hydraulic and pneumatic circuits
4. Experiments on Quadcopter micro air vehicle
5. Experiments on 3D Homogeneous transformations using 3D Coordinate frame models
6. Experiments on Robot for demonstrating.
   i. Pick and Place operation
   ii. Drawing Artwork
   iii. 3D Printing
   iv. Accept/Reject part based on output from machine vision system
7. Experiments on Differential Wheel Mobile robot
8. Experiments on Meccanum Wheel mobile robot **26 Hours**

Course Outcomes: At the end of the course student will be able to

1.	Define, describe, and classify the different types of robots, and identify the different components of a robotic manipulator, such as links, joints, actuators, sensors, and controllers.
2.	Classify, select, and design end effectors for robots, and apply 3D homogeneous transformations to robot motion.
3.	Identify the different types of sensors and their applications, and use them to collect data for robotics applications
4.	Identify the different types of actuators and their applications and use them to control the motion of robots.
5.	Gain a comprehensive understanding of the diverse applications of robots, including industrial robots, aerial robots, wheeled mobile robots, legged robots, medical/healthcare robots, space robots, service robots, underwater and floating robots, and military robots, and their respective functions, advantages, and impact in various domains.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→	1	2	3	4	5	6	7	8	9	10	11	12	PSO↓		
↓ Course Outcomes													1	2	3
RI2009-1.1	3	1	-	-	-	-	-	-	-	-	-	-	2	-	1
RI2009-1.2	3	1	-	-	-	-	-	-	-	-	-	-	2	-	-
RI2009-1.3	3	1	-	-	-	-	-	-	-	-	-	-	2	1	-
RI2009-1.4	3	1	-	-	-	-	-	-	-	-	-	-	2	1	-
RI2009-1.5	2	1	-	-	-	-	-	-	-	-	-	-	2	-	2

1: Low 2: Medium 3: High

TEXTBOOKS:

1.	*"Robotics and Control"* **R. K. Mittal, I. J. Nagrath**, Tata-McGraw-Hill Publications, 2007
2.	*"Robotics: Control, Sensing, Vision, Intelligence"* **Fu K. S., Gonzelez R. C., Lee C. S. G.**, McGraw Hill Book Co., 2008

REFERENCE BOOKS

1.	**"Advances in Rehabilitation Robotics", Z. Zenn BienDimitar Stefanov**, Springer Publications, Year-2004, ISBN: 978-3-540-44396-4.
2.	**"Army of None: Autonomous Weapons and the Future of War", Paul Scharre**, Publisher: W. W. Norton & Company; 1st edition, Year- 2018, ISBN-978-0393608984.
3.	**"Design of Dynamic Legged Robots", Sangbae Kim, Patrick M. Wensing**, Publisher: Now Foundations and Trends, Year-2017, ISBN: 9781680832570.
4.	**"Introduction to Multicopter Design and Control", Quan Quan,** Springer Publications, Year-2017 ISBN: 978-981-10-3382-7.
5.	**"Introduction to the Mechanics of Space Robots", Giancarlo Genta**, Springer Publications, Year-2012, ISBN: 978-94-007-3785-3.
6.	**"Service Robots and Robotics: Design and Application", Marco Ceccarelli**, Published by Engineering Science Reference, Year-2012, ISBN: 9781466602915.
7.	**"Small Unmanned Fixed-Wing Aircraft Design", Andrew J. Keane, András Sóbester, James P. Scanlan,** Wiley Publications Year-2017, ISBN:9781119406303.
8.	**"Surgical Robotics: Systems Applications and Visions", Jacob Rosen, Blake Hannaford, Richard M. Satava,** Springer Publication, Year-2011, ISBN:978-1-4419-1126-1.
9.	**"Swarm Robotics: A Formal Approach", Heiko Hamann,** Springer Publication, Year-2018, ISBN: 978-3-319-89279-5.
10.	**"Underwater Robots Motion and Force Control of Vehicle-Manipulator Systems", Gianluca Antonelli,** Springer Publication, Year-2006, ISBN: 978-3-642-06859-1.
11.	**"Wearable Exoskeleton Systems Design, control and applications", Shaoping Bai, Gurvinder S. Virk, Thomas G. Sugar,** Publisher: The Institution of Engineering and Technology, Year-2018, ISBN: 978-1785613029.
12.	**"Wheeled Mobile Robotics: From Fundamentals Towards Autonomous Systems", Gregor Klancar , Andrej Zdesar, Saso Blazic, Igor Skrjanc,** Publisher: Butterworth-Heinemann, Year-2017, ISBN: 978-0128042045.

E Books / MOOCs/ NPTEL

1.	Introduction to Robotics https://ocw.mit.edu/courses/mechanical-engineering/2-12-introduction-to-robotics-fall-2005/syllabus/
2.	INTRODUCTION TO ROBOTICS https://nptel.ac.in/courses/107/106/107106090/
3.	Robotics Specialization https://www.coursera.org/specializations/robotics

Automation using PLC

Course Code:	**RI2606-1**	**Course Type**	**PCC Lab**
Teaching Hours/Week (L: T: P: S)	**0:0:2:0**	**Credits**	**02**
Total Teaching Hours	**25**	**CIE + SEE Marks**	**50+50**
Prerequisite	**RI2009-1**		

Teaching Department: Robotics and Artificial Intelligence

Course Objectives:

1.	To control Stepper motor with PLC program and DC motor with PLC program
2.	To control AC motor with PLC program and To understand HMI programing and interfacing.

UNIT-I

Stepper Motor Control using PLC	**05 Hours**

Understanding the construction and lead identification of stepper motors, rating checking stepper motor driver selection and connection.

DC Motor Control using PLC	**05 Hours**

construction and working of a DC motor, meaning of pulse width modulation, understanding relationship between duty cycle and speed of the motor. Establishing a relationship between duty cycle and speed experimentally.

AC Motor Control using PLC	**05 Hours**

Construction and working of AC induction motors, its different types and interfacing AC motors and PLC.

UNIT-II

HMI programming and Interfacing	**05 Hours**

Need for human machine interfacing, creation of an interface for controlling an industrial machine linking of control switches and data registers to the ladder instruction through HMI tools.

Mini Project	**05 Hours**

Application of PLC control and HMI to and actual machine, testing the correctness of the instruction, and reiterating after improvements.

Course Outcomes: At the end of the course student will be able to

1.	Control of Stepper motor, DC motor, AC motor with PLC
2.	Operate various devices using HMI through programing and interfacing, Interface PLC circuit, write programs in PLC to control motion in different motors and use HMI for easier operations of machines.

Course Outcomes Mapping with Program Outcomes & PSO															
Program Outcomes→	1	2	3	4	5	6	7	8	9	10	11	12	**PSO↓**		
↓ Course Outcomes													1	2	3
RI2606-1.1	1	2	1	-	-	-	-	-	-	-	-	1	3	3	3
RI2606-1.2	2	2	1	-	-	-	-	-	-	-	-	1	3	3	3

1: Low 2: Medium 3: High

TEXTBOOKS:

1. Control of electrical machines by S.K.Bhattacharya Birjindersingh, New Age International.
2. Robotics and Industrial Automation by R.K. Rajput, S. CHAND PUBLISHING.
3. Introduction to PLC by Gary Dunning, Cengage Learning.
4. PLC, Principles and Applications by John W. Webb and Ronald A. Reis

Web links and Video Lectures (e-Resources):

1. https://www.udemy.com/course/siemens-s71200-motion-control-training/
https://www.udemy.com/course/plc-programming-100/

Robot Motion Analysis

Course Code:	**RI2010-1**	**Course Type:**	**IPCC**
Teaching Hours/Week (L: T: P: S):	**(3:0:2:0)**	**Credits:**	**04**
Total Teaching Hours:	**50**	**CIE + SEE Marks:**	**50+50**
Prerequisite	**RI2009-1**		

Teaching Department: Robotics and Artificial Intelligence

Course Objectives:

1. To study the direct kinematics solutions for the different robot configurations
2. To study the Inverse kinematics solutions for the different robot configurations
3. To study the Jacobian Matrix for the different robot configurations
4. To identify the singular configurations for different robot configurations
5. To study the dynamic equation of motion and trajectory planning of a robot

UNIT-I

Direct Kinematics and Inverse kinematics — **15 Hours**

Links joints and their parameters, Kinematic Modeling of the manipulator, Denavit – Hartenberg notation, Kinematic relationship between adjacent links, Manipulator transformation matrix, Problems, Manipulator workspace, Solvability of inverse kinematic model, Existence of solution, Multiple solutions, Solution technique, Closed form solution, Guidelines to obtain closed form solutions, Problems.

UNIT-II

Manipulator Differential Motion and Statics — **15 Hours**

Linear and angular velocity of rigid body, Linear velocity, Angular velocity, Linear velocity due to angular motion, Combined linear and angular motion, Relationship between transformation matrix and angular velocity, Mapping velocity vector, Velocity propagation of a link, Angular velocity of a link, Manipulator Jacobian, Jacobian computation, The prismatic joint Jacobian, The rotary joint Jacobian, Jacobian inverse, Jacobian singularity, Computation of singularities, Wrist singularities, Arm singularities and singular configurations.	
UNIT-III	
Robot Dynamics	**05 Hours**
Lagrangian mechanics, Two degree of freedom manipulator – dynamic model, Lagrange – Euler formulation, Velocity of a point on the manipulator, The inertia tensor, the kinetic energy, The potential energy, Equation of motion, The LE dynamic model algorithm, Derivation of Dynamic equation of motion for 2DOF robot configuration.	
Robot Trajectory Planning and Control	**04 Hours**
Definitions and planning tasks, Terminology, joint space techniques, Use of a p- Degree polynomial as interpolation function, Cubical polynomial trajectories, Linear function with parabolic blends, Cartesian space techniques, A straight –line path, A circular path, Position path, Orientation path, Joint-space versus Cartesian space, trajectory planning, problems.	

Suggested List of Experiments

1.	Experiments on direct kinematics using pipe models of 3R, SCARA, RPY robots
2.	Experiments on inverse kinematics using pipe models of 3R, SCARA, RPY robots
3.	Experiments on Linear joint Jacobian
4.	Experiments on Rotary joint Jacobian
5.	Experiments on Estimation of Jacobian for (a) 2R robot (b) 3R robot (c) RPY wrist
6.	Experiments on Robot Singularities for (a) 2R robot (b) 3R robot (c) RPY wrist
7.	Experiments on simulation of cubic polynomial trajectory
8.	Experiments on simulation of trapezoidal velocity trajectory
9.	Dynamic simulation of 2R robot

Course Outcomes: At the end of the course student will be able to

1.	Calculate the direct kinematic solution for a given robot configuration
2.	Calculate the inverse kinematic solution for given robot configuration
3.	Calculate the Jacobian matrix for the given robot configuration
4.	Identify the singular configurations for the given robot configuration
5.	Calculate the dynamic equation of motion and to perform the trajectory planning for the given robot configuration

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→	1	2	3	4	5	6	7	8	9	10	11	12	PSO↓

↓ Course Outcomes													1	2	3
RI2010-1.1	3	2	1	1	1	-	-	-	-	-	-	-	3	2	-
RI2010-1.2	3	2	1	1	1	-	-	-	-	-	-	-	3	2	-
RI2010-1.3	3	2	1	1	1	-	-	-	-	-	-	-	3	2	-
RI2010-1.4	3	2	1	1	1	-	-	-	-	-	-	-	3	2	-
RI2010-1.5	3	3	2	1	1	-	-	-	-	-	-	-	3	2	-

1: Low 2: Medium 3: High

TEXTBOOKS:

1.	Robotics and Control, R K Mithal and I J Nagrath , McGraw Hill
2.	Fu, K., Gonzalez, R. and Lee, C. S. G., Robotics: Control, Sensing, Vision and Intelligence, McGraw- Hill, 2008
3.	Introduction to Robotic Analysis - Niku, S.B., Systems, Applications, Pearson Education, 2008.

REFERENCE BOOKS:

1.	Introduction to Robotics: Mechanics and Control- 2nd Edition - Craig, J. J., Addison-Welsey, 2nd Edition1989.
2.	Fundamentals of Robotics, Analysis and Control- Schilling R. J., PHI, 2006.

E Books / MOOCs/ NPTEL

1.	https://onlinecourses.nptel.ac.in/noc20_me53/preview
2.	https://www.classcentral.com/course/swayam-mechanics-and-control-of-robotic-manipulators-43637
3.	http://vlabs.iitkgp.ac.in/mr/#

Wheeled Mobile Robots

Course Code:	**RI2112-1**	**Course Type:**	**PCC**
Teaching Hours/Week (L: T: P: S):	**(2:0:2:0)**	**Credits:**	**03**
Total Teaching Hours:	**40**	**CIE + SEE Marks:**	**50+50**
Prerequisite	**RI2009-1**		

Course Learning Objectives:

This Course will enable students to:

1. Introduce students to the fundamental concepts of mobile robotics, including various types of mobile robots, their key components, locomotion systems, and wheel configurations.
2. Teach students how to develop kinematic models for holonomic and nonholonomic mobile robots and understand their implications on robot motion and control.
3. Provide students with a thorough understanding of mobile robot dynamics, focusing on Lagrange-Euler and Newton-Euler methods, and instruct them on how to create computer-based dynamic simulations for wheeled mobile robots.

4. Equip students with the skills necessary to implement localization and mapping techniques, such as SLAM and EKF SLAM, and utilize various sensor technologies to enhance mobile robot navigation capabilities.
5. Enable students to apply mobile robot navigation competences, including path planning methods, graph construction and search algorithms, and obstacle avoidance techniques, in order to design and implement effective autonomous navigation strategies for mobile robots.

Unit I

Introduction: Introduction to mobile robots and mobile manipulators. Components of a mobile robot. Types of mobile robots.

Locomotion: Introduction, Key issues for locomotion, Types of land-based mobile robots, wheeled locomotion case studies.

Mobile Robot Kinematics: Introduction, Need of mathematical model, degree of freedom. Differential Kinematics: Representing robot position, forward differential kinematics, Inverse differential kinematics, Degree of manoeuvrability, Types of wheels for mobile robots. Kinematic simulation of a mobile robot. A generalized wheel model, Examples: Differential wheel drive mobile robot, Skid steering wheel drive mobile robot, Omni wheel drive mobile robot, Mecanum wheel drive mobile robot, Tricycle wheel drive mobile robot.

Types of Mobile Robots based on Wheel configuration: Holonomic and non-holonomic systems, kinematic model, Pseudo Inverse. Kinematic Simulation of Wheeled Mobile Robots

15 Hours

Unit II

Dynamics of mobile robot: Lagrange-Euler and Newton-Euler methods. Computer based dynamic (numerical) simulation of different wheeled mobile robots.

Perception: Sensors for Mobile Robots, Sensor classification, characterizing sensor performance, Wheel/motor sensors, Heading sensors, Ground-based beacons, Active ranging, Motion/speed sensors, Vision-based sensors

Mobile Robots –Localisation and Mapping: Autonomy for Robots, Building Blocks of Navigation, Challenges of Localization, Noise and Aliasing, Mobile robot localisation: Odometry, Dead reckoning, Map based localisation, Markov Localisation, Kalman Filter. Autonomous map building: SLAM, EKF SLAM. **15 Hours**

Unit-III

Mobile Robot Navigation: Competences for Navigation, Path Planning Methods, Graph Construction: Visibility graph, Voronoi diagram, Cell decomposition methods. Graph Search Methods and Algorithms: Deterministic Graph Search, Breadth-first search, Depth-first search, Grass fire, Dijkstra’s algorithm. Path Planning- A* Algorithm and Potential Field methods. Obstacle Avoidance: Bug Algorithm. **10 Hours**

List of Simulation Experiments:

ii. Kinematic simulation of a land based mobile robot using a MATLAB script along with Euler method
iii. Kinematic simulation and motion animation of a land based mobile robot using MATLAB
iv. Kinematic simulation of a Deferential wheel drive mobile robot using MATLAB
v. Kinematic simulation of an Omni directional wheel drive mobile robot using MATLAB
vi. Kinematic simulation of a Mecanum wheel drive mobile robot using MATLAB

Course Outcomes: At the end of the course student will be able to

1.	Develop a comprehensive understanding of the different types of mobile robots and their key components, including locomotion systems and wheel configurations.
2.	Build kinematic models of holonomic and nonholonomic mobile robots
3.	Apply and analyze the principles of mobile robot dynamics, including Lagrange-Euler and Newton-Euler methods, to design and develop efficient computer-based dynamic simulations of various wheeled mobile robots, accounting for their motion and control.
4.	Acquire skills in implementing localization and mapping techniques for mobile robots, including SLAM and EKF SLAM, and apply various sensor technologies for robot perception to enhance navigation capabilities.
5.	Apply mobile robot navigation competences, including path planning methods, graph construction and search algorithms, and obstacle avoidance techniques, to effectively design and implement autonomous navigation strategies for mobile robots.

Program Outcomes→	1	2	3	4	5	6	7	8	9	10	11	12	PSO↓		
↓ Course Outcomes															
RI2112-1.1	3	2	1	-	-	-	-	-	-	-	-	1	3	1	2
RI2112-1.2	3	2	1	-	-	-	-	-	-	-	-	1	3	2	2
RI2112-1.3	3	2	1	-	1	-	-	-	-	-	-	1	3	2	2
RI2112-1.4	3	2	1	-	1	-	-	-	-	-	-	1	3	3	2
RI2112-1.5	3	2	1	-	1	-	-	-	-	-	-	1	3	3	2

1: Low 2: Medium 3: High

TEXTBOOKS:

1. R Siegwart, IR Nourbakhsh, D Scaramuzza, Introduction to Autonomous Mobile Robots, MIT Press, USA, 2011.
2. SG Tzafestas, Introduction to Mobile Robot Control, Elsevier, USA, 2014.
3. A Kelly, Mobile Robotics: Mathematics, Models, and Methods, Cambridge University Press, USA, 2013.
4. S Thrun, W Burgard, D Fox, Probabilistic Robotics, MIT Press, USA, 2005.
5. G Dudek, M Jenkin, Computational Principles of Mobile Robotics, Cambridge University Press, USA, 2010.

Web links and Video Lectures (e-Resources):

https://onlinecourses.nptel.ac.in/noc22_me38/preview

Robot Programming

Course Code:	**RI2607-1**	**Course Type:**	**PCC Lab**
Teaching Hours/Week (L: T: P: S):	**0:0:2:0**	**Credits:**	**01**
Total Teaching Hours:	**15**	**CIE + SEE Marks:**	**50+50**
Prerequisite	**RI2009-1**		

Teaching Department: Robotics & AI Engineering

Course Objectives:

1.	Understand the features of Dobot Magician and Dobot Studio Software
2.	Understand the concept of RAPID Programming
3.	Understand the hardware configuration and abilities of ABB IRB 1600 Robot
4.	Understand the features of COGNIX camera and its application

List of Experiments

1.	Experiment on pick and place operation using DOBOT Magician (mini robot) Using Suction Cup and b) Using Pneumatic Gripper
2.	Experiment to perform different operations using DOBOT Magician (mini robot) (a) Sorting operation (b) Stacking operation (c) Palletising operation
3.	Experiment to Write and Draw with pen tool using DOBOT Magician (mini robot)
4.	Demonstration of 3D Printing an object using DOBOT magician (mini robot)
5.	Software simulation in Robot Studio Software: Introduction to Robot Studio, Programming concepts, Libraries, geometries, and CAD files.
6.	Introduction to RAPID programming: - Basics of RAPID Programming, Loops, Rules and recommendations for RAPID syntax. RAPID robot functionality: Instructions, I/O signals, RAPID Programming Structure: Rapid Procedure, Modules, Data with Multiple Values: Arrays, Composite Data types
7.	Simulation to perform pick and place operation of an object in Robot Studio Software
8.	Simulation to perform conveyor tracking and palletizing operation in Robot Studio Software
9.	Simulation to perform sorting operation of an object in Robot Studio Software
10.	Introduction to COGNEX Camera: basics of COGNEX camera, introduction to camera programming using insight explorer software.
11.	ABB IRB 1600 robot: Introduction to ABB robot, IRC5 single cabinet controller, teach pendent, hardware connection diagrams, end effectors,
12.	Demonstration of ABB IRB 1600 robot: Pick and place operation using two jaw gripper, three jaw gripper and suction cup. Welding operation.
13.	Demonstration of RAPID programming in teach pendant and execution of the same using ABB robot.

Course Outcomes: At the end of the course student will be able to

1.	Develop ABB program for executing any defined task
2.	Perform process automation using involved with Robots

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→	1	2	3	4	5	6	7	8	9	10	11	12	**PSO↓**		
↓ Course Outcomes													1	2	3
RI2607-1.1	3	2	-	3	3	-	-	-	-	-	-	1	-	3	2
RI2607-1.2	3	1	-	3	3	-	-	-	-	-	-	1	-	3	2

1: Low 2: Medium 3: High

REFERENCE BOOKS:

1.	ROBOTICS Product specification IRB 1600/1660,ABB Robots
2.	ABB Robotics Operating Manual Robotstudio

Micro Aerial Vehicles

Course Code:	**RI2011-1**	**Course Type:**	**IPCC**
Teaching Hours/Week (L: T: P: S):	**(3:0:2:0)**	**Credits:**	**04**
Total Teaching Hours:	**50**	**CIE + SEE Marks:**	**50+50**
Prerequisite	**PH 1001-1, RI2009-1**		

Teaching Department: Robotics and Artificial Intelligence

Course Objectives:

1.	Comprehend the basic aviation history and UAV systems.
2.	Acquire the knowledge of basic aerodynamics and performance.
3.	Understand the stability and control air vehicles
4.	Understand the propulsion, loads and structures.
5.	Develop and test the remote controlled, autonomous aerial vehicles

UNIT-I

The Air Vehicle — **06 Hours**

Introduction aviation history and overview of UAV systems, classes and missions of UAVs, definitions and terminology, UAV fundamentals, examples of UAV systems-very small, small, medium and large UAV

Basic Aerodynamics — **05 Hours**

Basic aerodynamics equations, aircraft polar, the real wing and airplane, induced drag, the boundary layer, flapping wings, total air-vehicle drag

Performance — **04 Hours**

Overview, climbing flight, range and endurance – for propeller-driven aircraft, range- a jet-driven aircraft, guiding flight.

UNIT-II

Stability and Control — **15 Hours**

Overview, stability, longitudinal, lateral, dynamic stability, aerodynamics control, pitch control, lateral control, autopilots, sensor, controller, actuator, airframe control, inner and outer loops, flight-control classification, overall modes of operation, sensors supporting the autopilot.

Propulsion overview, thrust generation, powered lift, sources of power, the two-cycle engine, the rotary engine, the gas turbine, electric motors, and sources of electrical power. Loads and structures loads, dynamic loads, materials, sandwich construction, skin or reinforcing materials, resin materials, core materials, construction techniques.

UNIT-III

Mission Planning and Control	**09 Hours**

Air vehicle and payload control, reconnaissance/surveillance payloads, weapon payloads, other payloads, data-link functions and attributes, data-link margin, data-rate reduction, launch systems, recovery systems, launch and recovery trade-offs.

Suggested List of Experiments

1.	Study on development and integration of Drones.
2.	Study on development and integration of Unmanned Aerial Systems.
3.	Integration and testing Remote Controlled Fixed Wing UAV
4.	Integration and testing Remote Controlled Vertical Take-off and Landing UAV
5.	Integration and testing Autonomous Fixed Wing UAV
6.	Integration and testing Autonomous Vertical Take-off and Landing UAV
7.	Integration and testing of Hybrid UAV
8.	Application of UAV in Remote sensing
9.	Application of UAV in Disaster management
10.	Image processing using Raspberry Pi for agricultural applications

Course Outcomes: At the end of the course student will be able to

1.	Explain the basic of aerodynamics performance and apply the basic concepts of UAV systems and experimentally study the integration of drones.
2.	Explain the stability and control required for UAV and Select the propulsion system, materials for structures. Experimental studies on disaster management.
3.	Develop and test the remote controlled autonomous aerial vehicles. Experimental study on remote controlled and autonomous UAV.
4.	Design air vehicles for different payloads and design standards. Experimental study on autonomous and remote-controlled Vertical Take-off and Landing UAV
5.	Develop and test the rotary wing, fixed wing aerial vehicles. Experimental study on Unmanned aerial vehicles and fixed wing UAV.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→	1	2	3	4	5	6	7	8	9	10	11	12	PSO↓		
↓ Course Outcomes													1	2	3
RI2011-1.1	2	2	3	2	2	-	-	-	-	-	-	2	2	-	2
RI2011-1.2	2	2	3	2	2	-	-	-	-	-	-	2	2	-	2

RI2011-1.3	2	2	3	2	2	-	-	-	-	-	-	2	2	-	2
RI2011-1.4	2	2	3	2	2	-	-	-	-	-	-	2	2	-	2
RI2011-1.5	2	2	3	2	2	-	-	-	-	-	-	2	2	-	2

1: Low 2: Medium 3: High

TEXTBOOKS:

1.	Paul Gerin Fahlstrom, Thomas James Gleason, Introduction to UAV Systems, Wiley Publication, 4th Edition,2012.
2.	Landen Rosen, Unmanned Aerial Vehicle, Alpha Editions

REFERENCE BOOKS:

1.	Unmanned Aerial Vehicles: DOD's Acquisition, Alpha Editions
2.	Valavanis, Kimon P, Unmanned Aerial Vehicles, Springer, 2011
3.	Valavanis, K., Vachtsevanos, George J, Handbook of Unmanned Aerial Vehicles, Springer, 2015.

E Books / MOOCs/ NPTEL

1.	https://onlinecourses.nptel.ac.in/noc22_me38/preview

Control Systems for Robotics Lab

Course Code:	**RI2608-1**	**Course Type:**	**PCC Lab**
Teaching Hours/Week (L: T: P: S):	**0:0:2:0**	**Credits:**	**01**
Total Teaching Hours:	**15**	**CIE + SEE Marks:**	**50+50**
Prerequisite	**RI2009-1**		

Teaching Department: Robotics and Artificial Intelligence

Course Objectives:

1.	To determine the time and frequency domain reposes of a given second order system using software package or discrete components.
2.	To design and analyze Lead, Lag and Lag – Lead compensators for given specifications.
3.	To draw the performance characteristics of ac and DC servomotors and synchro-transmitter receiver pair.
4.	To study the DC position & feedback control system and to study the effect of P, PI, PD and PID controller and Lead compensator on the step response of the system.
5.	To write a script file to plot root locus, bode plot, to study the stability of the system

List of Experiments

1.	Speed control Experiments a) Speed control of DC motor b) Speed control of AC motor c) Speed control of Stepper motor d) Speed control of BLDC motor
2.	Experiment to determine frequency response of a second order system

	a) To design a passive RC lead compensating network for the given specifications, viz, the maximum phase lead and the frequency at which it occurs and to obtain the frequency response. b) To design a passive RC lag compensating network for the given specifications, viz, the maximum phase lag and the frequency at which it occurs and to obtain the frequency response. c) To determine experimentally the transfer function of the lag compensating network
3.	To study a second order system and verify the effect of (a) P, (b) PI, (c) PD and (d) PID controller on the step response.
4.	To simulate a typical second order system and determine step response and evaluate time response specifications. To evaluate the effect of adding poles and zeros on time response of second order system. To evaluate the effect of pole location on stability
5.	To examine the relationship between open-loop frequency response and stability, open-loop frequency and closed loop transient response
6.	To study the effect of open loop poles and zeros on root locus contour Comparative study of Bode, Nyquist and root locus with respect to stability.
7.	To simulate a D.C. Position control system and obtain its step response.
8.	To verify the effect of input waveform, loop gain and system type on steady state errors.
9.	Inverted Pendulum control Experiment
10.	Experiments on Height and orientation control of a Quadcopter

Course Outcomes: At the end of the course student will be able to

1.	Utilize software package and discrete components in assessing the time and frequency domain response of a given second order system.
2.	Determine the performance characteristics of AC and DC motors used in control systems.
3.	Simulate the DC position and feedback control system to study the effect of P, PI, PD and PID controller and Lead compensator on the step response of the system.
4.	Develop script files to plot Root locus, Bode plot and Nyquist plot to study the stability of control system.
5.	Stabilization and control of the unstable inverted pendulum system with a close-loop control system and Design a Controller for Quadcopter height and orientation

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→	1	2	3	4	5	6	7	8	9	10	11	12	PSO↓		
↓ Course Outcomes															
RI2608-1.1	3	3	2	2	2	-	-	-	-	-	-	2	2	-	2
RI2608-1.2	3	3	2	2	2	-	-	-	-	-	-	2	2	-	2
RI2608-1.3	3	3	2	2	2	-	-	-	-	-	-	2	2	-	2
RI2608-1.4	3	3	2	2	2	-	-	-	-	-	-	2	2	-	2

RI2608-1.5	3	3	2	2	2	-	-	-	-	-	-	2	2	-	2

1: Low 2: Medium 3: High

REFERENCE BOOKS:

1.	Katsuhiko Ogata (2004) " Modern Control Engineering" Prentice Hall of India Ltd., New Delhi
2.	I. J. Nagarath and M. Gopal,(2002) "Control system" New Age International Publisher
3.	Harrison H.L. and Bollinger J.G. (1968) "Automatic controls", 2PndP edition, Interna¬tional Text Book Co. U.S.A.
4.	Gopal M (2005) " Modern Control Systems", New Age International Publisher
5.	Benjamin.Kuo.C. (1995) "Automatic Control Systems", EEE, 7PthP Edition Prentice Hall of India Ltd. New Delhi
6.	Appukuttan K. K. Control Engineering, Oxford university publication, 2009