Course Code	Course Title	Unit	Course Description	Learning Outcomes	Pre-requisites	Co-requisites	Preclusions	Syllabus	Assessment	Illustrative Reading List
RB1101	Fundamentals of Robotics I	4	This is the first of two courses that introduces students to what engineers do and the engineer's thought process, with a particular orientation towards the field of robotics. This course focuses on how systems work and fail, and how they are designed. Through both theory and hands-on activities, students are introduced to the fundamental concepts that govern engineering systems (such as forces and motion, energy, material properties), and a holistic view of how a robotic system works. At the end of the course, students will have developed an understanding of the major topics relevant to the fundamentals of robotic systems engineering.	1 Describe a system and its components using block diagrams 2 Use computing tools for engineering analysis and simple design 3 Explain, visualise and compare the size and capacity of engineering components or systems using dimensional and scientific notations 4 Construct and solve mathematical and behavioural models of engineering applications with back-of-envelope calculations 5 Use robotics-related software to simulate a simple virtual robotic task 6 Analyse the basic operation of a system using principles of equilibrium and system dynamics 7 Estimate losses in a system and its impact on system performance 8 Determine the normal operating range and estimate the operation outside that range that causes a system to fail	-	-	ME1102	- Safety, dimensions and guesstimation - Forces and equilibrium - Bodies in motion - Energy and power - Material properties and selection - Modelling and simulation of robotic systems - Elementary control of robotic systems	Project/Group Project Laboratory Tests Final Exam	
RB2101	Fundamentals of Robotics II	4	This introductory course in robotics covers electrical analysis, sensors, microcontrollers, and DC motors, exploring how these components can be integrated to build a mobile platform capable of autonomous behavior using low-cost sensors. Through a combination of theoretical learning and hands-on activities, students gain essential knowledge that provides a solid foundation for further studies in robotics.	1 Understand and apply basic principles and techniques used in DC circuits 2 Grasp fundamental concepts of capacitance and inductance, including their behavior in circuits 3 Comprehend the essential principles of AC circuits, including phasors and impedance 4 Understand how to interface sensors in robotic system. 5 Understand how to drive a PMDC motor using digital signals 6 Gain the skill to utilise microcontrollers for programming and control in robotic applications	-	-	ME2104, ME2105, CG1111A, EE1111B, EE2111A, ESP2111	1 DC Circuit Analysis: Circuits, currents, and voltages Power and energy Kirchhoff's Current and Voltage Laws, Circuit elements and basic design, Resistive circuits in series and parallel, Voltage-divider and current-divider circuits, Node-voltage analysis Thevenin and Norton equivalents, Diodes and load-line analysis for nonlinear elements 2 Capacitance and Inductance: Series and parallel connections, First-order circuits, transient analysis, time constant 3 AC Circuits: AC currents and voltages, Phasors, Complex impedances 4 Sensors: Sensor classifications and characteristics, Selected sensors for mobile robots, Interfacing circuits such as Wheatstone bridge 5 Actuators: Types of actuators, PMDC motor models, Motor driver and gear transmission 6 Microcontroller (Arduino): Programming and data acquisition, PWM signal generation 7 Differential Drive Kinematics: Principles for mobile robot control	Project/Group Project Quizzes/Tests Laboratory Tests Final Exam	
RB2202	Kinematics and Dynamics for Robots	4	This is a concise, yet comprehensive course covering the essentials of kinematics and dynamics, from the mathematics of movement, through the principles of robot design, to the dynamics of machine operation. Students will engage with topics such as forward and inverse kinematics, the equations of motion and dynamic modeling, and trajectory planning, applying these concepts through tutorial exercises and simulation projects. The course lays the groundwork for studying the design, analysis, and implementation of robotic systems at senior undergraduate level.	1 Understand and apply the principles of kinematics and dynamics to the analysis and design of robotic systems. 2 Develop mathematical models for robotic arms and mechanisms. 3 Implement algorithms for trajectory planning and control of robots. 4 Analyse robotic systems critically in terms of efficiency, accuracy and stability.	MA1513	-	-	1. Introduction to Robotics Overview of robotics and its applications, Historical development of robotic systems, Types of robots and their uses 2. Mathematics for Robotics Review of vectors and matrices, Coordinate frames and transformations, Spatial descriptions 3. Fundamentals of Kinematics Definitions and concepts in kinematics, Forward kinematics of serial chain manipulators, Inverse kinematics basics 4. Advanced Kinematics Solving inverse kinematics problems, The Jacobian and its applications, Workspace analysis and singularities 5. Dynamics of Robotics Introduction to dynamics in robotics, Derivation of equations of motion, Lagrangian and Newton-Euler methods 6. Robot Motion Planning Basics of trajectory planning, Point-to-point motion planning, Continuous path planning 7. Dynamic Modeling and Simulation Dynamic modeling of robotic systems, Simulation tools and techniques, Case studies in dynamic simulation 8. Real-world Applications and Case Studies Robotics in manufacturing, healthcare and surgery, Autonomous vehicles and drones	Project/Group Project Quizzes/Tests Final Exam	Introduction To Robotics: Mechanics And Control, 3/E John J. Craig Robot Analysis and Control H. Asada; J.-J. E. Slotine
RB2203	Robot Control	4	This course teaches the fundamental principles and methods essential for controlling robots. It covers PID (Proportional-Integral-Derivative) control, state-space control, as well as robot motion control and applications for diverse robotic platforms such as mobile robots and robot manipulators. Trajectory planning and tracking strategies are also introduced. Emphasis is placed on real-world scenarios, fostering skills applicable to industries ranging from manufacturing to autonomous vehicles.	1 Apply fundamental control theory concepts for robotic applications 2 Model and simulate dynamic behavior of robotic systems using Laplace transforms and Bode plots. 3 Understand the concept of state-space representation 4 Design and evaluate trajectory tracking and motion control algorithms for mobile robots and manipulators 5 Demonstrate the abilities to integrate theoretical knowledge with practical skills through hands-on laboratory sessions on robot motion control	MA1513, RB2202	-	-	1 Introduction to Robotics and Control Overview of robotics applications in industry and research, Basic principles of control theory and its relevance to robotics, Introduction to common robotic systems such as manipulators and mobile robots 2 Review of Kinematics and Dynamics for Robots Representation of robot motion in Cartesian and joint space, Solving kinematic equations for simple robot configurations, Basic analysis of robot dynamic behavior 3 Modeling and System Identification Linear time-invariance systems, Laplace transform analysis of systems Bode diagrams, Modeling from Bode plots 4 PID Control Fundamentals of proportional, integral, and derivative control, Tuning methods (Ziegler-Nichols, trial-and-error), Application to velocity and position control of DC motors, PID in robotic joints or wheel control 5 Review of Linear Algebra Vectors, matrices and transformations, Systems of linear equations, Symmetric matrices and their properties, Eigenvalues and eigenvectors 6 State-Space Representation Introduction to state-space representation of dynamic systems, Understanding state variables and state equations, Application to linearised robot system 7 Mobile Robot Control Differential drive kinematics, Position and velocity control of wheeled robots 8 Manipulator Joint-Space and Task-Space Control Differential kinematics (Jacobian), Velocity control using kinematics 9 Trajectory Planning and Tracking Motion control, trajectory planning, and path planning, Reference trajectory generation (polynomials or splines), Trajectory tracking basics 10 Laboratory Sessions PID tuning, Mobile robot trajectory tracking	Laboratory Tests Assignment Final Exam	Robotics and Control Peter Corke Control System Design Bernard Friedland Modern Control Engineering Katsuhiko Ogata

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RB2301	Robot Programming	4	In this course, students will learn how to make a robot operate via the main "robotic loop": see, think, act. Specifically, they will learn how to connect and control sensors and actuators via a controller, and how to programme the system with intersecting behavior. To achieve this, students will first learn the basics of coding and programming robotic systems, before learning techniques for obtaining information from sensors, which can then be processed for decision-making. Students will apply this knowledge to control important robotic systems (mobile ground robots, robotic arms, mobile manipulators, etc.), in simulation and/or on simple hardware.	1 Understand basic coding and programming systems used in modern robotics control workflows 2 Collect data from a variety of robotic sensors 3 Process observed data to make decisions 4 Programme and control basic robotic actuators	CS1010% (any variant)	-	-	- Analysis and evaluation of a computer programme - Common communication protocols for sensors and actuators - ROS, Python, and other programming libraries useful for robotics - Interface with and control a variety of sensors (e.g., touch, force, ultrasonic, cameras, lidar, etc.) - Interface with and control a variety of actuators (e.g., motors, servos, lights, solenoids, etc.) - Anatomy of complex robotic systems (e.g., mobile ground robots, robotic arms, mobile manipulators, drones, etc.) - Project-based labs controlling robots via simulation and/or simple hardware	Project/Group Project Quizzes/Tests Laboratory Tests	
RB2302	Fundamentals of Artificial Neural Networks	4	This course introduces fundamental concepts in artificial neural networks, covering topics such as basic biological and artificial neurons, perceptron, multi-layer perceptron, basic network topologies, activation functions, supervised, unsupervised and reinforcement learning paradigms, backpropagation, Hebbian rule. The course introduces established network architectures, including convolutional networks (CNNs) and recurrent networks (RNNs). The students will apply this knowledge to solve problems using state-of-the-art tools. By the end of the course, the students will grasp fundamental concepts of neural networks and will be proficient in utilising these tools to design neural networks suitable for applications in robotics, including robot vision and robot control.	1 Comprehend the fundamental principles of artificial neural networks and the neural network learning process. 2 Acquire knowledge about different types of neural networks and their use in robotics. 3 Use software tools to design and implement neural networks.	-	-	EE4312	1.Machine Learning Paradigms Supervised learning, Unsupervised learning, Reinforcement learning 2.Basic Working Principles of Neural Networks Biological neuron, Artificial neuron, Action potential, Synapses and connection weights, Networks of neurons 3.Network Architectures Multi-layer networks, Recurrent neural networks, Convolutional neural networks, Self-organising maps Autoencoder, Transformers 4.Learning in Artificial Neural Networks Backpropagation, Hebbian rule, Competitive learning 5.Examples of Neural Network Applications Classifiers, Image recognition, Large language models, Neurocontrollers for robots 6.Hands-on Implementation of Neural Networks	Project/Group Project Mid-term Test Final Exam	
RB3301	Introduction to Machine Intelligence	4	In this course, students will learn the basic machine intelligence techniques used in robotics, from conventional methods all the way to neural techniques. The course will start by introducing students to rule-based systems, finite-state machines, exhaustive-, tree-, and graph-based search methods, as well as evolutionary algorithms. The course will then briefly cover more recent advances in artificial intelligence for robotics, such as neural-based supervised, unsupervised, and reinforcement learning.	1 Explain the main classes of Machine Learning methods, and their use in robotics. 2 Describe how you would formalise a specific robotic autonomy task as a machine intelligence problem. 3 Implement a rule-, logic-, or search-based solution to a given robotic autonomy task. 4 Debate the use of conventional and/or data-driven methods for a given robotic autonomy problem.	-	-	-	- Brief History of Machine Intelligence. - Rule-Based Systems and Finite-State Machines. - Search-Based systems. - Game Theory, Markov Decision Processes. - Logical Reasoning under uncertainty. - Classification and Clustering (conventional methods). - Introduction to Neural Networks and Backpropagation. - Neural systems, natural language processing, and generative models.	Project/Group Project Quizzes/Tests Peer feedback exercise towards group project	
RB3302	Planning and Navigation	4	This course introduces path planning and navigation methods for mobile robots. Content includes localisation and mapping techniques (e.g., SLAM), as well as navigation algorithms in known and unknown environments. This course will start by focusing on easier/textbook cases, where the environment is static and known and the robot model simple, before delving into more complex cases that may involve dynamic environments, non-holonomic robots, or even pathfinding for multi-robot systems.	1 Explain the main classes of path planning/navigation approaches and their advantages/limitations. 2 Formalise a specific path planning/navigation problem and propose potential approaches to solve it. 3 Implement a graph-based/trajectory optimisation planner for a given robot/task. 4 Debug and ensure robustness of a given path/navigation planner for online deployment on-robot (in closed-loop).	-	-	-	- Introduction to Motion Planning, Trajectory Planning, Navigation. - Navigation/Path planning in known environments. - Motion planning for non-holonomic robots. - Path planning in dynamic environments. - Localisation and mapping (including SLAM). - Navigation in unknown environments. - Motion and task planning. - Informative path planning (coverage, search, orienteering problem). - Multi-robot path planning.	Project/Group Project Quizzes/Tests Peer feedback exercise towards group project	
RB3303	Robotic System Design and Application	4	This course offers an in-depth exploration of robots as integrated systems, focusing on their functionality and operation. It begins with foundational components such as sensors, actuators, kinematics, and control systems, progressing to the architectures that enable their integration and the methods by which their core functions are implemented and controlled. The course connects theoretical concepts with practical applications by analysing robotic systems across various domains, including Automated Guided Vehicles (AGVs), Autonomous Mobile Robots (AMRs), industrial robot manipulators, mobile manipulators, and humanoid robots. Through this analysis, students will learn how the integration of components is tailored to the specific tasks a robot is designed to perform.	1 Apply principles of sensor operation to select appropriate components for a robot system to perform a specified task. 2 Design a robotic system architecture to meet specified performance criteria. 3 Discriminate between appropriate locomotion mechanisms based on task requirements and environmental constraints. 4 Select appropriate robotic technologies for specific industry challenges.			ME3243, EE3305	1 Introduction to robotics: Definitions and History of Robotics, Robot Components, Overview of Robot Applications 2 Robot Sensors: Position sensors (encoders, potentiometers, Hall-effect sensors), Contact and tactile sensors (resistive, capacitive, magnetic, optical), Strain and force sensors (strain gauges, F/T sensors), Proximity and distance sensors (Hall-effect sensors, IR sensors, US sensors, LIDARs) 3 Robot Manipulator: Degrees of Freedom, Joint types and robot types, Forward and inverse kinematics 4 Robot Control: Types of Control (Proportional, Integral and Derivative), Robot control architectures (hierarchical, reactive and hybrid) 5 Robot Locomotion: Introduction to Legged and wheeled Mobile Robots, Wheeled Mobile Robot Kinematics, Navigation: Localisation, Path Planning 6 Selected Robot Applications AGV, AMR, Industrial robot manipulators, Mobile Manipulators, Humanoid Robots	Quizzes/Tests Mid-term Test Assignments or term papers	The Robotics Primer Maja J. Mataric Elements of Robotics Mordechai Ben-Ari; Francesco Mondada Robotics Matjaž Mihelj; Tadej Bajd; Aleš Ude; Jadran Lenarčič; Aleš Stanovnik; Marko Munih; Jure Rejc; Sebastjan Šlajpah Introduction to Autonomous Mobile Robots, second edition Roland Siegwart; Illah Reza Nourbakhsh; Davide Scaramuzza
RB4101A	B.Eng Dissertation	4	This course consists mainly of a research-based project related to Robotics and/or Machine Intelligence carried out under the supervision of one or more faculty members. It introduces students to the basic methodology of research in the context of a problem of current research interest in Robotics and/or Machine Intelligence. The course is normally taken over two consecutive semesters.	1 Think critically and acquire independent research skills that are vital for life-long learning. 2 Undertake research projects in a methodological manner including literature search, formulation of problems, conduct experiments, and analysis of results. 3 Communicate effectively through technical report writing on the achievements of this final year project. 4 Achieve confidence in communication skills through various project oral presentations.	Stage 4 standing	-	-	The student is expected to proceed autonomously with the project, in consultation with their supervisor. The project will include an analysis of the state of the art, investigation of an original solution, design and development of simulations and prototypes, as suitable for each case. The student shall also conduct studies or experiments to support the proposed solution and will discuss the results obtained.	Dissertation work, report and oral presentation	