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 Apply foundational engineering principles—including Newtonian mechanics, energy methods, and material behaviour—to analyse and solve real-world problems with appropriate use of dimensional reasoning and significant figures. 2 Analyse stress-strain relationships to evaluate material properties and make informed decisions in selecting appropriate materials for engineering applications. 3 Set up and run simulations and carry out experiment using robot hardware platform to demonstrate reactive robot behaviours based on scenario template. 4 Apply fundamental localisation, mapping, and path planning algorithms in analytical problem-solving.	-	-	ME1102	Safety, dimensions and guesstimation Forces and equilibrium Bodies in motionEnergy 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	DC Circuit Analysis: Circuits, currents, and voltagesPower and energyKirchhoff's Current and Voltage LawsCircuit elements and basic designResistive circuits in series and parallelVoltage-divider and current-divider circuitsNode-voltage analysisThevenin and Norton equivalentsDiodes and load-line analysis for nonlinear elementsCapacitance and Inductance: Series and parallel connectionsFirst-order circuits, transient analysis, time constantAC Circuits: AC currents and voltagesPhasorsComplex impedancesSensors: Sensor classifications and characteristicsSelected sensors for mobile robotsInterfacing circuits such as Wheatstone bridgeActuators: Types of actuatorsPMDC motor modelsMotor driver and gear transmissionMicrocontroller (Arduino): Programming and data acquisitionPWM signal generationDifferential Drive Kinematics: Principles for mobile robot control	Project/Group Project, Quizzes/Tests, Laboratory Tests, Final Exam	-
RB2202	Kinematics and Dynamics for Robotics	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 Analyse robotic systems critically in terms of efficiency, accuracy and stability.	MA1508E or MA1513	-	ME4245	1. Introduction to RoboticsOverview of robotics and its applicationsHistorical development of robotic systemsTypes of robots and their uses2. Mathematics for RoboticsReview of vectors and matricesCoordinate frames and transformationsSpatial descriptions3. Fundamentals of KinematicsDefinitions and concepts in kinematicsForward kinematics of serial chain manipulatorsInverse kinematics basics4. Advanced KinematicsSolving inverse kinematics problemsThe Jacobian and its applicationsWorkspace analysis and singularities5. Dynamics of RoboticsIntroduction to dynamics in roboticsDerivation of equations of motionLagrangian and Newton-Euler methods6. Robot Motion PlanningBasics of trajectory planningPoint-to-point motion planningContinuous path planning7. Dynamic Modeling and SimulationDynamic modeling of robotic systemsSimulation tools and techniquesCase studies in dynamic simulation8. Real-world Applications and Case StudiesRobotics in manufacturing, healthcare and surgeryAutonomous vehicles and drones	Quizzes/Tests, Laboratory Tests, Final Exam	Introduction To Robotics: Mechanics And Control, 3/E John J. Craig Robot Analysis and Control H. Asada; J.-J. E. Slotine

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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 and RB2202	-	-	Introduction to Robotics and Control Overview of robotics applications in industry and researchBasic principles of control theory and its relevance to roboticsIntroduction to common robotic systems such as manipulators and mobile robotsReview of Kinematics and Dynamics for RobotsRepresentation of robot motion in Cartesian and joint spaceSolving kinematic equations for simple robot configurationsBasic analysis of robot dynamic behaviorModeling and System IdentificationLinear time-invariance systemsLaplace transform analysis of systemsBode diagramsModeling from Bode plotsPID ControlFundamentals of proportional, integral, and derivative controlTuning methods (Ziegler-Nichols, trial-and-error)Application to velocity and position control of DC motorsPID in robotic joints or wheel controlReview of Linear AlgebraVectors, matrices and transformationsSystems of linear equationsSymmetric matrices and their propertiesEigenvalues and eigenvectorsState-Space RepresentationIntroduction to state-space representation of dynamic systemsUnderstanding state variables and state equationsApplication to linearised robot systemMobile Robot Control Differential drive kinematicsPosition and velocity control of wheeled robotsManipulator Joint-Space and Task-Space Control Differential kinematics (Jacobian)Velocity control using kinematicsTrajectory Planning and TrackingMotion control, trajectory planning, and path planningReference trajectory generation (polynomials or splines)Trajectory tracking basics	Laboratory Tests, Assignment, Final Exam	Robotics and Control Peter Corke Control System Design Bernard Friedland Modern Control Engineering Katsuhiko Ogata
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 programmeCommon communication protocols for sensors and actuatorsROS, Python, and other programming libraries useful for roboticsInterface 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.	MA1513	-	EE4312	1.Machine Learning ParadigmsSupervised learningUnsupervised learningReinforcement learning2.Basic Working Principles of Neural NetworksBiological neuronArtificial neuronAction potentialSynapses and connection weightsNetworks of neurons3.Network ArchitecturesMulti-layer networksRecurrent neural networksConvolutional neural networksSelf-organising mapsAutoencoderTransformers4.Learning in Artificial Neural NetworksBackpropagationHebbian ruleCompetitive learning5.Examples of Neural Network ApplicationsClassifiers Image recognitionLarge language modelsNeurocontrollers for robots6.Hands-on Implementation of Neural Networks	Project/Group Project, Mid-term Test, Final Exam	-

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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	-
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).	RB2202	-	ME5413	Introduction to Robot Planning and Navigation Motion Representation Graph Search and Shortest Path Heuristic Search Introduction to Sampling-based Planning, Optimal and High-Dimensional Planners Robot Sensing and Perception Localisation Mapping SLAM Basics Navigation and Control Integration Introduction to Informative and Multi-robot Path Planning	Project/Group Project Quizzes/Tests	-
RB3303	Robotic System Design and Applications	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	Introduction to robotics:Definitions and History of RoboticsRobot ComponentsOverview of Robot ApplicationsRobot 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)Robot Manipulator:Degrees of FreedomJoint types and robot typesForward and inverse kinematicsRobot Control:Types of Control (Proportional, Integral and Derivative)Robot control architectures (hierarchical, reactive and hybrid)Robot Locomotion:Introduction to Legged and wheeled Mobile RobotsWheeled Mobile Robot KinematicsNavigation: Localisation, Path Planning Selected Robot ApplicationsAGV, AMRIndustrial robot manipulators Mobile ManipulatorsHumanoid Robots	Quizzes/Tests, Mid-term Test, Assignments	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	-	RB4101B	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,	-