Minor in Robotics

Course Code	Course Name
MI-BT041	Introduction to Robotics

Course pre-requisites	Basic Electrical & Electronics, Basic Programming

Course Objectives

The objectives of this course are to familiarize students with basic terminologies of the robotics sciences and essential knowledge required to get started in the field of Robotics.

Course Outcomes

Upon successful completion of the course, students should be able

1. To express his views as per terminologies related to Robotics technology.
2. To apply logic for selection of robotic components, ratings and safety.
3. To analyze basics of principals of robot system integration.
4. To understand ways to update knowledge in the required area of robotic technology.

Course Content

Module No.	*Details*	*Hrs.*
1	Introduction to robotics: Brief History, Basic Concepts of Robotics such as Definition, Three laws, Elements of Robotic Systems i.e. Robot anatomy, DOF.	**02**
2	Classification of Robotic systems on the basis of various parameters such as work volume, type of drive, etc., Associated parameters i.e. resolution, accuracy, repeatability, dexterity, compliance, RCC device etc., Industrial applications of robot.	**04**
3	Sensors and Actuators for Robots - Types of Sensors used in Robotics, Classification and applications of sensors, Characteristics of sensing devices, Selections of sensors. Need for sensors and vision system in the working and control of a robot. Actuators - Hydraulic, pneumatic and electric.	**04**
4	Grippers for Robotics: Types of Grippers, Guidelines for design for robotic gripper, Force analysis for various basic gripper system.	**04**
5	Drives and Control for Robotics: Drive - Types of Drives, Types of transmission systems, Actuators and its selection while designing a robot system. Control Systems: Types of Controllers, Introduction to closed loop control.	**06**
6	Robot Programming: Methods of robot programming, Functions, WAIT, SIGNAL and DELAY commands, subroutines, Gazebo.	**04**
7	Programming Languages: Generations of Robotic Languages, Introduction to various types such as VAL, RAIL, AML, Python, ROS etc., Development of languages since WAVE till ROS.	**04**

Text Books

1. Robert Shilling, Fundamentals of Robotics-Analysis and Control, Prentice Hall of

India.
2. Fu, Gonzales and Lee, Robotics, McGraw Hill.
3. S. K. Saha, Introduction to Robotics 2e, TATA McGraw Hills Education (2014)
4. Asitava Ghoshal, Robotics: Fundamental concepts and analysis, Oxford University Press (2006)
5. Dilip Kumar Pratihar, Fundamentals of Robotics, Narosa Publishing House, (2019)

Reference Books

1. J.J. Craig, Introduction to Robotics, Pearson Education.
2. Curtis D. Johnson, Process Control Instrumentation Technology, PHI publication.
3. R. K. Mittal, I. J. Nagrath, Robotics and Control, TATA McGraw Hill Publishing Co Ltd, New Delhi (2003)
4. S. B. Niku, Introduction to Robotics – Analysis, Contro, Applications, 3rd edition, John Wiley & Sons Ltd., (2020)
5. J. Angeles, Fundamentals of Robotic Mechanical Systems Theory Methods and Algorithms, Springer (1997)
6. Mikell Groover, Mitchell Weiss, Roger N. Nagel, Nicholas Odrey, Ashish Dutta, Industrial Robotics 2nd edition, SIE, McGraw Hill Education (India) Pvt Ltd (2012)
7. R. D. Klafter, Thomas A. Chmielewski, and Mechael Negin, Robotic Engineering – An Integrated Approach, EEE, Prentice Hall India, Pearson Education Inc. (2009)

Sr. No.	Examination	Module
1	T-I	1, 2
2	T-II	3,4
3	End Sem	1 to 7

Alternative SWAYAM/NPTEL Course:

NPTEL Course Name	Instructor	Host Institute
Introduction to robotics	Dr. Krishna Vasudevan, Dr. Balaraman Ravindran, Dr. T Asokan	IIT Madras
Sensors and Actuators	Prof. Hardik Jeetendra Pandya	IISc Bangalore

Course Code	Course Name
MI-BT042	Microcontroller and Embedded Systems

Course pre-requisites	

Course Objectives
This course aims to teach the detailed functioning of AVR Microcontroller and the role of embedded systems in a robotic system.

Course Outcomes
Upon successful completion of the course, students should be able 1. To prepare block diagrams for any robotic control-hardware design. 2. Learn and analyze assembly language programs for AVR Microcontroller for various peripheral interfacings. 3. Write programs for interfacing various sensors for robotics applications. 4. To use advanced embedded processor and software.

Course Content

Module No.	*Details*	*Hrs.*
1	Introduction to Microprocessors and Microcontrollers: History of microprocessors and microcontrollers, Differences between microprocessors and microcontrollers, Applications of microcontrollers, Role of microcontrollers in embedded systems.	**04**
2	AVR Microcontroller Architecture: Registers, AVR status register, Memory Space, ATmega32 (Arduino) pin-configuration & function of each pin, Addressing modes.	**04**
3	AVR Instruction Set: Data transfer, Arithmetic, Logic and Compare, Rotate and Shift, Branch and Call instructions, Bit manipulation instructions.	**04**
4	AVR Assembly and C Programming: AVR data types and assembler directives, AVR assembly language programs, AVR I/O Port Programming, Time delay loop, Bit addressability, MACROs, Pros and cons of C and assembly language programming, Data types, Simple C programs for general purpose I/O and bit accessibility.	**08**
5	AVR On-chip Peripherals and Programming: General purpose I/O Ports, Timers, Interrupts, Serial port, Serial port interfacing protocols: SPI, I2C, UART, Assembly and C Language programming for peripherals.	**08**
6	Device Interfacing and Programming: Introduction to Raspberry Pi, Sensor interfacing, Relay, Opto-isolator, and Stepper Motor Interfacing, Industrial servo interfacing, Raspberry Pi based programming for robots.	**08**
7	Advanced Robotics Programming: Inverse Kinematics and Path Planning, Programming using ROS (Robot Operating System), Raspberry Pi applications in robotics.	**06**

Text Books
1. Muhammad Ali Mazidi, Sarmad Naimi and Sepehr Naimi,"The AVR Microcontroller and Embedded Systems", Using Assembly and C, Pearson Education, 1st Edition, 2012. 2. S. K. Saha, "Introduction to Robotics", Tata McGraw Hill Education Pvt. Ltd., New Delhi. 3. Dhananjay Gadre, "Programming and Customizing the AVR Microcontroller", TMH, 1st Edition, 2001.
Reference Books
1. Thomas Grace, "Programming and Interfacing Atmel AVR Microcontrollers", Cengage Learning PTR; 1st edition (July 29, 2015). 2. R. K. Mittal, I. J. Nagrath, "Robotics and Control", Tata McGraw-Hill Publishing Company Ltd. 3. R. S. Gaonkar, ", Microprocessor Architecture: Programming and Applications with the 8085", Penram International Publishing, 1996Raj Kamal, Embedded Systems, TATA McGRAW Hill Publications (2003).

Sr. No.	Examination	Module
1	T-I	1,2
2	T-II	3
3	End Sem	1 to 5

Alternative SWAYAM/NPTEL Course:

NPTEL Course Name	Instructor	Host Institute
Embedded Systems	Prof. Santanu Chaudhary	IIT Delhi

Course Code	Course Name
MI-BT043	Mechanics of Robots

Course pre-requisites	Mechanics

Course Objectives

This course aims to inculcate thorough understanding about basic knowledge of mathematics, kinematics and dynamics required for understanding motion programming and operational / control functionality in robotics.

Course Outcomes

Upon successful completion of the course, students should be able

1. To understand terminologies related to Kinematics and Dynamics of Robotics.
2. To apply mathematics for manipulator positioning and motion planning.
3. To analyse basics of motion programming as per kinematics.
4. To estimate the force/torque required to drive a robot.

Course Content

Module No.	*Details*	*Hrs.*
1	Introduction and Mathematical Preliminaries: Spatial Descriptions: positions, orientations, and frame mappings, Changing descriptions from frame to frame, Operators: translations, rotations, and transformations, Transformation arithmetic: compound transformations, inverting a transform, transform equations.	**07**
2	Advanced Mathematical Preliminaries: Euler Angles, Fixed Angles, Euler Parameters.	**05**
3	Robot Kinematics I: Manipulator Kinematics: Link Description, Link to reference frame connections, Denavit-Hartenberg Approach, D-H Parameters, and Position Representations.	**06**
4	Robot Kinematics II: Homogeneous Transformation Matrix, Forward Kinematics, Inverse Kinematics: Geometric and analytical approach.	**04**
5	Velocities & Statics I: Cross Product Operator for kinematics, Jacobians: Direct Differentiation, Basic Jacobian, Jacobian Jv / Jw, Jacobian in a Frame, Jacobian in Frame {0}.	**06**
6	Velocities & Statics II: Kinematic Singularity, Kinematics redundancy, Force balance equation, Forces, Velocity/Force Duality, Virtual Work, Force ellipsoid, Mechanical Design of robot linkages.	**06**
7	Robot Dynamics: Introduction to Dynamics, Velocity Kinematics, Acceleration of rigid body, mass distribution, Newton's equation, Euler's equation, Iterative Newton – Euler's dynamic formulation, Closed dynamic Lagrangian formulation of manipulator dynamics, Dynamic simulation, and computational consideration.	**08**

Text Books

1. Robert Shilling, Fundamentals of Robotics-Analysis and Control, Prentice Hall of

India.
2. Fu, Gonzales and Lee, Robotics, McGraw Hill.
3. S. K. Saha, Introduction to Robotics 2e, TATA McGraw Hills Education (2014).
4. Dilip Kumar Pratihar, Fundamentals of Robotics, Narosa Publishing House, (2019)
5. Asitava Ghoshal, Robotics: Fundamental concepts and analysis, Oxford University Press (2006)
6. M. Spong, M. Vidyasagar, S. Hutchinson, Robot Modeling and Control, Wiley & Sons, (2005).

Reference Books

1. J.J. Craig, Introduction to Robotics, Pearson Education.
2. Curtis D. Johnson, Process Control Instrumentation Technology, PHI publication.

Sr. No.	Examination	Module
1	T-I	1
2	T-II	2
3	End Sem	1 to 4

Alternative SWAYAM/NPTEL Course:

NPTEL Course Name	Instructor	Host Institute
Robotics	Prof. Dilip Kumar Pratihar	IIT Kharagpur
Robotics	Prof. P. Seshu, Prof. P.S. Gandhi, Prof. K. Kurien Issac, Prof. B. Seth, Prof. C. Amarnath	IIT Bombay

Course Code	Course Name
MI-BT044	Control of Robotic Systems

Course pre-requisites	

Course Objectives
This course aims to develop the understanding of control systems, its designing and application.
Course Outcomes
Upon successful completion of the course, students should be able TO 1. Understand and apply linear control 2. Understand and apply non-linear control systems 3. Understand concepts of Motion Control.
Course Content

Module No.	*Details*	*Hrs.*
1	Basics of Control Systems: Differential Equation, Transfer function, Frequency response, Routh-Hurwitz test, Relative stability, Root locus design.	**06**
2	Control System Design Techniques: Construction of root loci, Phase lead and phase-lag design, Lag-lead design, Bode plot, Polar plot, Nyquist plot.	**06**
3	Introduction to Linear Control Systems: Concept of states, State space model, Different forms of state space models, Controllability and observability.	**06**
4	Advanced Linear Control Techniques: Pole placement by state feedback, Observer design, P, PI, & PID Controller, Control law partitioning.	**06**
5	Modelling and Control of Robotic Systems: Modelling and control of a single joint: Types of robotic joints (revolute, prismatic), Degrees of freedom (DOF), Robot configurations (serial, parallel, SCARA, etc.)	**04**
6	Non-Linear Control Systems: Common physical non-linear	**06**

	systems, Phase plane method, System analysis by phase plane method, Stability of non-linear systems.	
7	Advanced Non-Linear and Motion Control: Stability analysis by describing function method, Liapunov's stability criterion, The control problems for manipulators, Motion Control: Point to Point Control, trajectory generation, Continuous Path Control, Joint based control, Cartesian Control, Force Control, hybrid position/force control system.	**08**

Text Books

1. M. Gopal, Control Systems, McGraw-Hill (2012)
2. K. Ogata, "Modern Control Engineering", Prentice Hall India (2009).
3. M. Spong, M. Vidyasagar, S. Hutchinson, Robot Modeling and Control, Wiley & Sons, (2005).
4. J. J. Craig, "Introduction to Robotics: Mechanics and Control", 3rd edition, Addison-Wesley (2003).

Reference Books

1. S. K. Saha, Introduction to Robotics 2e, TATA McGraw Hills Education (2014).
2. Thomas Kailath, "Linear Systems", Prentice Hall (1980).
3. Alok Sinha, "Linear Systems: Optimal and Robust Control", Taylor & Francis (2007).

Sr. No.	Examination	Module
1	T-I	1
2	T-II	2
3	End Sem	1 to 4

Alternative SWAYAM/NPTEL Course:

NPTEL Course Name	Instructor	Host Institute
Robotics and Control : Theory and Practice	Rob Prof. N. Sukavanam, Prof. M. Felix Orlando	IIT Roorkee
Control systems	Prof. C.S.Shankar Ram	IIT Madras