



**Birla Institute of Technology & Science, Pilani**  
Hyderabad Campus

**Academic - Undergraduate Studies Division (AUGSD)**

**SECOND SEMESTER 2022-2023**

Course Handout Part II

Date: 16 January 2023

In addition to Part-I (General Handout for all courses appended to the time table) this portion gives further specific details regarding the course.

Course No. : **BITS F441**  
Course Title : **ROBOTICS**  
Instructor-in-Charge : **Y V D Rao**

**Course Description:** See Page VI-15 in Bulletin 2019-2020.

The objective of this course is to make the students familiar with Robotics, the main components of Robots, their kinematics, sensors, transmission and drives, control systems, intelligence and vision, geometric modelling and reasoning, assembly planning, grasping, collision avoidance, mobile robots, force strategies, uncertainty analysis, and representation of visual world.

**Academic Honesty and Integrity Policy:** *Academic honesty and integrity are to be maintained by all the students throughout the semester and no type of academic dishonesty is acceptable*

**Scope and Objective:** This course is intended to provide a comprehensive knowledge of the technology related to robotics. The necessity of human like machines to replace human beings from the work-sites have been long felt for a large variety of reasons. The field of robotics has emerged as one of the important present engineering areas.

The course will develop overall background of the student in interdisciplinary robotic technology with emphasis on mechanical aspects. Mechanisms which can be used in robots, their characteristics, kinematic and dynamic analysis and design will be discussed in detail along with the issues, applications and implementation principles of industrial and mobile robotics.

**Text Book:**

(T) Mittal R. K. & Nagrath I. J., “*Robotics and Control*”, TMH, 2003 (Reprint 2007 or later).

**Reference Books:**

(R1) Groover, M. P., et al., “*Industrial Robotics*”, MGHISE, 1986.

(R2) Fu, K. S., et al., *Robotics: Control, Sensing, Vision & Intelligence*, MGHISE, 1987.

(R3) Robert J., Schilling, *Fundamentals of Robotics: Analysis and Control*, Prentice Hall, NJ, 2002.

(R4) Siegwart R., Nourbakhsh I.R., Scaramuzza D., “*Introduction to Autonomous Mobile Robots*”, The MIT Press, second edition 2011.





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**Course Plan:**

Lecture No.	Learning Objectives	Topics to be covered	Reference Chap./Sec.
1	To understand the purpose of Robots and developments in the area of Robotics.	Introduction of Robotics, Progressive Advancement in field of robotics and the future prospects of Robotics.	T1-1
2, 3	To learn the fundamental aspects of a Robot.	Robot Anatomy, Degrees of Freedom (DOF) in a Manipulator, Arm & Wrist Configuration, The End-effector, Human arm characteristics, Design & Control issues	T1-1, R1-2
4,5, 6, 7	To understand the necessity of frames, Mapping, Transformations as applied in Robot Motion Analysis.	Co-ordinate frames mapping, Mapping between frames, Transformations, Fundamental Rotation Matrices – Principle axes Rotation fixed, Euler and Equivalent angle axis Representations	T1-2 R1-4 R2-2
8	To learn how to model a manipulator, Learn notations and description of Robotic links and joints.	Kinematic Modeling of Manipulator, Direct kinematics model mechanical structure & Notations Description of links & Joints.	T1-3 R1-4, R1-3
9,10, 11,12	To study Kinematic analysis of Manipulators and learn the forward kinematic analysis of a manipulator	Denavit – Hartenberg Notation, Frame assignment, Link transformation Matrix, Tool Matrix, Forward Kinematics, Examples using different degrees of freedom manipulators	
13, 14,15,16	To learn about inverse Kinematics, study design aspects, know the importance of workspace	The Inverse kinematics manipulator: workspace, solvability of inverse kinematic model. Solution technique, closed form solutions, Singularities.	T1-4, 5 R1-4, R3-3
17,18,19	To understand the what is differential Motion of a manipulator, study mapping of velocity vectors,	Differential kinematics, linear and angular velocity of a Rigid Body, Relationship between Transformation matrix and angular velocity, mapping velocity vectors, velocity propagation along links. Examples	T1-5 R1-5 R3-5
20,21,22	To learn the concept of Jacobian, derive the expression for a Jacobian based on type of joint.	Introduction to Jacobian, Manipulator Jacobian, Jacobian relation for revolute and prismatic joints, Jacobian Inverse, Jacobian singularities, Examples.	T1-5 R1-5 R3-5
23	Understand what is meant by Manipulator Statics	Static Analysis. Principle of Virtual work, Jacobian in static analysis, Examples	T1-5 R1-5 R3-5



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24,25,26,	To understand what is Dynamics of a manipulator, what are the basic relations for dynamic analysis of manipulators. To understand the formulations like Newton – Euler and Lagrange – Euler in dynamic analysis.	Introduction to the dynamics of a manipulator, Equation of motion, Lagrangian Mechanics, Lagrange – Euler formulation. Examples on Lagrangian equation to derive equation of motion in general and for a manipulator. Examples.	T1-6 R2-3 R3-6 R1-4
27, 28,29	To study systematic approach for formulation of equation of motion of a manipulator	Velocity of a point on the manipulator, The inertia tensor, The kinetic energy, the potential energy. Equations of Motions, the Lagrangian-Euler (LE) Dynamic model algorithm. Examples on Dynamic modeling	T1-6 R2-3 R3-6 R1-4
30, 31	To describe the time sequence of manipulator motion and Trajectory Planning	Goal of trajectory planning, introduce the basic terminology used in trajectory planning, define Joint-Space Technique, Cartesian Space Technique, Using polynomial as interpolation function. Examples using cubic polynomial trajectories, Use of via points.	T1-7
32, 33,34	In Robot Control, we make a model that analyses joint motion and torque history as compared to the designed tractor and generate an error signal. Learn about various strategies of control algorithms.	Control of movements of mechanical joints, control sequence, n-joints manipulator control system, system performance, control system with damping, control strategy, Architecture of control systems.	T1-8 R2-5 R1-8 R3-7
35, 36,37	To learn about various Sensors and Actuators used in Robotic manipulators	Introduction to the concept of sensing, sensors, transducers used in Robotics. Types of sensor and transducers used in Robotics like position, velocity, force sensors. Tactile sensors Force-Torque sensors. Types of actuators, AC, DC, Servo and stepper motors	T1-8, R2-5 R1-6, R3-7
38,39	To understand what is Robot Programming, Different programming languages	Types of programming method, Robot Programming issues, commands, Writing programs for different tasks	R1-8, 9 R2-9 R3-9
40	To learn about the basic features and developments of Mobile robots.	Introduction to Mobile robots, Legged and Wheeled Mobile Robots	R4-1, 2



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**Evaluation Scheme:**

Component	Duration	Weightage (%)	Date & Time	Nature of Component
Mid Semester Test	90 min	25 (50 M)	14/03 11.30 - 1.00PM	Closed book
Quiz	5 Min	20 (40 M)	During Lecture hours	Open book
Project	--	15 (30 M)	Announced in class	Open book
Comprehensive Examination	180 min	40 (80 M)	10/05 AN	Closed book

**Chamber Consultation Hour:** To be announced later

**Notices:** All notices will be put up on CMS/email/Google Classroom only.

Ten (10) Quizzes (each for 5 marks) will be conducted and best 8 will be taken for grading. No makeup is allowed.

Project: A working Model of a chosen Robotic manipulator is to be modelled, and assembled using the components needed.

**Make-up Policy:** Make-up in Midsem Test and Comprehensive Examination will be given with prior permission and for genuine reasons only.

**Academic Honesty and Integrity Policy:**

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**INSTRUCTOR-IN-CHARGE**

