BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI
HYDERABAD CAMPUS
ACADEMIC-GRADUATE STUDIES AND RESEARCH DIVISION
FIRST SEMESTER 2023-2024
Course Handout (Part II)

Date: 28/July/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.	: ME G511
Course Title	: MECHANISMS & ROBOTICS
Instructor-in-charge	: Prof. YVDRAO
Instructors	: Prof. Y V D RAO, Dr. Abhishek Sarkar and Mr. George Yuvaraj

Course Description:
Classification of robots & manipulators; fields of application; Synthesis of planar & spatial mechanisms; Methods of function & path generation; coupler curve synthesis; linkages with open loop; Actuators & drive elements; Microprocessor based application and control of Robots.

Scope and Objective:

This course provides a comprehensive knowledge of the theory of Mechanisms and Robotics. In the first part of the course, additional topics that are required for the design of mechanisms is dealt with. The next part deals with manipulators called Robots that are used to replace or supplement human beings in various work-sites. Good examples regarding the areas of applications of these robots are given. The required background for this area namely spatial mechanisms analysis is also dealt with. Finally, the emerging field of Robotics which is one of the current important interdisciplinary areas of application and research is described.

The contents of the course will give an overall insight into the theory of Robotic technology with more emphasis on mechanical aspects. The course is designed to cover the areas like Basic Anatomy related to Robotics, Mechanisms which can be used in Robots, Robot Configurations, kinematic and dynamic analysis of Robots and Programming of Robots will be taught in detail along with suitable examples, applications and implementation principles of industrial robotics.

Text Book:

(T1) "Theory of Machines and Mechanisms", John Joseph Uicker, Joseph Edward Shigley, Gordon R. Pennock, Oxford University Press, 3rd Edition, 2003.

(T2) "Robotics and Control", Mittal R. K. & Nagrath I. J, TMH, 2003 (Reprint 2007 or later).

Reference Books:

(R1) "Kinematics, Dynamics, and Design of Machinery", Kenneth J. Waldron& Gary L. Kinzel, 2nd Ed Wiley India, 2004.

(R2) "Mechanism and Machine Theory", Ashok G. Ambekar, PHI, 2007.

(R3) "Theory of Machines and Machines" - Amitabh Ghosh and A.K. Malik, Allied East West Press Pvt. Ltd., 3rd Ed.

(R4) "Industrial Robotics", Groover, M. P., et al., MGHISE, 1986.

(R5) "Robotic: Control, Sensing, Vision & Intelligence", Fu, K. S., et al., MGHISE, 1987.

(R6) "Fundamentals of Robotics: Analysis and Control", Robert J., Schilling, Prentice Hall, NJ, 2002.

Course Plan:

Lecturer No.	Learning Objectives	Topics to be covered	Reference Chap./Sec.
1	To understand a systematic procedure of design of Planar linkages	Motion, Path, and Function generation tasks	T1-11 R1-6
2, 3	Define and understand Synthesis of mechanisms	Introduction to Synthesis of planar mechanisms-Graphical and Analytical Methods, Bloch Method and Freudenstein equation.	T1- 11 R2-6, R3-3
4	Learn about Coupler- Curves and their use in synthesis of mechanisms	Coupler curves, Cognate linkages	T1- 11 R3-3
5	Understand what are Spatial Mechanisms	Introduction to Spatial Mechanism, Position analysis of Spatial Mechanism	T1-11 R3-5
6	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.	T2-1
7, 8	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	T2-1 R4-2
9, 10, 11, 12,	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.	T2-2 R4-4 R5-2
13, 14	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.	T2-1 R6-2
15, 16, 17	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	T2-2 R4-4 R6-2
18, 19, 20	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.	T2-3 R4-4
21,2 2	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.	T2-3 R5-2
23, 24	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.	T2-4 R4-4
25, 26	Understand what is meant by Manipulator Statics	Static Analysis. Principle of Virtual work, Jacobian in static analysis, Examples	T2-4, R5-2
27, 28	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	T2-4, R5-2

29, 30	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	T2-5, R6-3
31, 32, 33	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.	R4-5
34, 35, 36	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.	T2-5 R4-5 R6-5
37, 38, 39	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	T2-5 R4-5 R6-5
40	To understand what is Robot Programming, Different programming languages	Types of programming method, Robot Programming issues, commands, Writing programs for different tasks	T2-6 R5-3 R6-6 R4-4

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Evaluation:

Component	Duration	Weightage (%)	Date & Time	Remarks
Mid semester Test	90 Mins	25 (50 M)	09/10 - 2.00 - 3.30PM	CB
Quiz (Surprise)	5 Mins	10 (20 M)	During Class	OB
Assignment	--	5 (10 M)	---	OB
Project	--	5 (10 M)	---	OB
Lab work	--	20 (40 M)	---	OB
Compre. Exam	120 Mins	35 (70 M)	07/12 9 to 12 Noon	CB

CB: Closed Book OB: Open Book

Quizzes: 12 quizzes will be conducted and best 10 will be considered.

In **assignments** Literature Survey is to be done in selected topic. Write research Summaries.

Each student has to complete a **project** assigned. Submit a report and present the work done.

Weekly two times **lab work** will be there and each class is evaluative unless announced.

Consultation Hour: As announced in the Class Room.

Notices: All notices concerning the course are displayed on Google classroom of ME G511.

Make-up Policy: No makeup for Assignments/Project/Lab.

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

(Y V D Rao)
Instructor-in-charge
ME G511