BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI-Hyderabad Campus

FIRST SEMESTER 2019-2020

Course Handout (Part II)

Date: 12/06/2019

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 : YVDRAO

Course Description: Page 309 in Bulletin 2010-2011.

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.

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 provides a comprehensive knowledge of about 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. In 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 back ground for this area namely spatial mechanisms analysis is also dealt with. Finally, about 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:

Lecture r No.	Learning Objectives	Topics to be covered	Reference Chap./Sec.
1	Design of Planar linkages	Motion, Path and Function generation tasks	T1-11 R1-6
2,3	Synthesis of mechanisms	Introduction to Synthesis of planar mechanisms-Graphical and Analytical Methods	T1- 11 R2-6
4	Coupler- Curves	Coupler curves, Cognate linkages	T1- 11 R3-3
5	Analytical methods	Bloch Method and Freudenstein equation	T1- 11 R3-3
6,7	Spatial Mechanisms	Introduction to Spatial Mechanism, Position analysis of Spatial Mechanism	T1-11 R3-5
8	Introduction	Automation and Robotics. Robotics in Science Fiction, Progressive Advancement. The Robotics trends and the future prospects.	T2-1
9	Fundamentals of Robot Technology	Robot Anatomy – Links, Joints and Joint Notation scheme, Degrees of Freedom (DOF), Required DOF in a Manipulator	T2-1 R4-2
10	Configuration and end effector	Arm Configuration, Wrist Configuration; The End-effector, Human arm characteristics, Design & Control issues	T2-2 R4-2
11, 12, 13	Mapping	Introduction to co-ordinate frames mapping, Mapping between Rotated frames, Mapping between Translated frames, Mapping between Rotated & Translated frames.	T2-2 R4-4 R5-2
14, 15	Transformation of frames	Description of objects in space, Transformation of vectors - Rotation & Translation of vectors, Composite transformations.	T2-1 R6-2
16, 17	Homogeneous Transformation matrix	Inverting a Homogeneous Transform, Fundamental Rotation Matrices – Principle axes Rotation fixed, Euler and Equivalent angle axis Representations	T2-2 R4-4 R6-2
18	Practice on theory	Examples on mapping transformation	T2-2
19,20	Kinematic modelling of Manipulators	The kinematic Modeling of Manipulator, Direct kinematics model mechanical structure & Notations Description of links & Joints,	T2-3 R4-4
21,22	Denavit Hartenberg Notation	Denavit – Hartenberg Notation, kinematic Relationship between links, Manipulator transformation matrix, Examples.	T2-3 R5-2
23	Practice problems on Forward Kinematics	Examples of direct Kinematics	T2-4, R4-3
24,25	Inverse kinematics of manipulator	The Inverse kinematics of manipulator: workspace, solvability of inverse kinematic model. Solution technique, closed form solutions.	T2-4 R4-4
26	Algorithms for inverse kinematics	Algorithms Examples of inverse kinematics	T2-4, R5-2
27	Practice problems on Inverse Kinematics	Examples of inverse Kinematics	
28	Singularities in work space	Singularities of manipulators	T2-5, R6-3
29	Robot end-	Types of end-effectors, methods of holding, Mechanical	R4-5

	effectors	grippers, Mechanisms for grippers, Consideration in gripper selection & design, Gripping Force.	
30,31	Differential Motion and Statics	Differential kinematics, linear and angular velocity of a Rigid Body, Relationship between Transformation matrix and angular velocity, mapping velocity vectors, velocity propagation along links.	T2-5 R4-5 R6-5
32,33	Jacobian of a manipulator	Manipulator Jacobian, Jacobian Inverse, Jacobian singularities, Static Analysis. Jacobian in statics, Examples.	
34-39	Dynamics of Mechanisms	Introduction, Lagrangian Mechanics, Lagrange – Euler formulation - 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.	T2-6 R5-3 R6-6 R4-4
40	Trajectory Planning	Definition and planning tasks, Joint space techniques, Cartesian Space techniques, Joint space versus Cartesian Space TP	T2-7
41	Robot Control	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.	T2-8 R5-5 R4-8 R6-7
42	Robot Programming	Robot Programming issues, optimization position definitions, interpolation language command, data object command, motion commands, gripper command, tool commands, sensors command, other command, Writing programs for different tasks	R4-8, 9 R5-9 R6-9

Home Assignments, Laboratory and Project: There will be three components under this head. First one is Literature Survey, second one is Research Summaries and third part is: Each student has to work on a project assigned. The project will have seminars and culminate in submission of a written report and presentation of work done.

Evaluation:

Component	Duration	Weightage (%)	Date & Time	Remarks
Mid semester Test	90 Mins	20 (40 M)	03/10 , 11:00 – 12:30 PM	CB
Assignment	--	10 (20 M)	---	OB
Project	--	10 (20 M)	---	OB
Lab work	--	20 (40 M)	---	OB
Compre. Exam	180 Mins	40 (80 M)	09/12 AN	CB

Chamber Consultation Hour: As announced in the Class Room.

Notices: All notices concerning the course are displayed on CMS.

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

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