DEPARTMENT OF PRODUCTION TECHNOLOGY
MADRAS INSTITUTE OF TECHNOLOGY CAMPUS
ANNA UNIVERSITY: CHENNAI – 600 044.

COURSE PLAN

COURSE DETAILS:

Degree	**B.E.**		
Programme Name	**PRODUCTION ENGINEERING**		
Course Code & Title	**RO5402 & ROBOT KINEMATICS**		
Credits	3	**Session**	Feb 2023 – May 2023
Course Type	Theory/ ~~Theory with Lab/ Lab~~	**Regulation/ SEM**	R2019 / 4
Name of the Faculty	**Dr.P.KARTHIKEYAN** Assistant Professor Department of Production Technology MIT, Anna University, Chennai – 600044.		

RO5402 ROBOT KINEMATICS

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3	0	0	3

COURSE OBJECTIVES:

- To introduce Robots history, terminologies, classification and configurations.
- To get knowledge about basic Geometrical and Algebraic approach to solve forward
- kinematics of serial manipulator.
- To get knowledge about advanced forward kinematics of serial manipulator.
- To get knowledge about inverse kinematics of various serial manipulator.
- To get knowledge about Jacobian aspects and infinitesimal motion of robot mechanisms.

UNIT I	**OVERVIEW OF ROBOTICS**	**9**
Introduction to Robotics - History - Definitions - Law of Robotics – Terminologies – Classifications Overview – Links & Joints - Degrees of Freedoms - Coordinate Systems - Work Volume - Precision, Repeatability & Accuracy - Position and Orientation of Objects - Roll, Pitch and Yaw Angles - Joint Configuration of Five Types of Serial Manipulators- Wrist Configuration- Overview of end effector - Selection and Application of Serial Manipulators- Singularities – Manipulability of manipulators.		
UNIT II	**FORWARD KINEMATICS - GEOMETRICAL AND ALGEBRAIC APPROACH**	**9**
Need for forward and Inverse Kinematics Equation – Parameters in Design and Control – Methods of forward and inverse kinematics- Geometrical and Algebraic Approach in Forward Kinematics Solution, 1 DOF - 2 DOF Planar Robot (2P and 2R); 3DOF 2RP Spatial Robot.		
UNIT III	**FORWARD KINEMATIC MODELING – DENAVIT-HARTEBERG (DH) APPROACH**	**9**
Unit Circle Trigonometry - Translation Matrix - Rotation matrix, Euler Angles - Quaternion Fundamental –Dot and Cross Products - Frames and Joint Coordinates - Homogeneous Transformation - D-H Convention and Procedures and Solutions: 3 DOF wrist , RR Planar, 3 DOF RRP, Cartesian, Cylindrical, Spherical , SCARA and Articulated 3 DOF robots - 3 DOF robot with wrist.		
UNIT IV	**INVERSE KINEMATICS**	**9**

Introduction to inverse kinematics -Issues in inverse kinematics - Inverse kinematics of 2 DOF Planar robot - 2 and 3DOF planar and Spatial robot - Tool configuration - Inverse kinematics of 3 axis robot and 6 axis Robot - Inverse kinematics Computation- Closed loop solution		
UNIT V	**JACOBIAN AND DIFFERENTIAL MOTION**	**9**
Forward and Inverse Jacobian-introduction - Singularity - Linear and angular velocity of end effector using Jacobian - Differential operator - Finding new location of end effector based on differential motion.		
		TOTAL: 45 PERIODS

TEXT BOOKS:

1. Mikell P. Groover, "Industrial Robotics", McGraw Hill, 2nd edition, 2012.
2. John J. Craig, "Introduction to Robotics", 3rd Edition, Addison Wesley, ISE 2020.

REFERENCES:

1. S K Saha, Introduction to Robotics, Tata McGraw-Hill, ISBN: 9789332902800, Second Edition, 9789332902800, 2019.
2. Arthor Critchlow, "Introduction to Robotics", 1st edition, Macmillan, 2009.
3. Mohsen Shahinpoor, "A Robot Engineering Text Book", 1st edition, Harper and Row, 2004.
4. Deb S.R., "Robotics Technology and Flexible Automation", 2nd edition, Tata McGraw - Hill Publis Robotics: Control and Programming. 2010.
5. J. Srinivas, R. V. Dukkipati, K., "Robotics: Control and Programming", Narosa Publishing House, 2009.
6. Tsuneo Yohikwa, Foundations of Robotics Analysis and Control, Prentice Hall of India Pvt. Ltd., 2016.
7. Bijay K. Ghosh, Ning Xi, T.J. Tarn, Control in Robotics and Automation Sensor - Based integration, Academic Press, 1999.

COURSE OUTCOME

1. Explain the history, classifications and basic terminologies of robotics and various configuration of robots.
2. Evaluate forward kinematic model for planar and spatial robot manipulator.
3. Evaluate forward kinematic model for multi-DOF robot manipulators.
4. Evaluate inverse kinematic model for multi-DOF robot manipulators.
5. Evaluate differential motion of robot.

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
1.	3	2	1	1	-	-	-	-	-	-	-	1	-	-	3
2.	3	2	1	1	-	-	-	-	-	-	-	1	-	-	3
3.	3	2	1	1	-	-	-	-	-	-	-	1	-	-	3
4.	3	3	1	2	-	-	-	-	-	-	-	1	-	-	3
5.	3	1	1	2	-	-	-	-	-	-	-	1	-	-	3
	3	**2**	**1**	**1.4**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**		**-**	**3**

COURSE ALIGNED PROGRAMME OUTCOMES (PO) & PROGRAMME SPECIFIC OUTCOMES (PSO)

PO	Graduate Attribute	Programme Outcome
1	Engineering knowledge	Apply knowledge of mathematics, basic science and engineering science.
2	Problem analysis	Identify, formulate and solve engineering problems.
3	Design/development of solutions	Design a system or process to improve its performance, satisfying its constraints.
4	Conduct investigations of complex problems	Conduct experiments & collect, analyze and interpret the data.
5	Modern tool usage	Apply various tools and techniques to improve the efficiency of the system.
6	The Engineer and society	Conduct selves to uphold the professional and social obligations.
7	Environment and sustainability	Design the system with environment consciousness and sustainable development.
8	Ethics	Interacting industry, business and society in a professional and ethical manner.
9	Individual and team work	Function in a multidisciplinary team.
10	Communication	Proficiency in oral and written Communication.
11	Project management and finance	Implement cost effective and improved system.
12	Life-long learning	Continue professional development and learning as a life-long activity.

PSO	GRADUATES DEMONSTRATE
1	Multi-disciplinary Engineering in Robotics: Analyse the real world needs and design the robot and Automation solutions using the competency in multi domain engineering elements and integrated software tools.
2	Enhancement and upgradation of existing systems: Analyse conventional functions and process of various engineering elements and propose robots and automation solutions for enhanced performance of conventional systems
3	Robotic system integration and automated Solution and connectivity: Recommend the sensing, interfacing, controlling, actuating, communicating technologies and analysing the data through various subsystems and build the robots

COURSE TENTATIVE SCHEDULE / PLAN

SI.NO	DAY	DATE	HRS	UNIT	TOPICS	TEXT / REF.
1.					**OVERVIEW OF ROBOTICS**	
2.					Introduction to Robotics -	
3.					History –	
4.					Definitions -	
5.					Law of Robotics –	
6.					Terminologies –	
7.					Classifications Overview –	
8.					Links & Joints –	
9.					Degrees of Freedoms –	
10.					Coordinate Systems –	
11.				I	Work Volume –	
12.					Precision,	
13.					Repeatability & Accuracy –	
14.					Position and Orientation of Objects –	
15.					Roll, Pitch and Yaw Angles –	
16.					Joint Configuration of Five Types of Serial Manipulators-	
17.					Wrist Configuration-	
18.					Overview of end effector –	
19.					Selection and Application of Serial Manipulators-	
20.					Singularities –	
21.					Manipulability of manipulators.	
				II	**FORWARD KINEMATICS - GEOMETRICAL AND ALGEBRAIC APPROACH**	
22.					Need for forward and Inverse Kinematics Equation –	
23.					Parameters in Design and Control –	
24.					Methods of forward and inverse kinematics-	
25.					Geometrical and Algebraic Approach in Forward Kinematics Solution,	
26.					1 DOF - 2 DOF Planar Robot (2P and 2R);	
27.					3DOF 2RP Spatial Robot.	
				III	**FORWARD KINEMATICS - GEOMETRICAL AND ALGEBRAIC APPROACH**	
28.					Unit Circle Trigonometry –	
29.					Translation Matrix –	
30.					Rotation matrix, Euler Angles –	

31.					Quaternion Fundamental –	
32.					Dot and Cross Products –	
33.					Frames and Joint Coordinates –	
34.					Homogeneous Transformation –	
35.					D-H Convention and Procedures and Solutions:	
36.					3 DOF wrist, RR Planar, 3 DOF RRP, Cartesian, Cylindrical, Spherical, SCARA and Articulated 3 DOF robots –	
37.					3 DOF robot with wrist.	
					INVERSE KINEMATICS	
38.					Introduction to inverse kinematics -Issues in inverse kinematics –	
39.					Inverse kinematics of 2 DOF Planar robot –	
40.				**IV**	2 and 3DOF planar and Spatial robot –	
41.					Tool configuration –	
42.					Inverse kinematics of 3 axis robot and 6 axis Robot –	
43.					Inverse kinematics Computation- Closed loop solution	
					JACOBIAN AND DIFFERENTIAL MOTION	
44.					Forward and Inverse Jacobian-	
45.					introduction –	
46.				**V**	Singularity –	
47.					Linear and angular velocity of end effector using Jacobian –	
48.					Differential operator –	
49.					Finding new location of end effector based on differential motion.	
50.					**CONTINUOUS ASSESSMENT -1**	
51.					**CONTINUOUS ASSESSMENT - 2**	
52.					**ASSIGNMENT -1**	
53.					**ASSIGNMENT -2**	

COURSE DELIVERY/INSTRUCTIONAL METHODOLOGIES:

✓ Chalk & Talk	✓ LCD/~~Smart boards~~	✓ Web Resources
✓ Recorded videos	✓ software simulation	

COURSE ASSESSMENT METHODOLOGIES-DIRECT

✓ University (End Semester) Examination		**✓ Internal Assessment Tests**	
✓ Descriptive type Written test		**✓ Descriptive type Written test**	
		✓ Assignments/ Case Studies/ project work	

ASSESSMENT METHODS AND WEIGHTAGE R2019, 2021 batch onwards, theory, credit- 3

S.N.	Mode of Assessment	Date	Duration, marks, factor	% Weight
1	Continuous Assessment Test -1		1½ hr (50 marks) (mark *0.416)	12 %
2	Individual assignment/Case study/ seminar/ project work		10 Marks (mark*0.8)	8%
3	Continuous Assessment Test - 2		1½ hr 50 marks (mark *0.416)	12 %
4	Individual assignment/Case study/ seminar/ project work		10 Marks (mark*0.8)	8%
			Internal total	**40%**
5.	University Examination		3 hr (mark *0.6)	60 %
			End sem	**60%**

COURSE ASSESSMENT METHODOLOGIES-INDIRECT

✓ Student Feedback on Learning Outcomes	

COURSE (EXTRA) ESSENTIAL READINGS:

COURSE EXIT SURVEY (will be collected at end of the course)

The purpose of this survey is to find out from students about their learning experiences and their thoughts about the course.

COURSE POLICY (Compensation Assessment)

1. Attending all the assessment is mandatory for every student
2. Course policy will be followed as per the academic course regulation

COURSE ACADEMIC DISHONESTY AND PLAGIARISM

1. All rules and regulation prescribed by the ACOE, University Departments, are applicable in the Internal Assessment Tests and University (End Semester) Examinations. **(https://acoe.annauniv.edu/download_forms/student_forms/Guidelines.pdf)**
2. In general, possessing a mobile phone, carrying bits of paper with materials, talking to other students, copying from other students during Internal Assessment Tests and University (End Semester) Examinations will be treated as Malpractice and punishable as per the rules and regulations. The misuse of Assignment / Project / Seminar works from others is considered as academic dishonesty and will be treated with the rules and regulations of the University.

COURSE ADDITIONAL INFORMATION

Queries / clarifications / discussion (if required) may be e-mailed to / contact the course instructors during their Office Hours. pkarthikeyan@mitindia.edu. 9943419270 whatsapp

For Approval		
Faculty Incharge	Professor I/C (if any)	HOD (PT)