INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad -500 043

MECHANICAL ENGINEERING

COURSE DESCRIPTOR

Course Title	**ROBOTICS**					
Course Code	AME533					
Programme	B.Tech.					
Semester	VI	ME				
Course Type	PROFESSIONAL ELECTIVE					
Regulation	IARE - R16					
Course Structure	**Theory**			**Practical**		
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**	
	4	-	3	-	-	
Chief Coordinator	Mr. A Anudeep Kumar, Assistant Professor					
Course Faculty	Mr. A Anudeep Kumar, Assistant Professor					

I. COURSE OVERVIEW:

This course introduces fundamental concepts in robotics. Students will be exposed to a broad range of topics in robotics with emphasis on basics of manipulators, coordinate transformation and kinematics, trajectory planning, control techniques, sensors and robot applications.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
UG	AHS003	II	Computational Mathematics and Integral Calculus
UG	AME002	II	Engineering Mechanics

III. MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Robotics	70 Marks	30 Marks	100

IV. DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✘	Chalk & Talk	✔	Quiz	✔	Assignments	✘	MOOCs
✔	LCD / PPT	✔	Seminars	✘	Mini Project	✔	Videos

✘	Open Ended Experiments

V. EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE units and each unit carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each unit. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The emphasis on the questions is broadly based on the following criteria:

50 %	To test the objectiveness of the concept.
50 %	To test the analytical skill of the concept OR to test the application skill of the concept.

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 25 marks for Continuous Internal Examination (CIE), 05 marks for Quiz/ Alternative Assessment Tool (AAT).

Table 1: Assessment pattern for CIA

Component	**Theory**		**Total Marks**
Type of Assessment	CIE Exam	Quiz / AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part-A shall have five compulsory questions of one mark each. In Part-B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz / Alternative Assessment Tool (AAT)

Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four).

Marks shall be awarded considering the average of two quiz examinations for every course. The

AAT may include seminars, assignments, term paper, open ended experiments, five minutes video, MOOCs.

VI. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes (POs)		Strength	Proficiency assessed by
PO 1	**Engineering knowledge**: Capability to apply the knowledge of Mathematics, science and Engineering in the field of Mechanical Engineering.	3	Presentation on real-world problems
PO 2	**Problem analysis**: An Ability to analyze complex engineering problems to arrive at relevant conclusions using knowledge of Mathematics, Science and Engineering.	2	Seminar
PO4	**Conduct investigations of complex problems**: To design and conduct research-oriented experiments as well as to analyze and implement data using research methodologies.	1	Term Paper

3 = High; 2 = Medium; 1 = Low

VII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes (PSOs)		Strength	Proficiency assessed by
PSO 1	**Professional Skills:** To produce engineering professional capable of synthesizing and analyzing mechanical systems including allied engineering streams.	3	Presentation on real-world problems
PSO 2	**Software Engineering Practices:** An ability to adopt and integrate current technologies in the design and manufacturing domain to enhance the employability.	-	-
PSO 3	**Successful Career and Entrepreneurship:** To build the nation, by imparting technological inputs and managerial skills to become technocrats.	-	-

3 = High; 2 = Medium; 1 = Low

VIII. COURSE OBJECTIVES:

The course should enable the students to:	
I	Develop the knowledge in various robot structures and their workspace.
II	Develop the skills in performing kinematics analysis of robot systems.
III	Provide the knowledge of the dynamics associated with the operation of robotic systems.
IV	Provide the knowledge and analysis skills associated with trajectory planning.
V	Understand material handling and robot applications in industries.

IX. COURSE OUTCOMES (COs):

COs	Course Outcome	CLOs	Course Learning Outcome
CO 1	Understand characteristic	CLO 1	Differentiate between automation and robotics.

	features of robots and usage of different grippers for industrial applications.	CLO 2	Classify robots and describe its anatomy.
		CLO 3	Specify various types of industrial sensors.
		CLO 4	Classify various grippers.
CO 2	Understand direct and inverse kinematics of robot structure.	CLO 5	Discuss about motion analysis of robot.
		CLO 6	Understand methods for calculating the kinematics and inverse kinematics of a robot manipulator.
		CLO 7	Deduce D-H notations, joint coordinates and. world coordinates.
		CLO 8	Discuss about homogeneous transformation.
CO 3	Illustrate Differential Kinematics of planar and spherical manipulators.	CLO 9	Describe the differential kinematics of planar manipulators.
		CLO 10	Illustrate Lagrange-Euler formulation.
		CLO 11	Discuss jacobian and robot dynamics.
		CLO 12	Illustrate Newton-Euler formulation.
CO 4	Understand classification of robot actuators and trajectory planning.	CLO 13	Describe Joint space scheme.
		CLO 14	Illustrate cubic polynomial fit.
		CLO 15	Classify types of motion.
		CLO 16	Explain actuators and classify them.
CO 5	Remember material handling and applications in manufacturing.	CLO 17	Illustrate various robot applications in manufacturing.
		CLO 18	Discuss the role of robots in material handling.
		CLO 19	Explain work cell design.
		CLO 20	Discuss the role of robots in assembly and inspection,

X. COURSE LEARNING OUTCOMES (CLOs):

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
AME533.01	CLO 1	Differentiate between automation and robotics.	PO1	3
AME533.02	CLO 2	Classify robots and describe its anatomy.	PO2	2
AME533.03	CLO 3	Specify various types of industrial sensors.	PO1	3
AME533.04	CLO 4	Classify various grippers.	PO1	3
AME533.05	CLO 5	Discuss about motion analysis of robot.	PO1	2
AME533.06	CLO 6	Understand methods for calculating the kinematics and inverse kinematics of a robot manipulator.	PO2	2
AME533.07	CLO 7	Describe D-H notations, joint coordinates and. world coordinates.	PO2	2
AME533.08	CLO 8	Discuss about homogeneous transformation.	PO2	2
AME533.09	CLO 9	Describe the differential kinematics of planar manipulators.	PO4	1
AME533.10	CLO 10	Illustrate Lagrange-Euler formulation.	PO4	1
AME533.11	CLO 11	Discuss jacobian and robot dynamics.	PO2	2
AME533.12	CLO 12	Illustrate Newton-Euler formulation.	PO2	2
AME533.13	CLO 13	Describe Joint space scheme.	PO1	3
AME533.14	CLO 14	Illustrate cubic polynomial fit.	PO1	3
AME533.15	CLO 15	Classify types of motion.	PO1	3
AME533.16	CLO 16	Explain actuators and classify them.	PO1	3
AME533.17	CLO 17	Illustrate various robot applications in manufacturing.	PO2	3
AME533.18	CLO 18	Discuss the role of robots in material handling.	PO1	3
AME533.19	CLO 19	Explain work cell design.	PO2	3
AME533.20	CLO 20	Discuss the role of robots in assembly and inspection,	PO2	3

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XI. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES

Course Outcomes (COs)	Program Outcomes (POs)			
	PO 1	PO 2	PO 4	PSO1
CO 1	2	1		1
CO 2		2		
CO 3		1	1	1
CO 4	3			1
CO 5	1	2		1

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XII. MAPPING COURSE LEARNING OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Learning Outcomes (CLOs)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CLO 1	3												1		
CLO 2		2													
CLO 3	3												1		
CLO 4	3												1		
CLO 5		2													
CLO 6		2													
CLO 7		2													
CLO 8		2													
CLO 9				1											
CLO 10				1											
CLO 11		2											1		
CLO 12		2											1		
CLO 13	3														
CLO 14	3														
CLO 15	3														
CLO 16	3												1		
CLO 17		3											1		
CLO 18	3												1		

Course Learning Outcomes (CLOs)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CLO 19		3											1		
CLO 20		3											1		

3 = High; 2 = Medium; 1 = Low

XIII. ASSESSMENT METHODOLOGIES – DIRECT

CIE Exams	PO1,PO2, PO4, PSO1	SEE Exams	PO1, PO2, PO4, PSO1	Assignments	-	Seminars	PO1, PO2, PO4, PSO1
Laboratory Practices	-	Student Viva	-	Mini Project	-	Certification	-
Term Paper	PO1, PO2, PO4, PS01						

XIV. ASSESSMENT METHODOLOGIES - INDIRECT

✔	Early Semester Feedback	✔	End Semester OBE Feedback
✘	Assessment of Mini Projects by Experts		

XV. SYLLABUS

Unit-I	**INTRODUCTION TO ROBOTICS**
Introduction: Automation and robotic, an over view of robotics, classification by coordinate system and control systems; Components of the industrial robotics: Degrees of freedom, end effectors: Mechanical gripper, magnetic, vacuum cup and other types of grippers, general consideration on gripper selection and design, robot actuator and sensors.	
Unit-II	**MOTION ANALYSIS**
Motion analysis: Basic rotation matrices, composite rotation matrices, Euler angles, equivalent angle and axis, homogeneous transformation, problems; Manipulator kinematics: D-H notations, joint coordinates and world coordinates, forward and inverse kinematics, problems.	
Unit-III	**DIFFERENTIAL KINEMATICS**
Differential kinematics: Differential kinematics of planar and spherical manipulators, Jacobians, problems. Robot dynamics: Lagrange, Euler formulations, Newton-Euler formulations, problems on planar two link manipulators.	
Unit-IV	**TRAJECTORY PLANNING**
Trajectory planning: Joint space scheme, cubic polynomial fit, avoidance of obstacles, types of motion**:** Slew motion, joint interpolated motion, straight line motion, problems, Robot actuators and feedback components; Actuators: pneumatic.	
Unit-V	**ROBOTIC APPLICATIONS**
Robot application in manufacturing, material handling, assembly and inspection, work cell design.	
Text Books:	
1. M. P. Groover, Industrial Robotics, Pearson, 2nd Edition, 2012. 2. J.J Criag, Introduction to Robotic Mechanics and Controll, Pearson, 3rd Edition, 2013.	
Reference Books:	

1. K.S Fu, Robotics, McGraw-Hill, 1st Edition, 2013.
2. Richard, D. Klafter, Thomas A Chmielewski, Miachael Neigen, "Robotic Engineering An Integrated Approach‖, Prentice Hall", 1st Edition, 2013.
3. Asada, Slotine, "Robot Analysis and ltelligence", Wiley, 1st Edition, 2013.
4. Mark W. Spong, M. Vidyasagar, I.John, "Robot Dynamics & Control", John Wiley & Sons, 1st Edition, 2013.
5. R. K. Mittal, I.J. Nagrath, "Robotics and Control‖", Tata McGraw-Hill, 1st Edition, 2011.

XVI. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
1	Introduction of robots in chronological order.	CLO 1	T1:1.1
2-3	Classification of robots by co-ordinate and control system.	CLO 1	T1:1.2
4	Description of components of robotics.	CLO 2	T1:1.3
5	Need for the automation and robotics in manufacture.	CLO 2	T1:1.4
6	Description of various robots with degrees of freedom	CLO 2	T1:1.5
7	Description of various types of end effectors	CLO 4	T1:1.6
8-10	Illustration of gripper mechanism course analysis	CLO 4	T1:1.7
11-13	Requirement of gripper selection features	CLO 4	T1:1.7
14-15	Description and function of various types of sensors.	CLO 4	T1:1.8
16-18	Derivation of transformation matrix about X Y and Z axis. Composite rotation matrix.	CLO 5	T1:2.1
19-21	Derivation of matrix using Euler angles,	CLO 6	T1:2.2
22-23	Problem related to transformation in various axis.	CLO 6	T1:2.3
24-25	Description of D-H Variables, Describe procedure for forward kinematic motion analysis.	CLO 7	T1:2.4
26-28	Derivation of transformation matrix for small; incremental motion and problems.	CLO 7	T1:2.5
29-30	Problems on differential motion derivation of jacobian matrix for various configuration	CLO 7	T1:3.1
31-32	Derivation of Lagrange-Euler equation and solution of problems different configuration of robots	CLO 10	T1:3.2
33-34	Derivation of Newton-Euler equation and solution of problems different configuration of robots	CLO 10	T1:3.3
35-36	Illustration of Joint space motion for both straight line and point to point	CLO 13	T1:4.1
37	Illustration of slew motion and interpolated motion.	CLO 14	T1:4.2
39-40	Explanation of polynomial equation for various types of motion and solution of Problems in various types of trajectories.	CLO 15	T1:4.3
41	Description of functional aspects of each actuator and application	CLO 14	T1:4.4
42	Function wise description of various configuration of robots for different application.	CLO 17	T1:5.1
43	Role of robots in material handling.	CLO 18	T1:5.2
44	Applications of robots in manufacturing.	CLO 17	T1:5.3
45	Description of robot work cell design.	CLO 19	T1:5.4

XVII. GAPS IN THE SYLLABUS-TO MEET INDUSTRY / PROFESSION REQUIREMENTS:

S NO	DESCRIPTION	PROPOSED ACTIONS	RELEVANCE WITH POs	RELEVANCE WITH PSOs
1	To introduce coding and analyze the concepts.	Seminars	PO 1	PSO 1

2	Introduction of artificial intelligence	Seminars / NPTEL	PO 4	PSO 1
3	Encourage students to solve real time applications and prepare towards competitive examinations.	NPTEL	PO 2	PSO 1

Prepared by:
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