INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
Dundigal, Hyderabad -500 043

MECHANICAL ENGINEERING

COURSE DESCRIPTOR

Course Title	**LINEAR ALGEBRA AND ORDINARY DIFFERENTIAL EQUATION**				
Course Code	AHS002				
Programme	B.Tech				
Semester	I	AE | CSE | IT | ECE | EEE | ME | CE			
Course Type	Foundation				
Regulation	IARE - R16				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	1	4	-	-
Chief Coordinator	Ms. P Rajani, Assistant Professor				
Course Faculty	Dr. M Anita, Professor Mr. J Suresh Goud, Assistant Professor Ms. P Srilatha, Assistant Professor Ms. C Rachana, Assistant Professor Ms. B Praveena, Assistant Professor				

I. COURSE OVERVIEW:

The course focuses on more advanced Engineering Mathematics topics which provide with the relevant mathematical tools required in the analysis of problems in engineering and scientific professions. The course includes Types of matrices, difference calculus methods and differential equations. The mathematical skills derived from this course form a necessary base to analytical and design concepts encountered in the program.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
-	-	-	-

III. MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Linear Algebra and Ordinary Differential Equations	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 be answered by choosing the correct answer from a given set of choices (commonly four). Marks shall be awarded considering the average of two quizzes for every course. The AAT may include seminars, assignments, term paper, open ended experiments, five minutes video and MOOCs.

VI. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes (POs)		Strength	Proficiency assessed by
PO 1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Presentation on real-world problems
PO 2	**Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	2	Seminar
PO 4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	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.	1	Seminar
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 (COs):

The course should enable the students to:	
I	Enrich the knowledge of probability on single random variables and probability distributions.
II	Apply the concept of correlation and regression to find covariance.
III	Analyze the given data for appropriate test of hypothesis.

IX. 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
AHS002.01	CLO 1	Demonstrate knowledge of matrix calculation as an elegant and powerful mathematical languagein connection with rank of a matrix.	PO 1	1
AHS002.02	CLO 2	Finding rank by reducing the matrix to Echelon and Normal forms.	PO 1	3
AHS002.03	CLO 3	Determine inverse of the matrix by Gauss Jordon Method.	PO 1	3
AHS002.04	CLO 4	Apply the method of LU Decomposition and solve the simultaneous equations.	PO 2	2

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
AHS002.05	CLO 5	Use the method of LU factorization real world problems such as circuit designing and solving complex circuits	PO 2	3
AHS002.06	CLO 6	Use the method of LU factorization real world problems such as economize and accumulate sums in double precision Computer Programme.	PO 2	2
AHS002.07	CLO 7	Interpret the Eigen values and Eigen vectors of matrix for a linear transformation and use properties of Eigen values	PO 4	1
AHS002.08	CLO 8	Understand the concept of Eigen values in real world problems of control field where they are pole of closed loop system.	PO 4	1
AHS002.09	CLO 9	Apply the concept of Eigen values in real world problems of mechanical systems where Eigen values are natural frequency and mode shape.	PO4	1
AHS002.10	CLO 10	Use the system of linear equations and matrix to determine the dependency and independency.	PO 2	2
AHS002.11	CLO 11	Determine a modal matrix, and reducing a matrix to diagonal form.	PO 1	3
AHS002.12	CLO 12	Evaluate inverse and powers of matrices by using Cayley-Hamilton theorem.	PO 1	3
AHS002.13	CLO 13	Solving differential equations of first order.	PO 1	3
AHS002.14	CLO 14	Finding orthogonal trajectories of Cartesian and polar equations.	PO 1, PO 2	2
AHS002.15	CLO 15	Apply the first order differential equations in real world problems such as Newton's Law of cooling and Law of natural growth and decay	PO 2	2
AHS002.16	CLO 16	Solving Second and higher order differential equations with constant coefficients.	PO 2	2
AHS002.17	CLO 17	Apply the second order differential equations for real world problems of electrical circuits and simple harmonic motion.	PO 4	1
AHS002.18	CLO 18	Apply the Mean value theorems for the single variable functions.	PO 1, PO 2	2
AHS002.19	CLO 19	Understand the basic concepts of Partial Differential equations.	PO 1, PO 2	2
AHS002.20	CLO 20	Determine Jacobian for the coordinate transformation	PO 1, PO 2	2
AHS002.21	CLO 21	Apply the technique of Jacobian and inverse Jacobian relation to real world problems such as kinematics and inverse kinematic solutions of robot	PO 4	1

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
		manipulators.		
AHS002.22	CLO 22	Understand the techniques of multidimensional change –of –variables to transform the coordinates by utilizing the Jacobian.	PO 1	3
AHS002.23	CLO 23	Apply maxima and minima for functions of several variable's and Lagrange's method of multipliers	PO 1	3
AHS002.24	CLO 24	Understand the concept and acquire the knowledge for attempting the competitive exams	PO 4	1

3 = High; 2 = Medium; 1 = Low

X. MAPPING COURSE LEARNING OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC 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	1												1		
CLO 2	2												1		
CLO 3	3												1		
CLO 4		2													
CLO 5		3													
CLO 6		2													
CLO 7				1									1		
CLO 8				1											
CLO 9				2									1		
CLO 10		2											1		
CLO 11	3														
CLO 12	3														
CLO 13	3														
CLO 14	1	2											1		
CLO 15		2													
CLO 16		2													

CLOs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CLO 17				1									1		
CLO 18	1	2											1		
CLO 19	1	2											1		
CLO 20	1	2											1		
CLO 21				1											
CLO 22	3														
CLO 23	3														
CLO 24				1											

3 = High; 2 = Medium; 1 = Low

XI. ASSESSMENT METHODOLOGIES – DIRECT

CIE Exams	PO 1, PO 2	SEE Exams	PO 1, PO2, PO 4	Assignments	-	Seminars	PO 2
Laboratory Practices	-	Student Viva	-	Mini Project	-	Certification	-
Term Paper	PO 4						

XII. ASSESSMENT METHODOLOGIES - INDIRECT

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

XIII. SYLLABUS

Unit-I	THEORY OF MATRICES
Real Matrices**:** Symmetric, skew-symmetric and orthogonal matrices; Complex matrices: Hermitian, Skew-Hermitian and unitary matrices; Elementary row and column transformations, elementary matrix, finding rank of a matrix by reducing to Echelon form and normal form; Finding the inverse of a matrix using elementary row/column transformations: Gauss-Jordan method; Solving of linear system of equations by LU decomposition method.	
Unit-II	**LINEAR TRANSFORMATIONS**
Cayley-Hamilton theorem: Statement, verification, finding inverse and powers of a matrix; Linear dependence and independence of vectors; Linear transformation; Eigen values and eigen vectors of a matrix; Properties of eigen values and eigen vectors of real and complex matrices; Diagonalization of matrix.	
Unit-III	**DIFFERENTIAL EQUATIONS OF FIRST ORDER AND THEIR APPLICATIONS**
Formation of a differential equation; Differential equations of first order and first degree: Exact, non exact, linear equations; Bernoulli equation; Applications of first order differential equations: Orthogonal trajectories; Newton's law of cooling; Law of natural growth and decay.	

Unit-IV	HIGHER ORDINARY LINEAR DIFFERENTIAL EQUATIONS AND THEIR APPLICATIONS
Linear differential equations of second and higher order with constant coefficients, non homogeneous term of the type $f(x)=e^{ax}, \sin ax, \cos ax$ and $f(x)=x^n, e^{ax}v(x), x^n v(x)$; Method of variation of parameters; Applications to electrical circuits and simple harmonic motion.	
Unit-V	**FUNCTIONS OF SINGLE AND SEVERAL VARIABLES**
Mean value theorems: Rolle's theorem, Lagrange's theorem, Cauchy's theorem and generalized mean value theorems-without proofs. Functions of several variables: Functional dependence, Jacobian, maxima and minima of functions of two variables without constraints and with constraints; Method of Lagrang multipliers.	
Text Books:	
1. Kreyszig, "Advanced Engineering Mathematics", John Wiley & Sons Publishers, 9th Edition, 2014. 2. B. S. Grewal, "Higher Engineering Mathematics", Khanna Publishers, 42nd Edition, 2012.	
Reference Books:	
1. RK Jain & SRK Iyengar, "Advanced Engineering Mathematics", Narosa Publishers, 5th Edition, 2016. 2. Ravish R Singh, Mukul Bhatt, "Engineering Mathematics-1", Tata Mc Graw Hill Education, 1st Edition, 2009. 3. Srimanthapal & Suboth C.Bhunia, "Engineering Mathematics", Oxford Publishers, 3rd Edition, 2015.	

XIV. 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	Theory of Matrices Introduction of matrices	CLO 1	T1:22.5 R1:2.3
2-3	Real and complex matrices	CLO 2	T1:22.5 R1:2.4
4-6	Find rank by echelon and normal form	CLO 2	T1:22.6 R1:2.6
7	Gauss-Jordan method	CLO 4	T1:22.7 R1:4.4
8	LU decomposition method	CLO 4	T1:22.7 R1:4.10
9-12	Cayley Hamilton theorem	CLO 7	T1:22.8 R1:4.15
13-16	Eigen values and Eigen vectors	CLO 9	T1:22.9 R1:5.4
17-18	Diagonalisation	CLO 9	T1:22.9 R1:5.8
19--22	Differential equations Introduction of first order differential equations	CLO 11	T1:23.10 R1:6.8
23-24	Orthogonal trajectories	CLO 11	T1:23.10 R1:6.13
25-26	Applications	CLO 13	T1:23.9 R1:7.5
27-30	Second and Higher order differential equations with constant coefficients	CLO 11	T1:23.10 R1:7.5
31-34	Method of variation of parameters	CLO 9	T1:23.10 R1:8.1
35-36	Applications of second order differential equations	CLO 14	T1:23.1 R1:9.2

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
37	Differential Calculus Methods Verification of Rolle's Theorem to the given functions	CLO 14	T1:23.1 R1:9.4
38-39	Verification of Lagrange's Mean value theorem to the given functions	CLO 14	T1:23.1 R1:9.9
40	Verification of Cauchy's mean value theorem to the given functions	CLO 14	T1:23.1 R1:9.10
41	Functional dependence for two and three functions	CLO 14	T2:27.5 R1:10.2
42-43	Maxima and minima of functions of two variables without constraints	CLO 17	T2:27.7 R1:11.3
44-45	Lagranges method of undetermined multipliers	CLO 17	T2:27.8 R1:11.6

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

S No	Description	Proposed actions	Relevance with P0s	Relevance with PSOs
1	To improve standards and analyze the concepts.	Guest lecture	PO 1	PSO 1
2	Conditional probability, Sampling distribution, correlation, regression analysis and testing of hypothesis	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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