INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
Dundigal, Hyderabad -500 043

ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE DESCRIPTOR

Course Title	**ELECTRICAL MEASUREMENTS AND INSTRUMENTATION**				
Course Code	**AEE008**				
Programme	B.Tech				
Semester	IV	E EE			
Course Type	Core				
Regulation	IARE - R16				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	1	4	3	2
Chief Coordinator	Mr. P Shivakumar, Assistant Professor				
Course Faculty	Mr. P Shivakumar, Assistant Professor Ms. Lekha chandran, Assistant Professor				

I. COURSE OVERVIEW:

This course deals with measuring instruments mainly indicating instruments and the associated torques, instrument transformers, power factor meter, frequency meter, synchro scopes, wattmeter, energy meter, potentiometer, resistance measuring methods, ac bridges, ballistic galvanometer, flux meter, extension range of indicating instruments.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
UG	AHS006	I	Engineering Physics
UG	AEE002	II	Electrical Circuits

III. MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Electrical measurements and Instrumentation	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	Seminars
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	Term Paper
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	Laboratory experiments

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:** Able to utilize the knowledge of high voltage engineering in collaboration with power systems in innovative, dynamic and challenging environment, for the research based team work..	-	-
PSO 2	**Problem-Solving Skills:** Can explore the scientific theories, ideas, methodologies and the new cutting edge technologies in renewable energy engineering, and use this erudition in their professional development and gain sufficient competence to solve the current and future energy problems universally.	-	-
PSO 3	**Successful Career and Entrepreneurship:** The understanding of technologies like PLC, PMC, process controllers, transducers and HMI one can analyze, design electrical and electronics principles to install, test , maintain power system and applications	3	seminars

3 = High; 2 = Medium; 1 = Low

VIII. COURSE OBJECTIVES (COs):

The course should enable the students to:	
I	Demonstrate the construction, working and characteristics of electrical measurement instruments.
II	Illustrate the principles of energy measurement in electrical loads.
III	Outline the use of cathode ray oscilloscope.
IV	Evaluate various transducers for electrical measurement

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
CAEE008.01	CLO 1	Explain the various effects on measuring instruments used to measure electrical quantity.	PO 1,PO2	3
CAEE008.02	CLO 2	Understand PMMC and MI instruments in view of construction, extension range and various errors.	PO 1,PO2	2

CAEE008.03	CLO 3	Explain the instruments works on electrostatic effect principle.	PO2,PO4	2
CAEE008.04	CLO 4	Understand the working of potentiometer to measure the small voltages and discuss the importance of standardization in instruments.	PO 4	2
CAEE008.05	CLO 5	Explain Potentiometer applications in measurement of voltage, current, resistance and power.	PO 4	2
CAEE008.06	CLO 6	Distinguish between current transformer and potential transformer.	PO 4	2
CAEE008.07	CLO 7	Summarize ratio error and phase angle error in instrument transformers.	PO1,PO2	2
CAEE008.08	CLO 8	Understand the construction and operation of single phase wattmeter and three phase wattmeter.	PO 4	2
CAEE008.09	CLO 9	Identify the best method for the measurement of active and reactive powers in balanced, unbalanced system.	PO 1	3
CAEE008.10	CLO 10	Explain the importance of induction effect in the working of energy meter and also describe the energy meter calibration.	PO1,PO2	3
CAEE008.11	CLO 11	Find the unknown resistance using various DC bridges.	PO 1	3
CAEE008.12	CLO 12	Solve for unknown inductance and its quality factor using different types of AC bridges.	PO1,PO2	3
CAEE008.13	CLO 13	Estimate the capacitance between two conducting surfaces using various AC bridges.	PO 1	3
CAEE008.14	CLO 14	Explain transducers and classify the transducers based on measurement of electrical quantities.	PO4	2
CAEE008.15	CLO 15	Understand transducer used for the measurement of displacement, pressure, resistances, capacitance, speed and position.	PO2, PO4	2
CAEE008.16	CLO 16	Summarize the features, application and various working models of cathode ray oscilloscope.	PO1, PO2	3
CAEE008.17	CLO 17	Explain the measurement of phase angle and frequency of various electrical quantities.	PO 1, PO 2	3
CAEE008.18	CLO 18	Apply the concept of electromagnetic and electrostatic fields to solve real time world applications.	PO 1, PO 2	3
CAEE008.19	CLO 19	Explore the knowledge and skills of employability to succeed in national and international level competitive examinations.	PO 1, PO 2	3

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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	3	2													
CLO 2	3	2													
CLO 3		2		2											
CLO 4				2											
CLO 5				2											
CLO 6				2											
CLO 7	3	2													
CLO 8				2											
CLO 9	3														
CLO 10	3	2													
CLO 11	3	2													
CLO 12	3	2													
CLO 13				2											
CLO 14				2											3
CLO 15		2		2											3
CLO 16	3	2													3
CLO 17	3	2													3
CLO 18	3	2													
CLO 19	3	2													3

3 = High; 2 = Medium; 1 = Low

XI. ASSESSMENT METHODOLOGIES – DIRECT

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

XII. ASSESSMENT METHODOLOGIES - INDIRECT

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

XIII. SYLLABUS

Unit-I	INTRODUCTION TO MEASURING INSTRUMENTS
Introduction: Classification of measuring instruments, deflecting, damping and control torques, types of errors, ammeter and voltmeter: PMMC, MI instruments, expression for deflection and control torque, errors and compensation, extension of range using shunts and series resistances; Electro static voltmeter, electro dynamic type, attracted type, disc type, extension of range of ES voltmeters..	
Unit-II	**POTENTIOMETERS AND INSTRUMENT TRANSFORMERS**
DC Potentiometers: Principle and operation of Crompton potentiometer, standardization, measurement of unknown resistance, current, voltage; AC potentiometers: polar and coordinate type, standardization, applications; Instrument transformers: CT and PT, ratio and phase angle error.	
Unit-III	**MEASUREMENT OF POWER AND ENERGY**
Measurement of Power: Single phase dynamometer type wattmeter, LPF and UPF, double elements and three elements dynamometer wattmeter; Expression for deflection and control torque, extension of range of wattmeter by using instrument transformers, measurement of active and reactive power for balanced and unbalanced Systems. Measurement of Energy: Single phase induction type energy meter, driving and braking torques, errors and compensations, testing by phantom loading using RSS meter, three phase energy meter, introduction to net energy metering, maximum demand meters.	
Unit-IV	**DC AND AC BRIDGES**
Measurement of Resistance: Methods of measuring low, medium, high resistance, Wheatstone bridge, carry foster, Kelvin's double bridge, loss of charge method; Measurement of Inductance: Maxwell's bridge, hay's bridge , Anderson's bridge, Owen's bridge; Measurement of Capacitance: Desauty's bridge, Wein's bridge, Schering bridge.	
Unit-V	**TRANSDUCERS AND OSCILLOSCOPES**
Transducers: Definition of transducers, classification of transducers, advantages of electrical transducers, characteristics and choice of transducers, principle of operation of LVDT and capacitor transducers, LVDT applications, strain gauge and its principle of operation, gauge factor, thermistors, thermocouples, synchros, piezo-electric transducers, photovoltaic, photo conductive cells, photo diodes; Cathode ray oscilloscope: cathode ray tube, time base generator, horizontal and vertical amplifiers, CRO probes, applications of CRO, measurement of phase and frequency, Lissajous patterns, sampling oscilloscope, analog oscilloscope, tubeless	
Text Books:	
1. A K Sawhney, "Electrical and Electronic measurement and instruments", Dhanpat Rai and Sons Publications, 2002. 2. E W Golding and F C Widdis, "Electrical measurements and measuring instruments", Wheeler publishing, 5th Edition, 2006.	
Reference Books:	
1. Buckingham and Price, "Electrical measurements", Prentice Hall, 1nd Edition, 2000. 2. D V S Murthy, "Transducers and Instrumentation", Prentice Hall of India, 2nd Edition, 2009. 3. A S Morris, "Principles of measurement of instrumentation", Pearson/Prentice Hall of India, 2nd Edition, 1994. 4. H S Kalsi, "Electronic Instrumentation", Tata McGraw-Hill Publications, 1st Edition 1995.	

XIV. COURSE PLAN:

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

Lecture No	Topics to be covered	CLOs	Reference
1	Explain the types of instruments	CLO 1	T2:3
2	Explain the types of torques associated with secondary instruments	CLO 1	T2:3
3	Understand moving coil instruments	CLO 2	T2:238-249
4	Understand moving iron instruments	CLO 2	T2:257-262
5	Understand extension of range of ammeter	CLO 2	T2:238-249
6	Understand extension of range of voltmeter	CLO 2	T2:238-249
7	Understand the types of errors associated with mc and mi instruments	CLO 2	T2:257-262
8	Explain the principle of electro-static instruments	CLO 3	T2:282
9	Explain the types of electro-static instruments	CLO 3	T2:282
10	Remember the definition of instrument transformer and their uses	CLO 6	T2:313
11	Remember the principle and working of current transformer and their uses	CLO 6	T2:316-319
12	Remember errors of current transformer	CLO 7	T2:316-319
13	Illustrate the working of potential transformer	CLO 6	T2:330-335
14	Remember errors of potential transformer	CLO 7	T2:330-335
15	Understand the principle of operation of DC Crompton potentiometer	CLO 4	T2:330-335
16	Explain standardization of potentiometers	CLO 4	T2:330-335
17	Explain the measurement of resistance using potentiometer	CLO 5	T2:330-335
18	Understand the measurement of voltage, current using potentiometer	CLO 5	T2:330-335
19	Explain polar type AC potentiometer	CLO 5	T2:330-335
20	Understand co-ordinate type AC potentiometer	CLO 5	T2:330-335
21	Explain the standardization of AC potentiometer	CLO 5	T2:330-335
22	Understand the measurement of power using wattmeter	CLO 8	T2:363-371
23	Explain the construction and operation of single-phase wattmeter	CLO 8	T2:363-371
24	Measurement of power using single wattmeter method	CLO 9	T2:363-371
25	Measurement of power using two-wattmeter method	CLO 9	T2:363-371
26	Measurement of power using three- wattmeter method	CLO 9	T2:363-371
27	Explain double element wattmeter	CLO 8	T2:363-371
28	Illustrate the extension of range of wattmeter using instrument transformer	CLO 8	T2:363-371
29	Understand the extension of range of wattmeter using instrument transformer	CLO 8	T2:363-371
30	Explain the measurement of reactive power using various meter	CLO 8	T2:363-371

Lecture No	Topics to be covered	CLOs	Reference
31	Understand the principle of single-phase induction type energy meter	CLO 10	T2:383
32	Explain driving and braking torques	CLO 10	T2:383
33	Understand errors and compensation in energy meters	CLO 10	T2:387
34	Explain errors and compensation	CLO 10	T2:387
35	Illustrate the testing of energy meter using phantom loading	CLO 10	T2:396
36	Classify the various tests for energy meter	CLO 10	T2:387
37	Understand three-phase energy meter	CLO 10	T2:396
38	Explain tri-vector meter and maximum demand meter	CLO 10	T2:396
39	Remember methods of measuring low, medium and high resistance	CLO 11	T2:421-446
40	Explain methods of measuring low, medium and high resistance	CLO 11	T2:421-446
41	Analyse the sensitivity of Wheatstone bridge	CLO 11	T2:424
42	Explain the working of Carley's foster bridge	CLO 11	T2:428
43	Explain the working of Kelvin's double bridge	CLO 11	T2:428
44	Understand the measurement of high resistance based on loss of charge method	CLO 11	T2:437
45	Apply suitable AC bridge for the measurement of unknown parameters using AC bridges	CLO 12	T2:482-486
46	Demonstrate the measurement of unknown inductance using Maxwell's bridge Hay's bridge, Anderson's bridge and Owen's bridge	CLO 12	T2:482-486
47	Explain the use of Desauty's bridge, Wein's bridge and Schering bridge for the measurement of unknown capacitance	CLO 12	T2:488-491
48	Problems		
49	Explain the advantages, characteristics and choice of electric transducers	CLO 14	T2:935-949
50	Summarize the principle of operation of resistor, inductor and capacitor transducers	CLO 14	T2:979-986
51	Explain the principle of working and applications of LVDT	CLO 14	T2:964-966
52	Illustrate the principle of operation and applications of strain gauge	CLO 14	T2, R2,R4
53	Understand the principle, construction and working of thermistors and thermocouples	CLO 15	T2: 979-986
54	Explain the principle, construction and working of synchros and piezoelectric transducer	CLO 15	T2:1046-1050
55	Explain the principle, construction and working of photovoltaic cells, photoconductive cells and photo diodes	CLO 15	T2:964
56	Explain the measurement of strain and gauge sensitivity	CLO 15	T2:820-823
57	Understand the principle and working of cathode ray oscilloscopes and block diagram of cathode ray tube	CLO 16	T2:791-795
58	Explain horizontal amplifier, vertical amplifier, trigger circuit and time base generator of a cathode ray oscilloscope	CLO 16	T2:796,

Lecture No	Topics to be covered	CLOs	Reference
59	Understand screen and probes of cathode ray tube	CLO 16	T2:816-818
60	Explain the working of digital storage oscilloscopes	CLO 17	T2:819

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

S No	Description	Proposed actions	Relevance with POs	Relevance with PSOs
1	Construct basic and knowledge in instrumentation.	Guest lectures	PO 1, PO2	PSO3

Prepared by:

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HOD, EEE