INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

Department of Electrical and Electronics Engineering

COURSE DESCRIPTION FORMS

Course Title	**HIGH VOLTAGE ENGINEERING**			
Course Code	**51067**			
Programme	**B.Tech**			
Semester	**IV Year I Semester**			
Course Type	**Professional Elective**			
Regulation	**R15**			
Course Structure	**Lectures**	**Tutorials**	**Practicals**	**Credits**
	4	1	-	4
Course Coordinator	Mr. T Anil Kumar, Assistant Professor, EEE			
Course Faculty	Mr. T Anil Kumar, Assistant Professor, EEE			

I. COURSE OVERVIEW:

High voltage engineering deals with different mediums of insulation, break down of insulation, generation of high DC and AC voltage, measurement of high AC and DC voltages, testing of insulation under all types of conditions using generated high AC and DC voltages.

II. COURSE PREREQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	**51067**	VII	Knowledge of physics, chemistry, power systems, measurements , electro-magnetic fields are required	4

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III. MARKS DISTRIBUTION:

Sessional Marks	University End Exam Marks	Total Marks
Mid Semester Test There shall be 2 midterm examinations. Each midterm examination consists of subjective type and Objective type tests. The subjective test is for 10 marks, with duration of hour. Subjective test of each midterm exam shall contain 4 questions. The student has to answer 2 questions, each carrying 5 marks. The objective type test is for 10 marks with duration of 20minutes. It consists of 10 Multiple choice and 10 objective type questions. The student has to answer all the questions and each carries half mark. First midterm examination shall be conducted for the first 2 ½ units of syllabus and second midterm examination shall be conducted for the remaining 2 ½ units.	75	100

Five marks are earmarked for assignments. There shall be two assignments in every theory course. Marks shall be awarded considering the average of two assignments in each course reason whatsoever, will get zero marks(s).		

IV. EVALUATION SCHEME:

S. No	Component	Duration	Marks
1	I Mid Examination	90	20
2	I Assignment	-	05
3	II Mid Examination	90	20
4	II Assignment	-	05
5	External Examination	3 hours	75

V. COURSE OBJECTIVES:

At the end of the course, the students will be able to**:**

i. To understand what is high voltage engineering and its application.

ii. To attain the knowledge of different types of insulation medium and their breakdown phenomenon.

iii. To construct the circuits for high voltage generation and design circuits for measurement of high voltage.

iv. To understand the different causes for over voltage and insulation co-ordination for high voltage equipment.

v. Able to test the high voltage equipment for their withstand of insulation under different conditions.

VI. COURSE OUTCOMES:

After completing this course the student must demonstrate the knowledge and ability to:

1. Study the effect of electric field stresses on insulation mediums used in power systems.
2. Classify the different insulating mediums and their application in various power system equipment
3. Identify the numerical methods for computation of electric field stresses on insulation of power system apparatus.
4. Discuss different phenomenon which leads to break down of gas insulation medium and specify the particular gas any power system apparatus.
5. Explain the various methods which causes breakdown in liquid dielectric medium and their importance in power system protection
6. Illustrate the process which decreases the breakdown strength of solid insulating mediums and their application in power system.
7. Design the networks for generation of high direct current voltages and high alternating current voltages.
8. Measure the value of high direct current voltages , high alternating current voltages , impulse voltage and current after generation
9. Analyze tripping and control of impulse generator.
10. Determine the process which leads to over voltage and lightning phenomenon on power system equipment.
11. Study the insulation co-ordination in safe operation of extra high voltage power system.
12. Calculate the DC resistivity , loss factor and dielectric constant of different insulation mediums used in power system protection
13. Identify the difference between type test and routine test used to understand withstand capability of insulation system in power system.

14. Examine the power system equipment like insulators, bushings, isolators and circuit breakers for their breakdown strength.
15. Investigate the power system equipment like cable, transformers and surge arresters of their dielectric strength.
16. Understand importance of high voltage engineering, Insulation technology, generation, measurement and testing related to high voltage power system.
17. Explore the knowledge and skills of employability to succeed in national and international level competitive examinations.

VII. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		Level	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.	S	Discussion
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.	N	---
PO 3	**Design / development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	H	Exercise and seminars
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.	H	Exercise
PO 5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	N	------
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	S	Discussion
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	S	Discussion
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	N	---
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	N	---
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	S	Discussion, Seminars

Program Outcomes		Level	Proficiency assessed by
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	N	-----
PO 12	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	S	Prototype, Discussions

VIII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		Level	Proficiency assessed by
PSO1	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.	H	Exercise, Assignment and Discussion
PSO2	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.	N	------
PSO3	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.	N	------

IX. SYLLABUS:

UNIT- I

Introduction to High Voltage Engineering: Electric Field Stresses, Gas / Vacuum as Insulator, Liquid Dielectrics, Solids and Composites, Estimation and Control of Electric Stress, Numerical methods for electric field Computation, Surge voltages, their distribution and control, Applications of insulating materials in transformer, rotating machines, circuit breakers, cable, power capacitors and bushings.

UNIT- II

Break Down in Dielectric Materials: Gases as insulating media, collision process, Ionization process, Tow 'send's criteria of breakdown in gases, Paschen's law. Liquid as Insulator, pure and commercial liquids, breakdown in pure and commercial liquids. Intrinsic breakdown, elector mechanical breakdown, thermal breakdown, breakdown of solid dielectrics in practice, Breakdown in composite dielectrics, solid dielectrics used in practice.

UNIT-III

Generation & Measurement of High Voltages & Currents: Generation of High Direct Current Voltages, Generation of High alternating voltages,Generation of Impulse Voltages, Generation of Impulse currents, Tripping and control of impulse generators. Measurement of High Direct Current voltages, Measurement of High Voltages alternating and impulse, Measurement of High Currents direct, alternating and Impulse, Oscilloscope for impulse voltage and current measurements.

UNIT-IV

Over Voltages & Insulation Co-Ordination: Natural causes for over voltages — Lightning phenomenon, over Voltage due to switching surges, systems faults and other abnormal conditions, Principles of insulation Coordination voltage and Extra High Voltage power systems.

UNIT-V

Testing Of Materials & Electrical Apparatus: Measurement of D.C Resistivity, Measurement of Dielectric Constant and loss factor, Partial discharge measurements. Testing of Insulators and bushings, Testing of Isolators and circuit breakers, testing of cables, Testing of Transformers, Testing of Surge Arresters, and Radio Interference measurements.

X. TEXT BOOKS:

1 High Voltage Engineering, M.S.Naidu and V. Kamaraju, TMH Publications.

2 High Voltage Engineering, C.L.Wadhwa, New Age Internationals (P) Limited.

XI. REFERENCES:

1. High Voltage Engineering: Fundamentals, E.Kuffel, W.S.Zaengi, J.Kuffel by Elsevier.
2. High Voltage Insulation Engineering, Ravindra Arora, Wolfgang Mosch, New Age International (P) Limited
3. High Voltage Engineering, Theory and Practice, Mazen Abdel Salam, Hussein Anis, Ahdan El-Morshedy, Roshdy Radwan, Marcel Dekker.

XI. COURSE PLAN:

The course plan is meant as a guideline. There may probably be changes.

Lecture No.	Learning Objectives	Topics to be Covered	Reference
1	To understand electrical field stresses.	Electric Field Stresses	**T1,T2**
2	To know different gas and liquid substances as insulators.	Gas / Vacuum as Insulator, Liquid Dielectrics	**T1,T2**
3	To know different solid substances as insulators.	Solids and Compotes	**T1,T2**
4	To compute the electric field stresses using numerical methods.	Estimation and Control of Electric Stress, Numerical methods for electric field Computation	**T1,T2**
5	To understand surge voltages and their control	Surge voltages, their distribution and control	**T1,T2**
6	To know the insulation materials used for transformer, rotating machines	Applications of insulating materials in transformer, rotating machines	**T1,T2**
7	To know the insulation materials used for circuit breakers, cable power capacitors and bushings.	Applications of insulating materials in circuit breakers, cable power capacitors and bushings.	**T1,T2**

8	To know different gas insulation mediums are their breakdown phenomenon	Gases as insulating media, collision process, Ionization process,	**T1,T2, R1**
9	To understand Primary and secondary ionization process	Primary and secondary ionization process	**T1,T2, R1**
10	To derive the expression for electron growth in gas medium	Townsend's criteria of breakdown in gases,	**T1,T2, R1**
11	To state paschen'slaw ad introduction liquid insulation medium	Paschen's law. Liquid as Insulator,	**T1,T2, R1**
12	To differentiate pure and commercial liquids as insulators	pure and commercial liquids, breakdown in pure and commercial liquids.	**T1,T2, R1**
12-A	To know cycle of purification of liquids used as insulators	Purification process of commercial liquids	**T1,T2, R1**
13	To know intrinsic and electro-mechanical breakdown	Intrinsic breakdown, elector mechanical breakdown	**T1,T2, R1**
14	To understand breakdown phenomenon in solid di-electric mediums	thermal breakdown, breakdown of solid dielectrics in practice,	**T1,T2, R1**
14-A	To understand the phenomenon of treeing and tracking.	Treeing and tracking in solid insulation	**T1,T2, R1**
15	To understand breakdown phenomenon in solid di-electric mediums	Breakdown in composite dielectrics, solid dielectrics used in practice.	**T1,T2, R1**
16	To understand generation of high DC voltage using COPCK-ROFT WALTON circuit.	Generation of High Direct Current Voltages	**T1,T2, R1**
17	To understand generation of high DC voltage using Vande-graff generator.	Generation of High Direct Current Voltages	**T1,T2, R1**
18	To understand generation of high AC voltage using cascade transformer	Generation of High alternating voltages,	**T1,T2, R1**
19	To understand generation of high AC voltage using resonant transformer	Generation of High alternating voltages,	**T1,T2, R1**
20	To understand generation of high impulse voltage using impulse generator	Generation of Impulse Voltages,	**T1,T2, R1**
21	To understand generation of high impulse current using impulse generator	Generation of Impulse currents,	**T1,T2, R1**
22	To know the control of impulse generator	Tripping and control of impulse generators.	**T1,T2, R1**
23	To measure high DC voltage using different methods	Measurement of High Direct Current voltages,	**T1,T2, R1**
24	To measure high AC voltage using different methods	Measurement of High Voltages alternating and impulse	**T1,T2, R1**
25	To measure high impulse voltage using different methods	Measurement of High Voltages alternating and impulse	**T1,T2, R1**

26	To measure high DC using different methods	Measurement of High Currents direct,	**T1,T2, R1**
27	To measure high AC using different methods	alternating and Impulse	**T1,T2, R1**
28	To measure high impulse using different methods	alternating and Impulse	**T1,T2, R1**
29	To measure voltage using oscilloscope	Oscilloscope for impulse voltage and current measurements.	**T1,T2, R1**
30	To measure current using oscilloscope	Oscilloscope for impulse voltage and current measurements.	**T1,T2, R1**
31	To identify natural causes for over voltage	Natural causes for over voltages	**T1,T2, R1**
32	To understand lightning for causing surges	Lightning phenomenon	**T1,T2, R1**
33	To understand lightning for causing surges	Lightning phenomenon	**T1,T2, R1**
34	To understand the cause of over voltage because of switching	over Voltage due to switching surges	**T1,T2, R1**
35	To understand the cause of over voltage because of switching	over Voltage due to switching surges	**T1,T2, R1**
36	To know the systems faults	systems faults and other abnormal conditions,	**T1,T2, R1**
37	To identify other abnormal conditions	systems faults and other abnormal conditions,	**T1,T2, R1**
38	To understand insulation co-ordination	Principals of insulation Coordination voltage and Extra High Voltage power systems.	**T1,T2, R1**
39	To know principal of extra high voltage system	Principals of insulation Coordination voltage and Extra High Voltage power systems.	**T1,T2, R1**
40	To measure the dc resistivity of insulators	Measurement of D.C Resistivity,	**T1,T2, R1**
41	To measure the dc resistivity of insulators	Measurement of D.C Resistivity,	**T1,T2, R1**
42	To measure di-electric constant of solid insulators	Measurement of Dielectric Constant and loss factor,	**T1,T2, R1**
43	To measure loss factor of solid insulators	Measurement of Dielectric Constant and loss factor,	**T1,T2, R1**
44	To understand partial discharge in the voids of solid insulator	Partial discharge measurements. .	**T1,T2, R1**
45	To understand partial discharge in the voids of solid insulator	Partial discharge measurements. .	**T1,T2, R1**
46	To know different types testing on insulators	Introduction to testing of insulator	**T1,T2, R1**
47	To understand breakdown conditions of bushings	Testing of bushings,	**T1,T2, R1**
48	To understand breakdown conditions of Isolators	Testing of Isolators	**T1,T2, R1**
49	To understand breakdown conditions of circuit breakers	Testing of circuit breakers,	**T1,T2, R1**
50	To understand breakdown conditions of cables	testing of cables,	**T1,T2, R1**

51	To understand breakdown conditions of Transformers,	Testing of Transformers,	**T1,T2, R1**
52	To understand breakdown conditions of Surge Arresters,	Testing of Surge Arresters,	**T1,T2, R1**
53	To measure radio interference.	Radio Interference measurements	**T1,T2, R1**

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

S. NO	DESCRIPTION	PROPOSED ACTIONS	RELEVANCE WITH POs	RELEVANCE WITH PSOs
1	More content of Tesla coil may be suggested.	Seminars / NPTEL	PO1, PO3	PSO1
2	Testing of breakdown strength of insulation practically.	Installation Of Lab	PO1, PO3,PO4	PSO1

S = Supportive H = Highly Related

XIII. MAPPING COURSE OBJECTIVES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Course Objectives	Program Outcomes												Program Specific Outcomes		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
I	H	-	-	-	_	-	-	-	-	-	_	_	S	_	-
II	S	-	-	-	_	_	-	-	-	_	_	-	S	_	-
III	S	H	-	-	-	-	-	-	-	-	_	-	H	_	-
IV	S	S	H	-	_	_	-	-	_	-	-	_	H	_	-
V	S	H	-	-	_	-	-	_	_	-	_	-	S	_	-
VI	S	-	S	H	_	-	-	_	_	-	_	-	H	_	-
VII	-	-	S	H	_	-	-	_	_	-	_	-	S	_	-

S= Supportive H = Highly Related

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

Course Learning Outcomes	Program Outcomes												Program Specific Outcomes		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
PO 1	S	-	-	-	-	-	-	-	-	-	-	-	S	-	-
PO 2	S	-	-	-	-	-	-	-	-	-	-	-	S	-	-
PO 3	-	S	-	-	-	-	-	-	-	-	-	-	S	-	-
PO 4	S	S	-	-	-	-	-	-	-	-	-	-	H	-	-
PO 5	S	-	-	-	-	-	-	-	-	-	-	-	H	-	-
PO 6	S	-	-	-	-	-	-	-	-	-	-	-	H	-	-
PO 7	S	S	H	-	-	-	-	-	-	-	-	-	H	-	-
PO 8	-	H	-	-	-	-	-	-	-	-	-	-	S	-	-
PO 9	S	-	H	-	-	-	-	-	-	-	-	-	S	-	-
PO 10	H	-	-	-	-	-	-	-	-	-	-	-	S	-	-
PO 11	S	-	-	-	-	-	-	-	-	-	-	-	S	-	-
PO 12	S	H	-	-	-	-	-	-	-	-	-	-	H	-	-
PO 13	S	-	-	H	-	-	-	-	-	-	-	-	H	-	-
PO 14	S	-	-	H	-	-	-	-	-	-	-	-	H	-	-
PO 15	S	-	-	H	-	-	-	-	-	-	-	-	H	-	-
PO 16	S	H	H	H	-	-	-	-	-	-	-	-	H	-	-
PO 17	S	S	H	H	-	-	-	-	S	-	S	H	H	-	-

S= Supportive **H = Highly Related**

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