BASAVESHWAR ENGINEERING COLLEGE, BAGALKOT

COURSE PLAN

Title of Course	**:**	**Computer Application to Power Systems**	**Course Code**	**:**	**UEE751C**
Credits	**:**	**03**	**Contact Hours/ Week**	**:**	**03**
Total Hours	**:**	**40**	**Tutorial Hours**	**:**	**-**
CIE Marks	**:**	**50**	**SEE Marks**	**:**	**50**
Semester	**:**	**VII**	**Year**	**:**	**2023-24**

Prerequisites: Basic concept of generation, transmission and distribution systems. Types of transmission line and its characteristics, representation of power system using single line diagram and per unit calculation. Basic concept of network topology: terms like graph, subgraph, tree, cotree and concept like tie-set and cut-set

Course Objectives:

	The Course objectives are:
1	To impart the knowledge of Graph Theory applied to power systems and to develop incidence matrix of power systems network that represents interconnection of the lines and line power flow. To construct the Ybus matrix using inspection and singular transformation method that represent entire characteristics of power systems
2	To impart the knowledge of concept of load flow analysis, Power Flow Equation, Classification of Buses, Operating Constraints, Data for Load Flow: System data, Generator bus data, Load Data. To develop algorithm for GS method and Newton Raphson (NR) load flow method in polar coordinates and rectangular coordinates. To impart the knowledge of modification of algorithm GS and NR for PV buses, Q- limit violations and acceleration factor for convergence
3	To impart the knowledge about the concept of economic scheduling and Performance curves of thermal generators. To impart the knowledge of formulation of minimization of cost objective function along with constraints. To develop the solution technique to obtain necessary condition for cost minimization of thermal generator during scheduling without considering losses. To impart the knowledge for obtaining optimum condition of thermal generators considering losses. To understand the concept of penalty factor and its approximation during scheduling. To impart the knowledge of importance of power loss expression and derive the expression for loss formula using current distribution factors
4	To provide the knowledge regarding concept of transient stability of power system. To understand the importance of swing equation during transient stability. To derive the swing equation and develop mathematical models of machine and power system equations. To understand the concept of solution techniques solving swing equation for transient stability. To provide the knowledge about modelling of excitation systems, DC Excitation system and AC Excitation system. To understand concept about the computer model of Type 1, Type 2 and Type 3 excitation. To understand concept about the Load Model: Static, Dynamic load models

Course Outcomes:

	At the end of the course the student should be able to:
1	apply suitable network topology, primitive network, types of power system buses for load flow studies and economic scheduling algorithms and excitation systems for power system operation.
2	Investigate performance of the power systems using load flow analysis, optimum scheduling the of thermal generators and excitation systems.
3	calculate Y_{BUS} matrix, real power, reactive power and power flow for a given power systems using load flow studies and optimum cost of generation of thermal power plants using economic scheduling study and components of excitation systems.
4	formulate the load flow models, economic scheduling of thermal generators.

Course Articulation Matrix: Mapping of Course Outcomes (CO) with Programme Outcomes (PO) and Programme Specific Outcomes (PSO)

S.No	**Programme Outcomes / Course Outcomes**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
1	Students should able to apply suitable network topology, primitive network, types of power system buses for load flow studies and economic scheduling algorithms for power system operation	**3**	**2**	**1**	**-**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**1**	**3**	**2**	**1**
2	Investigate performance of the power systems using load flow analysis, optimum scheduling the of thermal generators and transient stability studies	**2**	**3**	**3**	**1**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**1**	**2**	**2**	**2**
3	calculate Y_{BUS} matrix, real power, reactive power and power flow for a given power systems using load flow studies and optimum cost of generation of thermal power plants using economic scheduling study	**3**	**3**	**2**	**2**	**1**	**-**	**-**	**-**	**-**	**1**	**1**	**1**	**3**	**2**	**1**
4	formulate the load flow models, economic scheduling of thermal generators and transient stability algorithm for given power systems	**3**	**3**	**2**	**-**	**2**	**-**	**-**	**-**	**-**	**1**	**1**	**1**	**2**	**2**	**1**

Unit Learning Outcomes (ULO):

Sl.	Unit Learning Outcome (ULO)	CO's	BLL
	Unit -I		
1.	Students shall be able to understand the importance of the computer in solving the power system problems	**1**	**1**
2.	Students shall be able to understand the significance of network topology in solving the power system problem	**1**	**1**
3.	Students shall be able to define/describe the terms such as graph, tree, cotree, cut set and tie set	**1**	**2**
4.	Students shall be able to draw graph, tree, cotree for given power system network	**1**	**2**
5.	Students shall be able to apply cut-set and tie-set method for constructing of incidence matrix for given power system network	**1**	**3**
6.	Students shall be able to solve numerical on obtaining incidence matrix for a given network using fundamental cut set and tie set methods	**3**	**4**
7.	Students shall be able to understand the concept of primitive network using impedance frame and admittance of reference	**2**	**2**
8.	Students shall be able to construct primitive network for a given power system network with and without mutual coupling	**3**	**3**
9.	Students shall be able to derive the YBUS matrix for given power system network using singular transformation and inspection method	**3**	**3**
10.	Students shall be able to solve the numerical on obtaining Y_{BUS} matrix for given power system network using singular transformation and inspection method	**4**	**4**
	Unit -II		
11.	Students shall be able to understand the concept and significance of load flow analysis in power system	**1**	**1**
12.	Students shall be able to classify and identify the various types of buses available in power system	**2**	**2**
13.	Students shall be able to understand the concept of bus loading equation in load flow studies	**1**	**2**
14.	Students shall be able to develop computer program for load flow studies	**4**	**4**
15.	Students shall be able to formulate load flow problem using gauss seidel method for P-Q	**4**	**3**
16.	Students shall be able to understand the concept of acceleration factor	**1**	**21**
17.	Students shall be able to solve the numerical on obtaining real power flow and reactive power flow only for P-Q buses using gauss seidel method	**3**	**4**
18.	Students shall be able to understand the modification of gauss seidel method for PV bus	**1**	**1**
19.	Students shall be able to understand importance of limitation of Q for PV bus	**1**	**1**
20.	Students shall be able to solve the numerical on obtaining real power flow and reactive power flow for P-V bus using gauss seidel method	**4**	**4**
21.	Students shall be able to explain the limitations of gauss seidel algorithm	**2**	**2**
22.	Students shall be able to formulate load flow problem using Newton Raphson method for P-Q and PV buses in cartesian and polar coordinates	**4**	**2**
23.	Students shall be able to solve the numerical on obtaining real power flow and reactive power flow for P-V bus using Newton Raphson method	**3**	**4**
24.	Students shall be able to explain the merits and demerits of Newton Raphson method	**2**	**2**
25.	Students shall be able to understand the need of fast decoupled load flow analysis	**1**	**1**
26.	Students shall be able to formulate fast decouple load flow problem for a given power systems	**4**	**4**
	Unit-III		
27	Students shall be able to understand the concept of economic scheduling of thermal generators	**2**	**2**
28.	Students shall be able to define the input-output and Incremental characteristics of thermal generators	**1**	**1**

29.	Students shall be able to formulate the objective function for minimization of energy cost of thermal generators with the constraints on the individual generator	**3**	**3**
30.	Students shall be able to apply optimization method to derive the necessary and sufficient conditions for the economic scheduling of thermal generators without considering transmission loss	**4**	**4**
31.	Students shall be able to solve the numerical on economic scheduling of thermal generators without considering transmission loss	**4**	**4**
32.	Students shall be able to derive the necessary and sufficient conditions for the economic scheduling of thermal generators considering transmission loss	**3**	**3**
33.	Students shall be able to illustrate the importance of penalty factor on thermal generator	**2**	**2**
34.	Students shall be able to apply Taylors iterative series to solve the necessary equation for scheduling thermal generator at optimum cost considering transmission loss	**3**	**3**
35	Students shall be able to solve the numerical on economic scheduling of thermal generators considering transmission loss using iterative technique	**4**	**4**
36.	Students shall be able understand current distribution factor and derive the expression of Loss formula.	**2**	**2**
37.	Students shall be able to solve the numerical for obtaining B-Coefficient of loss formula tors	**4**	**4**
38.	Students shall be able to understand the need of hydrothermal scheduling of generators	**2**	**2**
39.	Students shall be able to formulate the problem, provide solution and specify algorithm for hydrothermal scheduling of generators	**3**	**3**
	Unit-IV		
40.	Students shall be able to understand definition and concept of Transient Stability of power system	**1**	**1**
41.	Students shall be able to understand role of transient and quadrature axis reactance during transient stability	**1**	**2**
42.	Students shall be able to derive the swing equation describing the motion of the machine motors	**3**	**3**
43.	Students shall be able to model the synchronous machine in terms of quadrature component of voltage due to transient reactance	**4**	**3**
44.	Students shall be able to model induction motor as a load during transient stability	**3**	**3**
45.	Students shall be able to represent of the load and network performance equation during transient stability	**2**	**2**
46.	Students shall be able to apply numerical technique algorithm to check the stability of power system during transient stability	**4**	**4**
47.	Students shall be able to understand principle operation of excitation systems along with block diagram	**2**	**2**
48.	Students shall be able to understant various types of AC and DC excitation systems, Brushless and static exciation systems	**2**	**2**
49.	Students shall be able to analyze the computer model of excitation systems Type-1, Type-2 and Type-3	**2**	**4**
50.	Students shall be able to understand Load Model: Static, Dynamic load models	**1**	**1**

Programme Outcomes with Respective Competencies & Performance Indicators

PO1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation for the solution of complex engineering problems.			
	Competency	PI	Indicators
1.1	Demonstrate the competence in solving engineering mathematical problems	1.1.1	Apply fundamentals of mathematics to solve problems
		1.1.2	Apply advanced mathematical techniques to modelling and problem solving in electrical engineering
1.2	Demonstrate the competence in basic sciences	1.2.1	Apply laws of natural science to an engineering problem
1.3	Demonstrate competence in engineering fundamentals	1.3.1	Apply elements of electrical engineering principles and laws
1.4	Demonstrate competence in Electrical engineering knowledge	1.4.1	Apply discipline specific laws and principles to solve an engineering problem

PO2: Problem analysis: Identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.			
	Competency	PI	Indicators
2.1	Demonstrate an ability to identify and characterize an engineering problem	2.1.1	Evaluate problem statements and Identify objectives
		2.1.2	Identify engineering systems, variables, and parameters to solve the problems
		2.1.3	Identify the mathematical, engineering and other relevant knowledge that applies to a given problem
2.2	Demonstrate an ability to formulate a solution plan and methodology for an engineering problem	2.2.1	Reframe complex problems into interconnected sub-problems.
		2.2.2	Identify, assemble and evaluate information and resources.
		2.2.3	Identify existing processes/solution methods for solving the problem, including justified approximations and assumptions
		2.2.4	Compare and contrast alternative solution processes to select the best process.
2.3	Demonstrate an ability to formulate and interpret a system / model	2.3.1	Combine scientific and engineering principles to formulate models (mathematical or otherwise) of a system or process that isappropriate in terms of applicability and required accuracy.
		2.3.2	Identify assumptions (mathematical and physical) necessary to allow modelling of a system at the level of accuracy required.
2.4	Demonstrate an ability to execute a solution, process and analyse results	2.4.1	Apply engineering mathematics and computations to solve (form & analyse) mathematical models.
		2.4.2	Produce and validate results through skilful use of contemporary engineering tools and models
		2.4.3	Identify sources of error in the solution process, and limitations of the solution.
		2.4.4	Extract desired understanding and conclusions consistent with objectives and limitations of the analysis

PO3: Design/Development of Solutions: 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 public health and safety, and cultural, societal, and environmental considerations.

	Competency	PI	Indicators
3.1	Demonstrate an ability to define a complex open-ended problem in engineering terms	3.1.1	Recognize that good problem definition assists in the design process
		3.1.2	Elicit and document engineering requirements from stakeholders
		3.1.3	Synthesize engineering requirements from a review of the State of the Art
		3.1.4	Extract engineering requirements from relevant engineering Codes and Standards
		3.1.5	Explore and synthesize engineering requirements from larger social and professional concerns
		3.1.6	Determine design objectives, functional requirements and arrive at specifications
3.2	Demonstrate an ability to generate a diverse set of alternative design solutions	3.2.1	Apply formal idea generation tools to develop multiple engineering design solutions
		3.2.2	Build models, prototypes, etc., to develop diverse set of design solutions
		3.2.3	Identify the suitable criteria for evaluation of alternate design solutions
3.3	Demonstrate an ability to select the optimal design scheme for further development	3.3.1	Apply formal multi-criteria decision making tools to select optimal engineering design solutions for further development
		3.3.2	Consult with domain experts and stakeholders to select candidate engineering design solution for further development
3.4	Demonstrate an ability to advance an engineering design to defined end state	3.4.1	Refine a conceptual design into a detailed design within the existing constraints (of the resources)
		3.4.2	Generates information through appropriate tests to improve, or revise design states

PO4: 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.

	Competency	PI	Indicators
4.1	Demonstrate an ability to conduct investigations of technical issues consistent with their level of knowledge and understanding	4.1.1	Define a problem for purpose of investigation, its scope and importance
		4.1.2	Relate modern engineering experimentation including experiment design, system calibration, data acquisition, analysis and presentation
		4.1.3	Apply appropriate instrumentation, and/or software tools to make measurements of physical quantities
		4.1.4	Establish or validate a relationship between measured data and underlying physical principles.
4.2	Demonstrate an ability to design experiments to solve open ended problems	4.2.1	Develop and design experimental approach, specify appropriate equipment and procedures, implement these procedures, and interpret the resulting data to characterise an engineering material, component, or system.
		4.2.2	Understand the importance of statistical design of experiments and choose an appropriate experimental design plan based on the study objectives
4.3	Demonstrate an ability to critically analyze data to reach a valid conclusion	4.3.1	Use appropriate procedures, tools and techniques to collect and analyse data
		4.3.2	Critically analyse data for trends and correlations, stating possible errors and limitations
		4.3.3	Represent data (in tabular and/or graphical forms) so as to facilitate analysis and explanation of the data, and draw conclusions
		4.3.4	Synthesize information and knowledge about the problem from the raw data to reach appropriate conclusions

PO5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

	Competency	PI	Indicators
5.1	Demonstrate an ability to identify/create modern engineering tools, techniques and resources	5.1.1	Identify modern engineering tools, techniques and resources for engineering activities
		5.1.2	Create / adapt / modify / extend tools and techniques to solve problems
5.2	Demonstrate an ability to select and apply discipline specific tools, techniques and resources	5.2.1	Identify the strengths and limitations of tools for (i) acquiring information, (ii) modelling and simulation, (iii) monitoring system performance, and (iv) creating engineering designs.
		5.2.2	Demonstrate proficiency in using computing, mathematical, circuit simulation, and document presentation/preparation software. (MATLAB / Scilab, PSPICE, SABER, PROTEUS software tools, AutoCAD, project management tools, Latex and others)
5.3	Demonstrate an ability to evaluate the suitability and limitations of the tools used to solve an engineering problem	5.3.1	Identify limitations and validate tools, techniques and resources
		5.3.2	Verify the credibility of results from tool use with reference to the accuracy and limitations, and the assumptions inherent in their use.

PO6: 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.

	Competency	PI	Indicators
6.1	Demonstrate the ability to describe engineering roles in a broader context, e.g. as pertains to the environment, health, safety, and public welfare	6.1.1	Identify and describe various engineering roles; particularly pertaining to protection of the public and public interest
6.1	Demonstrate an understanding of professional engineering regulations, legislation and standards	6.2.1	Interpret legislation, regulations, codes, and standards relevant to electrical and electronics engineering discipline (such as IEEE) and explain its contribution to the protection of the public

PO7: 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.

	Competency	PI	Indicators
7.1	Demonstrate an understanding of the impact of engineering and industrial practice on social, environmental and economic contexts	7.1.1	Identify risks/impacts in the life-cycle of an engineering product or activity
		7.1.2	Demonstrate an understanding of the relationship betweenthe technical, socio-economic and environmental dimensions of sustainability
7.2	Demonstrate an ability to apply principles of sustainable design and development	7.2.1	Describe management techniques for sustainable development
		7.2.2	Apply principles of preventive engineering and sustainable development to an engineering activity or product relevantto Electrical and Electronics Engineering

PO8: Ethics: Apply ethical principles and commit to professional ethics, responsibilities and norms of the engineering practice.

	Competency	PI	Indicators
8.1	Demonstrate an ability to recognize ethical dilemmas	8.1.1	Identify situations of unethical professional conduct and propose ethical alternatives
8.2	Demonstrate an ability to apply the Code of Ethics	8.2.1	Identify tenets of the IEEE professional code of ethics
		8.2.2	Examine and apply moral & ethical principles to historically famous case studies

PO9: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

	Competency	PI	Indicators
9.1	Demonstrate an ability to form a team and define a role for each member	9.1.1	Recognize a variety of working and learning preferences; appreciate the value of diversity in a team
		9.1.2	Implement the norms of practice (e.g. rules, roles, charters, agendas, etc.) of effective team work, to accomplish a goal.
9.2	Demonstrate effective individual & team operations -- communication, problem solving, resolution & leadership skills	9.2.1	Demonstrate effective communication, problem solving, conflict resolution and leadership skills
9.3	Demonstrate success in a team-based project	9.3.1	Present results as a team, with smooth integration of contributions from all individual efforts

PO10: Communication: Communicate effectively on complex engineering activities with the engineering community and with the 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			
	Competency	PI	Indicators
10.1	Demonstrate an ability to comprehend technical literature and document project work.	10.1.1	Read, understand and interpret technical and non-technical information
		10.1.2	Produce clear, well-constructed, and well-supported written engineering documents
		10.1.3	Create *flow* in a document or presentation – a logical progression of ideas so that the main point is clear
10.2	Demonstrate competence in listening, speaking, and presentation	10.2.1	Listen to and comprehend information, instructions, and view point of others
		10.2.2	Deliver effective oral presentations to technical and non-technical audiences
10.3	Demonstrate the ability to integrate different modes of communication	10.3.1	Create engineering-standard figures, reports and drawings to complement writing and presentations
		10.3.2	Use a variety of media effectively to convey a message in a document or a presentation

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.			
	Competency	PI	Indicators
11.1	Demonstrate an ability to evaluate the economic and financial performance of an engineering activity	11.1.1	Describe various economic and financial costs/benefits of an engineering activity
		11.1.2	Analyze different forms of financial statements to evaluate the financial status of an engineering project
11.2	Demonstrate and ability to Compare and contrast the costs/benefits of alternate proposals for an engineering activity	11.2.2	Analyze and select the most appropriate proposal based on economic and financial considerations.
11.3	Demonstrate an ability to plan/manage an engineering activity withintime and budget constraints	11.3.1	Identify the tasks required to complete an engineering activity, and the resources required to complete the tasks.
		11.3.2	Use project management tools to schedule an engineering project so as to complete on time and within budget.

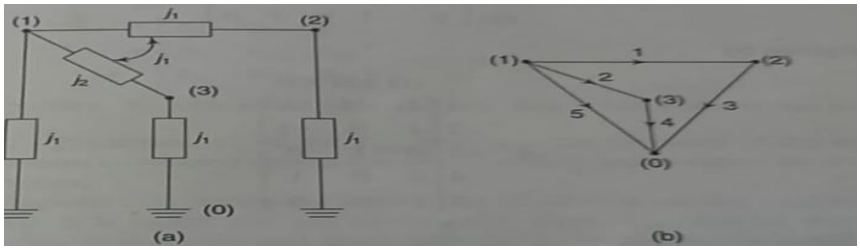
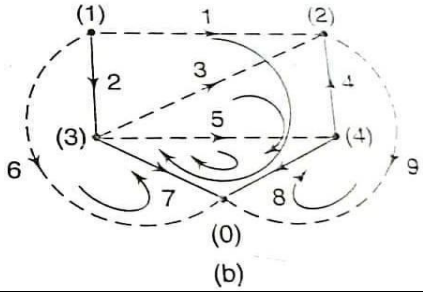
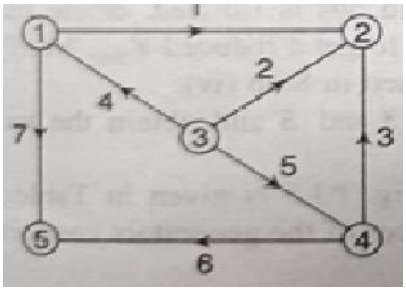
PO12: Life-long learning: Recognise the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.			
	Competency	**PI**	**Indicators**
12.1	**Demonstrate an ability to identify gaps in knowledge and a strategy to close these gaps**	**12.1.1**	**Describe the rationale behind the requirement for continuing professional development**
		12.1.2	**Identify deficiencies or gaps in knowledge and demonstrate an ability to source information to bridge the same**
12.2	**Demonstrate an ability to Identify changing trends in engineering knowledge and practice**	**12.2.1**	**Identify historic points of technological advance in engineering that require practitioners to seek education in order to stay updated**
		12.2.2	**Recognize the need and be able to clearly explain why it is vitally important to keep updated regarding new developments in the field**
12.3	**Demonstrate an ability to identify and access sources for new information**	**12.3.1**	**Demonstrate an ability to source and comprehend technical literature and other credible sources of information**

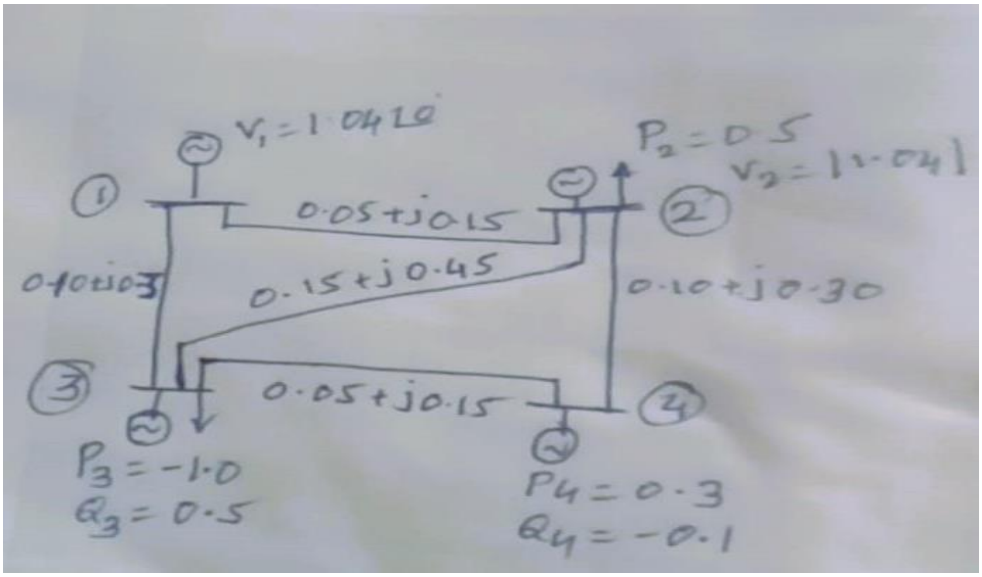
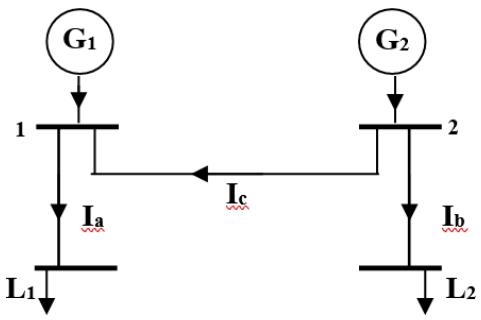
Course Content:

Day	Content	Mode of Delivery
1	Brief Introduction of the course, information regarding the course outcome of the course, program specific outcome and program outcome	
2	Introduction to computer application to power systems, Steps involved to solve power system algorithms such has problem formulations, objectives, Solution techniques and Programming	Chalk and talk in classroom
3	Importance of Bus frame of reference (Z-Bus) and Node frame of reference (Y-Bus). Selection of programming language.	
4	Introduction of elementary graph theory, Definitions and concept of connected graph, sub graph Loop, Cut-set, Tree, Co- tree, Basic loops, Basic cut-set	
5	Numerical examples for constructing graph, sub graph Loop, Cut-set, Tree, Co- tree, Basic loops, Basic cut-set for given power system network	
6	Concept of Incidence Matrices: Element-node incidence matrix A (Bus-incidence matrix), Branch path incidence matrix K,	
7	Concept of Basic (Fundamental) cut-set incidence matrix B, Augmented cut-set matrix, Basic loop incidence matrix C, Augmented loop incidence matrix.	
8	Numerical examples of Element-node incidence matrix A (Bus-incidence matrix), Branch path incidence matrix K, Basic (Fundamental) cut-set incidence matrix B, Augmented cut-set matrix, Basic loop incidence matrix C, Augmented loop incidence matrix	
9	General primitive element, Impedance and Admittance form of the primitive element, Primitive network matrices. Introduction, Derivation of $Y_{bus}= [A][y][A]^T$	

10	Numericals on Ybus matrix using singular transformation method	
11	Formation of Y_{bus} by inspection method and Numerical	
12	Introduction, Power Flow Equation, Classification of Buses, Operating Constraints, Data for Load Flow: System data, Generator bus data, Load Data, Transmission line data, Transformer data and Shunt element data.	Chalk and talk in classroom
13	Derivation of bus loading equation, formulation of Gauss seidel method for load flow problem for P-Q bus	
14	Numerical for obtaining bus voltage, line flow and power flow using Gauss seidel method for 3 iterations and importance of acceleration factor is explained.	
15	Modification of GS algorithm to include PV buses, Q-limit violations, Acceleration of convergence	
16	Numericals on Load flow analysis for PQ & PV buses using GS method	
17	Introduction to NR method, Formulation of NR method in rectangular coordinates for PQ-Bus.	
18	Formulation of NR method in polar coordinates for PQ-Bus and Numerical of obtaining bus voltages using NR method in rectangular	
19	Numerical of obtaining bus voltages using NR method in polar form for PQ	
20	Numerical of obtaining bus voltages using NR method in polar form for PQ-PV systems	
21	Concept of Decoupled Load Flow & Fast Decoupled Load Flow. Derivation of Jacobian matrix using Fast Decoupled load flow	
22	Introduction of economic scheduling of thermal generators, Importance of Performance curves in scheduling of thermal generators.	Power Point Presentation
23	Derivation of necessary condition of economic scheduling of thermal generators neglecting losses and generator limits	
24	Examples for obataining of power output of generators using scheduling algorithm without power limits	
25	Examples for obataining of power output of generators using scheduling algorithm with power limits	Chalk and talk in classroom
26	Derivation of necessary condition of economic scheduling of thermal generation considering transmission losses	Chalk and talk in classroom
27	Concept and impact of penalty factor on thermal generators, numerical	
28	Derivation of Iterative technique for the scheduling of thermal generators considering losses and Numerical	
29	Derivation of transmission loss formula using current distribution factors and numerical	
30	Numerical for obatining B-Coefficents of given power systems	Power Point Presentation
31	Introduction to optimal scheduling for hydrothermal plants. Problem formulation, solution procedure and algorithm	
32	Introduction of Transient Stability of power system, Derivation of swing equation using machine dynamics.	
33	Modelling of Synchronous salient and non-salient machine and induction machine	Power Point Presentation
34	Power system equations in-terms of admittance frame of reference and solution techniques with flow chart.	
35	Introduction of excitation systems, AC and DC excitation systems,	
36	Concept of Brushless and static exciation systems	
37	Concept of Power system stablizer, modeling of Type-1 and Type-2 excitationsystems	
38	Modeling of Type-3 excitation systems	
39	Load Model: Static, Dynamic load models	
40	Revision of syllabus	

Review Questions:

Sl.	Review Questions	CO	BLL	PI
1	Consider the network shown in Fig.1 a where two branches have mutual coupling as shown. Find the primitive impedance matrices z, y and the Y_{bus} matrix. Choose (0) as reference bus.  Fig.1.0	03	L3	2.4.1
2	The oriented graph shown in Fig. 2.0 select the tree *T* (6, 7, 8, 9) and the write the B. C matrices. Verify the orthogonality relations. Choosing ground as reference bus, write the A matrix.  (b)	03	L4	2.4.1
3	For the graph in Fig. 3.0 select the tree *T* (2, 4, 5, 6)  Fig.3.0 • Write the fundamental loop matrix C and the fundamental cutset matrix B. Verify the relation BC^T and $C_b = -B^T$ • Write the augmented incidence matrix A_a and the incidence matrix A by choosing 4 as reference node. Arrange A as $[A_a A,]$ corresponding to the tree	03	L3	2.4.1
4	Load flow concept helps in extension of existing power system network? Justify. Discuss the various types of buses for load flow studies.	02	L2	1.3.1
5	Formulate load flow problem for a given power system using gauss seidel method? Explain the importance of the acceleration factor	04	L4	2.3.1

6	Mention modification in gauss seidel method if PV bus is included? Discuss the criteria for specifying the reactive power at PV bus	01	L2	1.4.1
7	Formulate the load flow problem in cartesian form using the Newton Raphson method	04	L4	2.3.1
8	Formulate the load flow problem in polar form using the Newton Raphson method	04	L4	2.3.1
9	The system shown in Fig. First bus is slack bus, find the voltage and phase angles at all buses using gauss seidel and Newton Raphson methodafter first iteration. Assume flat voltage start 	03	L3	2.4.1
10	Justify assumption made to formulate Fast Decoupled Load Flow? Derive Fast Decoupled Load Flow Analysis	02	L2	2.3.1
11	Give the comparative analysis of Gauss seidel, Newton Raphson and Fast Decoupled Load Flow method	02	L3	2.3.1
12	Specify the importance of the incremental characteristics during the scheduling of thermal generators and obtain the necessary conditions of scheduling of thermal generators	02	L3	2.1.1
13	Derive the iterative method of economic scheduling of thermal generators with and without transmission loss	03	L3	2.1.1
14	The fuel cost functions in Rs/h for three thermal plants are given by $F_1=350+7.2P_1+0.004P_1^2$, $F_2=500+7.3P_2+0.0025P_2^2$, $F_3=600+6.74P_3+0.003P_3^2$ P_1, P_2, P_3 are in MW. Find the optimal scheduling using iterative technique for $P_D=800$MW, initial value of λ=8 Rs/MWh	03	L3	1.4.1
15	Compute the loss coefficients for the network shown in Fig using the given data $I_a = 1.0 - j0.15$ pu $Z_a = 0.02 - j0.15$ pu $I_b = 0.5 - j0.10$ pu $Z_a = 0.02 - j0.15$ pu $I_c = 0.2 - j0.005$ pu $Z_c = 0.02 - j0.25$ pu 	03	L3	2.3.1

16	Derive and specify the assumptions considered for obtaining the B-Coefficients using current distribution factor	04	L2	2.3.1
17	Discuss the hydro thermal scheduling Formulation, Solution technics and algorithm	04	L3	2.3.2
18	Define the Transient Analysis of power system? Explain need for transient analysis algorithm after the clearance of the fault	02	L2	2.1.3
19	Derive the swing equation using dynamics of the machines for transient stability study of power system	03	L2	2.3.2
20	Develop the model of synchronous machine and induction motor as load during transient analysis of power system	04	L2	2.3.2
21	Derive and explain solution technique to obtain rotor angle for the stability of power system during transient stability studies	03	L2	2.3.2

Evaluation Scheme:

Assessment	Marks	Weightage
CIE-I	**20**	**20**
CIE-II	**20**	**20**
Assignments/ Quizzes/ Case Study/ Course Project/ Term Paper/Field Work	**10**	**10**
SEE	**100**	**50**
Total	**150**	**100**

Details of Assignment:

Assignment	Marks (10)	CO	PI	CA	PO
Problem solving on construction of Y_{bus} Matrix and Load flow	2.5	01	1.1.2	1.1	1
Problem solving on economic scheduling of thermal generators	2.5	02, 03	2.2.2	2.2	2
Quiz	1.5	03, 04	2.3.1	2.3	2
Quiz	1.5	03, 04			
MATLAB Simulations on load flow analysis	2.0	04	5.2.2	5.2	5

Dr. R. L. Naik

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BASAVESHWAR ENGINEERING COLLEGE(AUTONOMOUS), BAGALKOT

MODEL COURSE PLAN

Title of Course	**:**	**High Voltage Switchgear and Protection**	**Course Code**	**:**	**UEE752C**
Credits	**:**	**03**	**Contact Hours/ Week**	**:**	**03hrs/Week**
Total Hours	**:**	**40**	**Tutorial Hours**	**:**	**00**
CIE Marks	**:**	**50**	**SEE Marks**	**:**	**50**
Semester	**:**	**VII**	**Year**	**:**	**2023-24 (ODD)**

Prerequisites: Basics of Electrical Engineering, Electrical Materials, Electrical Measurement Concepts, Testing and Commissioning of Electrical Equipment's.

Course Objectives:

- To understand the generation and measurement of high voltages
- To understand the phenomena involved in insulation and testing as well as over voltages in power systems.
- To understand operations & characteristics of various electromagnetic and static relays.
- To understand the operations of various types of circuit breakers and their ratings.

Course Outcomes:

	At the end of the course the student should be able to:
1	Select the suitable generating and measuring instrument for testing high voltage equipment's
2	Estimate the ripple factor, Maximum voltage and relay timing for different high voltage instruments.
3	Compare the different insulating material, protection equipment's for high voltage equipment's
4	Apply the suitable protection equipment's for selected rating of current and voltage

Course Articulation Matrix: Mapping of Course Outcomes (CO) with Programme Outcomes (PO) and Programme Specific Outcomes (PSO)

		PO1	PO2	PO 3	PO4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
No	**Programme Outcomes / Course Outcomes**															
The students will be able to:																
1	**UEE752C.1**	**3**	**1**		**1**	**3**	**1**		**1**		**1**		**1**	**1**	**2**	**1**
2	**UEE752C.2**	**3**	**2**	**1**	**1**				**1**		**1**		**1**	**1**	**2**	**1**
3	**UEE752C.3**	**3**	**3**	**2**	**2**	**1**			**1**		**1**		**1**	**1**	**2**	**2**
4	**UEE752C.4**	**3**	**3**	**3**	**2**	**1**			**1**	**1**	**1**	**1**	**2**	**1**	**1**	**3**

Sl.	Unit Learning Outcome (ULO)	CO's	BLL	PI addressed
	Unit -I			
1.	Students shall be able to Classify types of high voltage used in power system network	**01**	**01**	**1.4.1**
2.	Students shall be able to construct the working of HVAC transformer, cascade connection of High voltage transformers	**01**	**02**	**2.1.1**
3.	Students shall be able to understand the working principle on Series resonant circuit, Tesla coil, HV – DC voltage doublers circuit, Cock croft – Walton type high voltage DC set	**01**	**01**	**1.3.1**
4.	Students shall be able to derive the expression on high voltage regulation, ripple and optimum number of stages for minimum voltage drop	**01**	**03**	**2.1.2**
5.	Students shall be able to list the applications on High voltage	**01**	**01**	**1.4.1**
6.	Students shall be able to Analysis of single -stage impulse generator	**01**	**03**	
7.	Students shall be able to derive the expression for output impulse voltage, Multistage impulse generator	**01**	**03**	**2.1.2**
8.	Students shall be able to understand the working of Mark impulse generator, Rating of impulse generator	**01**	**01**	**1.3.1**
9.	Students shall be able to list the Components of multistage impulse generator	**01**	**02**	**1.4.1**
	Unit -II			
10.	Students shall be able to understand the working of Electrostatic voltmeter – principle, construction and limitation.	**02**	**01**	**1.3.1**
11.	Students shall be able to understand the working of Chubb and Fortes-sue method for HVDC measurements. Series resistance micro ammeter	**02**	**01**	**1.3.1**
12.	Students shall be able to understand the working of Standard Sphere gap measurements for HVAC, HVDC and factors affecting the measurements.	**02**	**02**	**2.1.1**
13.	Students shall be able to analyse Dielectric loss and loss angle measurement using Schering Bridge	**02**	**02**	**2.2.2**
14.	Students shall be able to analyse Transformer ratios arm bridge, Breakdown in solid dielectrics: Intrinsic breakdown	**02**	**02**	**2.2.2**
15.	Students shall be able to analyse Breakdown of liquid dielectrics	**02**	**02**	**2.2.2**
16.	Students shall be able to analyse Suspended particle theory, electronic Breakdown, cavity breakdown(bubble's theory)	**02**	**02**	**2.2.2**
	Unit -III			
17.	Students shall be able to recall Relay definition and its application	**03**	**01**	**1.4.1**
18.	Students shall be able to analyse Required qualities of Protective Relaying for Primary and Back up protection	**03**	**02**	**2.2.2**
19.	Students shall be able to Classify types of protective Relaying, Induction type Non-directional over current relay, Directional relay	**03**	**01**	**1.3.1**
18.	Students shall be able to Classify the different types of Differential relay and its working	**03**	**01**	**1.3.1**
19.	Students shall be able to understand working principle operation on Percentage Differential relay, Distance relays	**03**	**01**	**1.3.1**
20.	Students shall be able to understand the working on Impedance Relay, Reactance Relay	**03**	**01**	**1.3.1**
21.	Students shall be able to understand the working on Mho Relay, R-X diagram and Buchholz Relay	**03**	**01**	**1.3.1**
	Unit -IV			
22.	Students shall be able to understand Basic construction and working of static relay	**04**	**01**	**1.3.1**
23.	Students shall be able to classify the types of static relay	**04**	**01**	**1.3.1**
24.	Students shall be able to understand Basic construction and working of	**04**	**01**	**1.3.1**

	Definite time lag static over current relay, Inverse time static over current relay			
25.	Students shall be able to understand Basic construction and working of Static over voltage and under voltage relay, Microprocessor based over current relay	**04**	**01**	**1.3.1**
26.	Students shall be able to apply Principles and working of of AC circuit breaking,	**04**	**04**	**2.2.3**
27.	Students shall be able to apply Principles and working of DC circuit breaking	**04**	**04**	**2.2.2**
28.	Students shall be able to understand the concept on Initiation of arc, maintenance of arc, Arc interruption- High resistance and Low resistance interruption. Re striking voltage, Recovery voltage and resistance switching.	**04**	**01**	**1.3.1**
29.	Students shall be able to classify the Types of circuit breakers	**04**	**01**	**1.4.1**
30.	Students shall be able to understand the construction and working on - Air break and air blast circuit breakers, SF6 circuit breakers- Puffer type and Non Puffer type.	**04**	**01**	**1.3.1**

Competencies Addressed in the course and Corresponding Performance Indicators

Programme Outcome: Any of 1 to 12 PO's:

PO1: Engineering knowledge:Apply the knowledge of mathematics, science, engineering fundamentals, andan engineering specializationforthesolutionofcomplexengineeringproblems.

	Competency	PI	Indicators
1.1	**Demonstratethecompetenceinsolvingengineeringmathematicalproblems**	**1.1.1**	**Applyfundamentalsofmathematicstosolveproblems**
		1.1.2	**Apply advancedmathematical techniquestomodellingand problemsolvinginelectricalengineering**
1.2	**Demonstratethecompetenceinbasic sciences**	**1.2.1**	**Applylawsofnaturalsciencetoanengineering problem**
1.3	**Demonstrate competence in engineeringfundamentals**	**1.3.1**	**Applyelementsofelectricalengineeringprinciplesandlaws**
1.4	**DemonstratecompetenceinElectrical engineeringknowledge**	**1.4.1**	**Applydisciplinespecificlawsandprinciplestosolveanengineering problem**

PO2:Problem analysis:Identify, formulate, research literature, and analyse complex engineeri problemsreaching substantiated conclusions using first principles of mathematics, natural sciences, a engineeringsciences.

	Competency	PI	Indicators
2.1	**Demonstrateanabilitytoidentifyandcharacterizeanengineering problem**	**2.1.1**	**EvaluateproblemstatementsandIdentifyobjectives**
		2.1.2	**Identifyengineeringsystems,variables,andparameterstosolve theproblems**
		2.1.3	**Identify the mathematical, engineering and other relevant knowledgethatapplies toagivenproblem**
2.2	**Demonstrate an ability to formulate asolution plan and methodology for anengineeringproblem**	**2.2.1**	**Reframecomplexproblemsintointerconnectedsub-problems.**
		2.2.2	**Identify,assembleandevaluateinformationandresources.**
		2.2.3	**Identifyexistingprocesses/solutionmethodsforsolvingthe problem,includingjustifiedapproximationsandassumptions**
		2.2.4	**Compareandcontrastalternativesolution processestoselectthe bestprocess.**
2.3	**Demonstrateanabilitytoformulateandinterpret asystem/model**	**2.3.1**	**Combinescientificandengineeringprinciplestoformulatemodels (mathematicalorotherwise)ofasystemorprocessthatisappropriat nterms ofapplicabilityandrequiredaccuracy.**
		2.3.2	**Identifyassumptions(mathematicalandphysical)necessaryto allowmodelling ofasystematthelevelofaccuracyrequired.**

2.4	Demonstrateanabilitytoexecuteasolution,process andanalyseresults	2.4.1	Applyengineeringmathematicsandcomputationstosolve(form &analyse)mathematicalmodels.
		2.4.2	Produceandvalidateresultsthroughskilfuluseofcontemporary engineeringtoolsandmodels
		2.4.3	Identifysourcesoferrorinthesolutionprocess,andlimitationsof thesolution.
		2.4.4	Extractdesiredunderstandingandconclusionsconsistentwith objectivesandlimitationsoftheanalysis

PO3: Design/Development of Solutions: Design/development of solutions: Design solutions fo complexengineering problems and design system components or processes that meet the specified need withappropriateconsiderationforpublichealthandsafety,andcultural,societal,andenvironmental considerations.

	Competency	PI	Indicators
3.1	Demonstrateanabilitytodefineacomplexopen-endedprobleminengineeringterms	3.1.1	Recognizethatgoodproblemdefinitionassistsinthedesignprocess
		3.1.2	Elicitanddocumentengineeringrequirementsfromstakeholders
		3.1.3	SynthesizeengineeringrequirementsfromareviewoftheStateoftheArt
		3.1.4	Extract engineering requirements from relevanengineeringCodesandStandards
		3.1.5	Explore and synthesize engineeringrequirements fromlarger social andprofessional concerns
		3.1.6	Determinedesignobjectives,functionalrequirements andarriveatspecifications
3.2	Demonstrateanabilitytogenerateadiverse setofalternativedesignsolutions	3.2.1	Apply formal idea generation tools to develop multipleengineeringdesignsolutions
		3.2.2	Buildmodels,prototypes,etc.,todevelopdiverseset ofdesignsolutions
		3.2.3	Identify the suitable criteria for evaluation o alternatedesignsolutions
3.3	Demonstrateanabilitytoselecttheoptimal design scheme for further development	3.3.1	Applyformalmulti-criteriadecisionmakingtoolstoselectoptimalengineering designsolutionsforfurther development
		3.3.2	Consultwithdomainexpertsand stakeholderstoselectcandidateengineering designsolutionforfurtherdevelopment
3.4	Demonstrateanabilitytoadvanceanengineeringdesigntodefinedend state	3.4.1	Refineaconceptualdesignintoadetaileddesign withintheexistingconstraints(oftheresources)
		3.4.2	Generatesinformationthroughappropriatetestsimprove,orrevisedesignstates

PO4:Conductinvestigationsofcomplexproblems:Useresearch-basedknowledgeandresearchmethods includingdesignofexperiments,analysisandinterpretationofdata,andsynthesisoftheinformationtoprovideval dconclusions.

	Competency	PI	Indicators
4.1	Demonstrateanabilitytoconductinvestigationsoftechnicalissuesconsistent withtheirlevelofknowledgeandunderstanding	4.1.1	Defineaproblemforpurposeofinvestigation,itsscopeand importance
		4.1.2	Relatemodernengineeringexperimentationincludingexperimentdesi n, system calibration, data acquisition, analysis an presentation
		4.1.3	Applyappropriateinstrumentation,and/orsoftwaretoolstomake measurementsofphysicalquantities
		4.1.4	Establishorvalidatearelationshipbetween measureddataand underlyingphysicalprinciples.
4.2	Demonstrateanabilitytodesignexperimentstosolveopenendedproblems	4.2.1	Developanddesignexperimentalapproach,specifyappropriateequipm entandprocedures,implementtheseprocedures,andinterprettheresu tingdatatocharacteriseanengineeringmaterial, component,orsystem.
		4.2.2	Understandtheimportanceofstatisticaldesignofexperimentsandchoo eanappropriate experimentaldesignplanbasedonthestudy objectives
4.3	Demonstrate an ability to criticallyanalyzedatatoreachavalidconclusion	4.3.1	Useappropriateprocedures,toolsandtechniquestocollectand analysedata
		4.3.2	Criticallyanalysedatafortrendsandcorrelations,statingpossible errorsandlimitations
		4.3.3	Representdata (intabularand/orgraphicalforms) soastofacilitate analysisandexplanationofthedata, anddrawconclusions
		4.3.4	Synthesizeinformationandknowledge abouttheproblemfromtherawdatatoreachappropriateconclusions

PO5:Moderntoolusage:Create,select,andapplyappropriatetechniques,resources,andmodernengineering and IT tools including prediction and modelling to complex engineering activities wit anunderstandingofthelimitations.

	Competency	PI	Indicators
5.1	Demonstrateanabilitytoidentify/create modernengineeringtools, techniques andresources	5.1.1	Identifymodernengineeringtools,techniquesandresourcesfor engineeringactivities
		5.1.2	Create/adapt/modify/extendtoolsandtechniquestosolve problems
5.2	Demonstrate an ability to select andapplydisciplinespecifictools,techniques andresources	5.2.1	Identifythestrengthsandlimitationsoftoolsfor(i)acquiring information,(ii)modellingandsimulation,(iii)monitoringsystemperf rmance, and(iv)creating engineering designs.
		5.2.2	Demonstrate proficiency in using computing, mathematica circuitsimulation,anddocumentpresentation/preparationsoftware (MATLAB/Scilab,PSPICE,SABER,PROTEUSsoftwaretools, AutoCAD,projectmanagementtools,Latexandothers)
5.3	Demonstrateanabilitytoevaluatethesuitabilityandlimitationsofthetools usedtosolveanengineering problem	5.3.1	Identifylimitationsandvalidatetools,techniquesandresources
		5.3.2	Verifythecredibilityof resultsfromtooluse with referencetothe accuracyandlimitations,andtheassumptionsinherentintheiruse.

PO6: The engineer and society: Apply reasoning informed by the contextual knowledge to asses societal,health, safety, legal and cultural issues and the consequent responsibilities relevant to th professionalengineeringpractice.

	Competency	PI	Indicators
6.1	Demonstratetheabilitytodescribeengineeringrole sinabroadercontext,e.g.aspertainstothe environment,health,safety, andpublicwelfare	6.1.1	Identify and describe various engineering roles;particularlypertainingtoprotectionofthep ublicand publicinterest
6.1	Demonstrate an understanding of professionalengineeringregulations,legislationan dstandards	6.2.1	Interpretlegislation,regulations,codes,andstandardsreleva nttoelectricalandelectronicsengineeringdiscipline(suchasI EEE)andexplainitscontributiontothe protectionofthepublic

PO7: Environment and sustainability: Understand the impact of the professional engineering solution insocietalandenvironmentalcontexts,anddemonstratetheknowledgeof,andneedforsustainabledevelopmen .

	Competency	PI	Indicators
7.1	Demonstrate an understanding of the impactofengineeringandindustrialpracticeons ocial,environmentalandeconomiccontexts	7.1.1	Identifyrisks/impactsinthelife-cycleofanengineering productoractivity
		7.1.2	Demonstrateanunderstandingoftherelationshipbetweenth technical, socio-economic and environmenta dimensionsofsustainability
7.2	Demonstrateanabilitytoapplyprinciplesofsusta inabledesignanddevelopment	7.2.1	Describe management techniques for sustainabl development
		7.2.2	Applyprinciplesofpreventiveengineeringandsustainable development to an engineering activity or product relevanttoElectricalandElectronicsEngineering

PO8:Ethics: Applyethicalprinciplesandcommittoprofessionalethics,responsibilitiesandnormsofthe engineeringpractice.

	Competency	PI	Indicators
8.1	Demonstrateanabilitytorecognizeethical dilemmas	8.1.1	Identifysituationsofunethicalprofessionalconductand proposeethicalalternatives
8.2	Demonstrate an ability to applytheCode of Ethics	8.2.1	Identifytenets oftheIEEEprofessionalcodeofethics
		8.2.2	Examineandapplymoral&ethicalprinciplestohistorically famous casestudies

PO9:Individualandteamwork: Functioneffectivelyasanindividual,andasamemberorleaderindiverseteams, andinmultidisciplinary settings.

	Competency	PI	Indicators
9.1	Demonstrateanabilitytoformateamanddefine aroleforeachmember	9.1.1	Recognizeavarietyofworkingandlearningpreferences; appreciatethevalueof diversityinateam
		9.1.2	Implementthenormsofpractice(e.g.rules,roles,charters, agendas,etc.)ofeffectiveteamwork,toaccomplishagoal.
9.2	Demonstrateeffectiveindividual&teamoperati ons -- communication, problem solving,resolution&leadershipskills	9.2.1	Demonstrateeffectivecommunication, problemsolving,conflictresolutionandleadershipskills
9.3	Demonstratesuccessinateam-basedproject	9.3.1	Presentresultsasateam,withsmoothintegrationof contributionsfromallindividualefforts

PO10:Communication:Communicateeffectivelyoncomplexengineeringactivitieswiththeengineeringcommunityandwiththesocietyatlarge,suchas,beingabletocomprehendandwriteeffectivereportsand designdocumentation,makeeffectivepresentations,andgiveandreceiveclearinstructions			
	Competency	PI	Indicators
10.1	Demonstrateanabilitytocomprehendtechnical literature and documentprojectwork.	10.1.1	Read, under stand and interpret technical and non-technical information
		10.1.2	Produce clear, well-constructed,and well-supported writen engineering documents
		10.1.3	Createflowinadocumentorpresentation–alogical progressionofideassothatthemainpointisclear
10.2	Demonstrate competence in listening,speaking, andpresentation	10.2.1	Listentoandcomprehendinformation,instructions,and viewpointofothers
		10.2.2	Delivereffectiveoralpresentationstotechnicalandnon-technicalaudiences
10.3	Demonstrate the ability to integratedifferentmodesofcommunication	10.3.1	Createengineering-standardfigures,reportsanddrawings tocomplementwritingandpresentations
		10.3.2	Useavarietyofmediaeffectivelyto conveyamessageina documentorapresentation

PO11:Projectmanagementandfinance:Demonstrateknowledgeandunderstandingoftheengineeringandmanagement principles and apply these to one's own work, as a member and leader in a team, to manageprojects andinmultidisciplinary environments.			
	Competency	PI	Indicators
11.1	Demonstrateanabilitytoevaluatetheeconomic and financial performance of anengineeringactivity	11.1.1	Describevariouseconomicandfinancialcosts/benefitsof anengineeringactivity
		11.1.2	Analyzedifferentformsoffinancialstatementstoevaluate thefinancialstatusofanengineering project
11.2	DemonstrateandabilitytoCompareandcontrastthecosts/benefitsofalternate proposalsforanengineeringactivity	11.2.2	Analyzeandselectthemostappropriateproposalbasedoneconomicandfinancialconsiderations.
11.3	Demonstrateanability to plan/manageanengineeringactivitywithintimeandbudgetconstraints	11.3.1	Identify the tasks required to complet eanengineering activity,andtheresourcesrequiredtocompletethetasks.
		11.3.2	Useprojectmanagementtoolsto scheduleanengineering projectsoastocompleteontimeandwithinbudget.

PO12:Life-longlearning:Recognizetheneedforandhavethepreparationandabilitytoengagein independentandlife-longlearninginthebroadestcontextoftechnologicalchange.			
	Competency	PI	Indicators
12.1	Demonstrate an ability to identify gaps inknowledgeandastrategytoclosethesegaps	12.1.1	Describe the rationale behind the requirement for continuingprofessionaldevelopment
		12.1.2	Identify deficiencies or gaps in knowledge anddemonstrateanabilitytosourceinformationto bridgethe same
12.2	Demonstrate an ability to Identify changingtrendsinengineeringknowledge andpractice	12.2.1	Identifyhistoricpointsoftechnologicaladvanceinengineering thatrequirepractitionerstoseekeducationin ordertostayupdated
		12.2.2	Recognize theneed andbe ableto clearlyexplainwhyitisvitallyimportanttokeepupdatedregarding new developmentsinthefield
12.3	Demonstrateanabilitytoidentifyandaccess sourcesfor newinformation	12.3.1	Demonstrateanabilitytosourceandcomprehendtechnicallite ratureandothercrediblesourcesof information
		12.3.2	Demonstrate an ability to critically analyze sourced technicaland popular information forfeasibility, viabilityandsustainability

PO1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. **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.

PO3. **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.

PO4. **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.

PO5. **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.

PO6. **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.

PO7. **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.

PO8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. **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.

PO11. **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.

PO12. 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.

Course Content:

Hours Required	Topic to be covered	Mode of Delivery
01	Classification of high voltages, HVAC-transformer	**Chalk and talk in classroom/Lecture combined with discussions**
01	Need for cascade connection, working of transformer units connected in cascade,	
01	Series resonant circuit – principle of operation and advantages, Tesla coil.	
01	HV – DC voltage doublers circuit, Cock croft – Walton type high voltage DC set.	
01	Calculation of high voltage regulation, ripple and optimum number of stages for minimum voltage drop,	
01	Problems, Important applications of high voltages.	
01	Introduction to standard lightning and switching impulse voltages	
01	Analysis of single -stage impulse generator, expression for output impulse voltage.	
01	Multistage impulse generator, working of Mark impulse generator, Rating of impulse generator	
01	Components of multistage impulse generator.	
01	Electrostatic voltmeter – principle, construction and limitation.	**Chalk and talk in classroom/Lecture combined with discussions**
01	Chubb and Fortessue method for HVDC measurements.	
01	Series resistance micro ammeter, Standard Sphere gap	
01	Measurements for HVAC, HVDC factors affecting the measurements.	
01	HVDC factors affecting the measurements	
01	Dielectric loss and loss angle measurement using Schering Bridge,	
01	Transformer ratios arm bridge, Breakdown in solid dielectrics:	
01	Intrinsic breakdown, Breakdown of liquid dielectrics	
01	Suspended particle theory, electronic Breakdown, cavity breakdown(bubble's theory	
01	Problems	
01	Relay definition, Required qualities of Protective Relaying,	**Chalk and talk in classroom/Lecture combined with**
01	Primary and Back up protection, Classification of protective Relaying,	
01	Induction type Non-directional over current relay, Directional relay.	
01	Differential relay- Principle of operation, Percentage Differential relay,	
01	Distance relays: Impedance Relay, Reactance Relay, Mho Relay, R-X diagram and Buchholz Relay.	

		discussions
01	Problems	
01	Merz-Price protection for generator,	
01	Merz -Price protection of Transformer..	
01	Inter turn fault, Induction motor protection-Protection against phase fault, ground fault and single phasing	
01	Problems	
01	Introduction, Basic construction and classification.	**Chalk and talk in classroom/Lecture combined with discussions**
01	Definite time lag static over current relay, Inverse time static over current relay,	
01	Static over voltage and under voltage relay, Microprocessor based over current relay-block diagram approach.	
01	Principles of AC circuit breaking, Principles of DC circuit breaking,	
01	Initiation of arc, maintenance of arc, Arc interruption- High resistance and Low resistance interruption.	
01	Re striking voltage, Recovery voltage and resistance switching..	
01	Types of circuit breakers- Air break and air blast circuit breakers,	
01	SF6 circuit breakers- Puffer type and Non Puffer type	
01	Problems	
01	Problems	

Review Questions:

Review Questions	CO	BLL	PI addressed
Why high voltage is preferred for transmission of long distance?	**01**	**01**	**1.3.1**
What are the specifications for standard impulse voltage	**01**	**01**	**1.3.1**
Write the different forms of high voltages required for the testing of electrical apparatus	**01**	**01**	**1.3.1**
List the merits and demerits of Van de Graff generator?	**01**	**01**	**1.3.1**
Draw the voltage multiplier circuit	**01**	**03**	**1.3.1**
What is the principle of operation of a resonant transformer	**01**	**01**	**1.3.1**
What is tesla coil?	**01**	**01**	**1.3.1**
Draw the circuit for producing impulse voltage.	**01**	**03**	**1.3.1**
Draw Schematic diagram of Marx circuit arrangement for multistage impulse generator.	**02**	**03**	**2.2.3**
State the components of multistage impulse generator?	**02**	**01**	**1.3.1**
List the advantages of series resonant circuit.	**02**	**01**	**1.4.1**
Explain simple voltage doubler and cascaded voltage doubler used for generation of high DC voltages.	**02**	**02**	**2.2.3**
What is the principle behind the electrostatic energy conversion methods? Explain the construction and operation of Van de Graaff generator	**02**	**01**	**1.4.1**
With a neat sketch explain the Cockcroft – Walton voltage multiplier circuit for generation of high DC voltages.	**02**	**03**	**2.2.3**
Explain with diagrams, different types of rectifier 2 Understand CO3 circuits for producing high D.C. voltages	**02**	**02**	**2.2.3**
Discuss elaborately the principle and operation of Cascaded transformers for generating high AC voltages	**02**	**03**	**2.2.3**
What is Tesla coil? How is damped high frequency oscillations obtained from a Tesla coil?	**03**	**01**	**1.4.1**
Discuss in detail the dielectric power factor test and partial discharge test procedures	**03**	**03**	**2.2.3**

for HV			
Explain the dielectrics characteristics of liquid dielectrics and also explain the liquid purification system(	**03**	**02**	**2.2.3**
Describe the mechanism of breakdown in composite insulation in detail.	**03**	**03**	**2.2.3**
Draw Schematic diagram of Marx circuit arrangement for multistage impulse generator.	**03**	**03**	**2.2.3**
Explain VI & polar characteristic of a directional relay.	**03**	**02**	**2.2.3**
Write any two functions of protective relaying?	**03**	**01**	**1.4.1**
Describe the operation of static over current relay with neat diagram.	**03**	**03**	**2.2.3**
What are the kind of directional relays? Explain each in detail with its construction	**04**	**01**	**1.4.1**
What are the characteristic of numerical relay?	**04**	**01**	**1.4.1**
Draw the distance relay characteristics curve.	**04**	**03**	**2.2.3**
What is mean by current chopping	**04**	**01**	**1.4.1**
Explain in detail about basic requirement of protective relays.	**04**	**02**	**2.2.3**
Explain in detail about different zones of protection.	**04**	**02**	**2.2.3**

Evaluation Scheme:

Assessment	Marks	Weightage
CIE-I	**20**	**20**
CIE-II	**20**	**20**
Assignments/ Quizzes/ Case Study/ Course Project/ Term Paper/Field Work	**10**	**10**
SEE	**100**	**50**
Total	**150**	**100**

Details of Assignment:

Assignment	Marks (10)	CO	PI	CA	PO
Assignment 1	**Case study (05M)**	**1,2,3,4**	**1.4.1, 2.1.1,2.1.2,2.1.3, 2.2.3,2.4.1**	**1.1,1.4,2.1, 2.2, 2.4**	**01,02,03,04**
Assignment 2	**Quiz (05M)**	**1,2,3,4**	**1.1.1, 1.4.1**	**1.1, 1.4**	**01,02,03,04**

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BASAVESHWAR ENGINEERING COLLEGE (AUTONOMOUS), BAGALKOT

MODEL COURSEPLAN

Title of Course	**:**	**Solar Photovoltaic System Design**	**Course Code**	**:**	**UEE754E**
Credits	**:**	**3**	**Contact Hours/ Week**	**:**	**3**
Total Hours	**:**	**40**	**Tutorial Hours**	**:**	**40**
CIE Marks	**:**	**50**	**SEE Marks**	**:**	**100**
Semester	**:**	**VII**	**Year**	**:**	**2023**

Prerequisites:

Course Objectives:

	The Course objectives are:
1	To list the different components and features of SPV system for installation, O&M, troubleshooting and safety aspects.
2	To formulate the SPV systems for different loads and applications.
3	To compare and contrast the different solar SPV systems.
4	To design a solar PV system for standalone and grid connected operations.

Course Outcomes:

	At the end of the course the student should be able to:
1	Define parameters, components & features of solar cell, module, panel, array and SPV systems. They should be able to describe installation, O&M, troubleshooting and safety aspects of SPV systems.
2	Compute/estimate performance of SPV systems for different loads and applications based on numerical problems.
3	Compare and analyze output of different solar PV systems.
4	Operate, test, design & discuss a solar PV system – standalone or grid connected – based on typical loads.

Course Articulation Matrix: Mapping of Course Outcomes (CO) with Programme Outcomes (PO) and Programme Specific Outcomes (PSO)

		PO1	PO2	PO3	PO4	PO5	PO6	PO 7	PO8	PO9	PO1 0	PO1 1	PO1 2	PSO1	PSO2	PSO3
No	Programme Outcomes / Course Outcomes															
The students will be able to:																
1	UEE754E.1	**3**	**2**	**2**	**2**						**1**		**1**	**1**		**2**
2	UEE754E.2	**3**	**2**	**2**	**2**			**1**			**1**		**2**	**1**		**2**
3	UEE754E.3	**2**	**3**	**3**	**2**	**1**					**3**		**3**	**1**	**1**	**2**
4	UEE754E.4	**1**	**3**	**3**	**3**		**1**	**1**	**1**	**1**	**3**		**1**	**1**		**2**

Competencies Addressed in the course and Corresponding Performance Indicators

Programme Outcome:Any of 1 to 12 PO's:

Competency		Indicators
• Knowledge of Solar Energy Fundamentals:		• Understand the principles of solar energy conversion. • Explain the characteristics of sunlight, solar radiation, and its variability. • Describe the solar spectrum and how it affects PV cell performance.
• PV System Components and Types:		• Identify different PV module technologies and their advantages/disadvantages. • Understand the function and selection of inverters, charge controllers, batteries, and mounting structures. • Differentiate between grid-tied, off-grid, and hybrid PV systems.
• System Sizing and Design		• Calculate the size of a PV system based on energy demand, location, and available space. • Design PV arrays for optimal orientation and tilt angle. • Determine the appropriate battery bank size (if off-grid).
• Testing and Evaluation		• Proficiency in testing the performance of standalone PV systems using test methods and procedures that assess the performance of PV modules, charge controllers, batteries, and loads.

PO1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. **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.

PO3. **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.

PO4. **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.

PO5. **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.

PO6. **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.

PO7. **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.

PO8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. **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.

PO11. **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.

PO12. 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.

Unit Learning Outcomes (ULO):

Sl.	Unit Learning Outcome (ULO)	CO's	BLL	PI addressed
	Unit -II			
1.	Students should be able to define basic terms associated with solar energy	**1**	**1**	**1.1.1**
2.	Students shall be able to differentiate between diffuse and beam radiation	**2**	**2**	**2.1.2**
3.	Students shall be able to assess the scenario of solar energy in global and India.	**2**	**2**	**1.1.1**
4.	Students shall be able to state and illustrate the I-V & P-V characteristics of solar cell	**2**	**2**	**1.1.1**
5.	Students shall be able to define the I-V equation of solar cell	**2**	**2**	**1.1.1**
6.	Students shall be able to solve numerical problems associated with SPV	**4**	**4**	**1.2.1, 2.1.1**
	Unit -II			

7.	Students shall be able to define basic terms associated with SPVmodule–Ratings,standardparameters	**1**	**1**	**1.1.1**
8.	Students shall be able to describe I-V & P-V characteristics of solar module	**2**	**2**	**1.1.1**
9.	Students shall be able to derive the I-V equation of SPV module	**3**	**3**	**1.1.1**
10.	Students shall be able to describe Mismatchinseriesandparallel connections	**2**	**2**	**1.1.1**
11.	Students shall be able to defineBalance of System(BoS)–Batteries, charge controllers and inverter	**3**	**3**	**1.1.1**
12.	Students shall be able to list and illustrate the different types of inverters	**2**	**2**	**2.1.2**
13.	Students shall be able to solve numerical problems associated with SPV module.	**4**	**4**	**1.2.1, 2.1.1**
Unit -III				
14.	Students shall be able to explain the wires	**2**	**2**	**1.1.1**
15.	Students shall be able to describe the construction and operating principle for AC and DC generators	**2**	**2**	**1.1.1**
16.	Students shall be able to list and describe different types of wires, sizing and junction box	**2**	**2**	**2.1.2**
17.	Students shall be able to troubleshooting ofstand-aloneandgrid connectedsolarPVpowersystems	**3**	**3**	**3.1.2**
18.	Students shall be able to test the SPV systems	**4**	**4**	**3.4.2**
Unit -IV				
19.	Students shall be able to design the standalone SPV system	**2**	**2**	**1.1.1**
20.	Students shall be able to list types of SPV systems	**1**	**4**	**2.1.2**
21.	Students shall be able describe the configuration of GridconnectedSolarPVPowerSystems(GCSPVPS)	**2**	**2**	**1.1.1**
22.	Students shall be able to design the GCSPVPSfor small applicationsand for powerplants	**1**	**1**	**2.1.2**

Course Content:

Hours Required	Topic to be covered	Mode of Delivery
01	SolarEnergy–Introduction	Chalk and talk in classroom/Lecture combined with discussions/Lecture with a quiz/ Tutorial/ Assignments/ Demonstration/ Invited lectures/ Group Assignment/
01	ScenarioofIndiaandglobal	
01	SolarRadiation–solarradiation spectrum diffuse&beamradiation solar radiation measurement.	
01	Solar Cells–I-V & P-V characteristics	
01	Solar CellsTechnologies;	
01	Parameters;	
01	Factorsaffecting electricity generated	
01	Series,parallel of SPV	
01	Continuation of series&parallel connections	
01	Numerical problems	
01	SPVmodule–Ratings standardparameters	
01	factorsaffectingelectricitygenerated	
01	I-V&P-V Characteristics;	

01	connection of modulesinseries,parallelandseries∥	
01	Mismatchinseriesandparallel connections,Introduction toarrays.	
01	Balance of System(BoS)–Batteries	
01	ChargeControllers	
01	MPPT	
01	Inverters	
01	(BoS tocoverfunctions, working,types,features, typical specificationsandcost).Numerical problems	
01	Wires–Introduction	
01	basicsofcurrentconduction,typesofwires	
01	measurementofwiredimensions, wiresizing;junction box;	
01	Installation,troubleshooting ofstand-alone	
01	grid connectedsolarPVpowersystems;	
01	Safetyof SPVpowerplants	
01	Solar PVplantinstallationchecklist– ElectricaltestingofPVarray,inverter	
01	Islanding protection	
01	Commissioningand systemfunctioning	
01	Field visitswithin campustostudyinstallations.	
01	SPVsystemdesign	
01	SPV integration	
01	TypesofSPVsystems	
01	DesignMethodologyforStand-aloneSPV systems.	
01	GridconnectedSolarPVPowerSystems(GCSPVPS)– Introduction	
01	GCSPVPS Configurations	
01	Componentsof GCSPVPS	
01	GCSPVPSDesignfor small applications	
01	GCSPVPSDesignfor Power Plants	
01	Summary of SPVSD	

Review Questions:

Review Questions	ULO	BLL	PI addressed
What is the impact of temperature on $V_{oc}$and I_{sc}? Justify your answer.	1	4	1.1.1
Installed Power capacity of India as on march 2023	3	2	2.1.2
Installed solar capacity of India as on march 2023	3	2	1.1.1
Installed Solar capacity of Karnataka as on 2023	3	2	1.1.1
A 240 W, 30 V solar PV module gives maximum current of 8.6 A andmaximum voltage of 37 V. Calculate other parameters of the module.	6	3	1.1.1
A solar PV panel installed at Bagalkot generates 6 kWh of energy per hour. Calculate the energy generated by the same solar panel on 12th September 2019. (Coordinates for Bagalkot are 16.1691° N, 75.6615° E)	6	3	1.2.1, 2.1.1
Open circuit voltage is……. Maximum power point voltage.	2	1	1.1.1
Is Solar cell conversion efficiency is equal to module efficiency? T/F	4	1	2.1.2
Which among have solar cells have higher conversion efficiency	10	1	1.1.1
Maximum power……with increase in cell temperature. (increases/ decreases/ remains same)	7	1	1.1.1
Value of Boltzmann constant is	8	1	1.1.1
MVA rating of inverters used in SPV plant at BECbgk	9	1	1.1.1
List parameters to be checked before selecting power conditioner units for a system. Give brief description of each parameter.	11,12	2	1.1.1
List and explain parameters on which voltage drop in wire depends. Calculate the copper loss in a 132kV transmission line (assume 1-phase) from Bagalkot to Badami with conductor type Zebra and length 20km. (Zebra conductor specifications: 24.82mm, ρ = 0.081857 Ω/km)	14	4	2.1.2
Give the checklist for visual inspection performed during troubleshooting.	17	2	1.1.1
How the choice of appropriate wire while designing a SPV system plays an important role?	16	2	1.1.1
Is installation and commissioning same? Justify your answer. Give the safety measures to be taken during SPV system installation.	15	4	1.1.1
Define 'Islanding' wrt grid connected SPV power plants. What are the main reasons for islanding?	19	2	2.1.2
What is troubleshooting? Explain two common problems that require troubleshooting	18	1	3.1.2
Draw block diagram of a stand-alone solar PV system designed to load during sunshine and non-sunshine hours. How are the ratings of the following components, in a stand-alone solar PV system, designed/selected? (a)Battery (b) Charge controller (c) DC to DC converter, (d) DC to AC converter and (e) MPPT.	21	4	3.4.2
Design a stand-alone solar PV system for the home load given in table-2. Consider following data for design. Battery specifications: C = 150 Ah, V = 12 V, DoD = 70%, Efficiency =	22	4	3.2.3

90% with DoA = 2 days
Inverter losses = 7%
Module specifications: P_{mp} = 50 W, V_{mp} = 12 V, I_{mp}= 4A
Daily sunshine hours = 5 hrs

Table 2: Home load details

Sl	Load	Wattage	Quantity	Usage hours
1	Tube light	40	4	7
2	Ceiling Fan	60	2	10
3	Grinder	1000	1	0.25
4	TV	145	1	8

Design a solar power plant that can supply 20 MW power to the grid in summer days (It is found that SPV plant can generate 70% of installed capacity).

Use following data for the design

AC transmission loss= 4% DC transmission loss= 3% Transformer 11kV/415V, η=90%	Inverter specifications Nominal AC o/p power = 500kW Max DC i/p to inverter = 600kW Efficiency=98% Voltage o/p=415 V	SPV module specifications: P_m=320W I_m=10A V_m=40V

	20	**4**	**3.2.1**

Evaluation Scheme:

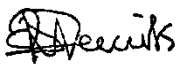
Assessment	Marks	Weightage
CIE-I	20	20
CIE-II	20	20
Assignments/ Quizzes/ Case Study/ Course Project/ Term Paper/Field Work	10	10
SEE	100	50
Total	150	100

Details of Assignment:

Assignment	Marks (10)	CO	PI	CA	PO
Assignment 1	5	3,4	1.2.1, 2.1.1	1.1, 2.1	1,2
Assignment 2	5	3,4	2.1.2, 4.1.1	2.1, 4.1	2, 4

Faculty Incharge:

Dr. Sangamesh Goudappanavar



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BASAVESHWAR ENGINEERING COLLEGE, BAGALKOT

COURSEPLAN- UEE732N

Title of Course	:	Electrical Safety for Engineers (Open Elective)	Course Code	:	UEE732N
Credits	:	3	Contact Hours/ Week	:	3
Total Hours	:	40	Tutorial Hours	:	--
CIE Marks	:	50	SEE Marks	:	50
Semester	:	VII	Year	:	2023-2024

Prerequisites:

Basics of electrical engineering, Concept of current, voltage and potential difference, Concept of AC and DC voltages, Working principle of electrical generator and motors, Transformer,

Course Objectives:

	The Course objectives are:
1	To identify the hazards associated with electricity - shock & fire and decide security measures in electrical safety systems
2	To describe how electricity works regarding hazards on the job and explain approaches to prevent accidents in electrical systems
3	To understand basic safety controls and practices at work and understand the methods to rescue & first aid approaches in case of electrical accidents
4	To identify and explain how to respond to electrical emergencies

Course Outcomes:

	At the end of the course the student should be able to:
1	List and explain the objectives and security measures in electrical safety systems
2	Illustrate approaches to prevent accidents in electrical systems and describe the operation of safety devices
3	Suggest the methods to rescue & first aid approaches in case of electrical accidents
4	Assess & provide solutions to a practical case study and write an investigation report with independent conclusions.

Course Articulation Matrix: Mapping of Course Outcomes (CO) with Programme Outcomes (PO) and Programme Specific Outcomes (PSO)

Sl.	CO's \ PO's	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
The students will be able to:																
1	UEE732N.1	2	1		1		1	1		1			1			
2	UEE732N.2	2	1		1		1	1		1			1			
3	UEE732N.3	2	1		1		1	1		1			1			
4	UEE732N.4	2	1		1		1	1		1			2			

Competencies Addressed in the course and Corresponding Performance Indicators

Programme Outcome:Any of 1 to 12 PO's:

PO	Competency		Performance Indicators	
1	1.3	Demonstrate competence in engineering fundamentals	1.3.1	Apply elements of electrical engineering principles and laws
	1.4	Demonstrate competence in Electrical engineering knowledge	1.4.1	Apply discipline specific laws and principlesto solve an engineering problem
2	2.1	Demonstrate an ability to identify and characterize an engineering problem	2.1.1	Evaluate problem statements and Identify objectives
4	4.1	Demonstrate an ability to conduct investigations of technical issues consistent with their level of knowledge and understanding	4.1.1	Define a problem for purpose of investigation, its scope and importance
	4.3	Demonstrate an ability to critically analyze data to reach a valid conclusion	4.3.1	Use appropriate procedures, tools and techniques to collect and analyse data
6	6.1	Demonstrate the ability to describe engineering roles in a broader context, e.g. as pertains to the environment, health, safety, and public welfare	6.1.1	identify and describe various engineering roles; particularly pertaining to protection of the public and public interest
9	9.2	Demonstrate effective individual & team operations -- communication, problem solving, resolution & leadership skills	9.2.1	Demonstrate effective communication, problem solving, conflict resolution and leadership skills

PO1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. **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.
PO3. **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.
PO4. **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.
PO5. **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.
PO6. **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.
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PO12**. 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.

Unit Learning Outcomes (ULO):

Sl.	Unit Learning Outcome (ULO)	CO's	BLL	PI addressed
	Unit -II			
1.	Students shall be able to define basic terms associated with electrical safety	**1**	**1**	**1.4.1**
2.	Students shall be able to list OSHA standards on electrical safety, objectives of safety and security measures	**1**	**1**	**1.3.1**
3.	Students shall be able to illustrate hazards associated with electric current and voltage	**2**	**2**	**2.1.1**
4.	Students shall be able to identify approaches to prevent accidents	**3**	**3**	**2.1.1**
5.	Students shall be able to list the Indian electricity rules for the said scenario	**2**	**2**	**6.1.1**
6.	Students shall be able to differentiate between primary and secondary electrical shocks	**2**	**2**	**1.4.1**
7.	Students shall be able to carry out medical analysis of electric shocks on the human body	**3**	**3**	**2.1.1**
8.	Students shall be able to suggest safety precautions against contact shocks, flash shocks	**4**	**4**	**9.2.1**
	Unit –II			
9.	Students shall be able to list and suggest first principles of actions after electric shock	**1**	**1**	**1.3.1**
10.	Students shall be able to illustrate first aid-artificial respiration methods	**2**	**2**	**1.4.1**
11.	Students shall be able to carry out accident management and safety management	**3**	**3**	**2.1.1**
12.	Students shall be able to justify the need for earthing, types of earthing	**3**	**3**	**2.1.1**
13.	Students shall be able to distinguish between system grounding and equipment grounding,	**2**	**2**	**4.1.1**
14.	Students shall be able to differentiate shocks due to step and touch potential	**2**	**2**	**4.3.1**
15.	Students shall be able to suggest methods to avoid the step potential shocks	**4**	**4**	**4.3.1**
16.	Students shall be able to list advantage of neutral grounding	**2**	**2**	**2.1.1**
	Unit –III			
17.	Students shall be able to identify the type of domestic wiring methods and installations	**2**	**2**	**2.1.1**

18.	Students shall be able to suggest safety requirements in domestic wiring systems	**2**	**2**	**1.3.1**
19.	Students shall be able to identify the solutions for the shocks from domestic equipment-water taps, wet walls-agricultural pumps	**3**	**3**	**1.4.1**
20.	Students shall be able to identify types of cables and specifications	**2**	**2**	**2.1.1**
21.	Students shall be able to list the best practices with use of electricity	**2**	**2**	**4.3.1**
22.	Students shall be able to conduct and write investigation report	**4**	**4**	**4.3.1**
23.	Students shall be able to conduct case studies of accidents in HESCOM/GESCOM region	**4**	**4**	**4.3.1**
24.	Students shall be able to carry out investigation for the case study taken up at HESCOM or GESCOM	**4**	**4**	**4.3.1**
Unit –IV				
25.	Students shall be able to describe the needs for safety devices in electrical systems	**2**	**2**	**1.3.1**
26.	Students shall be able to identify safety clearances and creepage distances in electrical plants	**2**	**2**	**2.1.1**
27.	Students shall be able to list types insulators and their significance	**1**	**1**	**2.1.1**
28.	Students shall be able describe arc phenomenon and principles of arc extinction	**2**	**2**	**4.1.1**
29.	Students shall be able to describe operation of oil & air blast breakers	**2**	**2**	**1.3.1**
30.	Students shall be able to describe fundamental requirements of relaying	**2**	**2**	**1.4.1**
31.	Students shall be able describe the protection of alternators, transformers, bus bars and lines	**2**	**2**	**2.1.1**
32.	Students shall be able describe protection against over voltages.	**2**	**2**	**2.1.1**

Course Content:

Hours Required	Topic to be covered	Mode of Delivery
01	Introduction to electrical safety, shocks and prevention	Ppt
01	OSHA standards on electrical safety, objectives of safety	Ppt
01	Hazards associated with electric current and voltage	Ppt
01	Principles of safety, approaches to prevent accidents	Ppt, Discussions
01	Review of IE rules & acts	Ppt
01	Primary and secondary electrical shocks	Ppt
01	Possibilities of getting electrical shock and its severity	Ppt
01	Medical analysis of electric shocks and its effects	Ppt, Discussions
01	Shocks due to flash/ spark over's	Ppt
01	Prevention of shocks	Ppt
01	Safety precautions against contact shocks, flash shocks	Ppt
01	Introduction to first aid in case of electric shock	Ppt
01	First principles of actions after electric shock	Ppt
01	First aid-artificial respiration methods	Ppt
01	Cardiac pulmonary resuscitation	Ppt

01	Accident management and safety management	Ppt, Discussions
01	Earthing, need for earthing, types of earthing	Ppt
01	Distinction between system and equipment grounding	Ppt
01	Functional requirement of earthing system	Ppt
01	Technical consideration of station earthing system	Ppt
01	Step and touch potential	Ppt
01	Neutral grounding and its advantages	Ppt
01	Domestic wiring methods and installations	Ppt
01	Shocks from domestic equipment-water taps	Ppt, Discussions
01	Shocks - wet walls-agricultural pumps	Ppt, Discussions
01	Types of cables and specifications, underground cables	Ppt
01	Best practices with use of electricity	Ppt
01	Investigation of accidents	Ppt, Discussions
01	Investigation report writing	Ppt
01	Case studies of accidents in HESCOM/GESCOM region	Ppt, Discussions
01	Case studies of accidents in HESCOM/GESCOM region	Ppt, Discussions
01	Case studies of accidents in HESCOM/GESCOM region	Ppt, Discussions
01	Safety devices and their characteristics	Ppt
01	Safety clearances &creepage distances in electrical plants	Ppt
01	Line supports and insulators	Ppt
01	Circuit breakers: arc phenomenon, arc extinction	Ppt
01	Oil & air blast breakers	Ppt
01	Fundamental requirements of relaying and classification	Ppt
01	Protection of alternators, transformers, bus bars and lines	Ppt
01	Protection against over voltages	Ppt

Chalk and talk in classroom/Lecture combined with discussions/Lecture with a quiz/ Tutorial/ Assignments/ Demonstration/ Invited lectures/ Group Assignment/ Project / Seminars, Presentations/Group Discussion/Asynchronous Discussion

Review Questions:

Review Questions	ULO	BLL	PI addressed
1. What are electrical accidents? List the causes for electrical accidents. Further, describe the key approaches to prevent accidents.	**4**	**3**	**2.1.1**
2. Give a list of possible accidents during the electrical installations. Further list the probable reasons for such accidents.	**5**	**2**	**6.1.1**
3. Explain the principle of unsafe acts and unsafe conditions behind electrical accident. Give an example.	**8**	**4**	**9.2.1**
4. Describe the resistance of human body under different conditions. Further, illustrate the effect of body resistance on electric shock. Also list the nominal resistance values for various parts of the human body.	**7**	**3**	**2.1.1**
5. With a neat descriptive figure list and explain the electric shock scenarios with 3 phase AC systems and bipolar DC system.	**6**	**2**	**1.4.1**
6. With details of current magnitude and detailed medical analysis of shock, illustrate the effect of electrical current on the human body.	**7**	**3**	**2.1.1**
7. Differentiate between touch potential and step potential?	**15**	**4**	**4.3.1**

Describe their significance. Further, list the precautions to be taken under the conditions of accidents leading to step potential shocks.			
8. List the first principles of action to be followed to save the life immediately after electric shock.	**9**	**1**	**1.3.1**
9. Explain the process of CPR-Cardiac pulmonary resuscitation and how it helps to prevent death.	**10**	**2**	**1.4.1**
10. List and explain the details of electrical safety measures employed in BEC camps. Further, mention the location of respective safety measures initiated.	**13**	**2**	**4.1.1**
11. Distinguish between system grounding (neutral grounding) and equipment grounding.	**13**	**2**	**4.1.1**
12. List and explain important electrical safety measures with reference to wirings and fittings in domestic systems.	**19**	**3**	**1.4.1**
13. Describe the precautions to be taken while carrying agricultural pump installation and operations to avoid electric accidents.	**19**	**3**	**1.4.1**
14. Describe the reasons and tips to avoid the following types of electric shock scenarios. • Water Tap Giving Shock • Shock From Wet Wall • Table Fan Giving Shock • Shock From Motor-Pump	**19**	**3**	**1.4.1**
15. What is electrical accident Investigation? Illustrate the need for the conducting the investigation.	**22**	**4**	**4.3.1**
16. List the components to be included in the electrical accident investigation kit. Discuss the need for each component.	**22**	**4**	**4.3.1**
17. Write the descriptive note on electrical accident happened with flagpole in Koppal in the year 2019. List the causes for the accident. Further, list precautions to be taken in such scenarios to avoid the electrical accidents.	**22**	**4**	**4.3.1**
18. List and explain the factors affecting the choice of wiring methods for a domestic electricity connection.	**21**	**2**	**4.3.1**
19. List the square mm cross section of electrical conductors and their applications in terms of load connections.	**25**	**2**	**1.3.1**
20. With neat diagram of cross section explain the Aluminum Conductor Steel-Reinforced (ACSR) Cable. List its advantages.	**25**	**2**	**1.3.1**
21. Conduct the critical survey and identify the electrical safety issues in BEC Campus. (With the mention of location in the campus)	**22**	**4**	**4.3.1**
22. Case Study Activity based Learning in HESCOM and GESCOM Region	**22**	**4**	**4.3.1**
23. Discuss the different types of porcelain insulators employed in electrical power systems. Describe the significance of each type.	**25**	**2**	**1.3.1**
24. Explain with a neat diagram the application of Merz-Price circulating current principle for the protection or alternator.	**31**	**2**	**2.1.1**
25. Explain the construction and working principle of SF_6 circuit breakers.	**31**	**2**	**2.1.1**
26. What is protective relay? Explain its function in an electrical system.	**31**	**2**	**2.1.1**

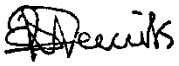
Evaluation Scheme:

Assessment	Marks	Weightage
CIE-I	20	20
CIE-II	20	20
Assignments/ Quizzes/ Case Study/ Course Project/ Term Paper/Field Work	10	10
SEE	100	50
Total	150	100

Details of Assignment:

Assignment	Marks (10)	CO	PI	CA	PO
Assignment 1 (Write and Submit)	02	1,2,3,4	1.4.1, 1.3.1, 2.1.1, 4.1.1		Po1, PO2, PO4
Assignment 2 (Write and Submit)	02	1,2,3,4	1.4.1, 1.3.1, 2.1.1, 4.3.1		PO1, PO2, PO4
Assignment 3 (Case Study in BEC)	02	1,2,3,4	4.3.1, 6.1.1		PO4, PO6
Assignment 4 (Case Study ESCOM's)	02	1,2,3,4	4.3.1, 6.1.1		PO4, PO6
Assignment 5 (Quiz)	02	1,2,3,4	1.4.1, 1.3.1, 2.1.1, 4.1.1		PO1, PO2, PO4

Dr. B F Ronad



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