BASAVESHWAR ENGINEERING COLLEGE, BAGALKOT

COURSEPLAN- UEE505C

Title of Course	**:**	**Power Systems - II**	**Course Code**	**:**	**21UEE505C**
Credits	**:**	**3**	**Contact Hours/ Week**	**:**	**3**
Total Hours	**:**	**40**	**Tutorial Hours**	**:**	**--**
CIE Marks	**:**	**50**	**SEE Marks**	**:**	**50**
Semester	**:**	**V**	**Year**	**:**	**2023-2024**

Course Objectives:

	The Course objectives are:
1	To convert given single line diagram to equivalent per unit reactance diagrams on the base of givenMVA and KV values
2	To analyse voltage and current components to obtain sequence networks using symmetrical components
3	To analyse different types of unsymmetrical faults on power system
4	To determine the stability of power system using the basics of equal area criterion/ swing equation

Course Outcomes:

	At the end of the course the student should be able to:
1	Represent power system networks as per unit reactance diagrams on the base of givenMVA and KV values
2	Assess phase & line components of voltage/current and to draw the positive, negative& sequence networks using symmetrical components
3	Carry out analysis of unsymmetrical faults (LG,LL,LLG) to determine fault currents when fault occurs at generator terminals/in power systems networks
4	Assess stability of power system under different types of disturbances by applying equal area criterion/solving the swing equation

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

Sl.	PO's / CO's	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
The students will be able to:																
1	UEE505C.1	**3**	**1**	**1**	**1**		**1**				**1**		**1**	**2**		**1**
2	UEE505C.2	**3**	**2**	**1**	**1**						**1**		**1**	**2**		**2**
3	UEE505C.3	**3**	**2**	**2**	**2**	**1**		**1**	**1**		**1**		**1**	**2**		**2**
4	UEE505C.4	**3**	**3**	**3**	**2**	**1**			**1**	**1**	**1**	**1**	**2**	**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 principles to 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

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 – I			
1.	Students shall be able to represent power system components using standard symbols	**1**	**1**	**1.4.1**
2.	Students shall be able to convert ohmic values of impedances to per unit values of single phase and three phase components	**1**	**1**	**1.3.1**
3.	Students shall be able to appreciate and experience the advantages of per unit system calculations	**2**	**2**	**2.1.1**
4.	Students shall be able analyse the 3 phase short circuit conditions - Sub transient, Transient and Steady state reactance	**2**	**3**	**4.1.1**
5.	Students shall be able to calculate Short circuit currents and Reactance of synchronous machines on load and no load	**2**	**2**	**4.3.1**
	Unit – II			
6.	Students shall be able to define sequence components for 3-Phase unbalanced power systems	**2**	**2**	**1.4.1**
7.	Students shall be able to make use of operator "a" and its properties in evaluation of symmetrical components	**2**	**3**	**2.1.1**
8.	Students shall be able to deduce expressions for sequence components	**2**	**4**	**4.3.1**
9.	Students shall be able to carry out phase shift of symmetrical components in star delta transformer bank.	**2**	**4**	**4.3.1**
	Unit –III			
10.	Students shall be able to handle various unsymmetrical fault at the terminals of unloaded generator	**3**	**1**	**4.1.1**
11.	Students shall be able to analyse unsymmetrical fault on unloaded power systems	**3**	**2**	**4.3.1**
12.	Students shall be able to analyse Open conductor faults in power system.	**3**	**3**	**4.3.1**
	Unit –IV			
13.	Students shall be able to classify power system stability conditions.	**4**	**2**	**2.1.1**
14.	Students shall be able to describe the relative motion of the rotor with respect to stator field as a function of time (swing equation)	**4**	**3**	**4.3.1**
15.	Students shall be able to deduce power angle equation for salient and non-salient pole synchronous machines.	**4**	**3**	**4.1.1**
16.	Students shall be able to carry out transient stability analysis	**4**	**4**	**4.1.1**

	using equal area criterion			
17.	Students shall be able to deduce expression for critical clearing angle	**4**	**3**	**4.3.1**
18.	Students shall be able to list methods to improve stability of power system.	**4**	**2**	**2.1.1**

Course Content:

Hours Required	Topic to be covered	Mode of Delivery
01	**Power System Representation:** Introduction, Standard symbols of power system components, Single line diagram,	Chalk & Talk, Ppt
01	Per unit system Per unit impedance of 3 phase components	Chalk & Talk, Ppt
01	Change of base, Per unit impedance diagram, Advantages of per unit system calculations.	Chalk & Talk, Ppt
01	Problem solving	Chalk & Talk, Discussions
01	Problem solving	Chalk & Talk, Discussions
01	**Symmetrical Three Phase Faults:** 3 - phase short circuit at the terminals of unloaded generator, Sub transient, Transient and Steady state reactance	Chalk & Talk, Ppt
01	Transients on a transmission line	Chalk & Talk, Ppt
01	Short circuit currents and Reactance of synchronous machines on load and no load	Chalk & Talk, Ppt
01	Short circuit MVA	Chalk & Talk, Ppt
01	Problem solving	Chalk & Talk, Discussions
01	**Symmetrical Components:** Definition of sequence components for 3-Phase unbalanced power systems, Operator “a” and its properties	Chalk & Talk, Ppt
01	Expressions for sequence components	Chalk & Talk, Ppt
01	Phase shift of symmetrical components in star delta transformer bank.	Chalk & Talk, Ppt
01	Problem solving	Chalk & Talk, Discussions
01	Problem solving	Chalk & Talk, Discussions
01	**Sequence Networks:** 3- Ph power in terms of sequence components, voltage drop due to sequence currents	Chalk & Talk, Ppt
01	Sequence impedance and sequence networks of power system elements (Alternator, Transformer and Transmission line)	Chalk & Talk, Ppt
01	Positive, negative and zero sequence networks ofpower system elements.	Chalk & Talk, Ppt
01	Problem solving	Chalk & Talk, Discussions
01	Problem solving	Chalk & Talk, Discussions
01	**Unsymmetrical Fault at the Terminals Unloaded Generator:**	Chalk & Talk, Ppt
01	L-G, L-L fault with and without fault impedance at the terminals of unloadedgenerator	Chalk & Talk, Ppt
01	L-L-G fault with and without fault impedance at the terminals of unloadedgenerator	Chalk & Talk, Ppt
01	Connection of sequence network and fault currents.	Chalk & Talk, Ppt

01	Problem solving	Chalk & Talk, Discussions
01	**Unsymmetrical Faults on Power Systems:** L-G, L-L faults on unloaded power systems	Chalk & Talk ,Ppt
01	L-L-G faults on unloaded power systems	Chalk & Talk ,Ppt
01	Open conductor faults in power system	Chalk & Talk ,Ppt
01	Problem solving	Chalk & Talk, Discussions
01	Problem solving	Chalk & Talk, Discussions
01	**Transient Stability Analysis:** Classification of Power System Stability, Steady Rotor dynamics	Chalk & Talk ,Ppt
01	Swing equation, Solution of swing equation by numerical techniques	Chalk & Talk ,Ppt
01	Power angle equation for salient pole synchronous machines	Chalk & Talk ,Ppt
01	Power angle equation for non-salient pole synchronous machines.	Chalk & Talk ,Ppt
01	Problem solving	Chalk & Talk, Discussions
01	**Equal Area Criterion:** Stability analysis for sudden change in mechanical input power	Chalk & Talk ,Ppt
01	3- ph fault on Generator terminals and on transmission line	Chalk & Talk ,Ppt
01	Expression for critical clearing angle	Chalk & Talk ,Ppt
01	Methods to improve stability of power system.	Chalk & Talk ,Ppt
01	Problem solving	Chalk & Talk, Discussions

Review Questions:

Review Questions
1. Show that the p.u impedance of a two winding transformer is same whether referred to primary or secondary? 2. List the advantages of per unit system? 3. Give the sketch of short circuit current waveform of a synchronous machine and hence define the various reactance's? 4. With the oscillogram of the short circuit current of a synchronous machine, define direct axis synchronous reactance, transient and sub transient reactance? 5. Define per unit quantity. Mention its advantages and also show that per unit reactance is same for both HV and LV side of a transformer? 6. Define sequence components and derive the expressions for the same interms of line currents of a3-phase system. 7. Show that a set of balanced voltages will have only positive sequence voltages. 8. The currents in lines b and c of a 3-phase star connected load areI_b=(5+j3)A, I_c=(2-j4)Amp. Under these conditions, the neutral wire carries (1-j2)Amp. Calculate the sequence components of line currents. 9. Derive an expression for the complex power interms of sequence components of voltages and currents in a 3-phasesystem 10. Draw and explain the zero-sequence network of 3-phase transformer with

following configurations:i)star-delta(neutral of star isolated), ii)star delta(neutral of star solidly earthed), iii)delta-delta

11. Prove that in symmetrical system currents of a given sequence produce voltage drops of the same sequence only.
12. Establish the relation between the line and phase components of symmetric components in star connected system.
13. Establish the relation between the line and phase components of symmetric components in delta connected system.
14. Derive the expression for fault current when Single Line to Ground fault (LG), Line to Line fault (LL) and Double Line to Ground fault (LLG) takes place at the terminals of unloaded generator without any fault impedance.
15. Derive the expression for fault current when Single Line to Ground fault (LG), Line to Line fault (LL) and Double Line to Ground fault (LLG) takes place through the fault impedance at the terminals of unloaded generator

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

Smt. Sunita Tambakad

BASAVESHWAR ENGINEERING COLLEGE, BAGALKOT

COURSE PLAN

Title of Course	**:**	**Power Electronics**	**Course Code**	**:**	**21UEE506C**
Credits	**:**	**03**	**Contact Hours/ Week**	**:**	**03**
Total Hours	**:**	**40**	**Tutorial Hours**	**:**	**-**
CIE Marks	**:**	**50**	**SEE Marks**	**:**	**50**
Semester	**:**	**V**	**Year**	**:**	**2023-24**

Prerequisites:

Course Objectives:

	The Course objectives are:
1	To explain the application of power electronics, different types of power electronic circuits and their peripheral effects.
2	To analyze the different power semiconductor switches based on their performances and switching characteristics.
3	To understand the various protection techniques used for power switches in industrial applications.
4	To explain the design, analysis techniques, performance parameters and characteristics of controlled rectifiers, DC-DC, DC-AC converters and Voltage controllers.

Course Outcomes:

	At the end of the course the student should be able to:
1	Select suitable power switches, heat sinks and power converters for industrial applications.
2	Investigate performance of the power switches-based on switching characteristics, power converters based on performance indices
3	Compute power loss in power switches and power converters, average and rms voltage, average and rms currents, ripple factors and harmonic components of power converters
4	Design various components of power converters employed in industrial application

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

Sl.	CourseOutcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	21UEE506C.1	3							1		1		1	2	1	2
2	21UEE506C.2	3	3						1		1		1		2	
3	21UEE506C.3	3	3	2	1	1			1		1		1		3	
4	21UEE506C.4	3	3	2	2	1			1		1		2	2	2	2

Unit Learning Outcomes (ULO):

Sl.	Unit Learning Outcome (ULO)	CO's	BLL
	Unit -I		
1.	Students shall be able to understand the importance of power electronics in industrial applications.	**01**	**1**
2.	Students shall be able to understand and compare various power electronic circuits for controlling the electric power.	**01**	**1**
3.	Students shall be able to understand the characteristics and specifications of various types of power switching devices.	**01**	**1**
4.	Students shall be able to understand the working principle of power BJTs and power MOSFETs.	**01**	**1**
5.	Students shall be able to understand the steady-state and switching characteristics of power transistors.	**01**	**1**
6.	Students shall be able to understand the various losses of a power transistor.	**01**	**1**
7.	Students shall be able to understand the importance of cooling methods, heat sinks and snubber circuits for power electronic switches.	**02**	**1**
8.	Students shall be able to understand the performance of thyristor through static and switching characteristics.	**02**	**2**
9.	Students shall be able to understandthe concept of two transistor model as a thyristor.	**01**	**2**
10.	Students shall be able to understand the di/dt and dv/dt protection of a thyristor.	**01**	**2**
	Unit -II		
11.	Students shall be able to understand the various classifications of rectifiers.	**01**	**2**
12.	Students shall be able to understand the principle of operation of phase controlled converter operation.	**01**	**2**
13.	Students shall be able to understand the operation of single phase half and full wave controlled rectifiers.	**01**	**1**
14.	Students shall be able to solve the numerical belongs to the single phase half wave and full wave controlled rectifiers.	**03**	**3**
15.	Students shall be able to understand the concept of semi converters and full converters using thyristors.	**02**	**2**
16.	Students shall be able to understand the concept of three phase half wave rectifier with R, R-L and RLE load.	**03**	**2**
17.	Students shall be able to understand the concept of three phase full wave rectifier with R, R-L and RLE load.	**02**	**3**
18.	Students shall be able to understand the concept of three phase semi converter and full converter with R, R-L and RLE load.	**02**	**3**
19.	Students shall be able to understand the performance evaluation of a controlled rectifier.	**02**	**3**
	Unit-III		
20.	Students shall be able to understand the meaning of commutation in converters.	**02**	**1**
21.	Students shall be able to differentiate the natural and forced commutation in converters.	**03**	**2**
22.	Students shall be able to understand different types of forced commutation.	**02**	**1**
23.	Students shall be able to understand the importance of DC-DC converters in industrial applications.	**01**	**2**
24.	Students shall be able to understand the principle operation of DC-DC converters.	**02**	**1**
25.	Students shall be able to understand the 4 quadrant operation of DC-DC converters.	**02**	**1**

26.	Students shall be able to understand the principle operation of various choppers.	**02**	**1**
27.	Students shall be able to understand the operation of Buck, Boost, Buck Boost and Fly back converters.	**03**	**1**
28.	Students shall be able to solve the numerical on DC-DC converters.	**04**	**1**
	Unit-IV		
29.	Students shall be able tounderstand the different types of inverters.	**01**	**1**
30.	Students shall be able to understand the principle operation of half bridge and full bridge inverter with R and R-L load.	**02**	**2**
31.	Students shall be able to understand the three phase inverter configuration with 120^0 and 180^0 mode of operation.	**02**	**1**
32.	Students shall be able to understand the voltage control of single phase inverter with single, multiple and sinusoidal pulse width modulation.	**02**	**1**
33.	Students shall be able to understand operation principle of ON-OFF control and phase control of AC voltage controllers.	**02**	**1**
34.	Students shall be able to understand operation single phase half wave and full wave AC voltage controllers with R and RL loads.	**02**	**1**

ProgrammeOutcomeswithRespectiveCompetencies&PerformanceIndicators

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

	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**	**Applydisciplinespecificlawsandprinciplestosolveanengineeringproblem**

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

	Competency	PI	Indicators
2.1	**Demonstrateanabilitytoidentifyandcharacterizeanengineering problem**	**2.1.1**	**EvaluateproblemstatementsandIdentifyobjectives**
		2.1.2	**Identifyengineeringsystems,variables,andparameterstosolvetheproblems**
		2.1.3	**Identify the mathematical, engineering and other relevantknowledgethatapplies 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/solutionmethodsforsolvingtheproblem ,includingjustifiedapproximationsandassumptions**
		2.2.4	**Compareandcontrastalternativesolution processestoselectthebestprocess.**
2.3	**Demonstrateanabilitytoformulateandinterpret asystem/model**	**2.3.1**	**Combinescientificandengineeringprinciplestoformulatemodels(mathematicalorotherwise)ofasystemorprocessthatisappropriateinterms ofapplicabilityandrequiredaccuracy.**

		2.3.2	Identifyassumptions(mathematicalandphysical)necessarytoallow modelling ofasystematthelevelofaccuracyrequired.
2.4	Demonstrateanabilitytoexecuteasolution,process andanalyseresults	2.4.1	Applyengineeringmathematicsandcomputationstosolve(form&analyse)mathematicalmodels.
		2.4.2	Produceandvalidateresultsthroughskilfuluseofcontemporaryengineeringtoolsandmodels
		2.4.3	Identifysourcesoferrorinthesolutionprocess,andlimitationsofthesolution.
		2.4.4	Extractdesiredunderstandingandconclusionsconsistentwithobjectivesandlimitationsoftheanalysis

PO3: Design/Development of Solutions: Design/development of solutions: Design solutions for complexengineering problems and design system components or processes that meet the specified needs withappropriateconsiderationforpublichealthandsafety,andcultural,societal,andenvironmental considerations.			
	Competency	PI	Indicators
3.1	Demonstrateanabilitytodefineacomplex open-endedprobleminengineeringterms	3.1.1	Recognizethatgoodproblemdefinitionassistsinthe designprocess
		3.1.2	Elicitanddocumentengineeringrequirementsfrom Stakeholders
		3.1.3	Synthesizeengineeringrequirementsfromareviewof theStateoftheArt
		3.1.4	Extract engineering requirements from relevant engineeringCodesandStandards
		3.1.5	Explore and synthesize engineeringrequirements fromlarger social andprofessional concerns
		3.1.6	Determinedesignobjectives,functionalrequirements andarriveatspecifications
3.2	Demonstrateanabilitytogenerateadivers esetofalternativedesignsolutions	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 of 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	Generatesinformationthroughappropriateteststo improve,orrevisedesignstates

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

	Competency	PI	Indicators
4.1	Demonstrateanabilitytoconductinvestigationsoftechnicalissuesconsistentwiththeirlevelofknowledgeandunderstanding	4.1.1	Defineaproblemforpurposeofinvestigation,itsscopeand importance
		4.1.2	Relatemodernengineeringexperimentationincludingexperimentdesign, system calibration, data acquisition, analysis and presentation
		4.1.3	Applyappropriateinstrumentation,and/orsoftwaretoolstomake measurementsofphysicalquantities
		4.1.4	Establishorvalidatearelationshipbetween measureddataand underlyingphysicalprinciples.
4.2	Demonstrateanabilitytodesignexperimentstosolveopenendedproblems	4.2.1	Developanddesignexperimentalapproach,specifyappropriateequipmentandprocedures,implementtheseprocedures,andinterprettheresultingdatatocharacteriseanengineeringmaterial, component,orsystem.
		4.2.2	Understandtheimportanceofstatisticaldesignofexperimentsandchooseanappropriate 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 with anunderstandingofthelimitations.

	Competency	PI	Indicators
5.1	Demonstrateanabilitytoidentify/createmodernengineeringtools, 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)monitoringsystemperformance, and(iv)creating engineering designs.
		5.2.2	Demonstrate proficiency in using computing, mathematical, 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 assess societal,health, safety, legal and cultural issues and the consequent responsibilities relevant to the professionalengineeringpractice.

	Competency	PI	Indicators
6.1	Demonstratetheabilitytodescribeengineeringrolesinabroadercontext,e.g.aspertainstothe environment,health,safety, andpublicwelfare	6.1.1	Identify and describe various engineering roles;particularlypertainingtoprotectionofthepublicand publicinterest
6.1	Demonstrate an understanding of professionalengineeringregulations,legislationandstandards	6.2.1	Interpretlegislation,regulations,codes,andstandardsrelevanttoelectricalandelectronicsengineeringdiscipline(suchasIEEE)andexplainitscontributiontothe protectionofthepublic

PO7: Environment and sustainability: Understand the impact of the professional engineering solutions insocietalandenvironmentalcontexts,anddemonstratetheknowledgeof,andneedforsustainabledevelopment.

	Competency	PI	Indicators
7.1	Demonstrate an understanding of the impactofengineeringandindustrialpracticeonsocial,environmentalandeconomiccontexts	7.1.1	Identifyrisks/impactsinthelife-cycleofanengineering productoractivity
		7.1.2	Demonstrateanunderstandingoftherelationshipbetweenthe technical, socio-economic and environmental dimensionsofsustainability
7.2	Demonstrateanabilitytoapplyprinciplesofsustainabledesignanddevelopment	7.2.1	Describe management techniques for sustainable 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	Demonstrateanabilitytoformateamanddefinearoleforeachmember	9.1.1	Recognizeavarietyofworkingandlearningpreferences; appreciatethevalueof diversityinateam
		9.1.2	Implementthenormsofpractice(e.g.rules,roles,charters, agendas,etc.)ofeffectiveteamwork,toaccomplishagoal.
9.2	Demonstrateeffectiveindividual&teamoperations -- 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,beingabletocomprehendandwriteeffectivereportsanddesigndocumentation,makeeffectivepresentations,andgiveandreceiveclearinstructions

	Competency	PI	Indicators
10.1	Demonstrateanabilitytocomprehendtechnical literature and documentprojectwork.	10.1.1	Read,understandandinterprettechnicalandnon-technical information
		10.1.2	Produce clear, well-constructed, and well-supported writtenengineeringdocuments
		10.1.3	Create*flow*inadocumentorpresentation–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	Identifythetasksrequiredtocompleteanengineering activity,andtheresourcesrequiredtocompletethetasks.
		11.3.2	Useprojectmanagementtoolsto scheduleanengineering projectsoastocompleteontimeandwithinbudget.

PO12:Life-longlearning:Recognisetheneedforandhavethepreparationandabilitytoengagein 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 anddemonstrateanabilitytosourceinformationt obridgethe same**
12.2	**Demonstrate an ability to Identify changingtrendsinengineeringknowledgean dpractice**	**12.2.1**	**Identifyhistoricpointsoftechnologicaladvanceinengineerin gthatrequirepractitionerstoseekeducationin ordertostayupdated**
		12.2.2	**Recognize theneed andbe ableto clearlyexplainwhyitisvitallyimportanttokeepupdatedregar dingnew developmentsinthefield**
12.3	**Demonstrateanabilitytoidentifyandaccess sourcesfor newinformation**	**12.3.1**	**Demonstrateanabilitytosourceandcomprehendtechnicallit eratureandothercrediblesourcesof information**

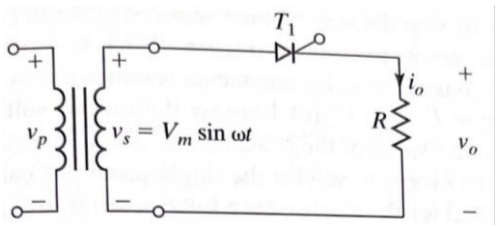
Course Content:

Day	Content	Mode of Delivery
1	Introduction of BJT and its application in power electronics, Basic structure of BJT, Input and output characteristics, steady state and transfer characteristics.	Chalk and Talk
2	Numerical on obtaining the base current for driving the saturation, computation of ODF, forced β, total power loss	
3	Transient model of BJT used as switch in power electronics, Numerical problem on obtaining average power, instantaneous power during delay time, rise time, storage time and fall time. Total power loss during switching operation	
4	Introduction of MOSFET, Basic structure of the MOSFET, Steady state output characteristics, transfer and switching characteristics	
5	Discussion on snubber circuit for limitation of di/dt and dv/dt, derivation of Ls and Cs. Problems on computation of Ls and Cs for critically damping and for various discharge currents	
6	Introduction to thyristors, Basic structure of thyristors, static characteristics of thyristors: forward blocking, forward conduction and reverse blocking and conduction. Importance of latching and holding currents	
7	Concept of regenerative process of thyristor is discussed using two transistor model, derivation of the anode current as a function of gate current. various Turn ON methods of thyristors. Switching characteristics of thyristor	
8	Discussion on di/dt and dv/dt limitation of the thyristors, concept of power derating circuits for the switches and numerical on power derating	
9	Introduction of phase-controlled rectifier, necessary of controlled rectifier, broad classification. Discussion on 1- phase half wave-controlled rectifier with R and R L load, derivation of average and rms voltage and average load current.	
10	Importance of freewheeling diode for R L load in phase-controlled rectifier, Numerical on half wave-controlled rectifier	
11	Full-wave controlled rectifier: midpoint and Bridge rectifier, Analysis of midpoint for R, R-L load	

	and its limitations	
12	Principle operation of fully controlled bridge rectifier for R, R-L load, derivation of average load voltage, current and RMS voltage.	Mixed Mode
13	Introduction of phase-controlled rectifier, necessary of controlled rectifier, broad classification. Discussion on 1- phase half wave-controlled rectifier with R and R L load, derivation of average and rms voltage and average load current.	
14	Importance of freewheeling diode for R L load in phase-controlled rectifier, Numerical on half wave-controlled rectifier	
15	Full-wave controlled rectifier: midpoint and Bridge rectifier, Analysis of midpoint for R, R-L load and its limitations	
16	Principle operation of fully controlled bridge rectifier for R, R-L load, derivation of average load voltage, current and RMS voltage.	
17	Principle operation of Half controlled Bridge converter (Symmetric and unsymmetric) for R-L load, Analysis with suitable waveforms	
18	Derivation of performance parameter of the full bridge converters such Displacement angle, current and voltage ripple factor, input power factor	
19	3- Phase full bridge controller converter, Discussion on the firing sequence for the thyristor based on the phase sequence and line voltages of 3-phase supply, different modes of operation and	
20	3- Phase full bridge controller converter, discussion of output voltage using waveform for 30, 60, 90 deg firing angle for R and R-L load	
21	Three phase Half controlled Bridge Converter for R-L load, Need and importance, discussion on the nature of output voltage for 30^0 and 60^0firing angle	
22	Commutation: Introduction, Broad classification of commutation, Class A: Self commutation.	Mixed Mode
23	Concept of Class- B commutation and Class-C commutation (Complimentary) commutations	
24	Concept of Impulse and Resonant Commutations	
25	Chopper: Introduction of chopper, application and classification of chopper	
26	Concept of Four Quadrant Chopper, Control strategies: Current limit control, TRC control. Problems on control strategies	
27	Principal operation of Step up and Step-down chopper, derivation of average and rms value output voltage	
28	Concept of First Quadrant and Second Quadrant chopper: Discussion of operation of circuit along with waveform. Applications of the above choppers	
29	Concept of Type-A and Type-B two quadrant chopper: Discussion of working operation of the chopper along with waveforms	
30	Discussion of 4-Quadrant chopper, Detailed analyses of TYPE-A chopper, Derivation of the expression I_{omin} and I_{omax}	
31	Derivation of Ripple current, Derivation of expression which relates the ripple current variation with duty cycle. The curve relating condition for the continues and discontinues	
32	The numerical to check the load current continuity of the load current. Additional problems on the TYPE-A chopper	
33	Concept of Fly Back converter, Concept of boost converter, derivation of output voltage, ripple voltage and ripple current	
34	Concept of buck converter, derivation of output voltage, ripple voltage and ripple current, Numerical on buck and boost converter	

35	Introduction of Inverter, concept of half bridge and full bridge inverter for R and R-L load	
36	Derivation of Instantaneous output voltage, performance parameter of inverter. Numerical on half bridge and full bridge inverter	Mixed Mode
37	Methods of Voltage control for 1-phase inverter: PWM control – Single pulse width modulation, multiple pulse width modulation and sinusoidal pulse width modulation	
38	Introduction of three phase converter, application and advantages three phase inverter, classification of inverter based on conduction period of switch. Concept of 180 degree and 120 degree conduction.	
	Principle operation of 180 degree conduction along with equivalent circuit and waveform	
40	Principle operation of 120-degree conduction along with equivalent circuit and waveform	
41	Introduction of AC voltage controller, Single phase: Unidirectional or half wave controller, Principle of on-off control and phase control, derivation of rms value of output voltage, Application	
42	Bidirectional or Full wave controller for R load and R-L load, Different circuit topology of bidirectional AC voltage controller	

Review Questions (Unit-Wise):

Sl.	Review Questions	CO	BLL	PI
1	Mention the types of power electronic circuits. Explain the different power electronic circuits with neat circuit diagram. Show the input and output waveform.	1	1	1.3.1
2	With the circuit diagram and voltage waveforms, explain the control characteristics of (i). Thyristor (ii). GTO (III). MOSFET and (iv). BJT	1	1	1.3.1
3	With the neat circuit diagram and switching waveforms, explain switching characteristics of MOSFET.	1	1	1.2.1
4	Explain the switching limits of BJT.	1	1	1.2.1
5	List the types of MOSFETs. Explain with sketch and structure of n-channel enhancement type MOSFET.	2	1	1.3.1
6	Discuss di/dt and dv/dt protection in thyristor.	2	1	1.3.1
7	Using two transistor analogy, derive an expression for anode current of thyristor.	2	2	1.3.1
8	What are the issues to be addressed for the design of a power converter?	1	3	1.2.1
9	What are the peripheral effects of power electronic equipments?	2	3	1.2.1
10	The converter in Fig.10 is connected to a 120 V, 60 Hz supply and has a purely resistive load of R = 10 Ω. If the delay angle is $\alpha = \pi/2$, determine (a) the rectification efficiency (b). the form factor (c). the ripple factor (d). the TUF and (e). the peak inverse voltage of thyristor T1.  **Fig.10**	3	4	2.4.1
11	A single phase 220 V, 1 kW heater is connected to a half- wave controlled rectifier and fed from a 220 V, 50 Hz ac supply, Determine the power absorbed by the heater when the firing angle is i) $\alpha = 30^o$ and ii) $\alpha = 90^o$.	3	4	2.4.1
12	Write the advantage of freewheeling diode in single–phase half –wave controlled rectifier	2	2	2.4.2

	with RL load.			
13	Draw the circuit diagram of three – phase, half –wave controlled rectifier with R load and explain its operating principle with voltage and current waveforms. Determine the following parameters for R load with firing angle $\alpha = 60^{o}$: i) dc output voltage ii) Average dc load current iii) rms output voltage iv) rms load current.	4	3	2.4.2
14	Explain the different control strategies in DC-DC circuits?	1	1	1.1.1
15	With the help of a neat circuit diagram and associated waveforms, discuss the operation of Buck-Boost converter.	2	2	2.2.1
16	With help of neat circuit diagram and associated waveforms discuss the operation of a Buck converter in continuous conduction mode and discontinuous conduction mode.	2	2	1.2.1
17	Discuss the Principle of operation of forward and fly back converters in CCM.	2	1	2.2.1
18	Describe working of 3-Phase AC-AC regulators with R load only and draw the relevant waveforms.	2	1	1.3.1
19	Derive the expression for rms output voltage of bidirectional 1-phase ac voltage controller with RL load. And draw the relevant waveforms.	2	3	2.3.1
20	Explain the working of a 1-phase full bridge Inverter with RL load. Draw the relevant output waveform.	1	2	2.2.2
21	A single-phase PWM inverter is fed from a 220 V dc supply and it is connected to a RL load with R=10 ohms and L=10 mH. Determine the total harmonic distortion in the load current .Assume width of each pulse is $\pi/2$ and the output frequency is 50 Hz.	3	4	2.4.1

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
Problem solving on switching characteristics of BJT, MoSFET and IGBT, Computation of Anode current of thyristor, Controlled Rectifier	1.5	02, 03	**1.1.2**	1.1	01
Problem solving on Chopper, Commutation, Inverters and AC Voltage Regulator	1.5	02, 03	1.4.1	1.4	01
Quiz	1.0	01, 02	1.1.1	1.1	01
Quiz	1.0	01, 02		1.1	01
Mini-Project on MATLAB-Modelling and SimulationsPWM Techniques of Inverter,	5.0	03, 04	5.2.1 5.2.2	5.2	05

Step-up and Step-down chopper					

BASAVESHWAR ENGINEERING COLLEGE(AUTONOMOUS), BAGALKOT

MODEL COURSEPLAN

Title of Course	**:**	**Fundamentals of Wind Energy Conversion System**	**Course Code**	**:**	**21UEE516N**
Credits	**:**	**3**	**Contact Hours/ Week**	**:**	**3**
Total Hours	**:**	**40**	**Tutorial Hours**	**:**	**40**
CIE Marks	**:**	**50**	**SEE Marks**	**:**	**100**
Semester	**:**	**V**	**Year**	**:**	**2023-24**

Prerequisites:

Course Objectives:

	The Course objectives are:
1	To identify the installed capacity and developments in wind energy conversion systems.
2	To apply and analyse concepts and theory for assessment of wind energy resources
3	To illustrate the aerodynamics and control mechanism of wind energy system
4	To describe pros and cons of vertical and horizontal axis wind energy system

Course Outcomes:

	At the end of the course the student should be able to:
1	List and define various parameters and features of wind energy conversion systems.
2	Explain various concepts and theory related to wind energy conversion systems.
3	Evaluate/calculate various parameters related to wind energy conversion systems.
4	Relate/articulate the concepts and theories related to wind energy conversion systems.

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	22UEE136B.1	3	1	1			1	1	1		1	1	1	3	1	
2	22UEE136B.2	3	1	1	1		1	1	1		1		1	2	3	
3	22UEE136B.3	3	2	3	1							1	1	1	1	
4	22UEE136B.4	3	3	3	2				1				1	1		1

Competencies Addressed in the course and Corresponding Performance Indicators

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

P0	Competency		Indicators
1	Recall key terms and concepts related to wind energy conversion systems.		• Define terms such as wind turbine, rotor, nacelle, pitch, and yaw. • Identify the components of a typical wind energy conversion system. • List the main types of wind turbines.
2	Comprehend the basic principles underlying wind energy conversion.		• Explain the relationship between wind speed and power generation. • Describe the aerodynamic principles governing the operation of wind turbines. • Interpret the impact of wind direction on turbine performance.
7	Apply engineering principles to solve problems related to wind energy conversion systems.		• Calculate the power output of a wind turbine given specific wind conditions. • Propose adjustments to optimize the efficiency of a wind energy conversion system. • Solve real-world problems related to the design and operation of wind turbines.
12	Analyze the performance and limitations of various wind energy conversion technologies.		• Evaluate the factors influencing the efficiency of horizontal and vertical axis wind turbines. • Compare and contrast the advantages and disadvantages of different wind turbine aerodynamics. • Analyze data from wind energy systems to identify trends and patterns.

	Assess the comparison of power implications of wind energy systems.		• Describe the effectiveness of implementing wind energy projects in specific locations. • Assess the environmental impact of wind energy systems compared to traditional energy sources.

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 -I1			
Students shall be able to				
1.	Explain the historical development of wind energy from ancient civilizations to the 20th century.	**1**	**1**	**1.1.1**

2.	Identify key milestones and technological advancements in early wind energy systems.	**2**	**2**	**2.1.2**
3.	Analyze the evolution of wind energy technology during the 20th century.	**2**	**2**	**1.1.1**
4.	Assess the major advancements and innovations in wind energy technology from the 1980s to the present.	**2**	**2**	**1.1.1**
5.	Analyze the geographical and environmental factors influencing wind patterns around the world.	**2**	**2**	**1.4.1**
6.	Describe the unique challenges and opportunities associated with offshore wind energy.	**2**	**2**	**1.4.1**
7.	Compare and contrast the advantages and disadvantages of wind energy with conventional power generation methods.	**4**	**4**	**2.2.4**
Unit -II				
8.	Explain the spatial variation of wind resources and its significance in wind energy assessment.	**1**	**1**	**1.1.1**
9.	Analyze the temporal variations in wind speed and direction, considering diurnal and seasonal patterns.	**2**	**2**	**1.1.1**
10.	Explain how understanding steady wind characteristics contributes to effective wind energy planning.	**1**	**1**	**1.4.1**
11.	Calculate Weibull parameters and use them in wind resource assessments	**3**	**3**	**2.4.2**
12.	Interpret vertical wind profiles for different types of terrain and their relevance to wind energy applications.	**2**	**2**	**2.2.1**
13.	Interpret wind roses to identify prevailing wind directions and their implications for wind energy projects.	**2**	**2**	**2.2.1**
14.	Evaluate the reliability and accuracy of different tools and models used in wind resource assessments.	**4**	**4**	**2.4.2**
Unit -III				
15.	Define and calculate relative wind velocity in the context of wind turbine aerodynamics.	**2**	**2**	**1.1.1**
16.	Analyze the importance of accurate wind flow modeling in predicting wind turbine performance.	**2**	**2**	**1.1.1**
17.	Apply axial momentum theory to calculate the induced velocity and thrust on a wind turbine rotor.	**2**	**2**	**2.1.2**
18.	Apply momentum theory for rotating wake to analyze the wake effect on downstream turbines in an array.	**3**	**3**	**3.1.2**
19.	Analyze the characteristics of different types of wind machines, including horizontal and vertical axis wind turbines.	**2**	**2**	**2.1.2**
Unit -IV				
20.	Classify wind turbines based on various criteria such as axis orientation, number of blades, and application.	**2**	**2**	**1.1.1**
21.	Explain the function and role of each component in the overall operation of a wind turbine.	**1**	**4**	**2.1.2**
22.	Analyze the factors influencing the efficiency of wind energy conversion and extraction.	**2**	**2**	**1.1.1**
23.	Apply Betz's Law in numerical problems to determine the maximum theoretical efficiency of wind turbines.	**2**	**2**	**2.4.1**

24.	Analyze the Wind Power Generation Curve to understand the relationship between wind speed and power output.	**3**	**3**	**4.3.4**

Course Content:

Hours Required	Topic to be covered	Mode of Delivery
01	Historical Development (BC – 20th Century)	Chalk and talk in classroom/Lecture combined with discussions/Lecture with a quiz/ Tutorial/ Assignments/ Demonstration/ Invited lectures/ Group Assignment/
01	Historical Development (20th Century – 1980s)	
01	Recent Developments (1980s – present);	
01	The Nature of the Wind	
01	Origin of wind	
01	Wind Energy Potential	
01	Offshore Wind Energy	
01	Modern Wind Turbines	
01	Wind Vs Conventional power generation	
01	**Wind Resource Assessment:** Introduction	
01	Spatial variation	
01	Time variation	
01	Characteristics of steady wind	
01	Weibull wind speed distribution function	
01	Vertical profiles of steady wind	
01	Wind rose	
01	Energy content of wind	
01	Resource assessment	
01	**Aerodynamics:** Introduction	
01	Aerofoil – Two dimensional theory	
01	Axial momentum theory	
01	Stall control	
01	Wind flow models – Wind flow pattern	
01	Momentum theory for rotating wake	
01	Savinous and Darrius types	
01	Blade element theory	
01	Strip theory; Tip losses and correction	
01	Wind Machine Characteristics	
01	**Wind Turbines:** Introduction	
01	Classification of Wind Turbines	
01	Wind Turbine Components	
01	Basic principles of wind energy extraction	
01	Extraction of wind turbine power(Numerical problems)-Weibull distribution	
01	Wind power generation curve-Betz's Law-Modes of wind power generation.	
01	Modes of wind power generation	

Review Questions:

<table>
<tr><th>Review Questions</th><th>ULO</th><th>BLL</th><th>PI addressed</th></tr>
<tr><td>Explain the principle of wind generation.</td><td>1</td><td>4</td><td>1.1.1</td></tr>
<tr><td>Write the advantages and disadvantages of wind electric power generation.</td><td>2</td><td>2</td><td>2.1.2</td></tr>
<tr><td>With neat diagram, explain power versus wind speed characteristics</td><td>3</td><td></td><td></td></tr>
<tr><td>Write a brief note on socioeconomic impact of wind electric power generation</td><td>4</td><td>2</td><td>1.1.1</td></tr>
<tr><td>Explain the historical development of wind energy conversion systems.</td><td>5</td><td>2</td><td>1.1.1</td></tr>
<tr><td>Explain how the wind speed distribution can be determined statistically.</td><td>6</td><td>3</td><td>1.1.1</td></tr>
<tr><td>Determine the distribution of the wind speeds 3, 4, 5, 6, 7 m/s for a site having shape factor of 1.8 and capacity factor of 1 and draw the graph of wind distribution curve on graph sheet with appropriate scale.
<table>
<tr><td>V</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td></tr>
<tr><td>F</td><td>5</td><td>10</td><td>15</td><td>20</td><td>20</td><td>25</td></tr>
</table></td><td>7</td><td>3</td><td>2.2.2</td></tr>
<tr><td>Write a note of wake affect.</td><td>8</td><td>1</td><td>1.1.1</td></tr>
<tr><td>With neat diagram, explain global circulation of wind</td><td>9,10</td><td>1</td><td>1.1.1</td></tr>
<tr><td>With neat diagram, explain long term variability with respect to time variation</td><td>11</td><td>1</td><td>1.1.1</td></tr>
<tr><td>Give brief Classification of wind turbines.</td><td>12, 13</td><td>1</td><td>2.1.2</td></tr>
<tr><td>Determine the distribution of the wind speeds 3, 4, 5, 6, 7 m/s for a site having shape factor of 1.8 and capacity factor of 1 and draw the graph of wind distribution curve on graph sheet with appropriate scale.</td><td>14</td><td>1</td><td>1.1.1</td></tr>
<tr><td>Write a short note on right of way for wind turbine electric power plants.</td><td>15,16</td><td>1</td><td>1.4.1</td></tr>
<tr><td>Briefly explain spatial variation of wind speed</td><td>17,18</td><td>1</td><td>1.4.1</td></tr>
<tr><td>Explain the basic principles of wind energy extraction.</td><td>19</td><td>1</td><td>1.1.1</td></tr>
<tr><td>Write the merits and limitations of wind power electric power plants.</td><td>20</td><td>2</td><td>1.1.1</td></tr>
<tr><td>Write a short note on wind rose</td><td>21</td><td>1</td><td>1.4.1</td></tr>
<tr><td>With neat diagram, explain vertical profiles of steady wind</td><td>22</td><td>4</td><td>2.1.2</td></tr>
<tr><td>Explain in detail, momentum theory for rotating wake.</td><td>22</td><td>2</td><td>1.1.1</td></tr>
<tr><td>With neat diagram, explain stall control</td><td>23</td><td>2</td><td>1.1.1</td></tr>
<tr><td>Using Betz model of a wind turbine, derive the expression for power extracted from wind.</td><td>24</td><td>4</td><td>2.4.1</td></tr>
</table>

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

BASAVESHWAR ENGINEERING COLLEGE BAGALKOTE
DEPARTMENT OF BIOTECHNOLOGY

Environmental Studies COURSE PLAN

Title of Course	**:**	**Environmental Studies**	**Course Code**	**:**	**21UBT523C/21UBT623C**
Credits	**:**	**01**	**Contact Hours/ Week**	**:**	**01**
Total Hours	**:**	**15**	**Tutorial Hours**	**:**	**00**
CIE Marks	**:**	**50**	**SEE Marks**	**:**	**50**
Semester	**:**	**V**	**Year**	**:**	**2023-24**

Course Objectives:

	The Course objectives are:
1	To make familiarize with various energy resources.
2	To understand environmental pollutions and its effects, and to implement sustainable future in the work place.
3	To gain knowledge of various current environmental issues.
4	To implement different waste management techniques .

Course Outcomes:

	At the end of the course the student should be able to:
1	Recognize energy resources and its uses.
2	Understand pollution and its effects on environment and to implement sustainable future in the work place.
3	Understand current environmental issues.
4	Apply the waste management techniques in various fields

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

No	Programme Outcomes / Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
The students will be able to:																
1	Recognize Energy resources and its uses.	**2**	-	-	-	-	**2**	**3**	-	-	-	-	**3**	1	-	-
2	Understand pollution and its effects on environment and to implement sustainable future in the work place.	**2**	-	-	-	-	**2**	**3**	-	-	-	-	**3**	1	-	-
3	Understand current environmental issues.	**1**	-	-	-	-	**2**	**3**	-	-	-	-	**3**	1	-	-
4	Apply the waste management techniques in various fields	**1**	-	-	-	-	**3**	**2**	-	-	-	-	**3**	1	-	1

Competencies Addressed in the course and Corresponding Performance Indicators

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

PO 1: Engineering knowledge: Applytheknowledgeof mathematics,science,engineeringfundamentals,and anengineering specialisation for the solution of complex engineering problems.

Competency	Indicators
1.1 Demonstrate competence in basic sciences	1.1.1 Apply fundamentals of natural science to anengineering problem
1.2 Demonstrate competence in engineering fundamentals	1.2.1 Apply fundamental engineering concepts tosolve engineering problems
1.3 Demonstrate competence in specializedengineering knowledge to the program	1.3.1 Apply Biotechnology engineering concepts tosolve engineering problems.

PO 6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

Competency	Indicators
6.1 Demonstrate an ability to describeengineering roles in a broader context, e.g. pertaining to the environment, health,safety, legal and public welfare	6.1.1 Identify and describe various engineering roles; particularly as pertains to protection of the public and public interest at the global,regional and local level

6.2 Demonstrate an understanding of professional engineering regulations, legislation and standards	6.2.1 Interpret legislation, regulations, codes, and standards relevant to your discipline and explain its contribution to the protection ofthe 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	Indicators
7.1 Demonstrate an understanding of the impact of engineering and industrial practices on social, environmental and in economic contexts	7.1.1 Identify risks/impacts in the life-cycle of an engineering product or activity 7.1.2 Understand the relationship between the technical, socio-economic and environmentaldimensions of sustainability
7.2 Demonstrate an ability to apply principles ofsustainable design and development	7.2.1 Describe management techniques forsustainable development 7.2.2 Apply principles of preventive engineering and sustainable development to an engineering activityor product relevant to the discipline

PO12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independentand life-long learning in the broadest context of technological change.

Competency	Indicators
12.1 Demonstrate an ability to identify gaps inknowledge and a strategy to close these gaps	12.1.1 Describe the rationale for the requirement forcontinuing professional development 12.1.2 Identify deficiencies or gaps in knowledge and demonstrate an ability to source information to closethis gap
12.2 Demonstrate an ability to identify changingtrends in engineering knowledge and practice	12.2.1 Identify historic points of technological advance in engineering that required practitioners toseek education in order to stay current 12.2.2 Recognize the need and be able to clearlyexplain why it is vitally important to keep current regarding new developments in your field

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):

Unit Learning Outcome (ULO)	CO	BLL	PI addressed
Recognize the importance of EIA & energy resources	**1**	**1**	**7.1.1**
Understand pollution and its effects on environment and to implement sustainable developments in future.	**2**	**1**	**7.2.2**
Understand current environmental issues.	**3**	**1**	**6.1.1, 6.2.1**
Implement the knowledge in the waste management techniques.	**4**	**1**	**6.2.1, 7.2.1, 7.2.2**

Course Content:

Units	Hours Required	Topic to be covered	Mode of Delivery
UNIT-I	**01**	Human activities and their impacts	**Chalk and talk in classroom/Lecture combined with discussions**
	01	Environmental impact assessment and the Environmental impact statements	**Chalk and talk in classroom**
	01	**Renewable Energyresources** Solar, Wind, Hydropower, Tidal, Ocean thermal, Geo thermal, Biomass-Biogas, Biodiesel, Bioethanol, Hydrogen as fuel	**Chalk and talk in classroom/Lecture combined with discussion**
	01	**Non renewable Energyresources**: Coal, Petroleum, Natural gas, Nuclearenergy	**Chalk and talk / Group Discussion**
UNIT-II	**01**	**Environmental Pollution:** Water pollution, water quality standards, water borne diseases, Fluoride problem,.	**Chalk and talk in classroom/Lecture combined with discussion**
	01	Air pollution, Noise pollution. Effect of electromagnetic waves	**Chalk and talk in classroom/Lecture combined with discussion**
	01	**Sustainable future**: Concept of sustainable development, threats to sustainability, strategies for sustainable development.	**Chalk and talk in classroom/Lecture combined with discussions**
	01	Environment economics – concept of green building, Circular economy.	**Chalk and talk in classroom**
UNIT-III	**01**	**Current Environmental Issues of concern-** Greenhouse Effect- Greenhouse gases	**Chalk and talk in classroom/Lecture combined with discussion**
	01	Global Warming, Climate change, ozone layer depletion	**Chalk and talk / Group Discussion**
	01	Acid rain, Eutrophication. Environmental policy legislation rules & regulations	**Chalk and talk in classroom/Lecture combined with discussion**

UNIT-IV	**01**	**Fundamentals of Waste management:** Solid waste management: Sources, classification, characteristics, collection	**Chalk and talk in classroom/Lecture combined with discussion**
	01	Transportation, disposal, and processing methods for waste management.	**Chalk and talk in classroom/Lecture combined with discussions**
	01	Hazardous waste management and handling. Concept of waste water treatment, Bioremediation	**Chalk and talk in classroom**
	01	Industrial waste management (Case studies:Cement, plastic, chemical, E–waste, food & construction industry waste management).	**Chalk and talk in classroom/Lecture combined with discussion**

Reference Books:

1. Benny Joseph "Environmental Studies" Tata McGraw Hill, 2005
2. Dr. D. L. Manjunath, "Environmental Studies" Pearson Education, 2006
3. Koushik and Koushik "Environmental Science & Engineering" New Age International Publishers, New Delhi, 2006
4. Meenakshi "Environmental Science & Engineering" Pranticce Hall of India, 2006

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	**50**	**50**
Total	**100**	**100**

Details of Assignment:

Assignment	Marks (10)	CO	PI	CA	PO
Assignment 1	**5 marks [Solve any two years SEE question papers]**	**1,2,3 & 4**	**6.1.1, 6.2.1. 7.1.1,7.2.1,7.2.2**	**6 and 7**	**1,6,7 & 12**
Assignment 2	**Presentation [Topics covering all the units]**	**1,2,3 & 4**	**6.1.1, 6.2.1. 7.1.1,7.2.1,7.2.2**	**6 and 7**	**1,6,7 & 12**