K.R. MANGALAM UNIVERSITY

THE COMPLETE WORLD OF EDUCATION

SCHOOL OF ENGINEERING AND TECHNOLOGY

MASTER OF TECHNOLOGY - POWER & ENERGY SYSTEMS

M.TECH (PES)

Programme Code: 51

2020-23

Approved in the 23rd Meeting of Academic Council Held on 23 June 2020

Academic Council
Member Secretary
K.R. Mangalam University

Registrar
K.R. Mangalam University
Sohna Road. Gurugram (Haryana)

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PREFACE

In consultation with Deans, Faculty Members, Industry Experts, and University Alumni, the Academic Council constituted school-wise committees to draft the model curriculum of postgraduate engineering programmes. Realizing the need for post-graduation in engineering, the curriculum committee of School of Engineering & Technology (SOET) prepared Model Curriculum for Post Graduate Degree course in Power & Energy Systems. The total number of credits in M.Tech. Power & Energy Systems (Part Time) is 83.

M.Tech. (PES) programme is spread over three years in six semesters and includes mini-project, audit courses, open electives, and dissertation. Emphasis is made to have all the significant areas that affect product lifecycle. The dissertation is for one year and distributed over two semesters. The students and faculty members can design the research project in consultation with industry experts.

The programme is designed to retain the undergraduate students going for higher studies but also to attract international students making K.R. Mangalam University a global place of higher learning and research in engineering and technology.

1. Introduction

The K.R. Mangalam Group has made a name for itself in the field of education. Over a period of time, the various educational entities of the group have converged into a fully functional corporate academy. Resources at KRM have been continuously upgraded to optimize opportunities for the students. Our students are groomed in a truly inter-disciplinary environment wherein they develop integrative skills through interaction with students from engineering, management, journalism and media study streams.

The K.R. Mangalam story goes back to the chain of schools that offered an alternative option of world-class education, pitching itself against the established elite schools, which had enjoyed a position of monopoly till then. Having blazed a new trail in school education, the focus of the group was aimed at higher education. With the mushrooming of institutions of Higher Education in the National Capital Region, the university considered it very important that students take informed decisions and pursue career objectives in an institution, where the concept of education has evolved as a natural process.

K.R. Mangalam University was founded in the year 2013 by Mangalam Edu Gate, a company incorporated under Section 25 of the Companies Act, 1956.

K. R. Mangalam University is unique because of its

i. Enduring legacy of providing education to high achievers who demonstrate leadership in diverse fields.
ii. Protective and nurturing environment for teaching, research, creativity, scholarship, social and economic justice.

Objectives

i. To impart undergraduate, post-graduate and Doctoral education in identified areas of higher education.
ii. To undertake research programmes with industrial interface.
iii. To integrate its growth with the global needs and expectations of the major stake holders through teaching, research, exchange & collaborative programmes with foreign, Indian Universities/Institutions and MNCs.
iv. To act as a nodal center for transfer of technology to the industry.
v. To provide job oriented professional education to the pecia student community with particular focus on Haryana.

2. About School

The School of Engineering and Technology offers three undergraduate Programmes: four years B. Tech, three years BCA, B. Sc. in four specialization courses (Electronics Science/Computer

Science/Data Sciences/Cyber Security) and postgraduate Programme M.Tech. in various disciplines. These Engineering programs have the distinct objective of equipping the students with knowledge, skills, and attitude in engineering and technology to make them capable of successfully meeting the present requirements and future challenges in the engineering profession. SOET brings together outstanding academics, industry professionals, experienced researchers to deliver a unique hands-on and multi-disciplinary learning experience.

The curriculum of programs has been designed to cater to the industry's ever-changing needs and demands. The syllabus and curriculum are regularly updated. The school has the best infrastructure, including domain-specific labs. SOET aims to provide exposure to the principles and practices of Design / Developments and Projects in engineering. SOET is offering Ph.D. programs also.

School Vision

Aspires to become an internationally recognized School through excellence in interdisciplinary education, research and innovation, preparing socially responsible life-long learners contributing to nation building.

School Mission

- Foster employability and entrepreneurship through interdisciplinary curriculum and progressive pedagogy with cutting-edge technology.
- Instill notion of lifelong learning through stimulating research, Outcomes-based education and innovative thinking.
- Integrate global needs and expectations through collaborative programs with premier universities, research centers, industries and professional bodies
- Enhance leadership qualities among the youth having understanding of ethical values and environmental realities
- Developing active leadership skills, ethical values, and environmental responsibility.
- Foster employability and entrepreneurship through futuristic curriculum and progressive pedagogy with cutting-edge technology.
- Instill notion of lifelong learning through stimulating research, Outcomes-based education, and innovative thinking.
- Integrate global needs and expectations through collaborative programs with premier universities, research centers, industries, and professional bodies
- Enhance leadership qualities among the youth understanding ethical values and environmental reality.

3. Programmes offered by the School

School offers undergraduate B.Tech Programme, B.Sc. (Hons) Programmes, Postgraduate M.Tech Programmes and Doctoral Programmes. All these programmes are designed to impart scientific knowledge to the students and will provide theoretical as well as practical training in their respective fields.

3.1 Electrical Engineering

SOET administers bachelors, masters and doctoral degree programs in Electrical Engineering. The department is committed to provide quality, cutting-edge educational experiences that give students a holistic view of the engineering education and prepare them to take up their career in wide range of industries or establishing startup companies. Core strength of the department lays in its experienced and extremely competent faculty, advanced laboratory facilities, good placements, ever growing alumni network, emphasis on developing students' skill set while focusing on leadership and ethics in parallel.

3.1 M.Tech. Power & Energy Systems

This programme is aimed to exhibit analytical decision making and problem-solving skills by applying research principals for handling real life problems with realistic constraints related to Electrical Machines, Power, Power Electronics, Drives and related areas.

Eligibility Criteria: - The student has passed B. Tech in Electrical Engineering from recognized central or state university with an overall minimum aggregate of 50% or more.

Course Outline:- Electrical Machines, Power, Power Electronics, Drives.

Career Options:- Opportunities are there in the field of Energy Manager, Power System Engineer, Electrical Engineer, Lead Analyst, Test Engineer, Manufacturing Engineer, PSUs, Defense & Civil Services, Research.

4. Program Duration:

The maximum completion period of the full time M.Tech. (PES) Programme offered by the University shall be two years. The maximum completion period of the part time M.Tech. (PES) Programme offered by the University shall be three years.

5. Class Timings

The classes will be held from Monday to Friday from 09:10 am to 04:00 pm.

6. Syllabi

The syllabi of M.Tech. (PES) program for all semester is given in the following pages. These are arranged as semester-wise.
For each course, the first line contains; Course Code and Credits (C) of the course.
This is followed by the course objectives, course outcome and the syllabus (Unit I to IV), Text book and reference books.

M.Tech (PES) Programme at a Glance

	Semester I	**Semester II**	**Semester III**	**Semester IV**	**Semester V**	**Semester VI**	**Total**
Course	5	4	4	4	3	1	21
Credit	14	13	13	14	13	16	83

6.1 Scheme of studies- M.Tech(PES) as per Learning Outcome Based Curriculum Framework (LOCF) and Choice Based Credit System (CBCS)

SEMESTER I

SNo	Course Code	Course Title	L	T	P	C
1	ETEE701A	POWER SYSTEM ANALYSIS	4	0	0	4
2	ETEE703A	RENEWABLE ENERGY SYSTEMS	4	0	0	4
3		ELECTIVE-I	4	0	0	4
4	ETEE751A	POWER SYSTEM ANALYSIS LAB	0	0	2	1
5	ETEE753A	RENEWABLE ENRGY LAB	0	0	2	1
TOTAL			**12**	**0**	**4**	**14**

SEMESTER II

SNo	Course Code	Course Title	L	T	P	C
1	ETEE702A	POWER SYSTEM DYNAMICS	4	0	0	4
2	ETEE704A	NON-CONVENTIONAL ENERGY SYSTEMS	4	0	0	4
3		ELECTIVE-II	4	0	0	4
4	ETEE752A	POWER SYSTEM DYNAMICS LAB	0	0	2	1
TOTAL			**12**	**0**	**2**	**13**

SEMESTER III

SNo	Course Code	Course Title	L	T	P	C
1	ETEE711A	DIGITAL PROTECTION	4	0	0	4
2	ETEE713A	POWER SYSTEM TRANSIENTS	4	0	0	4
3		ELECTIVE-III	4	0	0	4
4	ETEE755A	POWER SYSTEM PROTECTION LAB	0	0	2	1
TOTAL			**12**	**0**	**2**	**13**

SEMESTER IV

SNo	Course Code	Course Title	L	T	P	C
1	ETEE712A	SOLAR AND WIND SYSTEMS	4	0	0	4
2	ETEE714A	RESEARCH METHODOLOGY & IPR	4	0	0	4
3		ELECTIVE-IV	4	0	0	4
4	ETEE754A	MINI PROJECT WITH SEMINAR	0	0	4	2
TOTAL			**12**	**0**	**4**	**14**

SEMESTER V

SNo	Course Code	Course Title	L	T	P	C
1	ETEE721A	SMART GRID	4	0	0	4
2		OPEN ELECTIVE	3	0	0	3
3	ETEE757A	DISSERTAION PHASE -I	0	0	12	6
TOTAL			**7**	**0**	**12**	**13**

SEMESTER VI

SNo	Course Code	Course Title	L	T	P	C
1	ETEE759A	DISSERTATION PHASE -II	0	0	32	16
TOTAL			**0**	**0**	**32**	**16**
Total Hours: Lect [L]+Prac [P]+Tut [T]			**111**			
Total Credits [C]			**83**			

ELECTIVE COURSES

ELECTIVES FOR SPECIALIZATION IN POWER SYSTEMS			L	T	P	C
1	ETEE731A	HIGH POWER CONVERTERS	4	0	0	4
2	ETEE732A	ELECTRICAL POWER DISTRIBUTION SYSTEM	4	0	0	4
3	ETEE733A	MATHEMATICAL METHODS FOR POWER ENGINEERINGS	4	0	0	4
4	ETEE734A	PULSE WIDTH MODULATION FOR PE CONVERTERS	4	0	0	4
5	ETEE735A	ELECTRIC AND HYBRID VEHICLES	4	0	0	4
6	ETEE736A	RECONSTRUCTED POWER SYSTEMS	4	0	0	4
7	ETEE737A	DYNAMICS OF ELECTRICAL MACHINES	4	0	0	4
8	ETEE738A	POWER APPARATUS DESIGN	4	0	0	4
9	ETEE739A	ADVANCED MICRO-CONTROLLER BASED SYSTEMS	4	0	0	4

10	ETEE740A	SCADA SYSTEMS AND APPLICATIONS	4	0	0	4
11	ETEE741A	POWER QUALITY	4	0	0	4
12	ETEE742A	AI TECHNIQUES	4	0	0	4
13	ETEE743A	FACTS AND CUSTOM POWER DEVICES	4	0	0	4
14	ETEE744A	INDUSTRIAL LOAD MODELLING AND CONTROL	4	0	0	4
15	ETEE745A	DYNAMICS OF LINEAR SYSTEMS	4	0	0	4

ELECTIVES FOR SPECIALIZATION IN POWER & ENERGY SYSTEMS			**L**	**T**	**P**	**C**
1	ETEE746A	ENGINEERING OPTIMIZATION	4	0	0	4
2	ETEE747A	HIGH VOLTAGE ENGINEERING	4	0	0	4
3	ETEE748A	SWITCHED MODE POWER CONTROL	4	0	0	4
4	ETEE749A	OPTIMAL AND ADAPTIVE CONTROL	4	0	0	4
5	ETEE750A	ENERGY CONVERSION PROCESSES	4	0	0	4
6	ETEE734A	PULSE WIDTH MODULATION FOR PE CONVERTERS	4	0	0	4
7	ETEE735A	ELECTRIC AND HYBRID VEHICLES	4	0	0	4
8	ETEE741A	POWER QUALITY	4	0	0	4
9	ETEE742A	AI TECHNIQUES	4	0	0	4
10	ETEE743A	FACTS AND CUSTOM POWER DEVICES	4	0	0	4
11	ETEE744A	INDUSTRIAL LOAD MODELLING AND CONTROL	4	0	0	4

OPEN ELECTIVE COURSES

OPEN ELECTIVES			L	T	P	C
1	ETMC901A	BUSINESS ANALYTICS	3	0	0	3
2	ETME901A	INDUSTRIAL SAFETY	3	0	0	3
3	ETMA901A	OPERATIONS RESEARCH	3	0	0	3
4	ETCE901A	COST AND MANAGEMENT OF ENGINEERING PROJECTS	3	0	0	3
5	ETCE902A	COMPOSITE MATERIALS	3	0	0	3
6	ETME902A	WASTE TO ENERGY	3	0	0	3

I Semester

ETEE701A	**POWER SYSTEM ANALYSIS**	L	T	P	C
Version 1.0		4	0	0	4
Pre-requisites/Exposure	**Analysis of power system**				
Co-requisites	--				

Course Objectives

1. Develop mathematical model of a given power system.
2. Perform power flow analysis using numerical techniques.
3. Analyse the behaviour of the power system under faulted condition
4. Study the stability status of power system under transient condition

Course Outcomes

- CO1: To understand basics of power system analysis
- CO2: To identify mathematical solution of system extension and planning
- CO3: Capable of understanding roles of power system buses and indication
- CO4: To capture overview of power system workflows

COURSE CONTENT

UNIT-I		**HRS: 10**
Introduction: Objective, scope and outcome of the course. Load flow: Overview of Newton-Raphson, Gauss-Siedel, Fast decoupled methods, convergence properties, sparsity techniques, handling Qmax and Q min violations in constant matrix, inclusion in frequency effects AVR in load flow, handling of discrete variable in load flow.		
UNIT-II		**HRS: 10**
Introduction: Objective, scope and outcome of the course. Load flow: Overview of Newton-Raphson, Gauss-Siedel, Fast decoupled methods, convergence properties, sparsity techniques, handling Qmax and Qmin violations in constant matrix, inclusion in frequency effects AVR in load flow, handling of discrete variable in load flow.		
UNIT-III		**HRS: 10**
Fault Analysis: Simultaneous faults, open conductors faults, generalized method of fault analysis. 04 4. Security Analysis: Different operating state with state classification Security state diagram, contingency		

analysis, generator shift distribution factors, line outage distribution factor, single line outages, contingency analysis overload index ranking		
UNIT-IV		**HRS: 10**
Power System Equivalents : WARD equivalents, Dynamic WARD equivalent , Static Ward-Injection Equivalent, REI equivalents 08 6. State Estimation : Power system state estimation, various methods, formation of Hx, Virtual and Pseudo Measurement, Observability. Voltage Stability : Voltage Stability, Reactive power flow and Voltage collapse, Mathematical formulation of voltage stability problem and analysis, Prevention of voltage collapse, future trends and challenges		
Text Books		
1. J.J. Grainger &W.D.Stevenson, "Power system analysis ", McGraw Hill ,2003 2. A. R. Bergen & Vijay Vittal , "Power System Analysis" ,Pearson , 2000 3. L.P. Singh , "Advanced Power System Analysis and Dynamics", New Age International, 2006 4. G.L. Kusic, "Computer aided power system analysis" ,Prentice Hall India, 1986		
Reference Books/Materials		
5. A.J. Wood, " Power generation, operation and control" , John Wiley, 1994 6. P.M. Anderson, "Faulted power system analysis" , IEEE Press , 1995 7. D.P Kothari," Modern power system analysis", Tata McGraw hill, New Delhi		

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination

Examination Scheme:

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs	
Course Outcomes (COs)	**Mapped Program Outcomes**

CO1: To understand basics of power system analysis	PO1
CO2: To identify mathematical solution of system extension and planning	PO8
CO3: Capable of understanding roles of power system buses and indication	PO2
CO4: To capture overview of power system workflows	PO4

		Engineering Knowledge	Problem analysis	Design/development of solutions	Conduct investigations of complex problems	Modern tool usage	The engineer and society	Environment and sustainability	Ethics	Individual or team work	Communication	Project management and finance	Life-long Learning	Application of Concepts	Innovation and Industry Friendly	Ethics and Communication Skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
ETEE701A	Power System Analysis	3	3	3	3				1					3		

1=weakly mapped
2= moderately mapped
3=strongly mapped

ETEE703A	**RENEWABLE ENERGY SYSTEMS**	L	T	P	C
Version 1.0		4	0	0	4
Pre-requisites/Exposure	**Basics of renewable energy system**				
Co-requisites	--				

Course Objectives

1. To explain concept of various forms of Non-renewable and renewable energy.
2. To outline division aspects and utilization of renewable energy sources for both domestics and industrial applications.
3. To analysis the environmental and cost economics of using renewable energy sources compared to fossil fuels.
4. At the end of the course, the students are expected to identify the new methodologies / technologies for effective utilization of renewable energy

Course Outcome:

CO1: Understanding of commercial energy and renewable energy sources

CO2: Knowledge in working principle of various energy systems

CO3: Capability to do basic design of renewable energy systems

CO4: Capable to identify the new methodologies.

CO5: Technologies for effective utilization of renewable energy sources.

COURSE CONTENTS

UNIT-I		**HRS: 10**
Introduction: Solar Radiation: Principles of Solar Radiation: Role and potential of new and renewable source, the solar energy option. Environmental impact of solar power – Physics of the sun, the solar constant, extra-terrestrial and terrestrial solar radiation, Solar radiation on titled surface, Instruments for measuring solar radiation and sun shine, solar radiation data.		
UNIT-II		**HRS: 10**
Solar Energy Collection: Flat plate and concentrating collectors, classification of concentrating collectors, orientation and thermal analysis, advanced collectors. Solar Energy Storage and Applications: Different methods, sensible, latent heat and stratified storage, solar ponds. Solar applications – solar heating? cooling techniques, solar distillation and drying, Photovoltaic energy conversion.		
UNIT-III		**HRS: 10**

UNIT – III Wind Energy: Sources and potentials, horizontal and vertical axis windmills, performance characteristics. Bio-Mass: Principles of Bio-Conversion, Anaerobic /aerobic digestion, types of Bio-gas digesters, gas yield, combustion characteristics of bio-gas, utilization for cooking, l.C. Engine operation, and economic aspects.		
UNIT-IV		**HRS: 10**
Geothermal Energy: Resources, types of wells, methods of harnessing the energy, potential in India. OTEC: Principles, utilization, setting of OTEC plants, thermodynamic cycles. Tidal and Wave Energy: Potential and conversion techniques, mini-hydel power plants, their economics.		
Text Books		
Renewable Energy Sources I Twidell & Weir / Taylor and Francis / 2nd Special Indian Edition. Non- conventional Energy Sources / G.D. Rai / Dhanpat Ral and Sons.		
Reference Books/Materials		
Energy Resources Utilization and Technologies /Anjaneyulu & Francis/ BS Publications/2012. Principles of Solar Energy / Frank Krieth & John F Kreider / Hemisphere Publications. Non-Conventional Energy / Ashok V Desai I Wiley Eastern. Non-Conventional Energy Systems / K Mittal / Wheeler. Renewable Energy Technologies I Ramesh & Kumar / Narosa.		

.**Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination**

Examination Scheme:

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs	
Course Outcomes (COs)	**Mapped Program Outcomes**
CO1: Understanding of commercial energy and renewable energy sources	**PO1**
CO2: Knowledge in working principle of various energy systems	**PO8**

CO3: Capability to do basic design of renewable energy systems	**PO2**
CO4: Capable to identify the new methodologies.	**PO4**
CO5: Technologies for effective utilization of renewable energy sources.	**PO3**

		Engineering Knowledge	Problem analysis	Design/development of solutions	Conduct investigations of complex problems	Modern tool usage	The engineer and society	Environment and sustainability	Ethics	Individual or team work	Communication	Project management and finance	Life-long Learning	Application of Concepts	Innovation and Industry Friendly	Ethics and Communication Skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
ETEE703A	Renewable Energy Systems	3	3	3	3				1					3		

1=weakly mapped
2= moderately mapped
3=strongly mapped

ETEE751A	**POWER SYSTEM ANALYSIS LAB**	L	T	P	C
Version 1.0		0	0	2	1
Pre-requisites/Exposure					
Co-requisites	--				

Course Objectives

1. Develop mathematical model of a given power system.
2. Perform power flow analysis using numerical techniques.
3. Analyse the behaviour of the power system under faulted condition
4. Study the stability status of power system under transient condition

Course Outcomes

CO1: To understand basics of power system analysis
CO2: To identify mathematical solution of system extension and planning
CO3: Capable of understanding roles of power system buses and indication
CO4: To capture overview of power system workflows

Course Description

The Power System Analysis Lab is designed to complement theoretical knowledge with practical skills in power system analysis. The course will cover a range of topics including power flow analysis, fault analysis, transient stability analysis, and economic dispatch. Students will be introduced to software tools such as MATLAB, Simulink, and PowerWorld Simulator, among others, to perform simulations and analyze power system behavior. Laboratory sessions will involve hands-on exercises where students will work individually and in groups to solve real-world power system problems. Emphasis will be placed on understanding the underlying principles behind various analysis techniques and interpreting simulation results accurately. Throughout the course, students will also explore contemporary issues in power system analysis and their implications for the design and operation of modern power grids. By the end of the course, students will have developed practical skills in power system analysis and simulation, preparing them for careers in power system engineering and related fields.

Course Content

LIST OF EXPERIMENTS

1) Generating station design: Design considerations, basic schemes and single line diagram of hydro, thermal, nuclear and gas power plants. Electrical equipment for power stations.
2) Distribution system Design: Design of feeders & distributors. Calculation of voltage drops in distributors. Calculation of conductor size using Kelvin's law.
3) Study of short term, medium term and long term load forecasting.
4) Sending end and receiving end power circle diagrams.
5) Substations: Types of substations, various bus–bar arrangements. Electrical equipment for substations.
6) Study high voltage testing of electrical equipment: line insulator, cable, bushing, power capacitor, and power transformer.
7) Design an EHV transmission line
8) Study filtration and Treatment of transformer oil.
9) Determine dielectric strength of transformer oil.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs	
Course Outcomes (COs)	**Mapped Program Outcomes**
CO1: To understand basics of power system analysis	PO1
CO2: To identify mathematical solution of system extension and planning	PO8
CO3: Capable of understanding roles of power system buses and indication	PO2
CO4: To capture overview of power system workflows	PO4

		Engineering Knowledge	Problem analysis	Design/development of solutions	Conduct investigations of complex problems	Modern tool usage	The engineer and society	Environment and sustainability	Ethics	Individual or team work	Communication	Project management and finance	Life-long Learning	Application of Concepts	Innovation and Industry Friendly	Ethics and Communication Skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
ETEE751A	Power System Analysis lab	3	3	3	3				1					3		

1=weakly mapped
2= moderately mapped
3=strongly mapped

ETEE753A	**RENEWABLE ENERGY LAB**	L	T	P	C

Version 1.0		0	0	2	1
Pre-requisites/Exposure					
Co-requisites	--				

Course Objectives

1. To train the students in Renewable Energy Sources and technologies.
2. To provide adequate inputs on a variety of issues in harnessing Renewable Energy.
3. To recognize current and possible future role of Renewable energy sources.

Course Outcome

CO1: Understanding of commercial energy and renewable energy sources

CO2: Knowledge in working principle of various energy systems

CO3: Capability to do basic design of renewable energy systems

CO4: Capable to identify the new methodologies.

CO5: Technologies for effective utilization of renewable energy sources.

Course Description

The Renewable Energy Lab course offers students an opportunity to delve into the practical aspects of renewable energy technologies. Through a series of laboratory sessions, students will engage in experiments covering different aspects of solar photovoltaic, wind, hydroelectric, and biomass energy systems. The course begins with an introduction to the fundamental principles of renewable energy, emphasizing concepts such as energy conversion, resource assessment, and system design. Subsequent sessions will focus on specific renewable energy technologies, including hands-on activities such as solar panel characterization, wind turbine performance testing, hydroelectric power generation, and biomass energy production. Students will learn how to use specialized equipment and software tools for data acquisition, analysis, and simulation. Additionally, they will explore topics related to system integration, grid interconnection, and energy storage technologies. Throughout the course, emphasis will be placed on safety protocols, environmental considerations, and the economic viability of renewable energy systems. By actively participating in laboratory experiments and projects, students will develop critical thinking skills, problem-solving abilities, and practical knowledge applicable to the field of renewable energy engineering.

Course Content

LIST OF EXPERIMENTS

1 Simulation study on Solar PV Energy System.
2 Experiment on “VI-Characteristics and Efficiency of 1kWp Solar PV System”.
3 Experiment on “Shadowing effect & diode-based solution in 1kWp Solar PV System”.
4 Experiment on Performance assessment of Grid connected and Standalone 1kWp Solar Power System. 5 Simulation study on Wind Energy Generator.
6 Experiment on Performance assessment of micro Wind Energy Generator.
7 Simulation study on Hybrid (Solar-Wind) Power System.
8 Experiment on Performance Assessment of Hybrid (Solar-Wind) Power System.
9 Simulation study on Hydel Power.

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs	
Course Outcomes (COs)	**Mapped Program Outcomes**
CO1: Understanding of commercial energy and renewable energy sources	**PO1**
CO2: Knowledge in working principle of various energy systems	**PO8**
CO3: Capability to do basic design of renewable energy systems	**PO2**
CO4: Capable to identify the new methodologies.	**PO4**
CO5: Technologies for effective utilization of renewable energy sources.	**PO3**

		Engineering Knowledge	Problem analysis	Design/development of solutions	Conduct investigations of complex problems	Modern tool usage	The engineer and society	Environment and sustainability	Ethics	Individual or team work	Communication	Project management and finance	Life-long Learning	Application of Concepts	Innovation and Industry Friendly	Ethics and Communication Skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
ETEE753A	Renewable Energy Lab	3	3	3	3				1					3		

1=weakly mapped
2= moderately mapped
3=strongly mapped

2ND SEM

ETEE702A	POWER SYSTEM DYNAMICS	L	T	P	C
Version 1.0		4	0	0	4
Pre-requisites/Exposure	POWER SYSTEM				
Co-requisites	--				

Course Objectives

1. **Knowledge Acquisition**: Upon completion of the program, students will demonstrate a deep understanding of the fundamental principles and concepts of power system dynamics, including stability, transient response, and frequency control mechanisms.
2. **Analytical Skills Development**: Graduates will possess advanced analytical skills in modeling and analyzing power system components such as generators, loads, and transmission lines, enabling them to predict and assess dynamic behaviors under various operating conditions.
3. **Stability Analysis Proficiency**: Students will develop proficiency in conducting stability analysis, including transient stability analysis, voltage stability analysis, and frequency stability analysis, allowing them to evaluate and enhance the stability of power systems effectively.
4. **Control Strategy Application**: Graduates will be capable of applying a variety of control strategies to enhance power system stability, including generator controls, FACTS devices, voltage regulation, and load frequency control techniques, to mitigate stability issues and improve system performance.

Course Outcomes

On completion of this course, the students will be able to

CO 1: Understanding of Power System Dynamics: Students will demonstrate a comprehensive understanding of the dynamic behavior of power systems, including stability, transient response, and frequency control mechanisms.

CO 2: Ability to Analyze and Model Power System Components: Students will be able to analyze and model various power system components such as generators, loads, and

transmission lines, and apply mathematical techniques to predict their dynamic behavior under different operating conditions.

CO3: Proficiency in Stability Analysis Techniques: Students will develop proficiency in stability analysis techniques, including transient stability analysis, voltage stability analysis, and frequency stability analysis, and apply these techniques to assess and improve the stability of power systems.

CO4: Competence in Control Strategies for Power System Stability: Students will gain competence in a range of control strategies for enhancing power system stability, including generator controls; FACTS devices, voltage regulation, and load frequency control techniques, and apply these strategies to mitigate stability issues.

CO5: Application of Knowledge to Real-World Problems: Students will be able to apply their knowledge of power system dynamics and stability analysis to real-world problems, including identifying and resolving stability issues in existing power systems, designing stability enhancement measures for future power systems, and analyzing the impact of renewable energy integration on system stability.

Catalog Description

This program provides advanced study in the dynamic behavior of power systems, covering stability analysis, transient response, and frequency control mechanisms. Students will develop analytical skills, control strategies, and problem-solving abilities essential for addressing real-world challenges in power system stability and operation.

Course Content

Unit I: Introduction to Power System Dynamics **14 lecture hours**

Introduction to the dynamic behavior of power systems, including the factors influencing stability and control, Understanding fundamental terms and concepts in power system dynamics such as stability, transient response, and frequency control, mathematical modeling of generators, loads, and transmission lines to analyze their dynamic behavior. Single-Machine Infinite Bus (SMIB) System Dynamics, Discussion on various types of stability including transient stability, steady-state stability, and dynamic stability, along with stability assessment methods.

Unit 2: Transient Stability Analysis **8 lecture hours**

Transient Stability Phenomena, equal Area Criterion, assessing transient stability and predicting critical fault clearing time, Swing Equation and its Solutions: Derivation and solution techniques

for the swing equation governing the rotor angle dynamics of synchronous generators, Numerical Integration Techniques for solving differential equations in transient stability analysis. Transient Stability Enhancement Techniques

Unit 3: Voltage Stability Analysis **10 lecture hours**

Voltage Stability Phenomena: Understanding voltage instability events such as voltage collapse and voltage instability margins, Load Flow Analysis for Voltage Stability: Techniques for conducting load flow studies to assess voltage stability conditions in power systems, Voltage Collapse Prediction Methods: Introduction to methods for predicting voltage collapse based on load characteristics, system topology, and reactive power limits, control Strategies for Voltage Stability Enhancement reactive power compensation, voltage regulation, and voltage stability controls.

Unit 4: Frequency Stability and Control **10 lecture hours**

Frequency Stability Analysis, Examination of frequency stability phenomena such as frequency deviations, frequency response characteristics, and stability limits. Primary and Secondary Frequency Control, Load Frequency Control (LFC) Techniques: Study of load frequency control strategies including conventional control, automatic generation control (AGC), and advanced LFC methods, Impact of Renewable Energy Integration, Evaluation of frequency control strategies through case studies involving interconnected power systems and renewable energy integration.

Textbook:

1. "Power System Dynamics: Stability and Control" by K. R. Padiyar
2. "Power System Stability and Control" by Prabha Kundur

Reference Books:

1. "Electric Energy Systems: Analysis and Operation" by Antonio Gomez-Exposito, Antonio J. Conejo, and Claudio Canizares
2. "Power System Dynamics and Stability" by Peter W. Sauer and M. A.
3. "Voltage Stability of Electric Power Systems" by Thierry Van Cutsem and Costas Vournas

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs		
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO1	Understanding of Power System Dynamics: Students will demonstrate a comprehensive understanding of the dynamic behavior of power systems, including stability, transient response, and frequency control mechanisms.	**PO1**
CO2	Ability to Analyze and Model Power System Components: Students will be able to analyze and model various power system components such as generators, loads, and transmission lines, and apply mathematical techniques to predict their dynamic behavior under different operating conditions.	**PO2**
CO3	Proficiency in Stability Analysis Techniques: Students will develop proficiency in stability analysis techniques, including transient stability analysis, voltage stability analysis, and frequency stability analysis, and apply these techniques to assess and improve the stability of power systems.	**PO4**
CO4	Competence in Control Strategies for Power System Stability: Students will gain competence in a range of control strategies for enhancing power system stability, including generator controls; FACTS devices, voltage regulation, and load frequency control techniques, and apply these strategies to mitigate stability issues.	**PO3**
CO5	Application of Knowledge to Real-World Problems: Students will be able to apply their knowledge of power system dynamics and stability analysis to real-world problems, including identifying and resolving stability issues in existing power systems, designing stability enhancement measures for future power systems, and analyzing the impact of renewable energy integration on system stability.	**PO6**

		Engineering Knowledge	Problem analysis	Design/development of solutions	Conduct investigations of complex problems	Modern tool usage	The engineer and society	Environment and sustainability	Ethics	Individual or team work	Communication	Project management and finance
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
ETEE702A	POWER SYSTEM DYNAMICS	3	2	3	3							

1=weakly mapped
2= moderately mapped
3=strongly mapped

ETEE704A	NON-CONVENTIONAL ENERGY SYSTEMS	L	T	P	C
Version 1.0		4	0	0	4
Pre-requisites/Exposure					
Co-requisites	--				

Course Objectives

At the end of this unit, the student will be able to

1. Describe various sources of renewable energy
2. Discuss different wind energy conversion technologies
3. Explain the working of different geothermal energy resources
4. Discuss various factors affecting the selection of biogas plants
5. Describe the working principle of different fuel cells

Course Outcomes

On completion of this course, the students will be able to

CO1: Discuss non-conventional sources of energy and explain the working of different solar energy applications

CO2: Discuss wind energy conversion systems and explain sources of geothermal energy

CO3: Describe different biogas plants and working of different gasifiers

CO4: Explain the working principle of different fuel cells and ocean thermal energy conversion systems

CO5: Describe the working of magneto hydro dynamic power systems and principles of energy conservation

Catalog Description

This course the provides the offers an in-depth analysis of each non-conventional energy system. It provides a detailed examination of their principles of operation, technological advancements, environmental impact, and potential

Course Content

Unit I: **14 lecture hours**

Introduction to Energy Sources: Energy sources and their availability, non-conventional sources, advantages of renewable energy sources, prospects of renewable energy sources. Solar Energy: Solar energy collectors – flat plate collectors and concentrating collectors, solar energy storage systems – mechanical, electrical, chemical and electro-magnetic, solar pond, applications of solar energy – solar water heating, solar distillation, solar cooking.

Unit II: **8 lecture hours**

Wind Energy: Basic principles of wind energy conversion, site selection considerations, basic components of Wind Energy Conversion System (WECS), classification of WEC systems, wind energy collectors – horizontal axis machines and vertical axis machines, generating systems, applications of wind energy. Geothermal Energy: Geothermal sources, hydrothermal resources – vapor dominated and liquid dominated systems, hybrid plants – geothermal preheat and fossil superheat; applications of geothermal energy, advantages and disadvantages of geothermal energy.

Unit III: **8 lecture hours**

III Energy from Biomass: Biomass conversion technologies, photosynthesis, biogas generation, factors affecting biogas generation, classification of biogas plants – floating drum plants and fixed dome plants, selection of site for biogas plant, utilization of biogas; Methods for obtaining energy from biomass, biomass gasification, classification of biomass gasifiers, fixed bed gasifiers and fluidized bed gasifiers, applications of gasifiers, advantages and limitations of gasifiers.

Unit IV: **10 lecture hours**

IV Chemical Energy sources: Fuel cells -principle of operation of fuel cell, types of fuel cells – hydrogen oxygen, solid-oxide, alkaline, polymer electrolyte membrane fuel cells, advantages, disadvantages and conversion efficiency of fuel cells, applications of fuel cells. Energy from the oceans: Ocean thermal energy conversion-open cycle and closed cycle systems, energy from tides – basic principle of tidal power, components of tidal power plants, single basin and double basin systems, ocean waves – wave energy conversion systems.

Magneto Hydro Dynamic (MHD), Thermo-electric and Thermo-ionic Power Generations: Principles of MHD power generation – open cycle and closed cycle – advantages and limitations.

Basic principles of thermo-electric and thermo-ionic power generation – advantages and limitations. Energy Conservation: Economic concept of energy, principles of energy conservation and energy audit, energy conservation technologies, co-generation, waste heat utilization, combined cycle power generation.

Text Books

Reference Books/Materials

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination

Examination Scheme:

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs		
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO1	Discuss non-conventional sources of energy and explain the working of different solar energy applications	**PO1**
CO2	Discuss wind energy conversion systems and explain sources of geothermal energy	**PO2**
CO3	Describe different biogas plants and working of different gasifiers	**PO4**
CO4	Explain the working principle of different fuel cells and ocean thermal energy conversion systems	**PO3**
CO5	Describe the working of magneto hydro dynamic power systems and principles of energy conservation	**PO6**

		Engineering Knowledge	Problem analysis	Design/development of solutions	Conduct investigations of complex problems	Modern tool usage	The engineer and society	Environment and sustainability	Ethics	Individual or team work	Communication	Project management and finance
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
ETEE 704A	NON-CONVENTIONAL ENERGY SYSTEMS	3	2	3	3							

1=weakly mapped
2= moderately mapped
3=strongly mapped

ETEE752A	POWER SYSTEM DYNAMICS LAB	L	T	P	C
Version 1.0		0	0	0	2
Pre-requisites/Exposure	POWER SYSTEM				
Co-requisites	--				

Course Objectives

1. **Understanding Power System Dynamics**: To familiarize students with the dynamic behavior of power systems, including the response to disturbances, stability, and control mechanisms.
2. **Simulation and Analysis Skills**: To develop students' skills in simulating power system dynamics using software tools like MATLAB/Simulink, PSS/E, or other specialized power system simulation software.
3. **Experimental Setup Familiarization**: Introducing students to experimental setups such as power system simulators, hardware-in-the-loop systems, or physical power system models to observe and analyze dynamic phenomena.

Course Outcomes

On completion of this course, the students will be able to

CO1: Analyze and Perform stability analysis and understand the difference between steady state analysis and transient stability analysis. Perform the analysis of voltage, rotor angle stability and on multi-machine and single machine systems in the presence of FACTS devices. Load frequency control of single and multi-area power system.

CO2: Understand the operation of PV solar panel and characteristics of solar array and simulate the load, shading effect and temperature effect on outputs.

CO3: Understand the operation of Fuel cell when connected with DC grid. Also understand various new technologies coming under the umbrella of fuel and hydrogen cells.

CO4: Design micro grid operation with the integration of the common grid in presence of wind and solar power plant.

CO5: Design a mini project on having 2-3 generation sources having 3 generation sources and perform the process of power transfer from source to load with the help of transformers and at least three loads.

Catalog Description

This course imparts the basic concepts of probability theory and statistics to gain insight into real, everyday statistical problems and solutions. The main objective is to develop an intuitive understanding of statistical procedures and strategies most often used by practicing engineers and scientist.

Course Content

List of Experiments

1. To Study and Write the Program to obtain P-V Curves at different Power factors.

2. Write the Program for Transient and Small Signal Stability Analysis: Single& Multi –Machine Infinite Bus System

3. Write the Program for Transient analysis of single machine infinite bus system with STATCOM

4. To study the PV MPPT testing and see effect of Shading.

5. To study the Current Sharing in DC microgrid and Communication enabled DC micro-grid.

6. Design & simulate a model for Load – Frequency Dynamics of Single- Area and Two-Area Power Systems.

7. Design & simulate a model to test the Capabilities of the Hydrogen Fuel Cells and Capacitors when connected to grid

8. To Study and Design & simulate a model of solar panel observe the effect of Temperature and other different variable on Solar Panel Outputs.

9. To Study and Design & simulate a model of solar panel and observe an Load Effect on Solar Panel Output

10. Design & simulate a model to test the Capabilities of Solar Panels and Wind Turbines, when integrated with common grid.

11. Mini Project “Design & simulate a model of Power Generation System”

A) Have minimum 3 different Power generating source.

B) 2 transformer

C) Minimum 3 Load.

Text Books

1. P. M. Anderson & A. A. Fouad “Power System Control and Stability”, Galgotia , New Delhi, 1981

2. J Machowski, J Bialek& J. R W. Bumby, “Power System Dynamics and Stability”, John Wiley &

Sons, 1997

Reference Books

1. P.Kundur, “Power System Stability and Control”, McGraw Hill Inc., 1994.
2. E.W. Kimbark, “Power system stability”, Vol. I & III, John Wiley & Sons, New York 2002

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs		
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO1	Analyze and Perform stability analysis and understand the difference between steady state analysis and transient stability analysis. Perform the analysis of voltage, rotor angle stability and on multi-machine and single machine systems in the presence of FACTS devices. Load frequency control of single and multi-area power system.	**PO1**
CO2	Understand the operation of PV solar panel and characteristics of solar array and simulate the load, shading effect and temperature effect on outputs.	**PO2**
CO3	Understand the operation of Fuel cell when connected with DC grid. Also understand various new technologies coming under the umbrella of fuel and hydrogen cells.	**PO4**
CO4	Design micro grid operation with the integration of the common grid in presence of wind and solar power plant.	**PO3**
CO5	Design a mini project on having 2-3 generation sources having 3 generation sources and perform the process of power transfer from source to load with the help of transformers and at least three loads.	**PO6**

		Engineering Knowledge	Problem analysis	Design/development of solutions	Conduct investigations of complex problems	Modern tool usage	The engineer and society	Environment and sustainability	Ethics	Individual or team work	Communication	Project management and finance
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
ETEE 752A	POWER SYSTEM DYNAMICS LAB	3	3	3	3							

1=weakly mapped
2= moderately mapped
3=strongly mapped

3rd sem

ETEE711A	**Digital Protection**	L	T	P	C
Version 1.0		4	0	0	4
Pre-requisites/Exposure	About digital protection				
Co-requisites	--				

Course Objectives:

Students will be able to:

1. Study of numerical relays

2. Developing mathematical approach towards protection

3. Study of algorithms for numerical protection

Course Outcomes: -

Students will be able to:

1. Understand the fundamental concepts of digital protection.
2. Identify common digital threats and vulnerabilities.
3. Implement encryption techniques to secure digital data.
4. Analyze and evaluate digital protection strategies.
5. Develop and implement security protocols for various digital environments.
6. Demonstrate proficiency in using digital protection tools and technologies.

Course Description:

This course provides an in-depth exploration of digital protection principles, strategies, and technologies. Topics covered include threat assessment, encryption techniques, access control mechanisms, security policies, incident response, and emerging trends in digital protection. Through lectures, discussions, case studies, and hands-on exercises, students will gain practical skills and knowledge essential for securing digital assets and privacy in today's interconnected digital world.

Course Content

UNIT-I		**HRS: 10**
Evolution of digital relays from electromechanical relays, Performance and operational characteristics of digital protection Mathematical background to protection algorithms Finite difference techniques		
UNIT-II		**HRS: 10**

Interpolation formulae, Forward, backward and central difference interpolation, Numerical differentiation, Curve fitting and smoothing , Least squares method, Fourier analysis Fourier series and Fourier transform, Walsh function analysis		
UNIT-III		**HRS: 10**
Basic elements of digital protection, Signal conditioning: transducers, surge protection, analog filtering, analog multiplexers, Conversion subsystem: the sampling theorem, signal aliasing, Error, sample and hold circuits, multiplexers, analog to digital conversion, Digital filtering concepts, The digital relay as a unit consisting of hardware and software		
UNIT-IV		**HRS: 10**
Sinusoidal wave-based algorithms, Sample and first derivative (Mann and Morrison) algorithm. • Fourier and Walsh based algorithms, Fourier Algorithm: Full cycle window algorithm, fractional cycle window algorithm., Digital Differential Protection of Transformers. Digital Line Differential Protection. • Recent Advances in Digital Protection of Power Systems.		
Reference Books/Materials		
1. A.G. Phadke and J. S. Thorp, "Computer Relaying for Power Systems", Wiley/Research studies Press, 2009 2. A.T. Johns and S. K. Salman, "Digital Protection of Power Systems", IEEE Press,1999 3. Gerhard Zeigler, "Numerical Distance Protection", Siemens Publicis Corporate Publishing, 2006 4.S.R.Bhide "Digital Power System Protection" PHI Learning Pvt.Ltd.2014		

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs	
Course Outcomes (COs)	**Mapped Program Outcomes**
CO1: Understand the fundamental concepts of digital protection.	**PO1**
CO2: Identify common digital threats and vulnerabilities.	**PO8**
CO3: Implement encryption techniques to secure digital data.	**PO2**
CO4: Analyze and evaluate digital protection strategies.	**PO4**
CO5: Develop and implement security protocols for various digital environments.	**PO3**
CO6: Demonstrate proficiency in using digital protection tools and technologies.	**PO8**

		Engineering Knowledge	Problem analysis	Design/development of solutions	Conduct investigations of complex problems	Modern tool usage	The engineer and society	Environment and sustainability	Ethics	Individual or team work	Communication	Project management and finance	Life-long Learning	Application of Concepts	Innovation and Industry Friendly	Ethics and Communication Skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
ETEE711A	Digital Protection	3	3	3	3				1					3		

1=weakly mapped
2= moderately mapped
3=strongly mapped

ETEE713A	**Power System Transients**	L	T	P	C
Version 1.0		4	0	0	4
Pre-requisites/Exposure					
Co-requisites	--				

Course Objectives: -

Students will be able to:

1. Learn the reasons for occurrence of transients in a power system
2. Understand the change in parameters like voltage & frequency during transients
3. To know about the lightning phenomenon and its effect on power system

Course Outcomes: -

Students will be able to:

1: Knowledge of various transients that could occur in power system and their mathematical formulation 2: Ability to design various protective devices in power system for protecting equipment and personnel
3: Coordinating the insulation of various equipment's in power system
4: Modelling the power system for transient analysis.

Course Description:
This course covers the study of transient phenomena in power systems, including their causes, effects, and methods for analysis and mitigation. Topics include transient overvoltages, switching transients, lightning surges, and insulation coordination. The course also explores modeling techniques, simulation tools, and protective devices used to manage transients in power systems.

Course Content:

Units	Content	Hours
I	• Fundamental circuit analysis of electrical transients • Laplace Transform method of solving simple Switching transients • Damping circuits - Abnormal switching transients, Three-phase circuits and transients • Computation of power system transients	10
II	• Principle of digital computation – Matrix method of solution • Modal analysis- Z transform- Computation using EMTP • Lightning, switching and temporary over voltages, Lightning • Physical phenomena of lightning.	10
III	Interaction between lightning and power system • Influence of tower footing resistance and Earth Resistance • Switching: Short line or kilometric fault • Energizing transients - closing and • re-closing of lines • line dropping, load rejection – over voltages induced by faults	10

IV	• Switching HVDC line Travelling waves on transmission line • Circuits with distributed Parameters Wave Equation • Reflection, Refraction, Behaviour of Travelling waves at the line terminations • Lattice Diagrams – Attenuation and Distortion • Multi-conductor system and Velocity wave	10

Reference Books/Materials

Allan Greenwood, "Electrical Transients in Power System", Wiley & Sons Inc. New York, 1991

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs	
Course Outcomes (COs)	**Mapped Program Outcomes**
CO1: Knowledge of various transients that could occur in power system and their mathematical formulation	**PO1**
CO2: Ability to design various protective devices in power system for protecting equipment and personnel	**PO4**
CO3: Coordinating the insulation of various equipment's in power system	**PO8**
CO4: Modelling the power system for transient analysis.	**PO2**

		Engineering Knowledge	Problem analysis	Design/development of solutions	Conduct investigations of complex problems	Modern tool usage	The engineer and society	Environment and sustainability	Ethics	Individual or team work	Communication	Project management and finance	Life-long Learning	Application of Concepts	Innovation and Industry Friendly	Ethics and Communication Skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
ETEE713A	Power system transients	3	3	3	3				1					3		

1=weakly mapped
2= moderately mapped
3=strongly mapped

ETEE755A	**Power System Protection Lab**	L	T	P	C
Version 1.0		0	0	2	1
Pre-requisites/Exposure					
Co-requisites	--				

Course Objective:

Students will be able to:

1. To provide students with practical experience in designing, analyzing, and testing protection schemes for power systems.
2. To familiarize students with various types of protective relays and their applications.
3. To develop skills in the selection and coordination of protective devices for power system components.
4. To enhance problem-solving abilities in addressing protection-related issues in power systems.

Course Outcomes: -

Students will be able to:

CO1: Knowledge of various transients that could occur in power system and their mathematical formulation
CO2: Ability to design various protective devices in power system for protecting equipment and personnel
CO3: Coordinating the insulation of various equipment in power system
CO4: Modelling the power system for transient analysis

Course Description:

This lab course focuses on practical aspects of power system protection. Students will engage in hands-on experiments and exercises related to protection scheme design, relay coordination, and fault analysis. The lab exercises will cover topics such as overcurrent protection, differential protection, distance protection, and transformer protection. Students will work with actual protective relays, simulation software, and experimental setups to understand the behavior of protection systems under normal and fault conditions. Emphasis will be placed on applying theoretical knowledge to real-world scenarios and troubleshooting protection system issues.

Course Content:

S.No.	List of experiments
1	Introduction to Power System Protection
2	Impact of Induction Motor Starting on Power System
3	Modelling of Differential Relay using MATLAB
4	Radial Feeder Protection

5	Parellel Feeder Protection
6	Principle of Reverse Power Protection
7	Differential Protection of Transformer
8	To the study time vs.voltage characteristcs of over voltage induction relay
9	Any other

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs	
Course Outcomes (COs)	**Mapped Program Outcomes**
CO1: Knowledge of various transients that could occur in power system and their mathematical formulation	**PO1**
CO2: Ability to design various protective devices in power system for protecting equipment and personnel	**PO4**
CO3: Coordinating the insulation of various equipment's in power system	**PO8**
CO4: Modelling the power system for transient analysis.	**PO2**

		Engineering Knowledge	Problem analysis	Design/development of solutions	Conduct investigations of complex problems	Modern tool usage	The engineer and society	Environment and sustainability	Ethics	Individual or team work	Communication	Project management and finance	Life-long Learning	Application of Concepts	Innovation and Industry Friendly	Ethics and Communication Skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
ETEE755A	Power System Protection Lab	3	3	3	3				1					3		

1=weakly mapped
2= moderately mapped
3=strongly mapped

4th SEM

ETEE712A	SOLAR AND WIND SYSTEMS	L	T	P	C
Version 1.0		4	0	0	4
Pre-requisites/Exposure	Knowledge of solar and wind system				
Co-requisites	--				

Course Objectives

1. Understand the fundamental principles of solar and wind energy conversion.
2. Analyze the technical and economic feasibility of solar and wind energy projects.
3. Identify and evaluate the components of solar and wind energy systems.
4. Design solar and wind energy systems for various applications.
5. Integrate solar and wind energy systems with existing power infrastructure.
6. Assess the environmental and social impacts of solar and wind energy deployment.
7. Explore emerging trends and advancements in solar and wind energy technologies.
8. Develop practical skills through hands-on exercises and projects.

Course Outcomes

On completion of this course, the students will be able to

CO1. Describe the principles of solar and wind energy conversion.

CO2. Analyze the performance characteristics of solar PV systems and wind turbines.

CO3. Design basic solar PV and wind energy systems.

CO4. Evaluate the feasibility of integrating solar and wind systems into existing power infrastructure.

CO5. Discuss the environmental and societal impacts of solar and wind energy technologies.

CO6. Case studies on system design and implementation.

Catalog Description

This course provides an in-depth exploration of solar and wind energy systems, covering fundamental principles, technologies, design considerations, and applications. Students will gain theoretical knowledge and practical skills necessary for understanding, designing, and implementing solar and wind energy systems.

Course Content

Unit I: 10 lecture hours

Introduction to Renewable Energy: Overview of renewable energy sources**,** Importance of solar and wind energy**,** Historical development and current status of solar and wind technologies**,** Environmental and economic benefits of renewable energy**,** Policies and regulations related to solar and wind energy.

Unit II: 8 lecture hours

Solar Energy Systems: Solar radiation and its measurement**,** Photovoltaic (PV) technology: principles and operation**,** Components of a PV system (solar panels, inverters, batteries, etc.)**,** Design considerations for grid-tied and off-grid PV systems**,** Installation, maintenance, and troubleshooting of PV systems.

Unit III: 8 lecture hours

Wind Energy Systems: Wind energy basics: wind characteristics, wind turbine types**,** Wind turbine components and configurations**,** Wind resource assessment and site selection**,** Grid integration and power electronics in wind energy systems**,** Operation, maintenance, and performance monitoring of wind turbines.

Unit IV: 8 lecture hours

Hybrid Renewable Energy Systems: Integration of solar and wind systems for enhanced reliability and efficiency**,** Design principles of hybrid renewable energy systems**,** Control strategies for hybrid systems**,** Case studies of successful hybrid renewable energy projects**,** Future trends and advancements in solar-wind hybrid systems.

Text Books

Solar Energy Engineering: Processes and Systems" by Soteris A. Kalogirou
Wind Energy Explained: Theory, Design, and Application" by James F. Manwell, Jon G. McGowan, and Anthony L. Rogers
Renewable Energy: Power for a Sustainable Future" by Godfrey Boyle
Introduction to Renewable Energy by Vaughn C. Nelson
Practical Handbook of Photovoltaics: Fundamentals and Applications by Augustin McEvoy, Tom Markvart, and Luis Castañer

Reference Books/Materials

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination

Examination Scheme:

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs		
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO1	Describe the principles of solar and wind energy conversion.	**PO1**
CO2	Analyze the performance characteristics of solar PV systems and wind turbines	**PO2**

CO3	Design basic solar PV and wind energy systems.	**PO2, PO3**
CO4	Evaluate the feasibility of integrating solar and wind systems into existing power infrastructure.	**PO3, PO5**
CO5	Discuss the environmental and societal impacts of solar and wind energy technologies.	**PO6, PO8, PO10**
CO6	Case studies on system design and implementation	**PO4**

		Engineering Knowledge	Problem analysis	Design/development of solutions	Conduct investigations of complex problems	Modern tool usage	The engineer and society	Environment and sustainability	Ethics	Individual or team work	Communication	Project management and finance	Life-long Learning	Application of Concepts	Research Oriented	Global Perspective	Reasoning and Communication Skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
ETEE712A	SOLAR AND WIND SYSTEMS		3	3			2		2		2					3	

1=weakly mapped
2= moderately mapped
3=strongly mapped

ETEE714A	Research Methodology And Ipr	L	T	P	C
Version 1.0		2	0	0	2
Pre-requisites/Exposure	--				
Co-requisites	--				

Course Objectives

1. To be able to formulate research problem from real life problems.
2. To learn ecosystem to conduct a research.
3. To inculcate research ethics in a researcher throughout conduction of research.
4. To develop sense of thinking out of the box to frame a novel research idea by analysing the available literature.
5. To make learner sensitive toward Intellectual Property Right (IPR) to enhance their growth of expansion in various band like socio-economic growth, Research and development growth.

Course Outcomes

On completion of this course, the students will be able to

CO1.Understand research problem formulation.

CO2.Analysis research related information

CO3.Follow research ethics

CO4. Understand that today's world is controlled by Computer, Information, Technology, but tomorrow world will be ruled by ideas, concept, and creativity.

CO5. Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.

CO6. Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

Catalog Description

This course imparts the basic concepts of research methodology and Intellectual Property Right. It enables them to understand flow of research starting from novel idea till ethically completion of the work. The course of Research Methodology and IPR help organizing the steps to be carried out during research to solve the problem efficiently. The course introduces the basic concepts about meaning and feature of good research problem, literature survey and writing an article. It also discusses about IPR and Patents.

Course Content

Unit I: 10 lecture hours

Nature of research problem: Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and

objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

Unit II: 8 lecture hours

Literature Survey: Effective literature studies approaches, analysis Plagiarism, Research ethics, Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee.

Unit III: 8 lecture hours

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

Unit IV: 8 lecture hours

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

Text Books

Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"

Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"

Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners"

Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.

Reference Books/Materials

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination

Examination Scheme:

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs		
	Course Outcomes (COs)	Mapped Program Outcomes
CO 1	Understand research problem formulation.	PO2
CO 2	Analyses research related information	PO2

CO 3	Follow research ethics	**PO8**
CO 4	Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.	**PO10**
CO 5	Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.	**PO3**
CO 6	Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits	**PO6**

		Engineering Knowledge	Problem analysis	Design/development of solutions	Conduct investigations of complex problems	Modern tool usage	The engineer and society	Environment and sustainability	Ethics	Individual or team work	Communication	Project management and finance	Life-long Learning	Application of Concepts	Research Oriented	Global Perspective	Reasoning and Communication Skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
ETEE714A	RESEARCH METHODOLOGY		3	3			2		2		2					3	

	AND IPR																

1=weakly mapped
2= moderately mapped
3=strongly mapped

ETEE754A	Mini Project With Seminar	L	T	P	C
Version 1.0		2	-	-	2
Pre-requisites/Exposure	--				
Co-requisites	--				

The course is designed to provide an opportunity to students to demonstrate the ability to devise, select and use a range of methodologies and tools to the Chosen/Given project, applying the theoretical knowledge to a real life situation. Experiential Learning outside classroom through self-exploration, practical experience, Industry, field experience, live experience, research, design projects etc.

The learning process in the Project seeks out and focuses attention on many latent attributes, which do not surface in the normal class room situations. These experiential learning attributes through project includes Intellectual ability, Professional judgment and decision making ability, Inter-disciplinary approach, Skills for data handling, Ability in written and oral presentation, Sense of responsibility Developing professional Skills Application of theory, concepts in given industry /practical / field scenario.

Course Outcomes

On completion of this course, the students will be able to

CO1. Use applied scientific knowledge to identify and implement relevant principles of mathematics and computer science.
CO2. Use the relevant tools necessary for engineering practice.
CO3. Define overall needs and constraints to solve a problem and develop/ design a prescribed engineering sub-system.
CO4. Communicate effectively and learn to be a team player.

Catalog Description

Students are expected make a project based on the latest advancements related to the parent branch of Engineering. Students may opt for an in-disciplinary project (if feasible).
The project may be a complete hardware or a combination of hardware and software under the guidance of a Supervisor from the Department. This is expected to provide a good training for the student(s) in technical aspects

Student will be continuously evaluated during the semester in form of Project Progress Seminars. At the end of the semester, assessment of the research/project work of each student will be made by the board of examiners including supervisors on the basis of a viva-voce examination and the report submitted by the student.

Course Content

The assignment to normally include:

1. Review and finalization of the Approach to the Problem relating to the assigned topic.
2. Preparing an Action Plan for conducting the investigation, including team work.
3. Detailed Analysis/Modelling/Simulation/Design/Problem Solving/Experiment as needed.
4. Final development of product/process, testing, results, conclusions and future directions.
5. Preparing a report in the standard format for being evaluated by the Department.
6. Final project presentation before a Departmental Committee.

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs		
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO1	Use applied scientific knowledge to identify and implement relevant principles of mathematics and computer science.	**PO3**
CO2	Use the relevant tools necessary for engineering practice.	**PO5**
CO3	Define overall needs and constraints to solve a problem and develop/ design a prescribed engineering sub-system.	**PO2**
CO4	Communicate effectively and learn to be a team player.	**PO10**

		Engineering Knowledge	Problem analysis	Design/development of solutions	Conduct investigations of complex problems	Modern tool usage	The engineer and society	Environment and sustainability	Ethics	Individual or team work	Communication	Project management and finance	Life-long Learning	Application of Concepts	Research Oriented	Global Perspective	Reasoning and Communication Skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4

ETCS660A	Mini Project with Seminar		3	3		3					3			3			

1=weakly mapped
2= moderately mapped
3=strongly mapped

5th sem

ETEE721A	Smart Grid	L	T	P	C
Version 1.0		4	0	0	4
Pre-requisites/Exposure	Basics of smart grid				
Co-requisites	--				

Course Objectives

The objective of this course is to provide students with a comprehensive understanding of smart grid technologies, principles, and applications. By the end of this course, students should be able to:

1. Understand the concept of smart grids and their significance in modern power systems.
2. Analyze the components and architecture of smart grids.
3. Evaluate the benefits and challenges associated with the implementation of smart grid technologies.
4. Apply knowledge of smart grid concepts to design, implement, and manage smart grid systems.
5. Discuss the role of smart grids in enhancing energy efficiency, reliability, and sustainability.
6. Critically assess emerging trends and future directions in smart grid development.

Course Outcomes

On completion of this course, the students will be able to

CO1: Understand the features of Smart Grid
CO2: Assess the role of automation and digitization in Transmission and Distribution
CO3: Analyse Smart grids and Distributed energy resources (DER) with evolutionary algorithms
CO4: Investigate operation and the importance of data acquisition devices and their location for Voltage and Frequency control

Catalog Description

The Smart Grid course delves into the transformative technologies reshaping the traditional electric power grid into a more adaptive, efficient, and sustainable system. The course begins with an overview of the conventional power grid and the drivers necessitating its evolution toward smart grid solutions. Students will explore the architecture of smart grids, encompassing advanced metering infrastructure (AMI), distribution automation, demand response systems, and energy storage technologies. Emphasis will be placed on understanding the role of information and communication technologies (ICT) in enabling bidirectional communication and real-time data exchange within smart grids.
The course delves into the integration of renewable energy sources, such as solar and wind, into the grid and examines the challenges associated with their intermittency and variability. Students will analyze grid stability, resilience, and cybersecurity considerations in the context of smart grid deployment. Additionally, the course covers advanced control strategies, including distributed

energy resource management, load forecasting, and optimization techniques for enhancing grid efficiency and reliability.
Throughout the course, case studies and real-world examples will be utilized to illustrate the implementation and benefits of smart grid technologies in diverse contexts, including urban, rural, and industrial settings. Practical exercises and simulations will allow students to gain hands-on experience in designing and simulating smart grid systems using industry-standard software tools.
Apply knowledge of smart grid concepts to design, implement, and manage smart grid systems.
Discuss the role of smart grids in enhancing energy efficiency, reliability, and sustainability.
Critically assess emerging trends and future directions in smart grid development

Course Content

Unit-I : 8 lecture hours
Introduction to Smart Grid: Basics of power systems, definition of smart grid, need for smart grid, smart grid domain, enablers of smart grid, smart grid priority areas, regulatory challenges, smart-grid activities in India.

Unit-II : 10 lecture hours
Smart Grid Architecture: Smart grid architecture, standards-policies, smart-grid control layer and elements, network architectures, IP-based systems, power line communications, supervisory control and data acquisition system, advanced metering infrastructure. The fundamental components of Smart Grid designs, Transmission Automation, Distribution Automation, Renewable Integration.

Unit-III : 8 lecture hours
Tools and Techniques for Smart Grid: Computational Techniques – Static and Dynamic Optimization Techniques for power applications such as Economic load dispatch – Computational Intelligence Techniques – Evolutionary Algorithms in power system – Artificial Intelligence techniques and applications in power system.

Unit–IV : 8 lecture hours
Distribution Generation Technologies: Introduction to Distribution Energy Sources, Renewable Energy Technologies – Microgrids – Storage Technologies –Electric Vehicles and plug – in hybrids – Environmental impact and Climate Change – Economic Issues.

Text Books

1. Smart Grids, Infrastructure, Technology and Solutions, S. Borlase, CRC Press, 2013, 1st Edition.
2. Renewable and Efficient Electric Power System, G. Masters, Wiley–IEEE Press, 2013, 2nd Edition.

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs		
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO1	Understand the features of Smart Grid	**PO2**
CO2	Assess the role of automation and digitization in Transmission and Distribution	**PO5**
CO3	Analyse Smart grids and Distributed energy resources (DER) with evolutionary algorithms	**PO2**
CO4	Investigate operation and the importance of data acquisition devices and their location for Voltage and Frequency control	**PO6**

		Engineering Knowledge	Problem analysis	Design/development of solutions	Conduct investigations of complex problems	Modern tool usage	The engineer and society	Environment and sustainability	Ethics	Individual or team work	Communication	Project management and finance	Life-long Learning	Application of Concepts	Research Oriented	Global Perspective	Reasoning and Communication Skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
ETEE759A	Dissertation Phase-II		3			3	3							3	3		

1=weakly mapped
2= moderately mapped
3=strongly mapped

ETEE757A	**Dissertation Phase-I**	L	T	P	C
Version 1.0		0	-	12	6

Pre-requisites/Exposure	--
Co-requisites	--

Course Objectives

1. To learn how to carry out literature survey
2. To be associated with an area of research/research project and contribute towards domain knowledge.
3. To learn the art of technical report writing
4. To learn the art of verbal communication with the help of modern presentation techniques

Course Outcomes

On completion of this course, the students will be able to

CO1. Carry out the extensive literature survey.
CO2. Learn to write and present technical reports/articles.
CO3. Learn to analyze various methods and techniques applicable to the topic to study and contribute to domain knowledge.
CO4. Have practical knowledge on the applications of topic of study on society.

Catalog Description

This is the first part of the major dissertation/industrial project wherein every student shall be expected to contribute to domain knowledge incrementally. It is expected that the research/project work should be focused in a particular area for concept, design, implementation and/or analysis. Each student will have to undertake a research/project work under a supervisor. Research/project work may be carried out within department or in any other academic / research / industrial / commercial organization under the guidance of the thesis supervisor who must be a faculty member of the department or under a joint supervision including at least one such faculty member. The work will have to be carried out during the 5th semester of study. The student will have to submit a typewritten or printed report on the work done by him / her according to a schedule to be announced by the department. The project-report should be duly approved by the supervisor concerned and should embody results of research / development work carried out by the student.

Student will be continuously evaluated during the semester in form of Dissertation/project Progress Seminars. At the end of the semester, assessment of the research/project work of each student will be made by the board of examiners including supervisors on the basis of a viva-voce examination and the report submitted by the student.

Course Content

The assignment to normally include:

1. Review and finalization of the Approach to the Problem relating to the assigned topic.
2. Preparing an Action Plan for conducting the investigation, including team work.
3. Detailed Analysis/Modelling/Simulation/Design/Problem Solving/Experiment as needed.

4. Final development of product/process, testing, results, conclusions and future directions.
5. Preparing a report in the standard format for being evaluated by the Department.
6. Final Dissertation Presentation before a Departmental Committee.

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs		
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO1	Carry out the extensive literature survey.	**PO2**
CO2	Learn to write and present technical reports/articles.	**PO5**
CO3	Learn to analyze various methods and techniques applicable to the topic to study and contribute to domain knowledge.	**PO2**
CO4	Have practical knowledge on the applications of topic of study on society.	**PO6**

		Engineering Knowledge	Problem analysis	Design/development of solutions	Conduct investigations of complex problems	Modern tool usage	The engineer and society	Environment and sustainability	Ethics	Individual or team work	Communication	Project management and finance	Life-long Learning	Application of Concepts	Research Oriented	Global Perspective	Reasoning and Communication Skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
ETCS659A	Dissertation phase-I		3			3	3							3			

1=weakly mapped
2= moderately mapped

3=strongly mapped

6TH SEM

ETEE759A	**Dissertation Phase-II**	L	T	P	C
Version 1.0		-	-	32	16

Pre-requisites/Exposure	Dissertation Phase-I
Co-requisites	--

Course Objectives

1. To learn how to carry out literature survey
2. To be associated with an area of research/research project and contribute towards domain knowledge.
3. To learn the art of technical report writing
4. To learn the art of verbal communication with the help of modern presentation techniques.

Course Outcomes

On completion of this course, the students will be able to

CO1. Carry out the extensive literature survey.
CO2. Learn to write and present technical reports/articles.
CO3. Learn to analyze various methods and techniques applicable to the topic to study and contribute to domain knowledge.
CO4. Learn to analyze/evaluate the result of the experiment carried out and present the results using data visualization methods.

Catalog Description

This will be culmination of Dissertation I of semester V. Research work may be carried out with in department or in any other academic / research / industrial / commercial organization under the guidance of the thesis supervisor who must be a faculty member of the depart mentor under a joint supervision including at least one such faculty member. The student will have to submit typewritten or printed report on the work done by him / her according to a schedule
to be announced by the department. The project-report should be duly approved by the supervisor concerned and should embody results of research / development work carried out
by the student.

Student will be continuously evaluated during the semester in form of Dissertation Progress Seminars. At the end of the semester, assessment of the research work of each student will be made by the board of examiners including supervisors on the basis of a viva-voce examination and the report submitted by the student.

Students are required to publish their research work in form of research publication. The result will be declared only after acceptance or publication of full length paper in peer reviewed Conference or Journal.

Course Content

The assignment to normally include:

1. Review and finalization of the Approach to the Problem relating to the assigned topic.
2. Preparing an Action Plan for conducting the investigation, including team work.

3. Detailed Analysis/Modelling/Simulation/Design/Problem Solving/Experiment as needed.
4. Final development of product/process, testing, results, conclusions and future directions.
5. Preparing a report in the standard format for being evaluated by the Department.
6. Final Dissertation Presentation before a Departmental Committee.

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs		
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO1	Carry out the extensive literature survey.	**PO2**
CO2	Learn to write and present technical reports/articles.	**PO5**
CO3	Learn to analyze various methods and techniques applicable to the topic to study and contribute to domain knowledge.	**PO2**
CO4	Learn to analyze/evaluate the result of the experiment carried out and present the results using data visualization methods.	**PO6**

		Engineering Knowledge	Problem analysis	Design/development of solutions	Conduct investigations of complex problems	Modern tool usage	The engineer and society	Environment and sustainability	Ethics	Individual or team work	Communication	Project management and finance	Life-long Learning	Application of Concepts	Research Oriented	Global Perspective	Reasoning and Communication Skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
ETEE759A	Dissertation Phase-II		3			3	3							3	3		

1=weakly mapped
2= moderately mapped
3=strongly mapped

Open Elective

ETMC 901A	Business Analytics	L	T	P	C
Version 1.0		3	0	0	3
Pre-requisites/Exposure	Probability and Set Theory				
Co-requisites	--				

Course Objectives

1. Understand and critically apply the concepts and methods of business analytics
2. Identify, model and solve decision problems in different settings
3. Interpret results/solutions and identify appropriate courses of action for a given managerial situation whether a problem or an opportunity
4. Create viable solutions to decision making problems

Course Outcomes

` On completion of this course, the students will be able to

CO1. Enable all participants to recognise, understand and apply the language, theory and models of the field of business analytics

CO2. Foster an ability to critically analyse, synthesise and solve complex unstructured business problems

CO3. Encourage an aptitude for business improvement, innovation and entrepreneurial action

CO4. Encourage the sharing of experiences to enhance the benefits of collaborative learning

CO5. Instil a sense of ethical decision-making and a commitment to the long-run welfare of both organisations and the communities they serve

Catalog Description

The problems faced by decision makers in today's competitive business environment are often extremely complex and can be addressed by numerous possible courses of action. Evaluating these alternatives and gaining insight from past performance is the essence of business analytics. This course is designed as an introduction to Business Analytics, an area of business administration that considers the extensive use of data, methods, and fact-based management to support and improve decision making. While business intelligence focuses on data handling, queries and reports to discover patterns and generate information associated with products, services and customers, business analytics uses data and models to explain the performance of a business and how it can be improved. This course discusses the benefits of employing analytics and a structured approach to problem-solving in management situations.

Course Content

UNIT I 8 hours

Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics. Statistical Tools: Statistical Notation, Descriptive Statistical

methods, Review of probability distribution and data modelling, sampling and estimation methods overview.

UNIT II 8 hours

Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression. Important Resources, Business Analytics Personnel, Data and models for
Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.
Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes.

UNIT III 7 hours

Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.
Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models.

UNIT IV 7 hours

Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model.
Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, the Value of Information, Utility and Decision Making. Recent Trends in: Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.

TEXT BOOKS:

1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.
2. Business Analytics by James Evans, persons Education.

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs		
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO1	Enable all participants to recognise, understand and apply the language, theory and models of the field of business analytics	**PO1**
CO2	Foster an ability to critically analyse, synthesise and solve complex unstructured business problems	**PO2, PO4**
CO3	Encourage an aptitude for business improvement, innovation and entrepreneurial action	**PO7**
CO4	Encourage the sharing of experiences to enhance the benefits of collaborative learning	**PO9**
CO5	Instil a sense of ethical decision-making and a commitment to the long-run welfare of both organisations and the communities they serve.	**PO8**

		Engineering Knowledge	Problem analysis	Design/development of solutions	Conduct investigations of complex problems	Modern tool usage	The engineer and society	Environment and sustainability	Ethics	Individual or team work	Communication	Project management and finance	Life-long Learning	Application of Concepts	Research Oriented	Global Perspective	Reasoning and Communication Skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4

ETMC901A	Business Analytics	3	3		3			3	3	3				3	3	3	2

1=weakly mapped
2= moderately mapped
3=strongly mapped

ETME 901A	INDUSTRIAL SAFETY	L	T	P	C
Version 1.0		3	0	0	3
Pre-requisites/Exposure	Basics knowledge of industrial engineering				
Co-requisites	--				

Course Objectives:

Upon completion of the course the students will be able to:

1. Familiar with standard workplace hazard/warning signs and labels.
2. Familiar with standard categories of hazardous materials.
3. Understand the documentation used with hazardous materials, such as the MSDS.
4. Describe the different levels of danger that exist with electrical shock.
5. Describe several appropriate actions to take in the event of an electrical accident.

Course Outcomes:

Upon the completion of this course the students will be able to:

1. Analyze the effect of release of toxic substances
2. Understand the industrial laws, regulations, and source models.
3. Apply the methods of prevention of fire and explosions.
4. Understand the relief and its sizing methods and methods of hazard identification and preventive measures& types.

Catalog Description

The basic purpose of this course is to deal with the safety practices in the electronics industry which includes electrical safety, HAZMAT, flammable and combustible liquids, safe handling of electronic components in the manufacturing environment including ESD control, product testing/certification, blood borne pathogens, fire safety, laser, and radiation safety. Audit available.

Course Content

Unit I: 12 lecture hours

Industrial safety**:** Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, washrooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety colour codes. Fire prevention and fire fighting, equipment, and methods.

Unit II: 12 lecture hours

Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its

relationship with replacement economy, Service life of equipment. Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods.

Unit III: 8 lecture hours

Lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle, and factors affecting the corrosion. Types of corrosion, corrosion prevention methods. Fault tracing: Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault-finding activities, show as decision tree.

Unit IV: 8 lecture hours

Draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal, and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes. Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning, and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps, and advantages of preventive maintenance.

TEXTBOOKS:

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand, and Company.
3. Pump-hydraulic Compressors, Aludels, McGraw Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs		
	Course Outcomes (COs)	Mapped Program Outcomes
CO1	Analyze the effect of release of toxic substances	PO1
CO2	Understand the industrial laws, regulations, and source models.	PO2
CO3	Apply the methods of prevention of fire and explosions.	PO3

CO4	Understand the relief and its sizing methods and methods of hazard identification and preventive measures& types.	**PO4**

		Engineering Knowledge	Problem analysis	Design/development of solutions	Conduct investigations of complex problems	Modern tool usage	The engineer and society	Environment and sustainability	Ethics	Individual or team work	Communication	Project management and finance	Life-long Learning	Application of Concepts	Research Oriented	Global Perspective	Reasoning and Communication Skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
ETME901A	Industrial Safety	2	2	2	3									3	2		

1=weakly mapped
2= moderately mapped
3=strongly mapped

ETMA 901A	Operations Research	L	T	P	C
Version 1.0		3	0	0	3
Pre-requisites/Exposure					
Co-requisites	--				

Course Objectives

1. Describe the linear programming duality. and the simplex and revised simplex algorithms
2. Describe the linear programming applications and formulations
3. Describe the transportation problem and its application
4. Describe the Network Analysis
5. To acquaint the students with the use of quantitative models in game theory

Course Outcomes

On completion of this course, the students will be able to

CO1- Understand the origin and development of Operations Research
CO2- Analyze the real life systems with limited constraints
CO3-Identify a problem in your locality, formulate it as an LPP and solve
CO4- Understanding the various laws and theorems related to electric networks
CO5The students will be able to recognize strategic environments and to use Game Theory.

Catalog Description

This course covers some core areas of Operational Research, namely Linear programming,, Transportation problem network analysis and Game Theory. Emphasis will be placed both on the mathematical techniques and on problem formulation through examples from applications.

Course Content

Unit I: 14 lecture hours

Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models.

Unit II: 8 lecture hours

Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming.
Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT.

Unit III: 11 lecture hours

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

Unit IV: 12 lecture hours

Competitive Models, Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation.

Text Books

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008.
4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs		
	Course Outcomes (COs)	Mapped Program Outcomes
CO1	Understand the origin and development of Operations Research	PO1, PO2
CO2	Analyze the real life systems with limited constraints	PO12
CO3	Identify a problem in your locality, formulate it as an LPP and solve	PO4, PO2
CO4	Understanding the various laws and theorems related to electric networks	PO3
CO5	The students will be able to recognize strategic environments and to use Game Theory	PO5, PO2

		Engineering Knowledge	Problem analysis	Design/development of solutions	Conduct investigations of complex problems	Modern tool usage	The engineer and society	Environment and sustainability	Ethics	Individual or team work	Communication	Project management and finance	Life-long Learning	Application of Concepts	Research Oriented	Global Perspective	Reasoning and Communication Skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
ETMA901A	Operations Research	3	2	3	3	2								3	2		

1=weakly mapped
2= moderately mapped
3=strongly mapped

ETCE901A	Cost Management Of Engineering Projects	L	T	P	C
Version 1.0		3	0	0	3
Pre-requisites/Exposure					
Co-requisites					

Course Objectives

The objective of this course is to help you in developing your knowledge and understanding of Cost Management Principles.

1. Recognize and apply appropriate theories, principles and concepts relevant to cost management.
2. Exercise appropriate judgment in selecting and presenting information using various methods relevant to cost management.
3. Plan, design and execute practical activities using techniques and procedures appropriate to cost management.
4. Respond to change within the external and internal business environments and its effect on cost management.
5. Develop appropriate effective written and oral communication skills relevant to cost management.
6. Use organization skills (including task and time management) relevant to cost management both individually and in a group situation.
7. Solve problems relevant to cost management using ideas and techniques some of which are at the forefront of the discipline.

Course Outcomes

On completion of this course, the students will be able to

CO1. To appreciate the use of different costs for different purposes.

CO2.Explain traditional and contemporary approaches to cost allocation.

CO3. Describe different product costing scenarios in job-order and process environments.

CO4. Identify relevant information for decision making purposes in order to produce financial analyses for a range of decisions such as product-mix, pricing, outsourcing and special orders.

CO5. Use standard costs to prepare budgets for planning and control purposes.

Catalog Description

The Cost Management course addresses the identification, elaboration, planning, and management of the project budget. Including selected processes from the PMI Integration, Cost, Scope and Risk Knowledge Areas, this class addresses the development of a Project Cost Estimate, Project Budget, and the Project Budget Baseline. In addition it addresses the preparation of a spending profile that supports variance analysis and corrective action using Earned Value Management. Using a combination of theory based lecture and hands on exercises, students are provided with an effective skill set for developing and controlling the project budget baseline.

Course Content

UNIT I 8 hours

Introduction and Overview of the Strategic Cost Management Process

Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control;

UNIT II 8 hours

Provision of data for Decision-Making Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and non technical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance.

UNIT III 7 hours

Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing,
Life Cycle Costing. Costing of service sector.

UNIT IV 7 hours

Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing. Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

TEXT BOOKS:

1. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
2. Charles T. Horngren and George Foster, Advanced Management Accounting
3. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
4. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs		
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO1	To appreciate the use of different costs for different purposes.	**PO1**
CO2	Explain traditional and contemporary approaches to cost allocation	**PO4**
CO3	Describe different product costing scenarios in job-order and process environments.	**PO7**
CO4	Identify relevant information for decision making purposes in order to produce financial analyses for a range of decisions such as product-mix, pricing, outsourcing and special orders.	**PO11**
CO5	Use standard costs to prepare budgets for planning and control purposes.	**PO3, PO5**

		Engineering Knowledge	Problem analysis	Design/ development of solutions	Conduct investigations of complex problems	Modern tool usage	The engineer and society	Environment and sustainability	Ethics	Individual or team work	Communication	Project management and finance	Life-long Learning	Application of Concepts	Research Oriented	Global Perspective	Reasoning and Communication Skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
ETCE901A	COST MANAGEMENT OF ENGINEERING	3		3	3	3		3				3		3	2	3	1

	PROJECTS															

1=weakly mapped
2= moderately mapped
3=strongly mapped

ETCE902A	Composite Materials	L	T	P	C
Version 1.0		3	0	0	3
Pre-requisites/Exposure					
Co-requisites					

Course Objectives

1. To provide an understanding of the fundamental principles behind composite materials.
2. To explore the various types of composite materials, their properties, and applications.
3. To develop skills in selecting appropriate composite materials for specific engineering applications.
4. To understand the manufacturing processes involved in producing composite materials.
5. To analyze the mechanical behavior and performance of composite materials under different loading conditions.
6. To introduce advanced topics in composite materials, such as nano composites and bio-based composites.
7. To foster critical thinking and problem-solving abilities through case studies and projects related to composite materials.

Course Outcomes

On completion of this course, the students will be able to

CO1.Identify different types of composite materials and their constituents
CO2.Describe the manufacturing processes of composite materials
CO3.Analyze mechanical properties and behavior of composite materials.
CO4. Evaluate the applications and design considerations of composites

Catalog Description

This course covers the fundamental principles of composite materials, including their constituent phases, fabrication methods, mechanical behavior, and applications in various engineering fields. Topics include types of composites, reinforcement materials, matrix materials, manufacturing techniques, mechanical properties, failure mechanisms, and design considerations.

Course Content

UNIT I 8 hours

Definition and classification of composite materials, Historical background and development of composites, Advantages and disadvantages of composite materials

Basic concepts: reinforcement, matrix, interface, Types of reinforcement (fibers, particulates, flakes) and matrices (polymer, metal, ceramic), Properties of composite materials: mechanical, thermal, electrical, and chemical, Applications of composite materials in different industries (aerospace, automotive, construction, sports, etc.);

UNIT II 8 hours

Fabrication Techniques for Composite Materials, Overview of fabrication methods: hand layup, spray-up, filament winding, pultrusion, compression molding, injection molding, resin transfer molding (RTM), autoclave molding, Prepreg materials and their processing, Composite curing processes: thermal curing, autoclave curing, microwave curing, Quality control and inspection

techniques for composite fabrication, Environmental considerations and sustainability in composite manufacturing

UNIT III 7 hours
Mechanical Behavior and Analysis of Composite Materials, Stress and strain analysis in composite materials, Mechanical properties of composites: stiffness, strength, toughness, fatigue, creep, Failure mechanisms in composites: delamination, fiber/matrix debonding, fiber fracture, matrix cracking, Micromechanics and macromechanics of composite materials, Failure criteria and design considerations for composite structures, Non-destructive testing (NDT) techniques for evaluating composite components.

UNIT IV 7 hours
Advanced Topics and Applications: Nanocomposites: properties, fabrication, and applications, Smart composites and their functionality, Bio-based and recycled composites, Composite materials for extreme environments (high temperature, corrosive conditions), Design considerations for specific applications: aerospace, automotive, marine, sports equipment, Case studies and research trends in composite materials

TEXT BOOKS:

1. Introduction to Composite Materials Design by Ever J. Barbero
2. Composite Materials: Fabrication Handbook by John Wanberg
3. Mechanics of Composite Materials by Autar K. Kaw

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs		
	Course Outcomes (COs)	Mapped Program Outcomes
CO1	Identify different types of composite materials and their constituents	PO1, PO5
CO2	Describe the manufacturing processes of composite materials	PO5
CO3	Analyze mechanical properties and behavior of composite materials	PO5
CO4	Evaluate the applications and design considerations of composites	PO2, PO4

		Engineering Knowledge	Problem analysis	Design/development of solutions	Conduct investigations of complex problems	Modern tool usage	The engineer and society	Environment and sustainability	Ethics	Individual or team work	Communication	Project management and finance	Life-long Learning	Application of Concepts	Research Oriented	Global Perspective	Reasoning and Communication Skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
ETCE902A	COMPOSITE MATERIALS	3		3	3	3		3				3		3	2	3	1

1=weakly mapped
2= moderately mapped
3=strongly mapped

ETME 902A	Waste To Energy	L	T	P	C
Version 1.0		3	0	0	3
Pre-requisites/Exposure	Basics of waste and energy				
Co-requisites	--				

Course Objectives:

The subject expects students to achieve the following objectives.

1. Understand of the concept of Waste to Energy.
2. Link legal, technical and management principles for production of energy form waste.
3. Learn about the best available technologies for waste to energy.
4. Analyse of case studies for understanding success and failures.
5. Facilitate the students in developing skills in the decision-making process.

Course Outcomes:

Upon the completion of this course the students will be able to:

CO1.Apply the knowledge about the operations of Waste to Energy Plants.
CO2.Analyse the various aspects of Waste to Energy Management Systems.
CO3.Carry out Techno-economic feasibility for Waste to Energy Plants.
CO4. Apply the knowledge in planning and operations of Waste to Energy plants.

Catalog Description

This course gives introductory knowledge about Waste to Energy conversion system,and utilization in various field. It enables the students to understand the waste to energy management system systems. This course is also helping students to answer fundamental questions of waste To Energy at the time of the interview.

Course Content

Unit I: 08 lecture hours

Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors.

Unit II: 12 lecture hours

Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.
Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

Unit III: 06 lecture hours

Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction, and operation - Operation of all the above biomass combustors.

Unit IV: 12 lecture hours

Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy program in India.

TEXTBOOKS:

1. Non-Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2. Biogas Technology - A Practical Handbook - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.

REFERENCE BOOKS:

1. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
2. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs		
	Course Outcomes (COs)	Mapped Program Outcomes
CO1	Apply the knowledge about the operations of Waste to Energy Plants.	PO1
CO2	Analyze the various aspects of Waste to Energy Management Systems.	PO4
CO3	Carry out Techno-economic feasibility for Waste to Energy Plants.	PO2

CO4	Apply the knowledge in planning and operations of Waste to Energy plants.	**PO7**

		Engineering Knowledge	Problem analysis	Design/development of solutions	Conduct investigations of complex problems	Modern tool usage	The engineer and society	Environment and sustainability	Ethics	Individual or team work	Communication	Project management and finance	Life-long Learning	Application of Concepts	Research Oriented	Global Perspective	Reasoning and Communication Skills
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
ETME902A	Waste to Energy	2	3		3			3						3			

1=weakly mapped
2= moderately mapped
3=strongly mapped

ELECTIVES

ETEE746A	Engineering Optimization	L	T	P	C
Version 1.0		3	1	0	4
Pre-requisites/Exposure					
Co-requisites	--				

Course Objectives

Introduce methods of optimization to engineering students, including linear programming, network flow algorithms, integer programming, interior point methods, quadratic programming, nonlinear programming, and heuristic methods. Numerous applications are presented in civil, environmental, electrical (control) engineering, and industrial engineering. The goal is to maintain a balance between theory, numerical computation, and problem setup for solution by optimization software, and applications to engineering systems.

Course Outcomes

Upon successful completion of this course, the student will be able to understand:
(1) Basic theoretical principles in optimization;
(2) Formulation of optimization models;
(3) Solution methods in optimization;
(4) Methods of sensitivity analysis and post processing of results
(5) Applications to a wide range of engineering problems

Course Content

Unit I:
Introduction to methods of optimization; optimality and convexity.

Unit II:
General optimization algorithm; necessary and sufficient conditions for optimality.

Unit III:
ntroduction to linear programming—a geometric perspective
Standard form in linear programming; basic solutions; fundamental theorem of linear programming. Simplex method; multiple solutions; tie-breaking procedures; two-phase method 6. Duality theory in linear programming; complementary slackness; economic interpretation of the duali

Unit IV:

Sensitivity analysis; right-hand-side and cost ranging. Applications: regression modeling in engineering; industrial blending problems; dynamic optimal control of engineering systems.

Unit V:

Applications: regression modeling in engineering; industrial blending problems; dynamic optimal control of engineering systems

Text Books

Linear and Nonlinear Optimization, by I. Griva, S. Nash, and A. Sofer, 2nd Edition, Society for Industrial and Applied Mathematics, 2009. [ISBN: 978-0-898716-61-0]

Reference Books/Materials

1. Sheldon M. Ross, "Probability and Statistics for Engineers and Scientist", Elsevier Academic Press.

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs		
	Course Outcomes (COs)	Mapped Program Outcomes
CO1	To understand the basic notions of discrete and continuous probability.	PO1
CO2	To understand the methods of statistical inference, and the role that sampling distribution play in those methods.	PO2
CO3	To be able to perform correct and meaningful statistical analyses of simple to moderate complexities.	PO4
CO4	To be able to apply basic principles of graph theory to solve real-time problems.	PO3

		Engineering Knowledge	Problem analysis	Design/development of solutions	Conduct investigations of complex problems	Modern tool usage	The engineer and society	Environment and sustainability	Ethics	Individual or team work	Communication	Project management and finance
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
ETCS601A	Mathematical Foundations For Computer Science	3	3	3	3							

1=weakly mapped
2= moderately mapped
3=strongly mapped

ETEE747A	High Voltage Engineering	L	T	P	C
Version 1.0		3	1	0	4
Pre-requisites/Exposure					
Co-requisites	--				

Course Objectives

Introduce methods of optimization to engineering students, including linear programming, network flow algorithms, integer programming, interior point methods, quadratic programming, nonlinear programming, and heuristic methods. Numerous applications are presented in civil, environmental, electrical (control) engineering, and industrial engineering. The goal is to maintain a balance between theory, numerical computation, and problem setup for solution by optimization software, and applications to engineering systems.

Course Outcomes

Upon successful completion of this course, the student will be able to understand:
(1) Basic theoretical principles in optimization;
(2) Formulation of optimization models;
(3) Solution methods in optimization;
(4) Methods of sensitivity analysis and post processing of results
(5) Applications to a wide range of engineering problems.

Course Content

UnitI : Wave Terminology

Wave terminology, Development of wave equations, Terminal problems, Lattice diagrams, Origin and nature of power system transient and surges, Surge parameters of plants, Equivalent circuit representations, Lumped and distributed circuit transients, Line energisation and de-energisation, Earth and earth wire effect.

UnitII

Current chopping in circuit breakers, Short line fault condition and its relation to circuit breaker duty, Trapped charge effect, Effect of source and source representation in short line fault studies.

UnitIII

Control of transients, Lightening phenomenon, Influence of tower footing resistance and earth resistance, Traveling waves in distributed parameters multi-conductor lines, Parameters as a function of frequency.

Unit IV

Methods of neutral grounding and their effect on system behavior, Insulation coordination, over voltage limiting devices, Dielectric properties, Requirement in surge protection of lines and equipment.

Unit V

Impulse generator development, Impulse-testing technique, Power frequency HV Transformers, Cascade connection, HVDC Generators, Tests with power frequency and DC voltage, Large current generating and measurement techniques, Partial discharge testing, High voltage and high current testing of power equipment.

Text Books

Linear and Nonlinear Optimization, by I. Griva, S. Nash, and A. Sofer, 2nd Edition, Society for Industrial and Applied Mathematics, 2009. [ISBN: 978-0-898716-61-0]

Reference Books/Materials

2. Sheldon M. Ross, "Probability and Statistics for Engineers and Scientist", Elsevier Academic Press.

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs		
	Course Outcomes (COs)	Mapped Program Outcomes

CO1	To understand the basic notions of discrete and continuous probability.	**PO1**
CO2	To understand the methods of statistical inference, and the role that sampling distribution play in those methods.	**PO2**
CO3	To be able to perform correct and meaningful statistical analyses of simple to moderate complexities.	**PO4**
CO4	To be able to apply basic principles of graph theory to solve real-time problems.	**PO3**

		Engineering Knowledge	Problem analysis	Design/development of solutions	Conduct investigations of complex problems	Modern tool usage	The engineer and society	Environment and sustainability	Ethics	Individual or teamwork	Communication	Project management and finance
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
ETCS601A	Mathematical Foundations For Computer Science	3	3	3	3							

1=weakly mapped
2= moderately mapped
3=strongly mapped

ETEE748A	Switched Mode Power Control	L	T	P	C
Version 1.0		3	1	0	4
Pre-requisites/Exposure					
Co-requisites	--				

Course Objectives

Introduce methods of optimization to engineering students, including linear programming, network flow algorithms, integer programming, interior point methods, quadratic programming, nonlinear programming, and heuristic methods. Numerous applications are presented in civil, environmental, electrical (control) engineering, and industrial engineering. The goal is to maintain a balance between theory, numerical computation, and problem setup for solution by optimization software, and applications to engineering systems.

Course Outcomes

Upon successful completion of this course, the student will be able to understand:
(1) Basic theoretical principles in optimization;
(2) Formulation of optimization models;
(3) Solution methods in optimization;
(4) Methods of sensitivity analysis and post processing of results
(5) Applications to a wide range of engineering problems.

Course Content

UnitI

Optimal Power System Operation: System constraints. Generator operating cost. InputOutput and incremental fuel characteristics of a generating unit. Optimal operation of generators on a bus bar, algorithm and flow chart. Optimal unit commitment, constraints in unit commitment, spinning reserve, thermal and hydro constraints.

UnitII

Commitment Solution Methods: Priority list method and dynamic programming method. Reliability consideration, Patton's security function, security constrained optional unit commitment, start- up considerations.

Unit III

Optimal Generation Scheduling: Development of transmission loss and incremental loss equations. Optimal generation scheduling including transmission losses, algorithm and flow chart. Optimal load flow solution. Hydrothermal coordination.

Unit IV

Load Frequency Control: Control of real and reactive power of generator. Turbine speed governing system, modelling of speed governing system. Methods of frequency control: flat frequency, flat tie line and tie line load bias control. Block diagram representation of load frequency control of an isolated system, steady state analysis, dynamic response. Introduction to Two – area load frequency control.

(i) **Power System Security**: Introduction to power system security, System monitoring, contingency analysis, System state classification, security control.

(ii) **Automatic Generation Control:** Speed governing characteristic of a generating unit. Load sharing between parallel operating generators. Introduction to automatic generation control of an area by computer (description of block diagram).

Text Books

Linear and Nonlinear Optimization, by I. Griva, S. Nash, and A. Sofer, 2nd Edition, Society for Industrial and Applied Mathematics, 2009. [ISBN: 978-0-898716-61-0]

Reference Books/Materials

3. Sheldon M. Ross, "Probability and Statistics for Engineers and Scientist", Elsevier Academic Press.

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs

	Course Outcomes (COs)	Mapped Program Outcomes
CO1	To understand the basic notions of discrete and continuous probability.	**PO1**
CO2	To understand the methods of statistical inference, and the role that sampling distribution play in those methods.	**PO2**
CO3	To be able to perform correct and meaningful statistical analyses of simple to moderate complexities.	**PO4**
CO4	To be able to apply basic principles of graph theory to solve real-time problems.	**PO3**

		Engineering Knowledge	Problem analysis	Design/development of solutions	Conduct investigations of complex problems	Modern tool usage	The engineer and society	Environment and sustainability	Ethics	Individual or teamwork	Communication	Project management and finance
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
ETCS601A	Mathematical Foundations For Computer Science	3	3	3	3							

1=weakly mapped
2= moderately mapped
3=strongly mapped

ETEE749A	Optimal and Adaptive Control	L	T	P	C
Version 1.0		3	1	0	4
Pre-requisites/Exposure					
Co-requisites	--				

Course Objectives

Introduce methods of Adaptive Control. Numerous applications are presented in civil, environmental, electrical (control) engineering, and industrial engineering. The goal is to maintain a balance between theory, numerical computation, and problem setup for solution by optimization software, and applications to engineering systems.

Course Outcomes

Upon successful completion of this course, the student will be able to understand:

(1) Apply the concept of different types of optimal control for solving problems
(2) Apply the concept of calculus of variation and principal of optimality for solving problems
(3) Apply the concept of Linear Quadratic method for solving problems
(4) Apply the concept of adaptive control technique for solving problems
(5) Apply the concept of Self Tuning Regulators and Model Reference Adaptive System for solving problem.

Course Content

Unit-I

INTRODUCTION TO OPTIMAL CONTROL PROBLEMS:

Statement of optimal control problem - Problem formulation and types of optimal control - Selection of performance measures, General Model of feedback control systems, Transient performance analysis, Tracking performance analysis, Disturbance rejection analysis, Cost functions and norms, Mathematical preliminary to optimal control.

Unit-II

CALCULUS OF VARIATION AND HAMILTON FORMULATION:

Fundamental concepts – Extremum functionals involving single and Semester - VI 216 G V P College of Engineering (Autonomous) 2016 EEE several independent functions – Piecewise smooth extremals - Variation of functionals with fixed and free terminal time constrained extrema Pontryagin's minimum principle - State inequality constraints - The Weierstrass Erdmann corner

conditions - Solution of Bolza problem. Partial differential equation for cost function - Hamilton Jacobi equation - Principle of optimality, solution of Hamilton Jacobi equation - Matrix Riccati equation - Optimal control law.

Unit-III

LINEAR QUADRATIC CONTROL PROBLEMS:

Optimal control by Liapunov method - Parameter optimization – Quadratic performance index - Optimal control of systems - Matrix Riccati equation and solution methods of State regulator and discrete systems - Choice of weighting matrices – Linear Quadratic Guassian control – Kalman filter – H2 and H∞ Control and Optimal estimation.

Unit-IV

DYNAMIC PROGRAMMING: Principle of optimality - Recurrence relation of dynamic programming for optimal control problem - Combinational procedure for solving optimal control problem.

INTRODUCTION TO ADAPTIVE CONTROL: Development of adaptive control problem-The role of Index performance (IP) in adaptive systems- Development of IP measurement process model.

UNIT-V

SELF TUNING REGULATORS (STR) AND MODEL REFERENCE ADAPTIVE SYSTEMS (MRAS):

Introduction - Pole placement design-Indirect Self-tuning regulators - Continuous time Self-Tuners - Direct self tuning regulators - Linear quadratic self - Tuning regulators - Adaptive predictive control. The MIT rule – Determination of Adaptation Gain – Design of MRAS using Liapunov theory – BIBO Stability – Applications to Adaptive control- Model Free Adaptive Control.

TEXT BOOKS:

1. Optimal control theory-An Introduction by Donald E.Krik - Prentice Hall Networks series, 2008.
2. Karl J Astrom and Bjorn Wittenmark, “Adaptive Control”, Pearson education Inc., New Delhi, Second Edition, 2008.
3. D S Naidu “Optimal Control Systems”, CRC Press 2002.

REFERENCES:

1. A.P. Sage - Optimum Systems Control, Prentice Hall.
2. Yoan D. Landu - Adaptive Control - Model Reference Approach, Marcel Dekker
3. HSU and Meyer - Modern Control. Principles and Applications, McGraw Hill

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs		
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO1	To understand the basic notions of discrete and continuous probability.	**PO1**
CO2	To understand the methods of statistical inference, and the role that sampling distribution play in those methods.	**PO2**
CO3	To be able to perform correct and meaningful statistical analyses of simple to moderate complexities.	**PO4**
CO4	To be able to apply basic principles of graph theory to solve real-time problems.	**PO3**

		Engineering Knowledge	Problem analysis	Design/development of solutions	Conduct investigations of complex problems	Modern tool usage	The engineer and society	Environment and sustainability	Ethics	Individual or team work	Communication	Project management and finance
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11

ETCS601A	Mathematical Foundations For Computer Science	3	3	3	3							

1=weakly mapped
2= moderately mapped
3=strongly mapped

ETEE735A	Electric and Hybrid Vehicles	L	T	P	C
Version 1.0		4	0	0	4
Pre-requisites/Exposure					
Co-requisites	--				

Course Objectives

1. To understand upcoming technology of electric and hybrid electric vehicles
2. Analyze different aspects of drive train topologies
3. To understand different communication systems used in electric and Hybrid electric vehicles .
4. To understand the concept of vehicle to grid configurations.

Course Outcomes

On completion of this course, the students will be able to

1. Impact of conventional vehicles on the society and different types of drive train topologies
2. Load modeling based on the road profile and braking concepts
3. Different types of motors used in electric and hybrid electric vehicles
4. The concept vehicle to grid (V2G) and grid to vehicle (G2V)

Catalog Description

Course Content

Unit I: **14 lecture hours**

Introduction to Electric and Hybrid Vehicles

Social and environmental importance of hybrid and electric vehicles, Impact of modern drive trains on energy supplies, Basics of vehicle performance, vehicle power source characterization, Transmission characteristics, Mathematical models to describe vehicle performance.

Basic concept of Hybrid Traction

Introduction to various hybrid drive-train topologies, Power flow control in hybrid drive-train topologies, Fuel efficiency analysis, braking fundamentals and regenerative braking in EVs.

Unit II: **8 lecture hours**

Introduction to Electric Components used in Hybrid and Electric Vehicles

Configuration and control of DC Motor drives, Configuration and control of Introduction Motor drives, configuration and control of Permanent Magnet Motor Drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.

Unit III: **8 lecture hours**

Matching the Electric Machine and the Internal Combustion Engine (ICE)

Sizing the propulsion motor, sizing the power electronics Selecting the energy storage technology, Communications, supporting subsystems

Unit IV: **10 lecture hours**

Introduction to Energy Management and their Strategies used in Hybrid and Electric Vehicle Classification of different energy management strategies Comparison of different energy management strategies Implementation issues of energy strategies. Plug-in electric vehicles, Vehicle to grid (V2G) and G2V fundamentals.

Text Books

1. Mehrdad Ehsani, Yimin Gao, Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals", CRC Press, 2010.
2. James Larminie, "Electric Vehicle Technology Explained", John Wiley & Sons, 2003
3. Iqbal Hussain, "Electric & Hybrid Vehicles – Design Fundamentals", Second Edition, CRC Press, 2011.

Reference Books

1. Hybrid Vehicles and the future of personal transportation, Allen Fuhs, CRC Press, 2011.

Reference Books/Materials

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs		
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO1	Impact of conventional vehicles on the society and different types of drive train topologies	**PO1**
CO2	Load modeling based on the road profile and braking concepts	**PO2,PO3**
CO3	Different types of motors used in electric and hybrid electric vehicles	**PO1**
CO4	The concept vehicle to grid (V2G) and grid to vehicle (G2V)	**PO1,PO4**

		Engineering Knowledge	Problem analysis	Design/development of solutions	Conduct investigations of complex problems	Modern tool usage	The engineer and society	Environment and sustainability	Ethics	Individual or team work	Communication	Project management and finance
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
ETEE735A	Electric and Hybrid Vehicles	3	2	3	2							

1=weakly mapped
2= moderately mapped
3=strongly mapped

ETEE742A	AI TECHNIQUES	L	T	P	C
Version 1.0		4	0	0	4
Pre-requisites/Exposure					
Co-requisites	--				

Course Objectives

1. **Optimization of Power Grid Operations**: One key objective is to equip students with the knowledge and skills to apply AI algorithms for optimizing the operation and management of power grids. This includes load forecasting, energy scheduling, fault detection and diagnosis, outage management, and asset maintenance optimization. Students should learn how to use techniques such as machine learning, reinforcement learning, genetic algorithms, and expert systems to improve the efficiency, reliability, and resilience of power grid operations.
2. **Smart Grid Technologies and Energy Management Systems**: Another objective is to educate students about smart grid technologies and energy management systems powered by AI. Students should learn about advanced metering infrastructure (AMI), demand response systems, distributed energy resources (DERs), micro grids, and energy storage systems, and how AI can be utilized to optimize their integration, control, and operation. This objective involves understanding the interplay between AI algorithms and power system components to achieve energy efficiency, grid stability, and cost-effectiveness.
3. **Predictive Maintenance and Condition Monitoring**: A third objective is to teach students how to leverage AI techniques for predictive maintenance and condition monitoring of power system assets. This includes developing algorithms for analyzing sensor data from transformers, generators, transmission lines, and other critical infrastructure components to detect early signs of equipment degradation, predict failures, and schedule maintenance activities proactively. Students should learn about machine learning models, anomaly detection techniques, and data fusion methods for predicting equipment health and optimizing maintenance strategies, thereby reducing downtime, minimizing operational risks, and extending asset lifespan.

Course Outcomes

On completion of this course, the students will be able to

CO1.Understanding of AI Fundamentals: Students should gain a solid understanding of the fundamental concepts, theories, and principles underlying artificial intelligence, including knowledge representation, problem-solving, search algorithms, and machine learning.

CO2. Understand AI Fundamentals in the Context of Power Systems: Students will develop a solid understanding of fundamental AI concepts, including machine learning, neural networks, deep learning, evolutionary algorithms, and expert systems, and learn how these techniques can be applied to solve problems specific to power systems engineering.

CO3. Apply AI Techniques to Power Systems Optimization and Control: Students will learn how to apply AI algorithms to optimize power grid operations, including load forecasting, energy scheduling, fault detection, and system control. They will explore case studies and simulation exercises to understand how AI techniques can enhance the efficiency, reliability, and resilience of power systems.

CO4.Implement AI-driven Solutions for Smart Grid Technologies: Students will explore the integration of AI techniques with smart grid technologies such as advanced metering infrastructure (AMI), demand response systems, distributed energy resources (DERs), and energy storage systems. They will learn how AI can be used to optimize the management and control of smart grid components, improve energy efficiency, and support renewable energy integration.

CO5. Develop Predictive Maintenance Strategies using AI: Students will learn how to develop predictive maintenance strategies for power system assets using AI techniques such as machine learning, data analytics, and condition monitoring. They will gain practical experience in analyzing sensor data, detecting equipment failures, and optimizing maintenance schedules to minimize downtime and reduce operational costs.

Catalog Description

This course introduces students to the application of artificial intelligence (AI) techniques in the field of power systems engineering. The course covers a range of AI methodologies and their utilization in various aspects of power generation, transmission, distribution, and consumption. Students will gain hands-on experience with implementing AI algorithms to address real-world challenges in power systems operations, optimization, and maintenance.

Course Content

Unit 1 Introduction to AI **14 Lectures**

Definition, Applications, Components of an AI program production system. Problem Characteristics. Overview of searching techniques. Knowledge representation: Knowledge representation issues; and overview. Representing knowledge using rules; procedural versus declarative knowledge. Logic programming, forward versus backward reasoning, matching. Control knowledge.

Unit 2 Statistical Reasoning **8 Lectures**

Probability and Daye's theorem. Certainty factor and rule based systems. Baysian Networks, Dampster Shafer theorem. Semantic nets and frames, Scripts. Examples of knowledge based systems.

Unit 3 Pattern Recognition **10 Lectures**

Introduction, automatic pattern recognition scheme. Design Concepts, Methodologies, Concepts of Classifier, concept of feature selection. Feature selection based on means and covariances. Statistical classifier design algorithms; increment-correction and LMS algorithms. Applications.

Unit 4 Artificial Neural Networks **8 Lectures**

Biological Neuron, Neural Net, use of neural 'nets, applications, Perception, idea of single layer and multilayer neural nets, back propagation, Hopfield nets, supervised and unsupervised learning.

Expert Systems: Introduction. Study of some popular expert systems, Expert System building tools and Shells, Design of Expert Systems.

Text/Reference Books

1. ClArtificial Intelligence Techniques in Power Systems (Energy Engineering), by Kevin Warwick (Editor), Arthur Ekwue (Editor), Rag Aggarwal (Editor),1997

2. Artificial Intelligence Techniques in Power Systems Edited by Kevin Warwick, Arthur Ekwue, Rag Aggarwal

Reference Books

1. AI Application Areas in Power Systems, Iraj Dabbaghchi, American Electric Power Richard D. Christie, Gary W. Rosenwald, and Chen-Ching Liu, University of Washington

2. N.K. Bose, " Neural network fundamental with graph algorithm and application" by Tata McGraw hill 2002

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs		
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO1	**Understanding of AI Fundamentals:** Students should gain a solid understanding of the fundamental concepts, theories, and principles underlying artificial intelligence, including knowledge representation, problem-solving, search algorithms, and machine learning.	**PO1**
CO2	**Understand AI Fundamentals in the Context of Power Systems:** Students will develop a solid understanding of fundamental AI concepts, including machine learning, neural networks, deep learning, evolutionary algorithms, and expert systems, and learn how these techniques can be applied to solve problems specific to power systems engineering.	**PO2**
CO3	**Apply AI Techniques to Power Systems Optimization and Control:** Students will learn how to apply AI algorithms to optimize power grid operations, including load forecasting, energy scheduling, fault detection, and system control. They will explore case studies and simulation exercises to understand	**PO4**

	how AI techniques can enhance the efficiency, reliability, and resilience of power systems.	
CO4	**Implement AI-driven Solutions for Smart Grid Technologies:** Students will explore the integration of AI techniques with smart grid technologies such as advanced metering infrastructure (AMI), demand response systems, distributed energy resources (DERs), and energy storage systems. They will learn how AI can be used to optimize the management and control of smart grid components, improve energy efficiency, and support renewable energy integration.	**PO3**
CO5	**Develop Predictive Maintenance Strategies using AI:** Students will learn how to develop predictive maintenance strategies for power system assets using AI techniques such as machine learning, data analytics, and condition monitoring. They will gain practical experience in analyzing sensor data, detecting equipment failures, and optimizing maintenance schedules to minimize downtime and reduce operational costs.	**PO6**

		Engineering Knowledge	Problem analysis	Design/development of solutions	Conduct investigations of complex problems	Modern tool usage	The engineer and society	Environment and sustainability	Ethics	Individual or team work	Communication	Project management and finance
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
ETEE742A	AI TECHNIQUES	2	3	3	3				2		3	

1=weakly mapped
2= moderately mapped
3=strongly mapped

ETEE744A	INDUSTRIAL LOAD MODELLING AND CONTROL	L	T	P	C
Version 1.0		4	0	0	4
Pre-requisites/Exposure	Power Systems				
Co-requisites	--				

Course Objectives

1. To understand the energy demand scenario
2. To understand the modeling of load and its ease to study load demand industrially
3. To know Electricity pricing models
4. Study Reactive power management in Industries

Course Outcomes

On completion of this course, the students will be able to
CO1 Knowledge about load control techniques in industries and its application.
CO2 Different types of industrial processes and optimize the process using tools like LINDO and LINGO.
CO3 Apply load management to reduce demand of electricity during peak time.
CO4 Apply different energy saving opportunities in industries.

Catalog Description

Course Content

Unit I: **8 lecture hours**

Electric Energy Scenario-Demand Side Management-Industrial Load Management, Load Curves-Load Shaping Objectives-Methodologies, Barriers; Classification of Industrial Loads- Continuous and Batch processes -Load Modeling

Unit II: **8 lecture hours**

Electricity pricing – Dynamic and spot pricing –Models, Direct load control- Interruptible load control, Bottom up approach- scheduling- Formulation of load models- Optimization and control algorithms - Case studies.

Unit III: **12 lecture hours**

Reactive power management in industries-controls-power quality impacts application of filters Energy saving in industries. Cooling and heating loads- load profiling- Modeling, Cool storage-Types- Control strategies, Optimal operation-Problem formulation- Case studies.

Unit IV: **12 lecture hours**

Captive power units- Operating and control strategies- Power Pooling- Operation models, Energy banking-Industrial Cogeneration UNIT-V: Selection of Schemes Optimal Operating Strategies, Peak load saving-Constraints-Problem formulation- Case study, Integrated Load management for Industries.

Text Books

1. C.O. Bjork “Industrial Load Management - Theory, Practice and Simulations", Elsevier, the Netherlands,1989.
2. 2. C.W. Gellings and S.N. Talukdar, “Load management concepts,” IEEE Press, New York, 1986, pp. 3-28.

Reference Books/Materials

1. Y. Manichaikul and F.C. Schweppe ," Physically based Industrial load", IEEE Trans. on PAS, April 1981.
2. H. G. Stoll, "Least cost Electricity Utility Planning”, Wiley Interscience Publication, USA, 1989.
3. I.J.Nagarath and D.P.Kothari, .Modern Power System Engineering., Tata McGraw Hill publishers, New Delhi, 1995.
4. 4. IEEE Bronze Book- “Recommended Practice for Energy Conservation and cost effective planning in Industrial facilities”, IEEE Inc, USA.

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs		
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO1	Knowledge about load control techniques in industries and its application.	**PO1**
CO2	Different types of industrial processes and optimize the process using tools like LINDO and LINGO	**PO1,PO5**
CO3	Apply load management to reduce demand of electricity during peak time.	**PO3**
CO4	Apply different energy saving opportunities in industries.	**PO4**

		Engineering Knowledge	Problem analysis	Design/development of solutions	Conduct investigations of complex problems	Modern tool usage	The engineer and society	Environment and sustainability	Ethics	Individual or team work	Communication	Project management and finance
Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
ETEE 744A	**INDUSTRIAL LOAD MODELLING AND CONTROL**	3	3	3	3	3						

1=weakly mapped
2= moderately mapped
3=strongly mapped

ETEE743A	FACTS AND CUSTOM POWER DEVICES	L	T	P	C
Version 1.0		4	0	0	4
Pre-requisites/Exposure	Power Electronics and Power Systems				
Co-requisites	--				

Course Objectives

1. To study the performance of a Transmission Line with or without FACT Devices.
2. To study and compare SVC and STATCOM
3. To study Static series Compensation techniques
4. To study the operation of Unified Power Flow Controller.
5. To study mitigation of power quality issues using FACT devices.

Course Outcomes

On completion of this course, the students will be able to

CO1 Distinguish the performance of Transmission line with and without FACTS Devices

CO2: Compare the SVC and STATCOM

CO3: Understand the operation and control of various Static Series Compensators

CO4: Understand the operation and control of Unified Power Flow Controller

CO5: Distinguish various power quality issues and how are they mitigated by various FACTS Devices

Catalog Description

Course Content

Unit I: **8 lecture hours**

BASICS OF TRANSMISSION SYSTEM AND FACTS CONTROLLERS

Reactive power flow control in Power Systems – Control of dynamic power un-balances in Power System. Power flow control - Constraints of maximum transmission line loading – Benefits of FACTS Transmission line compensation.- Uncompensated line -Shunt compensation - Series compensation –Phase angle control. Reactive power compensation.- Shunt and Series compensation principles – Reactive compensation at transmission and distribution level .

Unit II: **8 lecture hours**

SVC AND STATCOM

Static versus passive VAR compensator, Static shunt compensators: SVC and STATCOM - Operation and control of TSC, TCR and STATCOM -Compensator control. Comparison between SVC and STATCOM.

Unit III:

STATIC SERIES COMPENSATION **14 lecture hours**

TSSC, SSSC -Static Voltage and phase angle regulators – TCVR and TCPAR Operation and Control –Applications, Static series compensation – GCSC, TSSC, TCSC and their Control.

UNIFIED POWER FLOW CONTROLLER :

SSR and its damping Unified Power Flow Controller: Circuit Arrangement, Operation and control of UPFC. Basic Principle of P and Q control- Independent real and reactive power flow control- Applications.

Unit IV: **10 lecture hours**

INTERLINE POWER FLOW CONTROLLER:

Introduction to interline power flow controller. Modeling and analysis of FACTS Controllers – Simulation of FACTS controllers Power quality problems in distribution systems, harmonics. Loads that create harmonics, modeling, harmonic propagation, series and parallel resonances, mitigation of harmonics, passive filters, active filtering– shunt, series and hybrid and their control.

POWER QUALITY ISSUES:

Voltage swells, sags, flicker, unbalance and mitigation of these problems by power line conditioners- IEEE standards on power quality.

Text Books

1. K R Padiyar, FACTS Controllers in Power Transmission and Distribution, New Age International Publishers, 2007.
2. N.G. Hingorani, L. Gyugyi, Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems, IEEE Press Book, Standard Publishers and Distributors, Delhi, 2001.

Reference Books/Materials

1. X P Zhang, C Rehtanz, B Pal, “Flexible AC Transmission SystemsModellingandControl”, Springer Verlag, Berlin, 2006.
2. 2. K.S.Suresh Kumar, S.Ashok, “FACTS Controllers & Applications”, E-book edition, Nalanda Digital Library, NIT Calicut, 2003.
3. 3. G. THeydt, “Power Quality”, McGraw-Hill Professional, 2007.

Modes of Evaluation: Quiz/Assignment/ presentation/ extempore/ Written Examination
Examination Scheme:

Components	Quiz	Attendance	Mid Term Exam	Presentation/ Assignment/ etc.	End Term Exam
Weightage (%)	10	10	20	10	50

Relationship between the Course Outcomes (COs) and Program Outcomes (POs)

Mapping between COs and POs		
	Course Outcomes (COs)	**Mapped Program Outcomes**
CO1	Distinguish the performance of Transmission line with and without FACTS Devices	**PO1**
CO2	Compare the SVC and STATCOM	**PO1,PO2**
CO3	Understand the operation and control of various Static Series Compensators	**PO1**
CO4	Understand the operation and control of Unified Power Flow Controller	**PO1**
CO5	Distinguish various power quality issues and how are they mitigated by various FACTS Devices	**PO3**

		Engineering Knowledge	Problem analysis	Design/development of solutions	Conduct investigations of complex problems	Modern tool usage	The engineer and society	Environment and sustainability	Ethics	Individual or team work	Communication	Project management and finance

Course Code	Course Title	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
ETEE743A	**FACTS AND CUSTOM POWER DEVICES**	3	2	2								

1=weakly mapped
2= moderately mapped
3=strongly mapped