SEMESTER 5

ELECTRICAL AND ELECTRONICS ENGINEERING

SEMESTER S5

POWER GENERATION, TRANSMISSION AND PROTECTION

Course Code	**PCEET501**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:1:0:0	**ESE Marks**	60
Credits	4	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	PCEET302	**Course Type**	Theory

Course Objectives:

1. To deliver fundamental concepts in power system components.
2. To deliver basic idea of power generation, transmission and protection.
3. To introduce new topics to students like energy storage systems and deregulated systems.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Generation from renewable and non-renewable sources – Hydro, thermal, nuclear- (block schematic details, environmental and ethical factors, advantages, disadvantages) Solar and wind - (block schematic details, environmental factors, regulations, advantages, disadvantages) Energy storage systems as alternative energy sources – BESS, CESS, thermal SS Load curve – Load duration curve, Load factor, diversity factor, demand factor, Plant capacity factor, plant use factor - Numerical Problems	**11**
2	Power Transmission System - (Electrical Model)- Line parameters – resistance - inductance and capacitance (Derivation of three phase double circuit) Transmission line modelling - classifications (concept only) – transmission line as two port network – derivation and calculation of ABCD parameters (derivation and numerical problems)	**11**

	Skin Effect & Ferranti Effect – Corona (qualitative study only) – Surge Impedance Loading Insulators – string efficiency – grading (numerical problems	
3	Introduction to EHVAC and HVDC: Principle, advantages/disadvantages Underground cables – ratings - classification - Capacitance of cables – grading – 2 types AC Distribution systems – connection schemes – radial and ring main systems – single phase only (numerical problems) Method of power factor improvement using capacitors (numerical problems) Tariff - different types Introduction to energy markets (regulated and deregulated systems)	**11**
4	Need for protection- Types of protection schemes – primary and back-up Protective relays – Basics of typical electromechanical relay – induction type only Static (block diagrams of o/c and instantaneous o/c relays) Microprocessor (block diagram and flow chart of o/c relay) Fundamentals of Numerical relay Principles of overcurrent, directional, distance and differential Circuit breakers – operating principle – arc phenomenon – arc extinction – principle & methods – Important terms in arc extinction Problems of circuit interruption – capacitive current chopping – ratings of CBs Circuit breaker classification based on medium of arc extinction – SF6 & VCB Introduction to GIS	**11**

Note: Visit to a nearby substation, identify the components and prepare a report.

Additional topics:

1) *Calculation of Sag and tension in transmission lines*
2) *Introduction to Machine Learning in Power System Protection – Insulation co-ordination*
3) *Overview of Communication: PLCC - Fibre Optic - Introduction to IEC61850*

Course Assessment Method
(CIE: 40 marks,ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Learn different types of power generating systems and schedule generation appropriate fora given area.	**K3**
CO2	Evaluate the electrical performance of any transmission line.	**K3**
CO3	Compute various physical characteristics of overhead and underground transmission systems.	**K3**
CO4	Demonstrate the working of relays and switch gear for protection schemes.	**K2**
CO5	Design a simple ac electrical distribution system as per the standards.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3			2					3
CO2	3	3	3	3								3
CO3	3	3	3	3								3
CO4	3	3	3	3								3
CO5	3	3	3	3								3

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Electrical Power Systems	Wadhwa C. L.	New Age International	8th edition 2023
2	Principles of Power System	V. K. Mehta and Rohit Mehta	S. Chand	4th edition reprint 2020
3	Power System Protection and Switchgear	Badri Ramand D.N.Viswakarma	Tata McGraw Hill	2nd edition, 2011
4	Non-conventional energy sources	B. H. Khan	Tata McGraw Hill	3rd edition, 2017

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Engineering and Chemical Thermodynamics	Milo D. Koretsky	Wiley	2ndEdn, 2012
2	Chemical and Process Thermodynamics	Kyle B.G.	Pearson	3rdEdn, 2015

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/103/103/103103144/
2	https://archive.nptel.ac.in/courses/103/103/103103144/
3	https://archive.nptel.ac.in/courses/103/103/103103144/
4	https://archive.nptel.ac.in/courses/103/103/103103144/

SEMESTER S5

ELECTROMAGNETIC THEORY

Course Code	PCEET502	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:1:0:0	ESE Marks	60
Credits	4	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	GBMAT201	Course Type	Theory

Course Objectives:

1. To familiarize the students with the fundamentals of electrostatics, magnetostatics, time-varying fields and electromagnetic waves.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Mathematical Preliminaries :** Rectangular, Cylindrical and Spherical Coordinate Systems - Representation of Point, Unit vector, Vector, Constant surfaces, Transformation of points, unit vectors and vectors among the three coordinate systems - Transformation matrices, Del operator - Representation in the three coordinate systems, Gradient of scalar field - Physical meaning of gradient, Divergence of a vector field - Physical significance of divergence - Divergence Theorem -, Curl of a vector field - Physical significance of curl - Stoke's Theorem **Electrostatic Fields :** Coulomb's Law, Electric Field Intensity, Force and Field due to system of charges, Gauss's Law - integral form, Electric Flux Density, Field due to line of charge, surface and volume charge distributions.	11
2	**Electrostatic Fields in material media :**Gauss's law - point form, Electric potential, Relation between E and V, Field due to electric dipole, Energy density in static electric fields, Conduction and Convection Current, Ohm's law in point form, Resistance,	11

	Capacitance of parallel plate capacitor, Coaxial and Spherical capacitors, Continuity equation, Boundary conditions, Poisson's and Laplace's Equations (solution not required) **Magnetostatics :** Biot Savart's Law, Ampere's Circuital Law in integral and point form, Magnetic field due to infinite line current, infinite sheet of current, Coaxial cable, Non conservativeness of magnetic field, Magnetic scalar potential, Magnetic vector potential.	
3	**Magnetostatics in Material Media :**Force on a charged particle due to a magnetic field, Force between two current carrying conductors, Magnetic Torque and Moment, Magnetization in materials, Magnetic boundary conditions, Inductance, Energy stored in magnetostatic fields. **Electromagnetic Induction and Maxwell- Heaviside Equations:** Faraday's law, Transformer emf and Motional emf, Displacement Current, Maxwell-Heaviside equations.	**10**
4	**Electromagnetic Waves :**Time varying potentials, Waves in general, Electromagnetic waves, Wave propagation in lossy dielectrics, Plane waves in free space, conductors, skin effect, Power, Poynting theorem, Reflection of plane wave at normal incidence. **Transmission Lines:** Transmission line equations, Characteristic impedance, Input impedance, Standing wave ratio.	**10**
Additional topics (not for ESE evaluation)	Numerical procedures for solving Laplace's and Poisson's equation, Method of images, Force on magnetic materials, Magnetic levitation, Wireless power transfer, Microstrip lines	

** - Detailed mathematical treatment of Gradient, Divergence and Curl has been taught in Second Semester Mathematics in Vector Calculus. Hence an overview with electromagnetic theory perspective is sufficient. However, a couple of remedial classes may be provided to lateral entry students to cover the basics of Differentiation, Integration and Vector Calculus*

Demonstrations for coordinate systems and gradient, divergence and curl may be done using mathematical sketching softwares like GeoGebra, Geometer's sketchpad etc.

Demonstration of fields, integrals and derivatives can be done using high end softwares like Scilab/ Matlab / Octave and low end softwares like maxima.

Assignments can be software based wherever possible.

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination-2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Apply vector calculus in Electricity and Magnetism.	**K3**
CO2	Compute electric and magnetic fields in different media	**K3**
CO3	Deduce the Maxwell-Heaviside Equations from the basic laws of electricity and magnetism	**K3**
CO4	Predict the production of electromagnetic waves with electric and magnetic fields	**K4**
CO5	Demonstrate the propagation of electromagnetic excitations in transmission lines	**K4**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3			2	3						2
CO2	3	3			2	3						2
CO3	3	3			2	3						2
CO4	3	3			2	3						2
CO5	3	3			2	3						2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Elements of Electromagnetics	Mathew N O Sadiku	Oxford University Press	7th Edition, 2018
2	Engineering Electromagnetics	William H Hayt Jr, John A Buck	Tata McGraw Hill	9th Edition, 2018

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Introduction to Electrodynamics	David J Griffiths	Cambridge University Press	4th Edition, 2017
2	Electromagnetics	John D Kraus, Keith R Carver	Tata McGraw Hill	2nd Edition, 1981

Books for Further Reading				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Div, Curl, Grad and All That	H M Schey	W W Norton and Company	Fourth Edition, 2005
2	Basic Laws of Electromagnetism	I E Irodov	Mir Publishers	1983
3	Lectures on Physics, Volume II	Righard P Feynman	Narosa	2005

SEMESTER S5

SIGNALS AND SYSTEMS

Course Code	**PCEET503**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Mathematics for Electrical Science	**Course Type**	Theory

Course Objectives:

1. To introduce time domain and frequency domain representation of continuous and discrete time signals and perform various mathematical operations
2. To introduce various types of signals and systems
3. To introduce time domain and frequency domain representation of continuous and discrete time systems.
4. To familiarize mathematical modelling of dynamic systems and analyze it's stability

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to Signals and Systems:** Elementary Signals, Classification and representation of continuous time and discrete time signals, Signal operations. (3 hours) Concept of system: Continuous time and discrete time systems; Properties of systems: Time invariance, Linearity, Causality, Systems with and without memory, Stability. (3 hours) Convolution Integral and sum. (2 hours) Impulse and step response. (1 hour)	9

2	**Frequency domain characterization of Signals and Systems:** *Fourier transform:* Existence - Properties of Continuous time Fourier transform; Concept of Frequency response; Significance of Fourier transform and difference from Fourier series. (3 hours) Review of Laplace Transforms. *Characterization of LTI systems:* Differential equation representation of continuous time LTI systems. Transfer function representation of differential equation in Laplace domain. (2 hours) *Modeling of LTI systems:* Electrical, translational and rotational mechanical systems, DC servo-motor; Force voltage, Force current analogy. (4 hours)	**9**
3	**Sampled Data Systems and Z-Transform:** Sampling process - Impulse train sampling-sampling theorem- Aliasing effect. (2 hour) Zero-order and First-order hold circuits - Signal reconstruction. (2 hours) *Z-Transform:* Region of convergence- Properties of Z-Transform Inverse Z-Transform. Pulse transfer function. Difference equations representation using Z-transform and it's solution using inverse Z-Transform. (3 hours) Impulse and step response of discrete-time systems. (3 hours)	**10**
4	**Dynamic System Representation and Stability:** Open loop and closed loop systems. Effect of feedback in systems. Block diagram representation - block diagram reduction. Signal flow graph - Mason's gain formula. (5 hours) Type and Order of the systems - Pole-Zero representation of systems. Characteristic equation. Routh stability criterion. (3 hours)	**8**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Micro project	Internal Examination-1 (Written)	Internal Examination-2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	To represent continuous and discrete time signals in time domain and perform various mathematical operations	**K2**
CO2	To represent continuous time signals and systems in frequency domain	**K3**
CO3	To represent discrete time signals and systems in Z-domain.	**K3**
CO4	To analyse the stability of continuous time dynamical systems	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	2	1	3	3	3			3	2
CO2	3	3	2	2	2	3	3	3			3	2
CO3	3	3	2	2	2	3	3	3			3	2
CO4	3	3	2	2	2	3	3	3			3	2
CO5												

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Signals and Systems	Simon Haykin, Barry Van Veen	Wiley	2nd Edition, 2007
2	Discrete Time Control Systems	Katsuhiko Ogata	Pearson	2nd Edition, 2006
3	Control Systems Engineering	Norman S. Nise	Wiley	5th Edition, 2009

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Signals and Systems	Oppenheim A.V., Willsky A.S. & Nawab S.H.	Prentice Hall	2nd Edition, 2015
2	Modern Control Systems	Dorf R. C., Bishop R. H	Pearson Education India	12th Edition, 2013
3	Digital Signal Processing Principles	John G. Proakis& Dimitris G.Manolakis	Prentice Hall	4th Edition, 2007

SEMESTER S5

MICROPROCESSORS AND EMBEDDED SYSTEMS

Course Code	**PBEET504**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:1	**ESE Marks**	60
Credits	4	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	PBEET304, PBEET404, GBEST204	**Course Type**	Theory

Course Objectives:

1. This course aims to design and implement Embedded Systems using latest microprocessors / Microcontroller based boards.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to microprocessors**- Features and Architecture of 8085- Registers of 8085 - Flags - 8085 Pin diagram- Pins, Signals and functions - Assembly language programming- Basic Instruction set to write Simple programs - Arithmetic, Logical, Branching instructions, Opcodes, hand coding, Programs involving 8 and 16bit Addition, Subtraction, Memory Reading and writing, Sorting – Addressing modes-Classification of instructions.	**12**
2	**Stack and Subroutines** – CALL and RETURN instructions –Timing and control – Machine cycles, instruction cycle and T states – fetch and execute cycles –Timing diagram for instructions- Delay subroutines – Interrupts- Interrupt service Routines- Interfacing ADC and DAC	**10**
3	**Introduction to Embedded Systems**-Application domain, features and characteristics, Microprocessors and Micro controllers– Choice and suitability for applications	**12**

	Introduction to Arduino UNO(8bit)- Hardware fundamentals of ATmega328Pmicrocontroller based Board. Arduino Architecture, Pin diagram and functions of Pins- Overview of main features such as I/O Ports, Timers, interrupts, PWM, ADC (Introduction only). Introduction to Arduino IDE- Arduino Libraries, Steps for creating an Arduino program- Arduino Sketch Structure and Flow- Setup and loop functions. Programming in Embedded C. Data types- operators, conditional statements- Loops, Arrays and functions- Built in functions in Arduino - Program to blink an LED and its control., Interfacing LCD, Seven Segment LED, switch Interface, Binary counter Working with LED Controlled by Switch/ Potentiometer, Interfacing with Relays, Buzzer, Working with Basic sensors and actuators using Arduino.	
4	**ARM (Advanced RISC Machines) based Embedded System Design**: Classification of Microprocessors based on the word length, architecture and Instruction Set- Reduced Instruction Set Computer (RISC) and Complex Instruction Set Computer (CISC). Features and characteristics **Introduction to Arduino due(32bit)**- micro controller board (based on the atmel sam3x-- arm cortex- m3 cpu)- Features, General Specifications Overview, General architecture- Features OF Microcontroller, INPUTS,OUTPUTS, Ratings, Functional Overview, Pinout- familiarization of the ports of the board. Programming Basics- Arduino IDE-Use of Timer, Interfacing of ADC and DAC -PWM implementation – Introduction to Arduino Cloud Editor	**10**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination-2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Describe the architecture of 8085 microprocessor and 8085 Assembly language programming.	**K2**
CO2	Understand the need for interrupts, Subroutines, timing diagram of 8085 microprocessor and interfacing	**K2**
CO3	Understand and gain the basic idea about the embedded system and selection of processors.	**K2**
CO4	Able to gain working level knowledge about a Arduino Uno based system architecture and Arduino IDE	**K2**
CO5	Write Programs using Embedded C and implement an application using Arduino UNO board.	**K3**
CO6	Understand the RISC Architecture and Apply the knowledge for solving the real life problems using ARM - Arduino DUE board based embedded system.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2										
CO2	3	2	3	3	2	1						
CO3	3	2	2	2	2							
CO4	3	2										1
CO5	3	2	3	2	1	1						1
CO6	3	2	3	2	1	1						1

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Fundamentals of *Microprocessor* and *Micro controllers*	*Ram*, *B.DHANPAT*	Rai Publications (P) Ltd.-New Delhi	
2	Microprocessor, Architecture, Programming and Applications	Ramesh Gaonkar	Penram International Publishing;	Sixth edition, 2014.
3	Arduino Cookbook"	Michael Margolis,	O'Reilly Media, Inc.	1st Edition
4	Microprocessor Theory and Application	Rafiquzzaman	PHI Learning	First Edition

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Arduino-Based Embedded Systems	Rajesh Singh, Anita Gehlot,Bhupendra Singh, and Sushabhan Choudhury		
2	Arduino for beginners: Essential Skills Every Maker Needs"	John Baichtal	Person Education	
3	Arduino Made Simple	Ashwin Pajankar		
4	Embedded C, Pont	Michael J		
5	Programming Arduino Next Steps: Going Further with Sketches	Simon Monk		
6	Arduino: A Technical Reference by	J.M. Hughes	O'Reilly Media, Inc. ISBN: 9781491934494	
7	Arduino Workshop: A Hands-On Introduction with 65 Projects	John ***Boxall***		
8	Exploring Arduino: Tools and Techniques for Engineering Wizardry	Jeremy Blum WILEY		

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc20_ee42/preview
2	https://onlinecourses.nptel.ac.in/noc20_ee42/preview
3	https://onlinecourses.nptel.ac.in/noc20_ee42/preview https ://www.arduino.cc/en/Tutorial/HomePage
4	https://onlinecourses.nptel.ac.in/noc20_ee42/preview https://docs.arduino.cc/hardware/due/

SEMESTER S5

ENERGY STORAGE SYSTEMS

Course Code	PEEET521	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	NIL	Course Type	Theory

Course Objectives:

1. To introduce the importance and application of energy storage systems.
2. To familiarize with different energy storage technologies.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Need and role of energy storage systems in power system, General considerations, Energy and power balance in a storage unit, Mathematical model of storage system: modelling of power transformation system (PTS)-Central store (CS) and charge–discharge control system (CDCS), Econometric model of storage system. Thermal energy: General considerations -Storage media- Containment- Thermal energy storage in a power plant, Potential energy: Pumped hydro-Compressed Air.	9
2	Kinetic energy: Mechanical- Flywheel, Power to Gas: Hydrogen- Synthetic methane. Electro chemical energy: Batteries-Battery parameters: C-rating– SoC – DoD -Specific Energy- Specific power (numerical examples), Fuel cells, Electrostatic energy (Super Capacitors), Electromagnetic energy (Superconducting Magnetic Energy Storage), Comparative analysis, Environmental impacts of different technologies.	9

3	Types of renewable energy sources: Wave - Wind – Tidal – Hydroelectric - Solar thermal technologies and Photovoltaics, Storage role in isolated power systems with renewable powersources, Storage role in an integrated power system with grid-connected renewablepowersources.	**9**
4	Smart grid, Smart micro grid, Smart house, Mobile storage system: Electric vehicles – Grid to Vehicle (G2V)-Vehicle to Grid (V2G), Management and control hierarchy of storage systems. Aggregating energy storage systems and distributed generation (Virtual Power Plant Energy Management with storage systems), Battery SCADA, Hybrid energy storage systems: configurations and applications.	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination-2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Identify the role of energy storage in power systems.	**K3**
CO2	Classify thermal, kinetic and potential energy storage systems and their applications.	**K3**
CO3	Compare electrochemical, electrostatic and electromagnetic storage technologies.	**K3**
CO4	Illustrate energy storage technology in renewable energy integration.	**K2**
CO5	Summarise energy storage technology applications for smart grids.	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1					1					
CO2	3	1					1					
CO3	3	1					1					
CO4	3	1					1					
CO5	3	1					1					

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Energy Storage for Power Systems	A.G.Ter-Gazarian	The Institution of Engineering and Technology (IET)Publication,UK,	Second Edition, 2011
2	Energy Storage in Power Systems	Francisco Díaz-González, Andreas Sumper, Oriol Gomis-Bellmunt	Wiley Publication	2016.

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Electricity Energy Storage Technology Options: A White Paper Primer on Applications, Costs, and Benefits	D. Rastler	Electric Power Research Institute (USA)	Technical Update, December 2010
2	The Role of Energy Storage with Renewable Electricity Generation	Paul Denholm, Erik Ela, Brendan Kirby and Michael Milligan	National Renewable Energy Laboratory (NREL)	January 2010
3	Electrical energy management of virtual power plants in distribution networks with renewable energy resources and energy storage systems	P. Nezamabadi and G. B. Gharehpetian	IEEE Power Distribution Conferenc	2011

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://www.youtube.com/watch?v=o6Afp-MI_tQ&list=PLLy_2iUCG87AjWoOk0A3y4hpGQVTdtl6G&index=12 (NPTEL lecture IIT Roorkee)
2	https://www.youtube.com/watch?v=yar51GJVqgg (NPTEL lecture IIT Guwahati)
3	https://www.youtube.com/watch?v=frWxC5KL8kE (NPTEL lecture IIT Guwahati)
4	https://www.youtube.com/watch?v=AZIS_MCw8Qc (NPTEL lecture IIT Kanpur)

SEMESTER S5

ELECTRIC VEHICLES

Course Code	**PEEET522**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	2:1:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	PCEET303, PCEET304 PCEET403	**Course Type**	Theory

Course Objectives:

1. Familiarise the various characteristics of conventional vehicles and compare them with electric vehicles
2. Analyse the various drive train topologies for electric vehicles
3. Discuss the propulsion unit for electric vehicles
4. Analyse the various energy storage systems and energy management strategies
5. Selection of drive systems and study of various communication protocols for EV

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Conventional Vehicles**: Basics of vehicle performance, Vehicle power source characterization, Transmission characteristics (1hr). **Introduction to Electric Vehicles**: History of electric vehicles, Classification of electric vehicles. Overview of EV challenges. Overview of EV technologies-motor drive technology , energy source technology , battery charging technology , vehicle-to-grid technology(2hr) **Vehicle Dynamics & Load Forces:**Mathematical models to describe vehicle performance, vehicle load forces: aerodynamic drag,rolling resistance, grading resistance, vehicle acceleration, Calculation of motor power from traction torque, Numerical problems. (4 hrs)	**9**

	Electric Drive-trains: Basic concept of electric traction, Introduction to various electric drive-train topologies, Power flow control in electric drive-train topologies, Fuel efficiency analysis.(2 hrs)	
2	**DC Drives:**Motoring using a PM DC Machine - DC motor electric drive using DC-DC converter - Generating/Braking using a PM DC Machine. (3hrs) **PMSM Drives**: Review of PMSM motor basics – Independent control of orthogonal flux and torque (concept only)- Field Oriented Control (FOC) – Sensored and sensorless control (block diagram only). (4hrs) **Sizing the drive system**: Matching the electric machine and the Internal Combustion Engine (ICE) ,Sizing the propulsion motor, Sizing the power electronics-Switch technology selection,Ripple capacitor design, Switching frequency and PWM. (2hrs)	**9**
3	**Battery based energy storage systems**: Types of battery-battery parameters-units of battery energy storage - capacity rate, - cell voltage - specific energy - cycle life - self-discharge- static battery equivalent circuit model - series-parallel battery pack equivalent circuits.(3hrs) **Other storage topologies**: Fuel Cell based energy storage systems- Supercapacitors- Flywheel- Hybridization of different energy storage devices. (2 hrs) **Sizing considerations of battery** -Time and charge/discharge cycles - Lifetime – Beginning of life (BOL) - End of life (EOL) - DOD - Efficiency of Battery Pack - Determination of pack Voltage, range for EV - Determination of Cell/Pack Voltage for a Given Output\Input Power. Battery management system, Numerical problems.(4hrs)	**9**
4	**Overview of Electric Vehicle Battery Chargers**–Types of chargers-On-board chargers, Off- board chargers, Wireless charger. Electric Vehicle Supply Equipment (EVSE) - Grid to EVSE to On-board chargers to battery pack power flow block schematic diagrams – V2G concept(3hrs)	**9**

	Types of charging stations - AC Level 1 & 2, DC - Level 3 -Types of Connectors - CHAdeMO, CCS Type1 and 2, GB/T - PIN diagrams and differences (2hrs) **Autonomous Vehicles**: Levels of automation, significance, functional architecture-sensors, actuators, path planning& effects of automation in vehicles (2hrs) **Vehicle Communication protocols** : Need & requirements - Functions of Control Pilot (CP) and Proximity Pilot (PP) pins, Communication Protocols - CAN, LIN, FLEXRAY (Basics only)- Power line communication (PLC) in EV (2 hrs)	

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination-2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Familiarise the performance of conventional vehicles and electric vehicles	**K2**
CO2	Analyse the various drive train topologies for electric vehicles	**K3**
CO3	Discuss the propulsion unit for electric vehicles and selection of drive systems	**K3**
CO4	Analyse the various energy storage systems and energy management strategies	**K3**
CO5	Study of chargers, charging stations and various communication protocols for EV	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3											3
CO2	3		2									3
CO3	3		2									3
CO4	3		2									3
CO5	3											3

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Electric Vehicles Machines and Drives- Design, Analysis and Application	K. T. Chau	John Wiley	2015
2	Propulsion Systems for Hybrid Vehicles	John M. Miller	The Institution of Engineering and Technology, London, United Kingdom	2010
3	Hybrid Electric Vehicles – Principles and applications with practical perspectives	Chris Mi, M A Masrur, D W Gao	Wiley	2011

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Modern Electric, Hybrid and Fuel Cell Vehicles: Fundamentals, Theory and Design	Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay	CRC Press	
2	Permanent Magnet Synchronous and Brushless DC Motors Drives	R. Krishnan	CRC Press	
3	Electric and Hybrid Vehicles: Design Fundamentals	Iqbal Hussein	CRC Press	2003

SEMESTER S5

DIGITAL SYSTEM DESIGN

Course Code	PEEET523	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)		Course Type	PE -Theory

Course Objectives:

1. To acquire knowledge about Asynchronous and clocked Synchronous sequential circuit design.
2. To detect the faults and hazards in digital circuit design
3. To design and implement digital circuits using VHDL.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Clocked Synchronous Networks, Analysis of Clocked Synchronous Sequential Networks (CSSN), Modelling of CSSN, State assignment and reduction, Design of CSSN.	10
2	ASM Chart and its realization. Asynchronous Sequential Circuits, Analysis of Asynchronous Sequential Circuits (ASC), Flow table reduction, Races in ASC, State assignment problem and the transition table.	10
3	Hazards – static and dynamic hazards in combinational networks, Essential Hazards, Design of Hazard free circuits, Data synchronizers, Mixed operating mode asynchronous circuits, Practical issues- clock skew and jitter, Synchronous and asynchronous inputs.	8

	Faults: Fault table method – path sensitization method – Boolean difference method.	
4	VLSI Design flow: Design entry: Schematic, Data types and objects, different modelling styles in VHDL - Dataflow, Behavioural and Structural Modelling. VHDL constructs and codes for combinational and sequential circuits.	**8**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Micro project	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
● 2 Questions from each module. ● Total of 8 Questions, each carrying 3 marks **(8x3 =24 marks)**	● Each question carries 9 marks. ● Two questions will be given from each module, out of which 1 question should be answered. ● Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Analyze asynchronous and clocked synchronous sequential circuits	**K3**
CO2	Design hazard-free digital circuits	**K3**
CO3	Identify faults in digital circuits	**K3**
CO4	Apply VHDL programming in digital system design	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3								3
CO2	3	2	2	2								3
CO3	3	3	2		2							3
CO4	3	3	3	3	3							3

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Digital Principles & Design	Donald G Givone	Tata McGraw Hill	1/e 2002
2	Digital Design with an introduction to HDL, VHDL and Verilog	M.Morris Mano and Michel.D.Ciletti	Pearson education	6/e, 2018
3	Digital Design	John F Wakerly	Pearson Education	4/e 2008
4	Digital Logic Applications and Design	John M Yarbrough	Cengage India	1/e 2006

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Digital Systems Testing and Testable Design	Miron Abramovici, Melvin A. Breuer and Arthur D. Friedman	John Wiley & Sons Inc	
2	Logic Design Theory	N. N. Biswas	PHI	
3	Introduction to Digital Design Using Digilent FPGA Boards	Richard E. Haskell, Darrin M. Hanna	LBE Books- LLC	
4	Digital Circuits and Logic Design	Samuel C. Lee	PHI	
5	Digital System Design Using VHDL	R. Anand	Khanna Book Publishing Company	
6	Digital System Design using VHDL	Charles Roth	TMH	

SEMESTER S5

SOFTWARE ENGINEERING

Course Code	**PEEET524**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None/ (Course code)	**Course Type**	Theory

Course Objectives:

1. Provides fundamental knowledge in the Software Development Process which covers Software Development, and Project Management concepts.
2. Enables the learners to apply state of the art industry practices in Software development.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to Software Engineering:** Introduction to Software Engineering - Professional software development, Software engineering ethics. Software process models - The waterfall model, Incremental development. Process activities - Software specification, Software design and implementation, Software validation, Software evolution. Coping with change - Prototyping, Incremental delivery, Boehm's Spiral Model. Agile software development - Agile methods, agile manifesto - values and principles. Agile development techniques, Agile Project Management. Case studies : An insulin pump control system. Mentcare - a patient information system for mental health care.	**8**
2	**Requirement Analysis and Design:** Functional and non-functional requirements, Requirements engineering processes. Requirements elicitation, Requirements validation, Requirements change, Traceability Matrix. Developing use cases, Software Requirements Specification Template, Personas, Scenarios, User stories, Feature identification. Design concepts - Design within the context of software engineering,	**10**

	Design Process, Design concepts, Design Model. Architectural Design - Software Architecture, Architectural Styles, Architectural considerations, Architectural Design Component level design - What is a component?, Designing Class-Based Components, Conducting Component level design, Component level design for web-apps.	
3	**Implementation and Testing (12 hours)** Object-oriented design using the UML, Design patterns, Implementation issues, Open-source development - Open-source licensing - GPL, LGPL, BSD. Review Techniques - Cost impact of Software Defects, Code review and statistical analysis. Informal Review, Formal Technical Reviews, Post-mortem evaluations. Software testing strategies - Unit Testing, Integration Testing, Validation testing, System testing, Debugging, White box testing, Path testing, Control Structure testing, Black box testing, Testing Documentation and Help facilities. Test automation, Test-driven development, Security testing. Overview of DevOps and Code Management - Code management, DevOps automation, CI/CD/CD. Software Evolution - Evolution processes, Software maintenance.	**12**
4	**Software Project Management:** Software Project Management - Risk management, Managing people, Teamwork. Project Planning, Software pricing, Plan-driven development, Project scheduling, Agile planning. Estimation techniques, COCOMO cost modeling. Configuration management, Version management, System building, Change management, Release management, Agile software management - SCRUM framework. Kanban methodology and lean approaches.	**8**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination-2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Interpret software process models and core activities, including handling changes with techniques like prototyping and incremental delivery.	**K2**
CO2	Describe agile methods, including the Agile Manifesto and agile project management practices.	**K2**
CO3	Prepare Software Requirement Specification and Software Design for a given problem	**K3**
CO4	Interpret object-oriented design principles, design patterns, software testing methods (including unit testing, integration testing, and test automation), and open-source licensing models (such as GPL, LGPL, and BSD).	**K2**
CO5	Describe software review techniques, DevOps practices and code management principles, and software evolution processes and maintenance strategies.	**K2**
CO6	Make use of software project management concepts while planning, estimation, scheduling, tracking and change management of a project, with proper application of SCRUM, Kanban and Lean frameworks.	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3						3				3
CO2	3	3										3
CO3	3	3	3							3		3
CO4	3	3	3									3
CO5	3	3							3			3
CO6	3	3							3		3	3

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Software Engineering	Ian Sommerville	Pearson Education	Tenth edition, 2015
2	Software Engineering : A practitioner's approach	Roger S. Pressman	McGraw Hill publication	Eighth edition, 2014
3	Engineering Software Products: An Introduction to Modern Software Engineering	Ian Sommerville	Pearson Education	First Edition, 2020

Reference Books

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Kanban	David J. Anderson	Blue Hole Press	2010
2	Agile Management for Software Engineering	David J. Anderson	Pearson	2003
3	Software Project Management : A unified framework	Walker Royce	Pearson Education	1998
4	Implementing Lean Software Development: From Concept to Cash	Mary Poppendieck	Addison-Wesley Signature Series	2006

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/106105182
2	https://nptel.ac.in/courses/106105182
3	https://nptel.ac.in/courses/106105182
4	https://nptel.ac.in/courses/106105218

SEMESTER S5

DATA STRUCTURES

Course Code	**PEEET526**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	UCEST105, GBEST204	**Course Type**	Theory

Course Objectives:

1. To impart a thorough understanding of linear data structures such as arrays, stacks, queues and linked lists and their applications.
2. To impart a thorough understanding of non-linear data structures such as trees, graphs and their applications.
3. To impart familiarity with various sorting, searching and hashing techniques and their performance comparison.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Basic Concepts of Data Structures: Algorithms, Performance Analysis, Space Complexity, Time Complexity, Asymptotic Notations Arrays: Linear Search and Binary Search, Stacks, Queues-Circular Queues, Priority Queues, Double Ended Queues, Evaluation of Expressions	**11**
2	Linked List: Self-Referential Structures, Dynamic Memory Allocation, Singly Linked List- Operations on Linked List. Doubly Linked List, Circular Linked List, Stacks and Queues using Linked List, Polynomial representation using Linked List	**11**

3	Trees and Graphs: Trees, Binary Trees-Tree Operations, Binary Tree Representation, Tree Traversals, Binary Search Trees- Binary Search Tree Operations Graphs, Representation of Graphs, Depth First Search and Breadth First Search on Graphs, Applications of Graphs	**11**
4	Sorting and Hashing: Sorting Techniques – Selection Sort, Insertion Sort, Quick Sort, Merge Sort and Heap Sort Hashing- Hashing Techniques, Collision Resolution, Overflow handling, Hashing functions – Mid square, Division, Folding, Digit Analysis	**11**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination-2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Compare performance of algorithms using asymptotic notations	**K2**
CO2	Solve real world problems efficiently using appropriate data structures like arrays, linked list, stacks and queues.	**K3**
CO3	Make use of nonlinear data structures like trees and graphs to design algorithms for various applications.	**K3**
CO4	Apply and compare various techniques for searching and sorting.	**K3**
CO5	Apply appropriate hash function to store and access a given dataset	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	2	2	1	-	1	-	-	-	-	-	-
CO2	3	2	3	1	-	1	-	-	-	-	-	-
CO3	3	2	3	1	-	1	-	-	-	-	-	-
CO4	2	2	3	1	-	1	-	-	-	-	-	-
CO5	3	2	2	1	-	1	-	-	-	-	-	-

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Fundamentals of Data Structures in C	Ellis Horowitz,SartajSahni and Susan Anderson-Freed	Universities Press	
2	Classic Data Structures	Samanta D	Prentice Hall India	2/e, 2009

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Data Structures: A Pseudocode Approach with C	Richard F. Gilberg, Behrouz A. Forouzan	Cengage Learning	2/e, 2005
2	Data Structures and Algorithms	Aho A. V., J. E. Hopcroft and J. D. Ullman	Pearson Publication	1983
3	Introduction to Data Structures with Applications	Tremblay J. P. and P. G. Sorenson	Tata McGraw Hill	1995
4	Advanced Data Structures	Peter Brass	Cambridge University Press	2008
5	Theory and Problems of Data Structures	Lipschuts S.	Schaum's Series	1986

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/106102064 https://youtu.be/zWg7U0OEAoE https://youtu.be/g1USSZVWDsY https://youtu.be/PGWZUgzDMYI
2	https://nptel.ac.in/courses/106102064 https://youtu.be/PGWZUgzDMYI
3	https://nptel.ac.in/courses/106102064 https://youtu.be/tORLeHHtazM https://youtu.be/eWeqqVpgNPg https://youtu.be/9zpSs845wf8
4	https://youtu.be/KW0UvOW0XIo https://youtu.be/gtWw_8VvHjk

SEMESTER S5

INTRODUCTION TO MACHINE LEARNING

Course Code	**PEEET527**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	GYEST305, UCEST105	**Course Type**	PE - Theory

Course Objectives:

1. To equip students with overall understanding of the underlying mathematical and algorithmic concepts of machine learning.
2. To understand and perform various data pre-processing and visualization in using various python libraries
3. To implement various machine learning algorithms using python.
4. To evaluate and optimize machine learning models for diverse applications

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Mathematics for Machine Learning. -** Association of two variables - Discrete variables, Ordinal and Continuous variable, Probability calculus - Summary Statistics, probability distributions, Inductive statistics - Point estimation, Interval estimation, Hypothesis Testing - Basic definitions, t-test, F-test, ANOVA	9
2	**Introduction to machine learning algorithms** - supervised vs. unsupervised learning, regression and classification, linear discriminant analysis, decision trees, random forests, and bagging. Unsupervised - Principal Component Analysis, clustering algorithms, SVMs, re-sampling methods: cross-validation and bootstrapping	9
3	**Introduction to python for ML -** essential python libraries and ML functions (NumPy, pandas, Matplotlib, SciKit-Learn), working with data sets	

	– data cleaning and pre-processing functions, Data visualization- bar, scatter, histogram, heatmaps.	
4	**ML algorithm implementation with python -** Linear Regression Simple and multiple linear regression, Model evaluation metrics: MSE, RMSE, R^2, Classification Algorithms - Logistic regression, k-Nearest Neighbours (k-NN), Decision Trees, Model evaluation metrics: accuracy, precision, recall, F1-score, Support Vector Machines (SVM), Ensemble methods (Random Forest, Gradient Boosting), Clustering Algorithms -K-means clustering, Hierarchical clustering.	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Micro project	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	**Understand** the relationships between different types of variables (discrete, ordinal, and continuous) using summary statistics and probability distributions, and perform hypothesis testing including t-tests and F-tests.	**K2**
CO2	**Apply** different supervised and unsupervised machine learning algorithms (such as regression, classification, clustering, and dimensionality reduction) and their appropriate applications in solving real-world problems.	**K3**
CO3	**Apply** essential Python libraries (NumPy, Pandas, Matplotlib) to clean, pre-process, and visualize data sets, preparing data for machine learning applications.	**K3**
CO4	**Implement** machine learning algorithms (such as linear regression, logistic regression, k-Nearest Neighbours, Decision Trees, SVM, Random Forest, Gradient Boosting, and clustering) in Python and evaluate their performance using relevant metrics.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2										2
CO2	3	3	2	2								2
CO3	3	3	2									2
CO4	3	3	2	3								2
CO5												

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Mathematics for Machine Learning	Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong	Cambridge University Press	1st Edition, 2020
2	Pattern Recognition and Machine Learning	Christopher M. Bishop	Springer	1st Edition, 2006
3	Python Data Science Handbook: Essential Tools for Working with Data	Jake Vander Plas	O'Reilly Media	1st Edition, 2016
4	Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow	Aurélien Géron	O'Reilly Media	2nd Edition, 2019
5	Introduction to Machine Learning with Python: A Guide for Data Scientists	Andreas C. Müller, Sarah Guido	O'Reilly Media	1st Edition, 2016

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	The Elements of Statistical Learning: Data Mining, Inference and Prediction	Trevor Hastie, Robert Tibshirani, Jerome Friedman	Springer	2nd Edition, 2009
2	Data Mining: Concepts and Techniques	Jiawei Han, Micheline Kamber, Jian Pei	Morgan Kaufmann	3rd Edition, 2011
3	Python Machine Learning: Machine Learning and Deep Learning with Python, scikit-learn, and Tensor Flow 2	Sebastian Raschka, Vahid Mirjalili	Packt Publishing	3rd Edition, 2019
4	Applied Predictive Modelling	Max Kuhn, Kjell Johnson	Springer	1st Edition, 2013

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
Module - I	https://onlinecourses.nptel.ac.in/noc23_cs18/preview
Module - II	https://onlinecourses.nptel.ac.in/noc23_cs18/preview
Module - III	https://nptel.ac.in/courses/106105152
Module - IV	https://nptel.ac.in/courses/106105152

SEMESTER S5

COMPUTER NETWORK SYSTEMS

Course Code	PEEET528	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	Nil	Course Type	Theory

Course Objectives:

1. To familiarize various types of layers in OSI model.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction – Uses of computer networks, Network hardware, Network software - Protocol hierarchies – Design issues for the layers – Connection oriented versus connectionless service. Reference models – The OSI reference model, The TCP/IP reference model, Comparison of OSI and TCP/IP reference models. Physical Layer –Transmission media overview – Twisted pair and fiber optics. Performance indicators – Bandwidth, Throughput, Latency, Bandwidth–Delay product.	8
2	Data link layer - Data link layer design issues, Error detection and correction, Sliding window protocols. Medium Access Control (MAC) sublayer, Channel allocation problem, Multiple access protocols – CSMA, Collision free protocols. Ethernet – Switched Ethernet, fast Ethernet and gigabit Ethernet. Wireless LANs - 802.11 – Architecture and protocol stack, Use of Bridges, Repeaters, Hubs, Switches, Routers and Gateways.	8
3	Network layer design issues. Routing algorithms - The Optimality Principle, Shortest path routing, Flooding, Distance Vector Routing, Link State Routing, Routing for mobile hosts. Congestion control algorithms – Approaches to congestion control (Details not required). Quality of Service (QoS) - Requirements, Techniques for achieving good QoS – Traffic shaping, Packet scheduling.	12

	IPv4 protocol, IP addresses, IPv6, Internet Control Protocols - Internet Control Message Protocol (ICMP), Address Resolution Protocol (ARP), Dynamic Host Configuration Protocol (DHCP). Open Shortest Path First (OSPF) Protocol, Border Gateway Protocol (BGP), Internet multicasting.	
4	Transport service – Services provided to the upper layers, Transport service primitives. User Datagram Protocol (UDP) – Introduction, Remote procedure call. ELECTRICAL AND ELECTRONICS Transmission Control Protocol (TCP) – Introduction, TCP service model, TCP protocol, TCP segment header, Connection establishment & release. Application Layer –Domain Name System (DNS) – overview of DNS name space and Name servers, Electronic mail – Architecture and services- SMTP – IMAP - POP3, World Wide Web (WWW) - Architectural overview, HTTP, File Transfer Protocol (FTP).	**8**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination-2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Explain the computer networks, layered architecture, protocols and physical media used for setting up a network.	**K2**
CO2	Identify the role of Data link layer, role of the MAC sub layer and networking devices in Ethernets and wireless LANs	**K2**
CO3	Explain routing algorithms and congestion control algorithms and ways to achieve good quality of service, IP address classes, ICMP protocols and other external routing protocols.	**K2**
CO4	Explain the services provided by the transport layer and application layer.	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**2**											**2**
CO2	**2**	**1**										**2**
CO3	**2**	**1**										**2**
CO4	**2**											**2**

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Computer Networks	Andrew S. Tanenbaum	Pearson Education India.	5th edition
2	Data Communication and Networking	Behrouz A Forouzan	McGraw Hill Education	5th edition

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Computer Networks – A Systems Approach	Larry L Peterson and Bruce S Dave	Morgan Kaufmann	5th edition
2	Computer Networking and the Internet	Fred Halsall		5th edition
3	Computer Networking: A Top-Down Approach	James F. Kurose, Keith W. Ross		6th edition
4	An Engineering Approach to Computer Networks	Keshav	Addison Wesley	1998
5	TCP/IP Illustrated Volume 1,	W. Richard Stevens.	Addison-Wesley	2005
6	Computer Networking with Internet Protocols,.	William Stallings	Prentice-Hall	2004

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/106105183 https://nptel.ac.in/courses/106106091
2	https://nptel.ac.in/courses/106105183 https://nptel.ac.in/courses/106106091
3	https://nptel.ac.in/courses/106105183 https://nptel.ac.in/courses/106106091
4	https://nptel.ac.in/courses/106105183 https://nptel.ac.in/courses/106106091

SEMESTER: S5

AC MACHINES LAB

Course Code	**PCEEL507**	**CIE Marks**	50
Teaching Hours/Week (L: T:P: R)	0:0:3:0	**ESE Marks**	50
Credits	2	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	PCEET402	**Course Type**	Lab

Course Objectives:

1. Provide practical experience in operation and testing of synchronous and induction machines

Expt. No.	Experiments
	PART A – INDUCTION MACHINES
1	Load test on a 3-phase squirrel-cage induction motor (CO1) Objectives: a) Start the motor using star-delta starter / auto-transformer starter b) Determine the performance characteristics
2	**Load test on a 3-phase slip-ring induction motor (CO1)** Objectives: a) Start the motor using rotor resistance starter / auto-transformer starter b) Determine the performance characteristics
3	**No-load and blocked-rotor tests on a 3-phase squirrel-cage induction motor (CO1)** Objectives: a) Determine the equivalent circuit parameters b) Predetermine its performance at rated speed from equivalent circuit c) Predetermine its performance on full-load from circle diagram
4	**No-load and blocked-rotor tests on 3-phase pole-changing induction motor (CO1)** Objectives: a) Conduct no-load and blocked-rotor tests in two different pole configurations (example 4 pole and 8 pole) b) Predetermine its performance on full-load from circle diagrams in both cases

	OR
	Load test on 3-phase pole-changing induction motor (CO1) Objectives: a) Conduct load tests in two different pole configurations (example 4 pole and 8 pole) b) Determine the performance characteristics
5	**Variation of starting torque with rotor resistance in 3-phase slip-ring induction motor (CO1)** Objectives: a) Plot the variation of starting torque against rotor resistance b) Determine the external rotor resistance for which maximum starting torque is obtained
6	**Brake test on 1-phase induction motor (CO6)** Objectives: Plot the performance characteristics
7	**No-load and blocked-rotor tests on 1-phase induction motor (CO6)** Objectives: a) Determine the equivalent circuit b) Predetermine the efficiency on full-load from equivalent circuit
8	**3-phase induction machine working as motor and generator (CO2)** Objectives: Determine the performance of 3-phase induction machine working as motor and generator
9	**Speed control of 3-phase squirrel-cage induction motor using V/f technique (CO3)** Objectives: Perform the speed control of a 3-phase squirrel-cage induction motor by varying supply voltage and frequency
PART B –SYNCHRONOUS MACHINES	
10	**Voltage regulation of 3-phase synchronous generator by EMF and MMF method (CO4)** Objectives: a) Conduct OC and SC tests. b) Predetermine the full-load voltage regulation at different power factors.

11	**Voltage regulation of 3-phase synchronous generator by direct loading (CO4)** Objectives: a) Determine the voltage regulation at full-load or half full-load at any power factor. b) Compare the voltage regulation with emf method.
12	**Voltage regulation of 3-phase synchronous generator by Potier method (CO4)** Objectives: a) Conduct OC, SC and ZPFC tests. b) Predetermine the full-load voltage regulation at different power factors.
13	**V curves and Inverted V curves of synchronous machines (CO5)** Objectives: a) Synchronise the 3-phase alternator using dark lamp or bright lamp method b) Plot the V curves and inverted V curves of synchronous motor on no-load and half/full load. c) Plot the V curves and inverted V curves of synchronous generator on half/full load.
14	**Slip teston 3-phase salient-pole synchronous machines (CO4)** Objectives: a) Determine direct-axis and quadrature-axis synchronous reactances b) Predetermine the full-load voltage regulation at different power factors c) Predetermine the excitation and reluctance power with 120% excitation voltage and hence plot the power angle characteristics
NOTE: A minimum of TWELVE experiments are mandatory out of the fourteen listed.	

Course Assessment Method

(CIE: 50 marks, ESE: 50 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Preparation/Pre-Lab Work experiments, Viva and Timely completion of Lab Reports / Record (Continuous Assessment)	Internal Examination	Total
5	25	20	50

End Semester Examination Marks (ESE):

Procedure/ Preparatory work/Design/ Algorithm	Conduct of experiment/ Execution of work/ troubleshooting/ Programming	Result with valid inference/ Quality of Output	Viva voce	Record	Total
10	15	10	10	5	50

- ***Submission of Record: Students shall be allowed for the end semester examination only upon submitting the duly certified record.***
- ***Endorsement by External Examiner:*** *The external examiner shall endorse the record*

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Analyze the performance of 3-phase squirrel cage and slip ring induction motor at different loads.	**K3**
CO2	Analyze the performance of line excited induction machine working in motoring and generating modes	**K3**
CO3	Apply V/f control techniques for the speed control of 3-phase induction motors	**K3**
CO4	Determine the voltage regulation of 3-phase cylindrical rotor type and salient pole type synchronous generators	**K3**
CO5	Construct V and inverter V curves of synchronous machines at constant load.	**K3**
CO6	Compute the efficiency of single-phase induction motor at a specified load.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO- PO Mapping (Mapping of Course Outcomes with Program Outcomes)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2		2					3	2		3
CO2	3	2		2					3	2		3
CO3	3	2		2					3	2		3
CO4	3	2		2					3	2		3
CO5	3	2		2					3	2		3
CO6	3	2		2					3	2		3

1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Electrical Machinery	P.S. Bimbhra	Khanna Publishers	7th edition 2021
2	Electric Machines	D P Kothari & I J Nagrath	Tata McGraw Hill	5th edition 2017

Continuous Assessment (25 Marks)

1. Preparation and Pre-Lab Work (7 Marks)

- Pre-Lab Assignments: Assessment of pre-lab assignments or quizzes that test understanding of the upcoming experiment.
- Understanding of Theory: Evaluation based on students' preparation and understanding of the theoretical background related to the experiments.

2. Conduct of Experiments (7 Marks)

- Procedure and Execution: Adherence to correct procedures, accurate execution of experiments, and following safety protocols.
- Skill Proficiency: Proficiency in handling equipment, accuracy in observations, and troubleshooting skills during the experiments.
- Teamwork: Collaboration and participation in group experiments.

3. Lab Reports and Record Keeping (6 Marks)

- Quality of Reports: Clarity, completeness and accuracy of lab reports. Proper documentation of experiments, data analysis and conclusions.
- Timely Submission: Adhering to deadlines for submitting lab reports/rough record and maintaining a well-organized fair record.

4. Viva Voce (5 Marks)

- Oral Examination: Ability to explain the experiment, results and underlying principles during a viva voce session.

Final Marks Averaging: The final marks for preparation, conduct of experiments, viva, and record are the average of all the specified experiments in the syllabus.

Evaluation Pattern for End Semester Examination (50 Marks)

1. **Procedure/Preliminary Work/Design/Algorithm (10 Marks)**

    - Procedure Understanding and Description: Clarity in explaining the procedure and understanding each step involved.
    - Preliminary Work and Planning: Thoroughness in planning and organizing materials/equipment.
    - Algorithm Development: Correctness and efficiency of the algorithm related to the experiment.
    - Creativity and logic in algorithm or experimental design.

2. **Conduct of Experiment/Execution of Work/Programming (15 Marks)**

    - Setup and Execution: Proper setup and accurate execution of the experiment or programming task.

3. **Result with Valid Inference/Quality of Output (10 Marks)**

    - Accuracy of Results: Precision and correctness of the obtained results.
    - Analysis and Interpretation: Validity of inferences drawn from the experiment or quality of program output.

4. **Viva Voce (10 Marks)**

    - Ability to explain the experiment, procedure results and answer related questions
    - Proficiency in answering questions related to theoretical and practical aspects of the subject.

5. **Record (5 Marks)**

    - Completeness, clarity, and accuracy of the lab record submitted

SEMESTER S5

MICROPROCESSORS AND EMBEDDED SYSTEMS LAB

Course Code	**PCEEL508**	**CIE Marks**	50
Teaching Hours/Week (L: T:P: R)	0:0:2:0	**ESE Marks**	50
Credits	2	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Lab

Course Objectives:

1. Achieve proficiency in 8051 microcontroller assembly language and embedded C programming.
2. Acquire practical experience with Arduino.

Expt. No.	Experiments
1	ALP programming for (a) Data transfer: Block data movement, exchanging data, sorting, finding largest element in an array. (b)Arithmetic operations: Addition, Subtraction, Multiplication and Division. Comparing square and cube of 16 bit numbers.
2	ALP programming for the implementation of counters: Hex up and down counters, BCD up/down counters.
3	(a)ALP programming for implementing Boolean and logical instructions: bit manipulation. (b)ALP programming for implementing conditional call and return instructions: Toggle the bits of port 1 by sending the values of 55H and AAH continuously, Factorial of a number.
4	ALP program for Generation of delay.
5	C program for stepper motor control.

6	C program for DC motor direction and speed control using PWM.
7	C program for alphanumerical LCD panel/keyboard interface.
8	C program for ADC interfacing.
9	Demo experiment using 8051 Microcontroller programming. ALP programming for implementation code conversion- BCD to ASCII , ASCII to BCD, ASCII to Decimal , Decimal to ASCII, Hexadecimal to Decimal and Decimal to Hexadecimal
10	a)Familiarization of Aurdino IDE. b)LED blinking with different ON/OFF delay timings with (i) inbuilt LED (ii) externally interfaced LED.
11	Arduino based voltage measurement of 12 V solar PV module /12 V battery and displaying the measured value using 12C LCD display..
12	Demo experiments on Arduino / Raspberry Pi to upload /retrieve temperature and humidity data to thing speak cloud.
13	Arduino based DC current measurement using Hall effect current sensor displaying the value using 12C LCD module.
14	Directional control of the DC motor using Arduino.
15	Interfacing of the relay with Arduino.
16	Building intrusion detection system with Arduino and Ultrasonic sensor.

Course Assessment Method
(CIE: 50 marks, ESE: 50 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Preparation/Pre-Lab Work experiments, Viva and Timely completion of Lab Reports / Record (Continuous Assessment)	Internal Examination	Total
5	**25**	**20**	**50**

End Semester Examination Marks (ESE):

Procedure/ Preparatory work/Design/ Algorithm	Conduct of experiment/ Execution of work/ troubleshooting/ Programming	Result with valid inference/ Quality of Output	Viva voce	Record	Total
10	15	10	10	5	50

- ***Submission of Record: Students shall be allowed for the end semester examination only upon submitting the duly certified record.***
- ***Endorsement by External Examiner:*** *The external examiner shall endorse the record*

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Develop and execute ALP programs for solving arithmetic and logical problems using microcontroller	**K3**
CO2	Develop embedded C programming using instruction sets of 8051	**K3**
CO3	Examine circuits for interfacing processor with various peripheral devices	**K4**
CO4	Design a microcontroller based system with the help of various interfacing devices	**K6**
CO5	Design an Arduino based system with the help of various interfacing devices	**K6**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO- PO Mapping (Mapping of Course Outcomes with Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3							3
CO2	3	3	3	3	3							3
CO3	3	3	3	3	3							3
CO4	3	3	3	3	3							3
CO5	3	3	3	3	3							3

1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	The 8051 microcontroller	Kenneth Ayala	Cengage Learning	The 8051 microcontroller
2	Microprocessors and Microcontrollers	R. LylaB.Das	Pearson Education	Microprocessors and Microcontrollers

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	The 8051 Microcontroller	I. ScottMacKenzie,Raphael C.-W.Phan		
2	The 8051 microcontroller and embedded systems	Muhammad Ali Mazidi	Pearson Education	

Continuous Assessment (25 Marks)

1. Preparation and Pre-Lab Work (7 Marks)

- Pre-Lab Assignments: Assessment of pre-lab assignments or quizzes that test understanding of the upcoming experiment.
- Understanding of Theory: Evaluation based on students' preparation and understanding of the theoretical background related to the experiments.

2. Conduct of Experiments (7 Marks)

- Procedure and Execution: Adherence to correct procedures, accurate execution of experiments, and following safety protocols.
- Skill Proficiency: Proficiency in handling equipment, accuracy in observations, and troubleshooting skills during the experiments.
- Teamwork: Collaboration and participation in group experiments.

3. Lab Reports and Record Keeping (6 Marks)

- Quality of Reports: Clarity, completeness and accuracy of lab reports. Proper documentation of experiments, data analysis and conclusions.
- Timely Submission: Adhering to deadlines for submitting lab reports/rough record and maintaining a well-organized fair record.

4. **Viva Voce (5 Marks)**

- Oral Examination: Ability to explain the experiment, results and underlying principles during a viva voce session.

Final Marks Averaging: The final marks for preparation, conduct of experiments, viva, and record are the average of all the specified experiments in the syllabus.

Evaluation Pattern for End Semester Examination (50 Marks)

1. **Procedure/Preliminary Work/Design/Algorithm (10 Marks)**

- Procedure Understanding and Description: Clarity in explaining the procedure and understanding each step involved.
- Preliminary Work and Planning: Thoroughness in planning and organizing materials/equipment.
- Algorithm Development: Correctness and efficiency of the algorithm related to the experiment.
- Creativity and logic in algorithm or experimental design.

2. **Conduct of Experiment/Execution of Work/Programming (15 Marks)**

- Setup and Execution: Proper setup and accurate execution of the experiment or programming task.

3. **Result with Valid Inference/Quality of Output (10 Marks)**

- Accuracy of Results: Precision and correctness of the obtained results.
- Analysis and Interpretation: Validity of inferences drawn from the experiment or quality of program output.

4. **Viva Voce (10 Marks)**

- Ability to explain the experiment, procedure results and answer related questions
- Proficiency in answering questions related to theoretical and practical aspects of the subject.

5. Record (5 Marks)

- Completeness, clarity, and accuracy of the lab record submitted

SEMESTER 6

ELECTRICAL & ELECTRONICS ENGINEERING

SEMESTER S6

CONTROL SYSTEMS

Course Code	**PCEET601**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	PCEET503	**Course Type**	Theory

Course Objectives:

1. To introduce various classical tools for analysis of linear control system in time and frequency domain.
2. To provide a fundamental knowledge of modern control system.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to Control Systems and its time domain analysis** *Review of Open loop and Closed loop control systems; Automatic control systems; Necessity and significance. (Not for evaluation)* *(1 hour)* *Time domain analysis of control systems:* Impulse and Step responses of first and second order systems - Pole dominance for higher order systems. Time domain specifications. (4 hours) *Error analysis:* Steady state error analysis and static error constants. (2 hours)	7
2	**Root Locus Analysis and Controllers:** *Root locus technique:* Construction of Root locus - stability analysis- effect of addition of poles and zeros; Effect of positive feedback systems on Root locus. (5 hours) *Controller design:* Types of controllers and their control action-	7

	proportional (P), integral (I), derivative (D), PID control. PID tuning using Ziegler-Nichols method. (2 hours)	
3	**Frequency domain analysis:** *Bode Plot:* Construction, Concept of gain margin and phase margin-stability analysis. (4 hours) Frequency domain specifications - correlation between time domain and frequency domain responses (Resonant peak and resonant frequency). Introduction to compensators. (Concept only). (2 hours) Polar plot: Gain margin and phase margin, Stability analysis. (2 hours) Nyquist stability criterion. Concept of Nichols Chart. (3 hours)	**11**
4	**State space representation of systems:** *Introduction to state-space modelling:* State variables, state equations. State variable representation of electrical systems. (2 hours) *Relationship between State space and Transfer function models:* Derivation of transfer functions from state equations. Controllable, Observable and Diagonal/Jordan canonical forms. Introduction to similarity transformations (concept only). (4 hours) *Solution of time invariant systems:* Solution of time response of autonomous systems and forced systems. State transition matrix - computation using Method of Laplace Transform and Cayley Hamilton theorem. (4 hours) *Controllability & Observability:* Definition, Kalman's test. (1 hour)	**11**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Analyse the time domain responses of linear systems and predict and diagnose transient response parameters of the system for standard input functions.	**K2**
CO2	Analyse dynamics systems for their performance and stability using Root locus	**K3**
CO3	Apply frequency domain tools to analyse the performance of linear dynamic systems	**K3**
CO4	Represent and analyse dynamic systems using state-space.	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	2	1	3	3	3			3	2
CO2	3	3	2	2	2	3	3	3			3	2
CO3	3	3	2	2	2	3	3	3			3	2
CO4	3	2	1	2	1	3	3	3			3	2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Modern Control Engineering	Katsuhiko Ogata	Pearson	5th edition, 2009
2	Control Systems Engineering	Norman S. Nise	Wiley	5th edition, 2009
3	Control Systems Engineering	I. J. Nagrath, M. Gopal	New Age	5th edition, 2009

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Automatic Control Systems,	Kuo B. C.	Prentice Hall of India	9th edition, 2014
2	Control Systems Principles and Design	Gopal M.	Tata McGraw Hill.	4th edition, 2012
3	Modern Control Systems	Dorf R. C., Bishop R. H	Pearson Education India	12th edition, 2013

SEMESTER - S6

ELECTRICAL SYSTEM DESIGN AND ESTIMATION

Course Code	PCEET602	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None/ (Course code)	Course Type	Theory

Course Objectives:

1. To create awareness regarding electrical symbols, Indian Standard codes, Indian Electricity acts and NEC norms
2. To enable students to design the various electrical installations with necessary precautions to ensure life safety, risk prevention and continuous operation of the system
3. To help in energy-efficient electrical design in compliance with codes and regulations.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Awareness on IS Codes - IS 732, IS 3043, IS 2026- IS 3646-part 1 & 2 - IS 5216 part 1 & 2 Electricity supply code-2014, IE Act 1910, 2003, NEC LT system wiring components, selection of cables, wires, switches, distribution box, metering system, basics of star rating and labelling Principle of operation of Fuse, MCB, MCCB, ELCB/RCCB, isolator.	7
2	General requirements for electrical installations- Residential/ Commercial/ High rise building, method of load survey for electrical installation, Diversity factor Sizing and selection of wires, MSB, SSB, DB and protection devices. Design steps in electrical wiring, material estimation and development of single line diagrams. Electrical CAD (optional). Pre-commissioning test applicable to domestic installation	12

	Lighting design calculations - Definitions of Luminous flux, Luminous intensity, Illuminance. Illumination calculation, factors affecting Coefficients of Utilisation (CoU) - Light Loss Factor (LLF). Design and Estimation the quantity of material required in Electrical Installation for - Small residential building/Flat/Factory (Micro-Project)	
3	Indoor and Outdoor substation- selection of transformer, switch gears and protective devices, Procedure for HT connection, design and estimation the quantity of material required for substations, Pre-commissioning tests for transformers Industrial loads, selection of starters, cable and switchgears, Power factor improvement – kVAR calculation, correction methods Design of MSB & SSB including Motor Control Centre (MCC) - Selection of bus bars (CU & Al) and Switchgears Specifications of LT Breakers and other LT panel components (Basics only) Selection of industrial UG cables - Calculation of ampacity, voltage drop, short circuit withstand capacity	**10**
4	Standby DG Systems with AMF panel – Essential protections. UPS system and its design for residential application Selection and installation of elevators and lifts Earthing and Soil Resistivity calculation– Earth electrodes. Methods of earthing - Plate earthing - Pipe earthing - Rod earthing. Methods of improving earth resistance - Size of earth continuity conductor Substation earthing and design (Theory only), substation lightning protection (Theory only) Solar PV Power generation – Design and installation of standalone and grid interactive Solar PV system -Smart meter/Net meter	**7**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the Indian standards and code of practice for efficient and effective energy usage with various electrical system design components.	**K2**
CO2	Design electrical wiring for residential and commercial consumers as per IS codes and NEC and integration of PV systems	**K3**
CO3	Design electrical installation for industrial consumers and high rise buildings.	**K3**
CO4	Analyse electrical system conditioning equipment and power backups.	**K4**
CO5	Design various earthing methods and protection	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping od Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**3**	**2**	**1**			**2**		**2**	**2**			**2**
CO2	**3**	**3**	**3**	**1**		**2**	**2**		**2**	**1**		**2**
CO3	**3**	**3**	**3**	**1**		**2**			**2**	**1**		**2**
CO4	**3**	**3**	**3**	**1**		**2**			**2**	**1**		**2**
CO5	**3**	**3**	**3**	**1**		**2**			**2**	**1**		**2**

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	National Electrical Code, Bureau of Indian Standards.		Bureau of Indian Standards.	
2	Electrical Systems Design	M. K. Giridharan	IK International Publishers, New Delhi	
3	Electrical Design Estimating Costing	K. B. Raina, S. K. Bhattacharya	NEW AGE; Reprint edition	
4	Residential Commercial and Industrial Systems	H. Joshi	McGraw Hill Education	

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	National Lighting Code 2010, Bureau of Indian Standards.			
2	National Building Code of INDIA 2016 - Bureau of Indian Standards.			
3	A Course in Electrical Installation Estimating and Costing.	J. B. Gupta	S.K. Kataria & Sons	Reprint 2013 edition (2013)
4	Electrical estimating and costing	S. Singh, and R. D. Singh	Dhanpat Rai and Co.	1997

SEMESTER S6

DIGITAL PROTECTION OF POWER SYSTEMS

Course Code	**PEEET631**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	PCEET501, PBEET604	**Course Type**	Theory

Course Objectives:

1. To deliver fundamental concepts to design various electronic circuits to implement various relaying functions.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction**: Need for protective systems, Zones of protection, Current transformers and voltage transformers (Electromagnetic and Capacitive voltage transformers), Principle of operation of magneto optic CT/ PT, effect on relaying philosophy. **Relays:** Over current relays - time-current characteristics of over current relays: definite time over current relays, inverse Definite Minimum time - directional over current relays, current setting and time setting - Numerical Problems - Differential relays: Operating and restraining characteristics, types of differential relays, Distance relays: impedance relays, reactance relays, mho relays (basic principles and characteristics only)	9
2	**Protection of Transmission Lines:** Schemes of distance protection, Differential line protection, Phase comparison line protection. **Protection of Bus-bar, Transformer and Generator & Motor**: Types of faults, differential protection: High impedance and low impedance differential protection schemes, harmonic restraint relay, Restricted Earth Fault Protection, frame leakage protection, stator and rotor protection against various types of faults.	9

3	**Digital (Numerical) Relays**: Basic Components of numerical Relays with block diagram, Processing Unit, Human machine Interface, Principle of operation, Comparison of numerical relays with electromechanical and static relays, Advantages of numerical relays - communication in protective relays (IEC 61850), Information handling with substation automation system (SAS) Signal Conditioning Subsystems: Surge Protection Circuits, Anti-aliasing filter, Conversion Subsystem, The Sampling Theorem, aliasing, Sample and Hold Circuit, Concept of analog to digital and digital to analog conversion, Idea of sliding window concept, Fourier, Discrete and fast Fourier transforms	**9**
4	**Signal processing techniques:** Sinusoidal wave based algorithms, Fourier Analysis based algorithms (half cycle and full cycle), Least squares based algorithm. Digital filters – Fundamentals of Infinite Impulse Response Filters, Finite Impulse Response filters, Filters with sine and cosine windows. **Wide Area Protection and Measurement:** Phasor Measurement Units, concept of synchronized sampling, Definition of wide-area protection, Architectures of wide-area protection, concept of Adaptive relaying, advantages of adaptive relaying and its application, Adaptive Differential protective scheme.	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Identify the relay protection scheme suitable for overcurrent, differential and distance protection.	**K3**
CO2	Develop the protection scheme for bus bars, transformers, generators, motors and distribution systems using appropriate protective relays	**K3**
CO3	Illustrate the operation of a numerical relay.	**K2**
CO4	Explain signal processing methods and algorithms in digital protection	**K2**
CO5	Infer emerging protection schemes in power systems	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3		2									
CO2	3		2									
CO3	3		2									
CO4	3		2									
CO5	3		2									

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Digital Protection of Power System	A. T. Johns and S. K. Salman	Peter Peregrinus Ltd, UK	1995
2	Computer Relaying for Power Systems	A. G. Phadke and James S. Thorpe	Research study press Ltd, John Wiley & Sons, Taunton, UK	1988
3	Power System Protection and Switchgear	Badri Ram and D. N. Viswakarma	Tata McGraw Hill Education, Pvt Edition	2011
4	Digital Signal Processing in Power System Protection and Control	Waldemar Rebizant	Springer Publication	2008

Video Links (NPTEL, SWAYAM…)	
Sl No	**Link ID**
1	https://archive.nptel.ac.in/courses/117/107/117107148/ (NPTEL lecture IIT Roorkee)

SEMESTER S6
OPERATING SYSTEMS

Course Code	**PEEET632**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Mins.
Prerequisites (if any)	PEEET526	**Course Type**	PE - Theory

Course objectives:

1. To understand the overall working of computer system, trade-offs between performance and functionality and the division of jobs between hardware and software.
2. Introduces the concepts of memory management, device management, process management, file management and security & protection mechanisms available in an operating system.
3. To understand the fundamentals about any operating system design

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction: Operating system overview – Functions, Boot Process Processes - Process states, Process control block, threads, scheduling, Operations on processes - process creation and termination Inter-process communication - shared memory systems, Message passing systems.	**8**
2	Process Scheduling – Basic concepts- Scheduling criteria -scheduling algorithms- First come First Served, Shortest Job Firs, Priority scheduling, Round robin scheduling Process synchronization- Race conditions – Critical section problem – Peterson's solution, Synchronization hardware, Mutex Locks, Semaphores, Monitors – Synchronization problems - Producer Consumer, Dining Philosophers and Readers-Writers.	**10**
3	Deadlocks: Necessary conditions, Resource allocation graphs, Deadlock prevention, Deadlock avoidance – Banker's algorithms, Deadlock detection, Recovery from deadlock. Memory Management: Concept of address spaces, Swapping, Contiguous memory allocation, fixed and variable partitions, Segmentation, Paging. Virtual memory, Demand paging, Page replacement algorithms.	**10**

4	File System: File concept - Attributes, Operations, types, structure – Access methods, Protection. File-system implementation, Directory implementation. Allocation methods. Storage Management: Magnetic disks, Solid-state disks, Disk Structure, Disk scheduling, Disk formatting.	**8**

Course Assessment Method
(CIE: -40 Marks, ESE: 60 Marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	*Assignment/ Micro project*	*Internal Ex-1*	*Internal Ex-2*	*Total*
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE):

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	2 questions will be given from each module, out of which 1 question should be answered. Each question can have a maximum of 3 sub divisions. Each question carries 9 marks. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course the student will be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Explain the relevance, structure and functions of Operating Systems in computing devices.	**K2**
CO2	Illustrate the concepts of process management and process scheduling mechanisms employed in Operating Systems.	**K2**
CO3	Explain process synchronization in Operating Systems and illustrate process synchronization mechanisms using Mutex Locks, Semaphores and Monitors	**K2**
CO4	Explain any one method for detection, prevention, avoidance and recovery for managing deadlocks in Operating Systems.	**K2**
CO5	Explain the memory management algorithms in Operating Systems.	**K2**
CO6	Explain the security aspects and algorithms for file and storage management in Operating Systems.	K2

K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

CO PO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO 5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	3	3							1		2
CO2	2	3	3	2						1		2
CO3	2	3	3	2						1		2
CO4	2	3	3	2						1		2
CO5	2	3	3	2						1		2
CO6	2	3	3	2						1		2

1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Operating System Concepts	Abraham Silberschatz, Peter Baer Galvin, Greg Gagne	Wiley India.	9th Edition, 2015

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Modern Operating Systems	Andrew S Tanenbaum	Pearson, Global Edition	6th Edition, 2015.
2	Operating Systems	Garry Nutt, Nabendu Chaki, Sarmistha Neogy	Pearson Education	3rd Edition,
3	Operating Systems	D.M.Dhamdhere	Tata McGraw Hill	2nd Edition, 2011.
4	Operating Systems	Sibsankar Haldar, Alex A Aravind	Pearson Education	

Video Links (NPTEL, SWAYAM…)	
Sl No	**Link ID**
1	https://youtu.be/jciGIvn7UfM?si=iTyzYC1tztsAS8F4
2	https://youtu.be/I_7rthka2Is?si=kRo68aA_ozTBrNno

SEMESTER S6

HIGH VOLTAGE ENGINEERING

Course Code	PEEET633	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	NIL	Course Type	Theory

Course Objectives:

1. To introduce basic terms and techniques applicable to high voltage ac and dc networks.
2. To learn about generation of different type of High voltage waveforms, their measurement and analysis.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Generation of High DC and AC Voltages- half-wave rectifier circuit- Cockroft-Walton voltage multiplier circuit- Electrostatic generator- Generation of high AC voltages-Cascaded Transformers- Series resonant circuit. Generation of Impulse Voltages and Currents- Impulse voltage- Impulse generator circuits- Multistage impulse generator circuit- Construction of impulse generator- Triggering of impulse generator- Impulse current generation.	9
2	High Voltage Measurement Techniques -Measuring Spark Gaps - Sphere-to-sphere Spark Gap -Rod-to-rod Spark Gap - Electrostatic Voltmeter- Field Sensors - Electrically Short Sensors, Electrically Long Sensors, Potential-free Probes, Generator-mode Sensors, Electro- optical and Magneto-optical Field Sensors - Voltage Dividers - Instrument Transformers - Measurements of R.M.S. Value, Peak Value and Harmonics - Current Measurement Dielectric measurements- Dissipation Factor and Capacitance, Insulation Resistance, Conductivity, Dielectric System Response-Partial discharge measuring technique- Requirements on a partial discharge measuring	9

	system - Measuring systems for apparent charge – Partial discharge measurements on high-voltage transformers, high-voltage cables, high-voltage gas-insulated substations. .	
3	Classification of Voltages and Overvoltages-Origin of Overvoltages – Representative Overvoltages- Performance Criterion –Withstand voltage. Insulation Coordination Procedure- Determination of Representative Voltages and Overvoltages-Continuous Power Frequency Voltage, Temporary Overvoltages, Slow-Front Overvoltages, Fast-Front Overvoltages Determination of Coordination Withstand Voltage (Ucw)-Deterministic Approach, Statistical Approach: Risk of Failure - Determination of Required Withstand Voltage (Urw)-Altitude Correction Factor, Safety Factor (Ks)- Selection of Standard Withstand Voltage (Uw)- Surge Arresters- Rated Voltage- Discharge Current- Impulse Current Tests-Residual Voltages- Arrester Durability Requirements.	**9**
4	High voltage Testing of insulators, bushings, isolators, circuit breakers, transformers, surge diverters, cables. Insulation Systems for AC Voltages -Cables, bushings and transformers-Insulation Systems for DC Voltages- Capacitors, HVDC bushings and Cables-Insulation Systems for Impulse Voltages -Electrical Stress and Strength -Energy Storage -Impulse Capacitors (Energy Storage or Surge Capacitors) Lightning Protection- Light and Laser Technology- X-ray Technology-Electrostatic Particle Precipitation, Ionization- Spark plugs.	**9**

Course Assessment Method

(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Identify different high voltage and current waveform generation circuits.	**K1**
CO2	Implement different sensing & measurement techniques for high voltage and current measurement.	**K3**
CO3	Describe insulation coordination and surge arrestor design.	**K2**
CO4	Implement different testing methods for equipments and applications of HV systems.	**K3**
CO5	Explain the various technologies for lightning protection.	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3											2
CO2	3											2
CO3	3						2					2
CO4	3						2					2
CO5	3						2					2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	High Voltage Engineering	C. L. Wadhwa	New Age International	2011
2	High Voltage Engineering Fundamentals – Technology Applications	Andreas Kuchler	Springer	2018
3	High Voltage Engineering	Naidu M. S. and Kamaraju V.	Tata Mc Graw Hill	2004
4	High Voltage Engineering Fundamentals	Kuffel E. Zaengl S. and Kuffel J.	Elsevier India P Ltd	2005

SEMESTER S6

INTERNET OF THINGS

Course Code	PEEET634	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	Nil	Course Type	Theory

Course Objectives:

1. This course aims to introduce IOT fundamentals.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to IoT technology:** Definitions of IoT, Characteristics of IoT devices – power, computational constraints, IoT Architectural view – Middleware based architecture, Service oriented architecture, M2M Communication and IoT, Typical application areas of IoT technology (case studies of at least four domains) - Energy management and Smart grid, IoT for Home, Cities, Environment monitoring, Agriculture, Supply chain and customer monitoring	9
2	**Components of IoT technology:** Identification/Addressing - Electronic Product Codes, RFID, ubiquitous code, IPv4, IPv6. Sensors and Actuators*. IoT Hardware**, IoT Software – overview of Operating systems, Firmware, Middle ware, Application software used in IoT. Connectivity for IoT devices – characteristics.	9
3	**Communication technologies for IoT :** Zigbee - key features, architecture, limitations, Bluetooth technology - bluetooth stack, piconet, scatternet, limitations, Bluetooth Low Energy (key features, architecture, limitations), Wifi (IEEE 802.11) technology – key features, limitations, Cellular technology – GSM, 3G, 4GLTE (overview), features, limitations, LoRa technology – features, LoRaWAN architecture, 6LoWPAN – features, protocol stack, Narrow Band (NB- IoT) – features, applications, Sigfox – features, applications	9

4	**IoT Data Management :** Storage technologies for IoT hardware – Volatile, Non-volatile, Embedded (MTP/OTP), external flash (NAND/NOR), DRAM, eflash, UFS, eMMC (overview of technologies). Cloud and IoT, Cloud computing – architecture, advantages of cloud computing, Software as a Service (SaaS), Platform as a Service (PaaS), Infrastructure as a Service (IaaS). Case study of commercial cloud computing platforms like - Microsoft Azure IoT Suite, Google Cloud's IoT Platform, IBM Watson IoT Platform. IoT analytics	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Explain in a concise manner the architecture of IoT	**K2**
CO2	Identify various hardware and software components used in IoT	**K3**
CO3	Discuss the various communication technologies and interfaces in IoT	**K2**
CO4	Describe the usage of modern technologies like cloud computing for data management in IoT	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2								2
CO2	3	2	2	2								2
CO3	3	2	2	1								2
CO4	3	2	2	1								2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Internet of Things : Architecture and Design Principles"	Rajkamal	McGraw Hill (India) Private Limited.	2nd edition,2022
2	"Internet of Things (A Hands-on- Approach)"	Vijay Madisetti and Arshdeep Bahga	Orient Blackswan Private Limited - New Delhi	1st Edition,2015

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Internet of things: A survey on enabling technologies, protocols, and applications	Al-Fuqaha	IEEE Communications Surveys & Tutorials	2015
2	The Internet of Things	Samuel Greengard	The MIT Press Essential Knowledge series Paperback	March 20, 2015
3	The Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems	Ovidu Vermesan and Peter Friess	River Publishers	1st Edition, 2013
4	. Internet of Things - From Research and Innovation to Market Deployment	Peter Friess, Ovidiu Vermesan	River Publishers	1st Edition,2014

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://youtu.be/WUYAjxnwjU4?si=s58W-NKMrEQMaJ8m https://youtu.be/BXDxYh1EV2w?si=8oFtQB9vycC_c-t2
2	https://youtu.be/z3VEZPwl5gA?si=tNuzG_By-KBU3ks_ https://youtu.be/SXz0XR68dwE?si=1tVN1g9FQcGp87li https://youtu.be/TvzgzO6xKrY?si=gYzJstW51MTNsgKj
3	https://youtu.be/qko-f1VDhCM?si=0tWM_OHS395ESV_w https://youtu.be/d9QfVpCG00Y?si=qeHk8tPg_torr2yX https://youtu.be/1zQ8wbBozqI?si=7vOSHMt8OT3nQINO
4	https://youtube.com/playlist?list=PLE7VH8RC_N3bpVn-e8QzOAHziEgmjQ2qE&si=rr5Fpuew5q9_Y4qg

SEMESTER S6

DIGITAL SIGNAL PROCESSING

Course Code	PEEET636	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	PCEET603/ PEEOT522	Course Type	Theory

Course Objectives:

1. To provide a thorough understanding of the realisation, design and analysis of DSP systems

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to DSP and Discrete Fourier transform:** Basic elements of DSP system. Advantages and applications. Review of Discrete-Time Fourier transform (DTFT) and its properties. Frequency domain sampling, Discrete Fourier transform (DFT) - DFT pair, properties of DFT, frequency response analysis of signals using the DFT, circular convolution using DFT, linear filtering based on DFT. Fast Fourier transform (FFT): Introduction, Radix -2 decimation in time FFT algorithm, Radix-2 decimation in frequency algorithm, IDFT using FFT algorithm.	10
2	**Realisation of Filters:** **Introduction to IIR and FIR systems.** Structures for IIR Systems: Direct-Form Structures, Cascade-Form Structures, Parallel-Form Structures, Lattice Structures for IIR Systems. **Structures for FIR Systems:** Direct-Form Structure, Cascade-Form Structures, Lattice Structure. Linear Phase FIR filters. Signal Flow Graphs and Transposed Structures.	7
3	**Design of Digital Filters:** General considerations, Causality and its implications, characteristics of practical frequency selective filters.	10

	IIR filter design: Discrete time IIR filter from analog filter (Butterworth), IIR filter (LPF, HPF, BPF, BRF) design by Impulse Invariance, Bilinear transformation. FIR filter design: Structures of FIR filter, Linear phase FIR filter Filter design using windowing techniques (Rectangular, Hanning, Hamming), frequency sampling Techniques.	
4	**Finite Word Length effects in Digital Filters:** Fixed point and floating-point number representations, Comparison, Truncation and Rounding errors. Quantization noise, Derivation for quantization noise power, coefficient quantization error, Product quantization error. Overflow error, Round-off noise power. Limit cycle oscillations due to product round-off and overflow errors, signal scaling. **Introduction to TMS320 Family:** Architecture, C24x CPU and other components; Assembly language Instructions, Instruction Set summary, simple programs. *Design & Implementation and Filter Structures: MATLAB functions and TMS320 Implementation (Demo/Assignment only)*	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Analyse discrete-time systems using DFT	**K2**
CO2	Realise IIR and FIR filters	**K3**
CO3	Design of IIR and FIR filters	**K3**
CO4	Analyse effect of word length in digital filters	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	2	1	3	3	3			3	2
CO2	3	3	2	2	2	3	3	3			3	2
CO3	3	3	2	2	2	3	3	3			3	2
CO4	3	3	2	2	2	3	3	3			3	2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Digital Signal Processing: Principles, Algorithm & Application	John G. Proakis Dimitris G. Manolakis	Pearson	4th Edition
2	Discrete-Time Signal Processing	A. Oppenheim and R. Schafer	Pearson-Prentice Hall	2nd Edition

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Digital Signal processing-A Practical Approach	Emmanuel C. Ifeachor, and Barrie W. Jervis	Pearson Education	2nd Edition
2	Digital Signal Processing	S. Salivahanan, A. Vallavaraj, and C. Gnapriya	Tata Mcgraw Hill	2nd Edition

SEMESTER S6

CLOUD COMPUTING

Course Code	PEEET637	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs 30 Min
Prerequisites (if any)	Nil	Course Type	PE - Theory

Course Objectives:

1. To enable learners to understand the concepts of cloud computing and its enabling technologies
2. Familiarize with mainstream cloud computing platforms and the services they offer.
3. To enable learners to have a basic understanding of virtualization, cloud security and cloud-based programming

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Traditional computing- Limitations. Overview of Computing Paradigms-Grid Computing, Cluster Computing, Distributed Computing, Utility Computing, Cloud Computing. NIST reference Model-Basic terminology and concepts. Cloud characteristics, benefits and challenges, Roles and Boundaries. Cloud delivery (service) models-Infrastructure-as-a-Service (IaaS), Platform-as-a-Service(PaaS),Software-as-a-Service (SaaS), XaaS (Anything-as-a-service)-Cloud deployment models- Public cloud, Community cloud, Private cloud, Hybrid cloud.	8
2	Introduction to virtualization-Virtualizing physical computing resources, Virtual Machines (Machine virtualization), Non-virtualized v/s Virtualized machine environments. Types of VMs- Process VM v/s System VM. Emulation, Interpretation and Binary translation. Virtualization layers. Hypervisors/VMM - Types of Hypervisors. Full Virtualization, Para Virtualization, Hardware-assisted virtualization, OS level virtualization.	8

	Basics of Network Virtualization, Storage Virtualization and Desktop Virtualization.	
3	Resource provisioning techniques: Static and Dynamic Resource provisioning in cloud. Open Source Software platforms for Private Cloud : OpenStack, Eucalyptus, Open Nebula, Nimbus Popular public cloud platforms: AWS - AWS ecosystem, Compute services: EC2, Advanced compute services, Storage services: Amazon S3, Amazon EBS, Database services, other major services. Google Cloud: IaaS offerings-Compute Engine, Storage PaaS offerings-GAE. SaaS offerings. Microsoft Azure: Azure Platform Architecture, Hyper-V, Azure VM, Compute services, Storage services	**11**
4	Cloud programming: Parallel Computing and Programming Paradigms, Map Reduce – Hadoop Library from Apache, HDFS, Pig Latin Basics, Apache Spark Fundamentals of Cloud Security: Basic terms & concepts in security – Threat agents, Cloud security threat/risks, Trust. OS security – Virtual Machine security – Security of Virtualization – Security risk posed by Shared Images, Security risk posed by Management OS, Infrastructure security – Network Level, Host Level, Application Level, Security of the Physical systems, Identity and Access Management	**10**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Explain the various cloud computing models and services	**K2**
CO2	Demonstrate the significance of implementing virtualization techniques	**K2**
CO3	Explain about the different private cloud platforms, and the services offered by popular cloud service providers	**K2**
CO4	Apply appropriate cloud programming methods to solve big data problems	**K3**
CO5	Describe the need for security mechanisms in cloud	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping od Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**2**											**2**
CO2	**2**	**2**	**2**									**2**
CO3	**2**		**1**		**3**				**1**		**1**	**2**
CO4	**2**	**3**	**3**	**3**	**3**							**2**
CO5	**2**	**2**										**2**

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Cloud Computing: Concepts, Technology and Architecture	Thomas Erl, Zaigham Mahmood, Ricardo Puttini	Prentice Hall	2013
2	Mastering Cloud Computing	Rajkumar Buyya, Christian Vecchiola,	McGraw Hill Education	2017

		S. Thamarai Selvi		
3	Cloud Computing	Sandeep Bhowmik	Cambridge University Press	2017

Reference Books

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Cloud Computing: Theory and Practice	Dan C. Marinescu	Morgan Kaufmann publications	2018
2	Cloud Computing: Principles and Paradigms	Rajkumar Buyya, James Broberg, Andrzej M. Goscinski	Wiley	2013

Video Links (NPTEL, SWAYAM…)

Module No.	Link ID
Module - I	https://nptel.ac.in/courses/106105167
Module - II	https://nptel.ac.in/courses/106104182
Module - III	https://cloud.google.com/docs/ https://docs.aws.amazon.com/ https://learn.microsoft.com/en-us/azure/
Module - IV	https://nptel.ac.in/courses/106105167

SEMESTER 6

OPTIMIZATION TECHNIQUES

Course Code	PEEET638	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs 30 Min
Prerequisites (if any)	None	Course Type	PE - Theory

Course Objectives:

1. The broad objective of the course is to introduce classical optimization, its need and techniques suitable for application in engineering problems

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Motivation and introduction to optimization in engineering practice	1
	Properties of single variable functions and optimality criteria, Region elimination methods, Polynomial estimation methods - quadratic estimation, Bisection method, Newton raphson method, Secant method, Cubic search method	5
	Functions of several variables, optimality criteria, Direct search method, Hooke-Jeeves pattern search method, Powell's method, Gradient search methods - Cauchy's method, Newton's method	5
		11
2	Formulation of linear programming models, Graphical solution in two variables, Standard form	3
	Simplex method, Duality, Dual simplex method - Karmarkar's method	6
		9

3	Equality constrained problems - Lagrange multipliers - Kuhn Tucker conditions - Kuhn Tucker theorems - Saddlepoint conditions - Second order optimality conditions - Generalized Lagrangian multiplier method	7
	Transformation methods - Concept of penalty - penalty functions - Method of Multipliers	3
		10
4	Constrained direct search - simple direct search method - Complex method - Random search methods	4
	Linearization methods for constrained Problems - Successive linear problems - Separable programming - Method of feasible directions - Simplex extensions for linearly constrained problems - Generalized reduced gradient method	5
		9

PS: Demonstrations of various techniques can be done using softwares like Scilab / Matlab / Octave or lower end softwares like Maxima

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination-2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	To evaluate the optimality criteria and methods for functions with single variable	**K4**
CO2	To evaluate the optimality criteria and methods for functions with several variables	**K4**
CO3	To understand and apply linear programming techniques for optimization	**K3**
CO4	To explore optimization techniques for constrained problems	**K3**
CO5	To explore search techniques and applications in optimization	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping od Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**3**	**3**			**2**	**3**						**2**
CO2	**3**	**3**			**2**	**3**						**2**
CO3	**3**	**3**			**2**	**3**						**2**
CO4	**3**	**3**			**2**	**3**						**2**
CO5	**3**	**3**			**2**	**3**						**2**

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Engineering Optimization, Methods and Applications	A Ravindran, K M Ragsdell, G V Reklaitis	John Wiley and Sons	2006

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Introduction to Linear Optimization	Dimitris Bertsimas, John N Tsitsiklis	Athena Scientific	1997
2	Stories about Maxima and Minima	V M Tikhomirov	American Mathematical Society	1990

SEMESTER S6

INTRODUCTION TO CONTROL SYSTEMS

Course Code	**OEEET611**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None/ (Course code)	**Course Type**	Theory

Course Objectives:

1. To introduce various classical tools for analysis of linear control system in time and frequency domain.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to Control Systems, mathematical modelling and Transfer function Based Analysis** Open loop and Closed loop control systems; Automatic control systems; Necessity and significance. (1 hour) *Modelling of LTI systems:* LTI Systems, Transfer function representation of differential equation in Laplace domain. Electrical, translational and rotational mechanical systems, DC servo-motor modelling. (4 hours). Block diagram representation - block diagram reduction. Signal flow graph - Mason's gain formula. (4 hours)	**9**
2	**Performance Analysis of Control Systems:** *Time domain analysis of control systems:* Impulse and Step responses of first and second order systems - Pole dominance for higher order systems. Time domain specifications. Steady state error analysis and static error constants (5 hours)	**8**

	Characteristic equation. Routh stability criterion. (3 hours)	
3	**Root Locus Analysis and Controllers:** *Root locus technique:* Construction of Root locus - stability analysis- effect of addition of poles and zeros; Effect of positive feedback systems on Root locus. (5 hours) *Controller design:* Types of controllers and their control action-proportional (P), integral (I), derivative (D), PID control. PID tuning using Ziegler-Nichols method. (3 hours)	**8**
4	**Frequency domain analysis:** *Bode Plot:* Construction, Concept of gain margin and phase margin-stability analysis. (4 hours) Frequency domain specifications - correlation between time domain and frequency domain responses (Resonant peak and resonant frequency). (2 hours) Polar plot: Gain margin and phase margin, Stability analysis. (2 hours) Nyquist stability criterion. Concept of Nichols Chart. (3 hours)	**11**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	To represent continuous time systems in the classical domain.	**K2**
CO2	Analyse the time domain responses of linear systems and predict and diagnose transient response parameters of the system for standard input functions.	**K2**
CO3	Analyse dynamics systems for their performance and stability using Root locus.	**K3**
CO4	Analyse dynamics systems for their performance and stability in frequency domain..	**K3**
CO5	To represent continuous time systems in the classical domain.	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	2	1	3	3	3			3	2
CO2	3	2	1	2	1	3	3	3			3	2
CO3	3	3	2	2	2	3	3	3			3	2
CO4	3	3	2	2	2	3	3	3			3	2
CO5	3	2	1	2	1	3	3	3			3	2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Control Systems Engineering	Norman S. Nise	Wiley	5th Edition, 2009
2	Control Systems Engineering	I. J. Nagrath, M. Gopal	New Age	5th Edition, 2009

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Automatic Control Systems,	Kuo B. C,	Prentice Hall of India	9th Edition,2014
2	Control Systems Principles and Design	Gopal M.	Tata McGraw Hill.	4th Edition, 2012
3	Modern Control Systems	Dorf R. C. , Bishop R. H	Pearson Education India	12th Edition, 2013
4	Modern Control Engineering	Katsuhiko Ogata	Pearson	5th Edition, 2009

SEMESTER S6

ENERGY MANAGEMENT

Course Code	**OEEET612**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None/ (Course code)	**Course Type**	Theory

Course Objectives:

1. To apply energy conservation principles and management techniques to different energy conversion systems

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**General aspects of energy management and energy audit: Energy Management –** Definition, General principles of energy management and energy management planning **Energy Audit:** Definition, need, types and methodologies. Instruments for energy audit, Energy audit report - Power quality audit Energy conservation in buildings: ECBC code (basic aspects), Building Management System (BMS).	**9**
2	**Energy Efficiency in Electrical Utilities:** Electricity transmission and distribution system, cascade efficiency. **Lighting**: Modern energy efficient light sources, life and efficacy comparison with older light sources, energy conservation in lighting. **Motors:** Development of energy efficient motors and the present status, techniques for improving energy efficiency, necessity for load matching and selection of motors for constant and variable loads. **Demand side Management:** Introduction to DSM, benefits of DSM, different techniques of DSM. **Power factor improvement,** numerical examples.	**9**

	Ancillary services: Introduction of ancillary services – Types of Ancillary services	
3	**Energy Management in Electrical Utilities:** **Boilers:** working principle - blow down, energy conservation opportunities in boiler. **Steam:** properties of steam, distribution losses, steam trapping. Identifying opportunities for energy savings in steam distribution. **Furnace:** General fuel economy measures, energy conservation opportunities in furnaces. **HVAC system:** Performance and saving opportunities in Refrigeration and Air conditioning systems**.** **Heat Recovery Systems:** Waste heat recovery system - Energy saving opportunities. **Cogeneration:** Types and schemes, optimal operation of cogeneration plants, combined cycle electricity generation.	**9**
4	**Energy Economics:** Economic analysis: methods, cash flow model, time value of money, evaluation of proposals, pay-back period, average rate of return method, internal rate of return method, present value method, life cycle costing approach. Computer aided Energy Management Systems (EMS).	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Analyse the significance of energy management and auditing.	**K2**
CO2	Discuss the energy efficiency and management of electrical loads.	**K2**
CO3	Apply demand side management techniques	**K2**
CO4	Explain the energy management opportunities in industries.	**K2**
CO5	Compute the economic feasibility of the energy conservation measures	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2					1	1		1			
CO2	2		1	1		1	1					
CO3	2		1	1		1	1					
CO4	2		1	1		1	1					
CO5	2										2	

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Publications of Bureau of Energy Efficiency (BEE).			
2	Energy Management and Conservation Handbook	D. Yogi Goswami, Frank Kreith,	CRC Press	2007
3	Energy management Hand Book	Wayne C. Turner	The Fairmount Press, Inc.	1997
4	Energy Management and Conservation Handbook	D. Yogi Goswami, Frank Kreith	CRC Press	2007
5	Industrial energy conservation	Charles M. Gottschalk	John Wiley & Sons	1996

SEMESTER S6

RENEWABLE ENERGY SYSTEMS

Course Code	**OEEET613**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	NIL	**Course Type**	Theory

Course Objectives:

1. To understand energy scenario, energy sources and their utilization
2. To explore society's present needs and future energy demands
3. To study the principles of renewable energy conversion systems
4. To be exposed to energy conservation methods

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction:** Principles of renewable energy; energy and sustainable development, fundamentals and social implications. Worldwide renewable energy availability, renewable energy availability in India, types of renewable energy. **Wind Energy:** Properties of wind, availability of wind energy in India, wind velocity and power from wind (numerical problems); major problems associated with wind power, Basic components of wind energy conversion system (WECS); Classification of WECS- Horizontal axis- single, double and multi-blade system. Vertical axis - Savonius and Darrieus types.	9
2	**Solar Energy:** Fundamentals; Solar Radiation; Estimation of solar radiation on horizontal and inclined surfaces; Solar radiation Measurements - Pyrheliometers, Pyranometer, Sunshine Recorder. Solar Thermal systems: concentrating and non-concentrating collectors - Flat plate collectors; Solar tower electric power plant. Photovoltaic system for electric power generation	9

	– Classification of PV system - Principle of Solar cell, advantages, disadvantages and applications of solar photovoltaic system.	
3	**Biomass Energy:** Introduction; Principle of biomass energy generation - Biofuels; Biomass Resources; Biomass conversion technologies-fixed dome type biogas plant; Urban waste to energy conversion; Biomass gasification (Downdraft). **Tidal Power:** Tides and waves as energy suppliers and their mechanics; fundamental characteristics of tidal power, classification of tidal power plants - harnessing tidal energy, advantages and limitations.	**9**
4	**Ocean Thermal Energy Conversion:** Principle of working, classification, OTEC power stations in the world, environmental impacts associated with OTEC. Introduction to geothermal energy **Green Energy:** Introduction, Fuel cells: Classification of fuel cells – Hydrogen energy; Operating principles, Zero-energy Concepts. Benefits of hydrogen energy, hydrogen production technologies (electrolysis method only), hydrogen energy storage, applications of hydrogen energy, problem associated with hydrogen energy.	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Describe the environmental aspects of renewable energy resources in comparison with various conventional energy systems, their prospects and limitations.	**K1**
CO2	Understand the concepts of wind energy.	**K1**
CO3	Describe the use of solar energy and the various components used in the energy production with respect to applications like-heating, cooling, desalination, power generation.	**K2**
CO4	Understand the concept of biomass energy resources and conversion principles of tidal energy.	**K2**
CO5	Acquire the basic knowledge of ocean thermal energy conversion. Understand the principle of green energy and hydrogen energy.	**K1**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3										2
CO2	3	3										2
CO3	3	3										2
CO4	3	3										2
CO5	3	3										2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Non-conventional energy sources	G. D. Rai	Khanna	4th edition 2023
2	Renewable energy systems	Thomas E. Kissell, David M. Buchla, Thomas L. Floyd,	Pearson	2017
3	Non-Conventional Energy Resources	Sawhney G. S.	PHI Learning	2012
4	Renewable energy systems	Thomas E. Kissell, David M. Buchla, Thomas L. Floyd,	Pearson	Pearson 2017

SEMESTER S6

CONTROL SYSTEM LAB

(EE Branch)

Course Code	**PCEEL607**	**CIE Marks**	50
Teaching Hours/Week (L: T:P: R)	0:0:3:0	**ESE Marks**	50
Credits	2	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	PCEET302/ PCEET601	**Course Type**	Lab

Course Objectives:

1. To make the students learn how to determine the parameters experimentally and model the given system.
2. To make the students learn the experimental determination of responses of dynamic systems and analyse its behaviour.
3. To make the students learn the different analysis and controller design tools using appropriate simulation software

Expt. No.	Experiments
1	**Transfer Function and State Space Modelling of Armature and Field Controlled DC Motor.** **Objective:** Obtain the transfer function and state space model of the armature and field-controlled DC motor by experiment.
2	**Transfer function of A.C. Servo motor.** **Objective:** Obtain the transfer function of AC Servo motor by experiment.
3	**Synchro Transmitter and Receiver for open loop position control.** **Objective:** a) Plot the characteristics of synchro. Error study of the synchro transmitter and receiver pair as a simple open loop position control in Direct mode and Differential mode.

4	**Step response and frequency response of a second order system realised using passive components** **Objective**: Design a second order (RLC network) system to analyse the following: a. The effect of damping factor ($0<\xi<1$, $\xi = 1$, $\xi > 1$) for a step input . b. Verification of the delay time, rise time, peak overshoot and settling time with the theoretical values for $0<\xi<1$. c. Effect of damping ratio on frequency response. d. Verification of resonant peak, resonant frequency and bandwidth for $0<\xi<1$.
5	**Realisation of lead compensator.** **Objective:** Design, set up and analyse the gain and phase plots of a lead compensator by hardware experimentation using i) passive elements and ii) active components
6	**Realisation of lag compensator.** **Objective:** Design, set up and analyse the gain and phase plots of a lag compensator by hardware experimentation using: i) passive elements and ii) active components.
7	**Performance of a typical process control system** **Objective:** Study of performance characteristics and response analysis of a typical temperature/ Flow/ Level control system.
8	**System Identification and Modeling** **Objective:** Obtain the frequency response and identify the transfer function of the given system(black box),

9	**Step response and frequency response of a second order system using simulation** **Objective:** To analyse the response of the second order system (in experiment 1) using (MATLAB/SCILAB/similar softwares) a. The effect of damping factor ($0<\xi<1$, $\xi = 1$, $\xi > 1$) for a step input . b. Comparison of the delay time, rise time, peak overshoot and settling time with the experimental values for $0<\xi<1$. c. The effect of damping ratio on frequency response. d. Comparison of resonant peak, resonant frequency and bandwidth with the experimental values for $0<\xi<1$.
10	**Performance Analysis using Root-Locus and frequency Response Methods in MATLAB/SCILAB/similar softwares.** **Objective:** 1. Plot the i) root locus ii) Bode plot and iii) Nyquist plot and iv) Nichols chart for the given transfer functions and analyse the following: **Root Locus:** a. Determine the critical gain, frequency of oscillation at critical gain. b. The effect of gain, K on the stability. c. Determine the gain corresponding to a given damping ratio and obtain the step response of the system for the corresponding gain. d. The effect of the addition of poles and zeros on the given system. **Frequency response:** e.Determination of Gain Margin and Phase Margin (stable and unstable, minimum/non-minimum phase system)

	f. The effect of controller gain K on the stability margin g. The effect of the addition of poles and zeros on the given system (especially the poles at origin). h. Determine the stability of a given minimum and non-minimum phase system using Nyquist stability criterion. i. Determine the bandwidth of a given system from open loop frequency response using Nichols chart.
11	**Design of lag, lead and lag-lead compensator using root locus.** **Objective:** Design a suitable compensator for the given system to satisfy the given time domain specifications using MATLAB/SCILAB/ similar software.
12	**Design of lag, lead and lag-lead compensator using frequency response.** **Objective:** Design a suitable compensator for the given system to satisfy the given frequency domain specifications using MATLAB/SCILAB/ similar software.
13	**State Space Model, Analysis and Controller Design** **Objective:** Analyse the given system (eg. DC Servo motor modelled in experiment no.1 for **speed** control) in state space and design a controller by pole-placement technique using MATLAB/SCILAB/ similar software. a. Determine the open loop stability, controllability and observability b. Design a state-feedback controller by pole-placement technique for a given specification.
14	**PID Controller Design** **Objective:** Design a PID controller for the given system (eg. DC Servo motor modelled in experiment no. 1 for **position** control) using SIMULINK/ MATLAB based tool boxes. a. Design of P, PI, PD, PID controller using the Ziegler-Nichols method. b. Design of a suitable controller (P/PI/PD/PID) to meet the desired specifications using root locus/frequency response.

Note: 1. A minimum of **12 experiments** are compulsory.
2. Experiment No. **11, 12, and 13** are mandatory.

Course Assessment Method
(CIE: 50 marks, ESE: 50 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Preparation/Pre-Lab Work experiments, Viva and Timely completion of Lab Reports / Record (Continuous Assessment)	Internal Examination	Total
5	25	20	50

End Semester Examination Marks (ESE):

Procedure/ Preparatory work/Design/ Algorithm	Conduct of experiment/ Execution of work/ troubleshooting/ Programming	Result with valid inference/ Quality of Output	Viva voce	Record	Total
10	15	10	10	5	50

- ***Submission of Record: Students shall be allowed for the end semester examination only upon submitting the duly certified record.***
- ***Endorsement by External Examiner:*** *The external examiner shall endorse the record*

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Identify and conduct suitable experiments to determine the parameters to model a physical system.	**K3**
CO2	Conduct suitable experiments and determine the performance specifications.	**K3**
CO3	Analyse a linear continuous time system model using simulation tools.	**K3**
CO4	Design suitable controllers/compensators to meet the performance requirements using simulation tools.	**K5**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO- PO Mapping (Mapping of Course Outcomes with Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	3	3	3	3	2	3	2
CO2	3	3	2	2	2	3	3	3	3	2	3	2
CO3	3	3	2	2	2	3	3	3	3	2	3	2
CO4	3	3	3	3	3	3	3	3	3	2	3	2

1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Modern Control Engineering	Katsuhiko Ogata	Pearson	5th edition, 2009
2	Control Systems Engineering	Norman S. Nise	Wiley	5th edition, 2009
3	Control Systems Engineering	I. J. Nagrath, M. Gopal	New Age	5th edition, 2009

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Automatic Control Systems,	Kuo B. C.	Prentice Hall of India	
2	Control Systems Principles and Design	Gopal M.	Tata McGraw Hill.	
3	Modern Control Systems	Dorf R. C., Bishop R. H	Pearson Education India	

Continuous Assessment (25 Marks)

1. **Preparation and Pre-Lab Work (7 Marks)**

    - Pre-Lab Assignments: Assessment of pre-lab assignments or quizzes that test understanding of the upcoming experiment.
    - Understanding of Theory: Evaluation based on students' preparation and understanding of the theoretical background related to the experiments.

2. **Conduct of Experiments (7 Marks)**

    - Procedure and Execution: Adherence to correct procedures, accurate execution of experiments, and following safety protocols.
    - Skill Proficiency: Proficiency in handling equipment, accuracy in observations, and troubleshooting skills during the experiments.
    - Teamwork: Collaboration and participation in group experiments.

3. **Lab Reports and Record Keeping (6 Marks)**

    - Quality of Reports: Clarity, completeness and accuracy of lab reports. Proper documentation of experiments, data analysis and conclusions.
    - Timely Submission: Adhering to deadlines for submitting lab reports/rough record and maintaining a well-organized fair record.

4. **Viva Voce (5 Marks)**

    - Oral Examination: Ability to explain the experiment, results and underlying principles during a viva voce session.

Final Marks Averaging: The final marks for preparation, conduct of experiments, viva, and record are the average of all the specified experiments in the syllabus.

Evaluation Pattern for End Semester Examination (50 Marks)

1. **Procedure/Preliminary Work/Design/Algorithm (10 Marks)**

    - Procedure Understanding and Description: Clarity in explaining the procedure and understanding each step involved.

- Preliminary Work and Planning: Thoroughness in planning and organizing materials/equipment.
- Algorithm Development: Correctness and efficiency of the algorithm related to the experiment.
- Creativity and logic in algorithm or experimental design.

2. Conduct of Experiment/Execution of Work/Programming (15 Marks)

- Setup and Execution: Proper setup and accurate execution of the experiment or programming task.

3. Result with Valid Inference/Quality of Output (10 Marks)

- Accuracy of Results: Precision and correctness of the obtained results.
- Analysis and Interpretation: Validity of inferences drawn from the experiment or quality of program output.

4. Viva Voce (10 Marks)

- Ability to explain the experiment, procedure results and answer related questions
- Proficiency in answering questions related to theoretical and practical aspects of the subject.

5. Record (5 Marks)

- Completeness, clarity, and accuracy of the lab record submitted

SEMESTER S6

POWER SYSTEM LAB

Course Code	**PCEEL609**	**CIE Marks**	50
Teaching Hours/Week (L: T:P: R)	0:0:2:0	**ESE Marks**	50
Credits	1	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	PCEET501	**Course Type**	Lab

Course Objectives:

1. To encourage students learn through analytical problem solving and practical implementation.
2. To motivate the students for self-learning
3. To make them ready for practical implementation of the knowledge that they have gained from theory.

Expt. No.	Experiments
	Software
1	**Y-Bus formulation:** Aim: (i) To formulate the bus admittance matrix of the given power system from its single line diagram, using basic MATLAB programming. (ii) To incorporate changes in basic topology.
2	**Transmission Line Modelling: ABCD constants** Aim: (i) To model the given medium transmission line using nominal T and nominal pi representation and to derive the ABCD constants using basic MATLAB programming.
3	Load Flow Analysis – Gauss-Siedel Method, Newton - Raphson Method, Fast Decoupled Method – Aim: (i) To conduct load flow analysis using Gauss-Siedel method, Newton-Raphson method, Fast Decoupled method and to study the effect of change in load/generation schedule.
4	**Load Flow Analysis** – Gauss-Siedel Method, Newton - Raphson Method, Fast Decoupled Method Aim: (i) To conduct load flow analysis using Gauss-Siedel method, Newton-Raphson method, Fast Decoupled method and to study the effect of change in real power/reactive power limits.
5	**Short Circuit Analysis** – Symmetrical Faults and Unsymmetrical Faults Aim: (i) To conduct short circuit analysis for symmetrical and unsymmetrical faults.
6	**Transient Stability Analysis** Aim: To conduct transient stability analysis of a given system and plot suitable graphs using MATLAB Simulink or dedicated software (if available)

7	**Automatic Generation Control –** Single Area, Two Area Aim: To implement Automatic Generation Control in MATLAB Simulink.
8	**Automatic Voltage Regulator** Aim: To implement Automatic Voltage Regulator in MATLAB Simulink.
9	**Ferranti Effect and Reactive Power Compensation** Aim: (i) To exhibit Ferranti effect in a lightly loaded long transmission line in MATLAB Simulink and to show the effect of reactive power compensation. (ii) To calculate Surge Impedance Loading of the line
10	**Plot the IV characteristics of a PV module and determine Maximum Power Point** Aim: To plot the IV characteristics of a PV module in MATLAB Simulink and determine the Maximum Power Point
	Hardware
11	**High Voltage Testing** – Power frequency /impulse
12	**High Voltage Testing** - DC
13	**Relay Testing** – Over current Relay / Earth Fault (Electromechanical / Static /Numerical) Aim: To draw the characteristics of the given relay.
14	**Relay Testing** –Voltage relay/ Impedance Relay (Electromechanical/Static/Numerical) Aim: To draw the characteristics of the given relay.
15	**Insulation Testing** – LT & HT Cable Aim: To determine the insulation resistance of the given LT & HT cable.
16	**Testing of CT and PT** Aim: To conduct ratio test of the given CT and PT.
17	**Testing of transformer oil** Aim: To determine the dielectric strength of the given sample of transformer oil.
18	**Testing of dielectric strength of solid insulating materials** Aim: To determine the dielectric strength of the solid insulating material given.
19	**Testing of dielectric strength of air** Aim: To determine the dielectric strength of air.
20	**Power factor improvement** Aim: To calculate the power factor of the given RL series circuit (transmission line) and design the capacitance required to improve the power factor to the desired value.

Course Assessment Method
(CIE: 50 marks, ESE: 50 marks)

Continuous Internal Evaluation Marks (CIE):

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10	15	10	10	5	50

- ***Submission of Record: Students shall be allowed for the end semester examination only upon submitting the duly certified record.***
- ***Endorsement by External Examiner:*** *The external examiner shall endorse the record*

Course Outcomes (Cos)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Develop mathematical models and conduct steady state and transient analysis of power system networks using standard / dedicated software.	**K3**
CO2	Conduct appropriate tests for any power system component as per standards to analyse their performance.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO- PO Mapping (Mapping of Course Outcomes with Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3				3	3	3	3
CO2	3	3	3	3	3				3	3	3	3

1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Continuous Assessment (25 Marks)

1. Preparation and Pre-Lab Work (7 Marks)

- Pre-Lab Assignments: Assessment of pre-lab assignments or quizzes that test understanding of the upcoming experiment.
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- Quality of Reports: Clarity, completeness and accuracy of lab reports. Proper documentation of experiments, data analysis and conclusions.
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- Creativity and logic in algorithm or experimental design.

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- Setup and Execution: Proper setup and accurate execution of the experiment or programming task.

3. Result with Valid Inference/Quality of Output (10 Marks)

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- Analysis and Interpretation: Validity of inferences drawn from the experiment or quality of program output.

4. Viva Voce (10 Marks)

- Ability to explain the experiment, procedure results and answer related questions
- Proficiency in answering questions related to theoretical and practical aspects of the subject.

5. Record (5 Marks)

- Completeness, clarity, and accuracy of the lab record submitted