FIFTH SEMESTER (July-December)														
Sl. No:	**Slot**	**Course Code**	**Course Type**	**Course Category**	**Course Title (Course Name)**	**Credit Structure**				**SS**	**Total Marks**		**Credits**	**Hrs./ Week**
						L	**T**	**P**	**R**		**CIA**	**ESE**		
1	A	PCEET501	PC	PC	Power Generation, Transmission and Protection	3	1	0	0	5	40	60	4	4
2	B	PCEET502	PC	PC	Electromagnetic Theory	3	1	0	0	5	40	60	4	4
3	C	PCEET503	PC	PC	Signals & Systems	3	0	0	0	4.5	40	60	3	3
4	D	PBEET504	PC-PBL	PB	Microprocessor and Embedded Systems	3	0	0	1	5.5	60	40	4	4
5	E	PEEET522	PE	PE	Electric Vehicles	3	0	0	0	4.5	40	60	3	3
6	I*	UCHUM506	HMC	UC	Constitution of India (MOOC)	-	-	-	-	2	-	-	1	-
7	L	PCEEL507	PCL	PC	AC Machines Lab	0	0	3	0	1.5	50	50	2	3
8	Q	PCEEL508	PCL	PC	Microprocessor and Embedded Systems Lab	0	0	3	0	1.5	50	50	2	3
9	R/M/H		VAC		Remedial/Minor/Honours Course	3	1	0	0	5			4*	4*
	S_5/ S_6	Industrial Visit (Maximum 12 Days are permitted, Not Exceeding more than 6 Working Days) /Industrial Training												
Total										**30/ 35**			**23/27***	**24/28***

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

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

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)

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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