SEMESTER 3

ELECTRICAL & ELECTRONICS ENGINEERING

SEMESTER S3

MATHEMATICS FOR ELECTRICAL SCIENCE AND PHYSICAL SCIENCE – 3

(Common to B & C Groups)

Course Code	**GYMAT301**	**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)	Basic knowledge in complex numbers.	**Course Type**	Theory

Course Objectives:

1. To introduce the concept and applications of Fourier transforms in various engineering fields.
2. To introduce the basic theory of functions of a complex variable, including residue integration and conformal transformation, and their applications

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Fourier Integral, From Fourier series to Fourier Integral, Fourier Cosine and Sine integrals, Fourier Cosine and Sine Transform, Linearity, Transforms of Derivatives, Fourier Transform and its inverse, Linearity, Transforms of Derivative. **(Text 1: Relevant topics from sections 11.7, 11.8, 11.9)**	9
2	Complex Function, Limit, Continuity, Derivative, Analytic functions, Cauchy-Riemann Equations (without proof), Laplace's Equations, Harmonic functions, Finding harmonic conjugate, Conformal mapping, Mappings of $w = z^2$, $w=e^z$, $w=\frac{1}{z}$, $w=\sin z$. **(Text 1: Relevant topics from sections 13.3, 13.4, 17.1, 17.2, 17.4)**	9
3	Complex Integration: Line integrals in the complex plane (Definition & Basic properties), First evaluation method, Second evaluation method, Cauchy's integral theorem (without proof) on simply connected domain, Independence of path, Cauchy integral theorem on multiply connected	9

	domain (without proof), Cauchy Integral formula (without proof). **(Text 1: Relevant topics from sections 14.1, 14.2, 14.3)**	
4	Taylor series and Maclaurin series, Laurent series (without proof), Singularities and Zeros – Isolated Singularity, Poles, Essential Singularities, Removable singularities, Zeros of Analytic functions – Poles and Zeros, Formulas for Residues, Residue theorem (without proof), Residue Integration- Integral of Rational Functions of $cos\theta$ and $sin\theta$. **(Text 1: Relevant topics from sections 15.4, 16.1, 16.2, 16.3, 16.4)**	**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	Determine the Fourier transforms of functions and apply them to solve problems arising in engineering.	**K3**
CO2	Understand the analyticity of complex functions and apply it in conformal mapping.	**K3**
CO3	Compute complex integrals using Cauchy's integral theorem and Cauchy's integral formula.	**K3**
CO4	Understand the series expansion of complex function about a singularity and apply residue theorem to compute real integrals.	**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	-	2	-	-	-	-	-	-	-	2
CO2	3	3	-	2	-	-	-	-	-	-	-	2
CO3	3	3	-	2	-	-	-	-	-	-	-	2
CO4	3	3	-	2	-	-	-	-	-	-	-	2

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Advanced Engineering Mathematics	Erwin Kreyszig	John Wiley & Sons	10^{th} edition, 2016

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Complex Analysis	Dennis G. Zill, Patrick D. Shanahan	Jones & Bartlett	3rd edition, 2015
2	Higher Engineering Mathematics	B. V. Ramana	McGraw-Hill Education	39th edition, 2023
3	Higher Engineering Mathematics	B.S. Grewal	Khanna Publishers	44th edition, 2018
4	Fast Fourier Transform - Algorithms and Applications	K.R. Rao, Do Nyeon Kim, Jae Jeong Hwang	Springer	1st edition, 2011

SEMESTER S3

CIRCUITS & NETWORKS

Course Code	**PCEET302**	**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)	Introduction to Electrical Engineering	**Course Type**	Theory

Course Objectives:

1. This course analyses electrical circuits in steady-state and dynamic conditions with DC and sinusoidal excitations
2. It also describes the two-port networks in terms of various parameters.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Mesh analysis and nodal analysis (Review only)- super mesh and super node - Superposition principle - source transformation – analysis with DC and AC (sinusoidal) excitation Thevenin's theorem - Norton's theorem - Maximum power transfer theorem - analysis with DC and AC (sinusoidal) excitation with independent and dependent sources. Reciprocity Theorem - application to the analysis of DC Circuits.	**12**
2	Resonance - series resonance– resonant frequency – variations of impedance and current with frequency – bandwidth – quality factor– parallel resonance (series RL in parallel with C –calculation of resonant frequency). Power in 3-phase circuits – complex power - active, reactive and apparent power in balanced load – steadystate analysis of 3-wire unbalanced delta connected circuit - steady state analysis of 3-phase 4-wire and 3-wire (using Millman's theorem only) unbalanced star connected circuit –neutral shift	**12**
3	Laplace transforms(Review only) Transient response of simple series and parallel RL and RC circuits with	**12**

	DC excitation and initial conditions – natural response and forced response – time constant - solution using Laplace transforms – transformed circuits in s-domain – solution using mesh analysis and nodal analysis Transient response of series RLC circuit with DC excitation and initial conditions – damping –overdamped, underdamped, critically damped and undamped - solution using Laplace transforms Transient response of simple series and parallel RL and RC circuits with sinusoidal excitation and zero initial conditions – solution using Laplace transforms	
4	Two port networks – Z, Y, h, T parameters – conditions for symmetry and reciprocity – relationship between parameters – interconnection of two port networks – series, parallel and cascade Coupled circuit – dot convention – fixing of dots – coefficient of coupling - conductively coupled equivalent circuit - sinusoidal steady state analysis of coupled circuits.	**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	Apply circuit theorems to solve complex DC and AC electric networks	**K3**
CO2	Apply transformation from time domain to s-domain, solve dynamic electric circuits.	**K3**
CO3	Solve series and parallel resonant circuits	**K3**
CO4	Analyse three-phase networks in star and delta configurations under balanced and unbalanced conditions.	**K3**
CO5	Describe two-port networks in terms of various parameters.	**K3**
CO6	Explain the steady-state behaviour of coupled circuits with sinusoidal excitation	**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
CO2	3	3										3
CO3	3	3										3
CO4	3	3										3
CO5	3	3										3
CO6	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	Network Analysis	Van Valkenburg	Pearson	3rd 2019
2	Network Analysis and Synthesis	Ravish R Singh	McGraw Hill Education	2nd 2019
3	Electric Circuits & Networks	Suresh Kumar	Pearson	Ist 2008
4	Circuits and Networks, Analysis and Synthesis	A Sudhakar, Shyammohan S Palli	McGraw Hill Education	5th 2017

SEMESTER S3

DC MACHINES & TRANSFORMERS

Course Code	**PCEET303**	**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)	None	**Course Type**	Theory

Course Objectives:

1. Describe the constructional details, working and analyse the performance of DC machines and transformers under various load conditions.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Constructional details of dc machines - armature winding - lap and wave – simplex, progressive only – winding diagrams of simplex, lap wound, double layer, 12-slot, 4-pole, dc armature with 12 commutator segments – winding diagram of simplex wave wound, double layer, 16-slot, 6-pole, dc armature with 12 commutator segments (winding diagram not for evaluation) DC generator - principle of operation of DC generator – emf equation – numerical problems Classification DC generators – steady-state equations – numerical problems DC shunt generator - no-load characteristics – critical field resistance, critical speed, voltage build-up - load characteristics – numerical problems Armature reaction - cross magnetising & demagnetising effect (computation of ampere-turns not required) – compensating winding – interpoles – commutation (concept only) – numerical problems Power flow diagram – losses and efficiency – maximum efficiency - numerical problems Parallel operation of DC shunt generators – load sharing – numerical problems	**12**

2	DC motor – back emf – torque equation – numerical problems Classification of DC motors – steady-state equations – numerical problems Characteristics of DC motors – numerical problems Starting of DC motors – 3-point starter Braking – regenerative braking, dynamic braking and plugging (concepts only) Speed control of DC shunt and series motors – field control and armature control – numerical problems Power flow diagram – losses and efficiency – numerical problems Testing - Swinburne's test – Hopkinson's test – retardation test - separation of rotational losses - numerical problems	**12**
3	Single phase transformers – constructional details - principle of operation - EMF equation - ideal and practical transformer – numerical problems Operation on no load and on load - phasor diagram at different load conditions - equivalent circuit - voltage regulation – numerical problems Losses and efficiency - condition for maximum efficiency – numerical problems Testing of transformers - polarity test - OC test, SC test - Sumpner's test – separation of losses – numerical problems	**11**
4	Autotransformer – saving of copper – numerical problems 3- phase transformer – construction - different connections of 3-phase transformers - Y-Y, Δ-Δ, Y-Δ, Δ-Y – numerical problems Difference between power transformer and distribution transformer – all-day efficiency – numerical problems Scott connection for 3-phase to 2-phase conversion Vector groupings – Yy0, Dd0, Yd1, Yd11, Dy1, Dy11 Parallel operation of 1-phase and 3-phase transformers - essential and desirable conditions On load and off-load tap-changers	**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 constructional details of DC machines	**K2**
CO2	Analyse the performance DC generator under various load conditions	**K3**
CO3	Analyse the performance DC motor under various load conditions	**K3**
CO4	Analyse the performance of 1-phase transformer and auto-transformer under various load conditions.	**K3**
CO5	Describe the constructional details and operation of 3-phase transformers.	**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										3
CO2	3	3										3
CO3	3	3										3
CO4	3	3										3
CO5	3	2										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 Machinery	P.S. Bimbhra	Khanna Publishers	7th edition 2021
2	Electric Machines	D P Kothari & I J Nagrath	Tata McGraw Hill	5th edition 2017
3	DC Machines & Transformers	K Murugesh Kumar	Vikas Publishing House	2nd edition 2004
4	Theory & Performance of Electrical Machines	J.B. Gupta	S K Kataria	15th edition 2022

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	NPTEL https://archive.nptel.ac.in/courses/108/105/108105155/

SEMESTER S3

ANALOG ELECTRONICS

Course Code	**PBEET304**	**CIE Marks**	60
Teaching Hours/Week (L: T:P: R)	3:0:0:1	**ESE Marks**	40
Credits	4	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. At the end of the course the student will be able to design of analog electronic systems using BJT, FET and OP-Amp

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Review of Bipolar Junction Transistor-** Introduction to DC Biasing – Base Bias – Voltage Divider Bias **Common Emitter Amplifier** – AC concepts —Role of coupling capacitors and emitter bypass capacitor- Common Emitter AC equivalent circuit- Amplifier Gain - Calculation of amplifier gains and impedances using h parameter equivalent circuit. **Emitter Follower Amplifier** **Power Amplifiers** -AC load line – RC Coupled amplifiers – Transformer coupled Class A amplifiers – Class B amplifiers(Derivation of efficiency) – Class AB amplifiers – Class C and Class D amplifiers	**9**
2	**Introduction to JFET** – JFET biasing circuits – Common Source Amplifier **Introduction to MOSFET** -MOSFET construction -D-MOSFET, E-MOSFET-Complementary MOSFET **Amplifier Frequency Response** – Basic concepts – BJT amplifier Frequency response – FET amplifier Frequency Response **Feedback and Oscillator circuits** – Feedback concepts – Feedback connection types – Practical Feedback circuits **Oscillators** – Phase Shift Oscillator (Expression of frequency oscillation)–	**9**

	Wien Bridge Oscillator – Tuned Oscillator circuits – Crystal Oscillator	
3	**Introduction to Operational Amplifiers (Op-Amps)** – Operation Overview – Differential amplifiers and Op-Amp Specifications -Gain, CMRR and slew rate **Op- Amp Circuits** – Inverting Amplifiers – Non inverting Amplifiers – Summing and Difference Amplifiers – Instrumentation Amplifiers Differentiator and Integrator circuits-practical circuits Comparators: Zero crossing and voltage level detectors, Schmitt trigger.	**9**
4	**Active Filters** – Butterworth, Chebyshev and Bessel Filters, Low pass filter – high pass filter -band pass and notch filters- Butterworth **Wave form generation using Op-Amps**: Square, triangular and ramp generatorcircuits using Op-Amp- Effect of slew rate on waveform generation. **Timer555 IC**: Internal diagram of 555 IC– Astable and Monostable multi-vibrators using 555 IC	**9**

Suggestion on Project Topics

In this curriculum Analog Electronics is the first Project Based Learning Course for the Electrical and Electronics Engineering students.

Project-Based Learning (PBL) is a student-centered teaching approach where the teacher serves as a facilitator and advisor.

Students are encouraged to think the need of the society and industry. Select a project topic relevant to the present society as well as covers topics in the syllabus.

In the first step they start defining problem statement with requirements and specifications.

In the second step, students work in groups to discover optimal and creative solutions by sharing their unique and inventive ideas for solutions.

They begin designing and developing components using contemporary tools and technology in the third level. Design the circuit and simulate it using available simulation tools. Also perform the hardware implementation to make it a product.

Project Topic Suggestions:

1. Regulated power supply
2. Electronic Thermometer with diode/transistor/instrumentation amplifier
3. Audio Amplifier
4. Multistage amplifiers
5. Biomedical signal processing devices
6. RF Transmitter

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

Continuous Internal Evaluation Marks (CIE):

Attendance	Project	Internal Ex-1	Internal Ex-2	Total
5	**30**	**12.5**	**12.5**	**60**

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 2 marks **(8x2 =16 marks)**	• 2 questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 2 sub divisions. • Each question carries 6 marks. **(4x6 = 24 marks)**	**40**

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Design BJT and FET amplifier circuits	**K3**
CO2	Design Oscillator circuits	**K3**
CO3	Design and develop various OPAMP application circuits.	**K3**
CO4	Implementation of active filters	**K4**
CO5	Implement an electronic hardware circuit for the solution of a real time problem	**K4**

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	3	3	3	3							
CO3	3	3	3	3	3							
CO4	3	3	3	3	3							
CO5	3	3	3	3	3	3	2	1	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	Introductory Electronic Devices and Circuits	Robert T Paynter	Pearson Education	
2	Electronic devices and Circuit Theory	Boylestad R. L. and L. Nashelsky	Pearson Education	
3	Electronic Circuits : Analysis and Design	Donald A Neaman	McGraw Hill Companies	

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Fundamentals of Analog Circuits	Floyd T.L.	Pearson Education	
2	Op-Amps and Linear Integrated Circuits	Gayakward R. A.	PHI Learning Pvt. Ltd.	
3	Electronic Devices and Circuits	David A Bell	Oxford Higher Education	
4	Linear Integrated Circuits	Choudhury R.	New Age International Publishers	

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/108/105/108105158/
2	https://archive.nptel.ac.in/courses/108/102/108102112/
3	https://nptel.ac.in/courses/108106084

PBL Course Elements

L: Lecture (3 Hrs.)	R: Project (1 Hr.), 2 Faculty Members		
	Tutorial	**Practical**	**Presentation**
Lecture delivery	Project identification	Simulation/ Laboratory Work/ Workshops	Presentation (Progress and Final Presentations)
Group discussion	Project Analysis	Data Collection	Evaluation
Question answer Sessions/ Brainstorming Sessions	Analytical thinking and self-learning	Testing	Project Milestone Reviews, Feedback, Project reformation (If required)
Guest Speakers (Industry Experts)	Case Study/ Field Survey Report	Prototyping	Poster Presentation/ Video Presentation: Students present their results in a 2 to 5 minutes video

Assessment and Evaluation for Project Activity

Sl. No	Evaluation for	Allotted Marks
1	Project Planning and Proposal	5
2	Contribution in Progress Presentations and Question Answer Sessions	4
3	Involvement in the project work and Team Work	3
4	Execution and Implementation	10
5	Final Presentations	5
6	Project Quality, Innovation and Creativity	3
Total		**30**

1. Project Planning and Proposal (5 Marks)

- Clarity and feasibility of the project plan
- Research and background understanding
- Defined objectives and methodology

2. Contribution in Progress Presentation and Question Answer Sessions (4 Marks)

- Individual contribution to the presentation
- Effectiveness in answering questions and handling feedback

3. Involvement in the Project Work and Team Work (3 Marks)

- Active participation and individual contribution
- Teamwork and collaboration

4. Execution and Implementation (10 Marks)

- Adherence to the project timeline and milestones
- Application of theoretical knowledge and problem-solving
- Final Result

5. Final Presentation (5 Marks)

- Quality and clarity of the overall presentation
- Individual contribution to the presentation
- Effectiveness in answering questions

6. Project Quality, Innovation, and Creativity (3 Marks)

- Overall quality and technical excellence of the project
- Innovation and originality in the project
- Creativity in solutions and approaches

SEMESTER S3

INTRODUCTION TO ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Course Code	**GNEST305**	**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)	None	**Course Type**	Theory

Course Objectives:

1. Demonstrate a solid understanding of advanced linear algebra concepts, machine learning algorithms and statistical analysis techniques relevant to engineering applications, principles and algorithms.
2. Apply theoretical concepts to solve practical engineering problems, analyze data to extract meaningful insights, and implement appropriate mathematical and computational techniques for AI and data science applications.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to AI and Machine Learning**: Basics of Machine Learning - types of Machine Learning systems-challenges in ML- Supervised learning model example- regression models- Classification model example- Logistic regression-unsupervised model example- K-means clustering. Artificial Neural Network- Perceptron- Universal Approximation Theorem (statement only)- Multi-Layer Perceptron- Deep Neural Network- demonstration of regression and classification problems using MLP.(Text-2)	11
2	**Mathematical Foundations of AI and Data science**: Role of linear algebra in Data representation and analysis – Matrix decomposition- Singular Value Decomposition (SVD)- Spectral decomposition- Dimensionality reduction technique-Principal Component Analysis (PCA). (Text-1)	11
3	**Applied Probability and Statistics for AI and Data Science**: Basics of probability-random variables and statistical measures - rules in probability-	11

	Bayes theorem and its applications- statistical estimation-Maximum Likelihood Estimator (MLE) - statistical summaries- Correlation analysis- linear correlation (direct problems only)- regression analysis- linear regression (using least square method) (Text book 4)	
4	**Basics of Data Science**: Benefits of data science-use of statistics and Machine Learning in Data Science- data science process - applications of Machine Learning in Data Science- modelling process- demonstration of ML applications in data science- Big Data and Data Science. (For visualization the software tools like Tableau, PowerBI, R or Python can be used. For Machine Learning implementation, Python, MATLAB or R can be used.) (Text book-5)	**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	Apply the concept of machine learning algorithms including neural networks and supervised/unsupervised learning techniques for engineering applications.	**K3**
CO2	Apply advanced mathematical concepts such as matrix operations, singular values, and principal component analysis to analyze and solve engineering problems**.**	**K3**
CO3	Analyze and interpret data using statistical methods including descriptive statistics, correlation, and regression analysis to derive meaningful insights and make informed decisions.	**K3**
CO4	Integrate statistical approaches and machine learning techniques to ensure practically feasible solutions in engineering contexts.	**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								
CO2	3	3	3	3								
CO3	3	3	3	3								
CO4	3	3	3	3								
CO5	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	Introduction to Linear Algebra	Gilbert Strang	Wellesley-Cambridge Press	6th edition, 2023
2	Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow	Aurélien Géron	O'Reilly Media, Inc.	2nd edition,2022
3	Mathematics for machine learning	Deisenroth, Marc Peter, A. Aldo Faisal, and Cheng Soon Ong	Cambridge University Press	1st edition. 2020
4	Fundamentals of mathematical statistics	Gupta, S. C., and V. K. Kapoor	Sultan Chand & Sons	9th edition, 2020
5	Introducing data science: big data, machine learning, and more, using Python tools	Cielen, Davy, and Arno Meysman	Simon and Schuster	1st edition, 2016

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Data science: concepts and practice	Kotu, Vijay, and Bala Deshpande	Morgan Kaufmann	2nd edition, 2018
2	Probability and Statistics for Data Science	Carlos Fernandez-Granda	Center for Data Science in NYU	1st edition, 2017
3	Foundations of Data Science	Avrim Blum, John Hopcroft, and Ravi Kannan	Cambridge University Press	1st edition, 2020
4	Statistics For Data Science	James D. Miller	Packt Publishing	1st edition, 2019
5	Probability and Statistics - The Science of Uncertainty	Michael J. Evans and Jeffrey S. Rosenthal	University of Toronto	1st edition, 2009
6	An Introduction to the Science of Statistics: From Theory to Implementation	Joseph C. Watkins	chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.math.arizo	Preliminary Edition.

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/106/106/106106198/
2	https://archive.nptel.ac.in/courses/106/106/106106198/ https://ocw.mit.edu/courses/18-06-linear-algebra-spring-2010/resources/lecture-29-singular-value-decomposition/
3	https://ocw.mit.edu/courses/18-650-statistics-for-applications-fall-2016/resources/lecture-19-video/
4	https://archive.nptel.ac.in/courses/106/106/106106198/

SEMESTER S3/S4

ECONOMICS FOR ENGINEERS

Course Code	**UCHUT346**	**CIE Marks**	50
Teaching Hours/Week (L: T:P: R)	2:0:0:0	**ESE Marks**	50
Credits	2	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. To provide students with an understanding of fundamental economic principles essential for effective decision-making in engineering contexts.
2. To enable students to apply economic analysis to production decisions, cost management, and market strategies in engineering practice.
3. To equip students with the ability to evaluate macroeconomic scenarios, financial methods, and investment decisions relevant to engineering projects.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Basic economic problems – Production Possibility Curve – Utility – Law of diminishing marginal utility –Demand: Factors determining demand – Law of Demand – Demand curve- Price elasticity of demand- measurement of price elasticity and its applications – Supply: factors determining supply - Law of supply – Supply curve- Equilibrium price determination- Changes in demand and supply and its effects on equilibrium price and quantity Production: Production function - Law of variable proportion –Returns to scale- Cobb-Douglas Production Function	**6**
2	Cost: Cost concepts – Private cost and social cost – Sunk cost – Opportunity cost -Explicit and implicit cost –Short run cost curves –Long run average cost curve -Revenue concepts – Break-even point Market: Perfect Competition – Monopoly - Monopolistic Competition (features and equilibrium of a firm) - Oligopoly – Features – Kinked demand model	**6**

3	National income: Concepts (GDP, GNP and NNP)– Final goods and Intermediate goods - Methods of Estimation –output method – expenditure method-- Difficulties in the measurement of national income. Inflation: Causes and Effects – Measures to Control Inflation - Monetary and Fiscal policies – Repo and reverse repo rate	**6**
4	Value Analysis and value Engineering: Cost Value, Exchange Value, Use Value, Esteem Value - Aims, Advantages and Application areas of Value Engineering - Value Engineering Procedure Capital Budgeting: Time value of money - Net Present Value Method - Benefit Cost Ratio – Internal Rate of Return -– Payback – Accounting Rate of Return.	**6**

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

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/Case Study/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
10	**15**	**12.5**	**12.5**	**50**

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
• Minimum 1 and Maximum 2 Questions from each module. • Total of 6 Questions, each carrying 3 marks (6x3 =18 marks)	2 questions will be given from each module, out of which 1 question should be answered. Each question can have a maximum of 2 sub divisions. Each question carries 8 marks. (4x8 = 32 marks)	**50**

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the fundamentals of various economic issues using laws and learn the concepts of demand, supply, elasticity and production function.	**K2**
CO2	Develop decision making capability by applying concepts relating to costs and revenue, and acquire knowledge regarding the functioning of firms in different market situations.	**K3**
CO3	Outline the macroeconomic principles of monetary and fiscal systems and national income.	**K2**
CO4	Make use of the possibilities of value analysis and engineering, and take investment decisions through capital budgeting techniques.	**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	-	-	-	-	-	1	-	-	-	-	1	-
CO2	-	-	-	-	-	1	1	-	-	-	1	-
CO3	-	-	-	-	1	-	-	-	-	-	2	-
CO4	-	-	-	-	1	1	-	-	-	-	2	-

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Managerial Economics	Geetika, Piyali Ghosh and Chodhury	Tata McGraw Hill,	2015
2	Engineering Economy	H. G. Thuesen, W. J. Fabrycky	PHI	1966
3	Engineering Economics	R. Paneerselvam	PHI	2012
4	Financial Management	I M Pandey	Vikas Publishing House	2015

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Engineering Economy	Leland Blank P.E, Anthony Tarquin P. E.	Mc Graw Hill	7^{TH} Edition
2	Indian Financial System	Khan M. Y.	Tata McGraw Hill	2011
3	Engineering Economics and analysis	Donald G. Newman, Jerome P. Lavelle	Engg. Press, Texas	2002
4	Contemporary Engineering Economics	Chan S. Park	Prentice Hall of India Ltd	2001
5	Financial Management: Theory and Practice	Prasanna Chandra	Mc Graw Hill	2007

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD SEMESTER B. TECH DEGREE EXAMINATION, MONTH AND YEAR

Course Code: UCHUT346

Course Name: Economics for Engineers

Max. Marks: 50		Duration: 2 hours 30 minutes

PART A

		Answer all questions. Each question carries 3 marks	CO	Marks
1		What are the central problems of an economy?	CO1	(3)
2		Point out any three applications of price elasticity of demand.	CO1	(3)
3		What is the social cost of production?	CO2	(3)
4		What is repo rate?	CO3	(3)
5		What is esteem value?	CO4	(3)
6		Write a short note on time value of money.	CO4	(3)

PART B

Answer any one full question from each module. Each question carries 8 marks

Module 1

9	a)	Suppose a country is producing at a point inside the production possibility curve. Draw a PPC and examine this situation.	CO1	(5)
	b)	State the law of demand. Point out any two exceptions of this law.	CO1	(3)
10	a)	A consumer purchases 10 units of a commodity when its price is Rs.100. Later when its price falls to Rs.90, he purchases 8 units only. Estimate price elasticity. What type of a commodity is this?	CO1	(5)
	b)	State the law of variable proportion.	CO1	(3)

Module 2				
11	a)	What is oligopoly? Why price is rigid under oligopoly?	CO2	(5)
	b)	The cost function of a firm is given as $TC=1000+10Q-6Q^2+Q^3$.. Calculate fixed cost, variable cost and marginal cost when output is 10 units.	CO2	(3)
12	a)	Suppose a firm is earning super normal profit under monopolistic market condition. Explain this situation by drawing a diagram.	CO2	(5)
	b)	Suppose a firm sells its product at a price of Rs.10 per unit and its average variable cost is Rs.6. If the firm spend Ra.10000 as rent and pay Rs. 6000 as interest every month, estimate its break-even level of output.	CO2	(3)
Module 3				
13	a)	What is inflation? How does inflation affect investment and production.	CO3	(5)
	b)	How will you obtain NNPfc from GDPmp.	CO3	(3)
14	a)	From the data given below (In Rs. Crores) estimate GDPmp and national income. Private final consumption expenditure = 1000, Government expenditure = 500, Invest expenditure = 700, Net exports = 300, Depreciation = 200, NFIA=(-200) and Net indirect tax = 100	CO3	(5)
	b)	What is bank rate? Examine the bank rate policy of the government during inflation.	CO3	(3)
Module 4				
15	a)	Examine the procedures of value engineering.	CO4	(5)
	b)	Examine the application areas of value engineering	CO4	(3)

16	a)	1. Suppose the initial investment of a project is Rs. 3000 (Crores) and the cost of capital or the opportunity cost of capital is 10 percent. Calculate NPV of the project based on the cash flows given below. Year 1 2 3 4 5 Cash flow 1000 900 800 700 600 (In Crores)	CO4	(5)
	b)	Point out any three merits of NPV method.	CO4	(3)

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SEMESTER S3/S4

ENGINEERING ETHICS AND SUSTAINABLE DEVELOPMENT

Course Code	**UCHUT347**	**CIE Marks**	50
Teaching Hours/Week (L: T:P: R)	2:0:0:0	**ESE Marks**	50
Credits	2	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. Equip with the knowledge and skills to make ethical decisions and implement gender-sensitive practices in their professional lives.
2. Develop a holistic and comprehensive interdisciplinary approach to understanding engineering ethics principles from a perspective of environment protection and sustainable development.
3. Develop the ability to find strategies for implementing sustainable engineering solutions.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Fundamentals of ethics** - Personal vs. professional ethics, Civic Virtue, Respect for others, **Profession and Professionalism,** Ingenuity, diligence and responsibility, Integrity in design, development, and research domains, Plagiarism, a balanced outlook on law - challenges - case studies, **Technology and digital revolution**-Data, information, and knowledge, Cybertrust and cybersecurity, Data collection & management, **High technologies: connecting people and places**-accessibility and social impacts, **Managing conflict**, Collective bargaining, **Confidentiality**, Role of confidentiality in moral integrity, **Codes of Ethics**. **Basic concepts in Gender Studies** - sex, gender, sexuality, gender spectrum: beyond the binary, gender identity, gender expression, gender stereotypes, **Gender disparity and discrimination in education**, employment and everyday life, History of women in Science & Technology, Gendered technologies & innovations**, Ethical values and practices in**	**6**

	connection with gender - equity, diversity & gender justice, **Gender policy and women/transgender empowerment initiatives.**	
2	**Introduction to Environmental Ethics:** Definition, importance and historical development of environmental ethics, key philosophical theories (anthropocentrism, biocentrism, ecocentrism). **Sustainable Engineering Principles:** Definition and scope, triple bottom line (economic, social and environmental sustainability), life cycle analysis and sustainability metrics. **Ecosystems and Biodiversity:** Basics of ecosystems and their functions, Importance of biodiversity and its conservation, Human impact on ecosystems and biodiversity loss, An overview of various ecosystems in Kerala/India, and its significance. **Landscape and Urban Ecology:** Principles of landscape ecology, Urbanization and its environmental impact, Sustainable urban planning and green infrastructure.	**6**
3	**Hydrology and Water Management:** Basics of hydrology and water cycle, Water scarcity and pollution issues, Sustainable water management practices, Environmental flow, disruptions and disasters. **Zero Waste Concepts and Practices:** Definition of zero waste and its principles, Strategies for waste reduction, reuse, reduce and recycling, Case studies of successful zero waste initiatives. **Circular Economy and Degrowth:** Introduction to the circular economy model, Differences between linear and circular economies, degrowth principles, Strategies for implementing circular economy practices and degrowth principles in engineering. **Mobility and Sustainable Transportation:** Impacts of transportation on the environment and climate, Basic tenets of a Sustainable Transportation design, Sustainable urban mobility solutions, Integrated mobility systems, E-Mobility, Existing and upcoming models of sustainable mobility solutions.	**6**
4	**Renewable Energy and Sustainable Technologies:** Overview of renewable energy sources (solar, wind, hydro, biomass), Sustainable technologies in energy production and consumption, Challenges and opportunities in renewable energy adoption. **Climate Change and Engineering Solutions:** Basics of climate change science, Impact of climate change on natural and human systems, Kerala/India and the Climate crisis, Engineering solutions to mitigate, adapt and build resilience to climate change. **Environmental Policies and Regulations:** Overview of key environmental policies and regulations (national and international), Role of engineers in policy implementation and compliance, Ethical considerations in environmental	**6**

	policy-making. **Case Studies and Future Directions:** Analysis of real-world case studies, Emerging trends and future directions in environmental ethics and sustainability, Discussion on the role of engineers in promoting a sustainable future.	

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

Continuous Internal Evaluation Marks (CIE):

Continuous internal evaluation will be based on individual and group activities undertaken throughout the course and the portfolio created documenting their work and learning. The portfolio will include reflections, project reports, case studies, and all other relevant materials.

- The students should be grouped into groups of size 4 to 6 at the beginning of the semester. These groups can be the same ones they have formed in the previous semester.
- Activities are to be distributed between 2 class hours and 3 Self-study hours.
- The portfolio and reflective journal should be carried forward and displayed during the 7th Semester Seminar course as a part of the experience sharing regarding the skills developed through various courses.

Sl. No.	Item	Particulars	Group/Individual (G/I)	Marks
1	Reflective Journal	Weekly entries reflecting on what was learned, personal insights, and how it can be applied to local contexts.	I	5
2	Micro project (Detailed documentation of the project, including methodologies, findings, and reflections)	1 a) Perform an Engineering Ethics Case Study analysis and prepare a report 1 b) Conduct a literature survey on 'Code of Ethics for Engineers' and prepare a sample code of ethics	G	8
		2. Listen to a TED talk on a Gender-related topic, do a literature survey on that topic and make a report citing the relevant papers with a specific analysis of the Kerala context	G	5
		3. Undertake a project study based on the concepts of sustainable development* - Module II, Module III & Module IV	G	12
3	Activities	2. One activity* each from Module II, Module III & Module IV	G	15
4	Final Presentation	A comprehensive presentation summarising the key takeaways from the course, personal reflections, and proposed future actions based on the learnings.	G	5
		Total Marks		**50**

*Can be taken from the given sample activities/projects

Evaluation Criteria:

- **Depth of Analysis**: Quality and depth of reflections and analysis in project reports and case studies.
- **Application of Concepts**: Ability to apply course concepts to real-world problems and local contexts.
- **Creativity**: Innovative approaches and creative solutions proposed in projects and reflections.
- **Presentation Skills**: Clarity, coherence, and professionalism in the final presentation.

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Develop the ability to apply the principles of engineering ethics in their professional life.	**K3**
CO2	Develop the ability to exercise gender-sensitive practices in their professional lives	**K4**
CO3	Develop the ability to explore contemporary environmental issues and sustainable practices.	**K5**
CO4	Develop the ability to analyse the role of engineers in promoting sustainability and climate resilience.	**K4**
CO5	Develop interest and skills in addressing pertinent environmental and climate-related challenges through a sustainable engineering approach.	**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	2	3	3	2		2
CO2		1				3	2	3	3	2		2
CO3						3	3	2	3	2		2
CO4		1				3	3	2	3	2		2
CO5						3	3	2	3	2		2

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Ethics in Engineering Practice and Research	Caroline Whitbeck	Cambridge University Press & Assessment	2nd edition & August 2011
2	Virtue Ethics and Professional Roles	Justin Oakley	Cambridge University Press & Assessment	November 2006
3	Sustainability Science	Bert J. M. de Vries	Cambridge University Press & Assessment	2nd edition & December 2023
4	Sustainable Engineering Principles and Practice	Bhavik R. Bakshi,	Cambridge University Press & Assessmen	2019
5	Engineering Ethics	M Govindarajan, S Natarajan and V S Senthil Kumar	PHI Learning Private Ltd, New Delhi	2012
6	Professional ethics and human values	RS Naagarazan	New age international (P) limited New Delhi	2006.
7	Ethics in Engineering	Mike W Martin and Roland Schinzinger,	Tata McGraw Hill Publishing Company Pvt Ltd, New Delhi	4" edition, 2014

Suggested Activities/Projects:

Module-II

- Write a reflection on a local environmental issue (e.g., plastic waste in Kerala backwaters or oceans) from different ethical perspectives (anthropocentric, biocentric, ecocentric).
- Write a life cycle analysis report of a common product used in Kerala (e.g., a coconut, bamboo or rubber-based product) and present findings on its sustainability.
- Create a sustainability report for a local business, assessing its environmental, social, and economic impacts
- Presentation on biodiversity in a nearby area (e.g., a local park, a wetland, mangroves, college campus etc) and propose conservation strategies to protect it.
- Develop a conservation plan for an endangered species found in Kerala.
- Analyze the green spaces in a local urban area and propose a plan to enhance urban ecology using native plants and sustainable design.
- Create a model of a sustainable urban landscape for a chosen locality in Kerala.

Module-III

- Study a local water body (e.g., a river or lake) for signs of pollution or natural flow disruption and suggest sustainable management and restoration practices.
- Analyse the effectiveness of water management in the college campus and propose improvements - calculate the water footprint, how to reduce the footprint, how to increase supply through

rainwater harvesting, and how to decrease the supply-demand ratio

- Implement a zero waste initiative on the college campus for one week and document the challenges and outcomes.
- Develop a waste audit report for the campus. Suggest a plan for a zero-waste approach.
- Create a circular economy model for a common product used in Kerala (e.g., coconut oil, cloth etc).
- Design a product or service based on circular economy and degrowth principles and present a business plan.
- Develop a plan to improve pedestrian and cycling infrastructure in a chosen locality in Kerala

Module-IV

- Evaluate the potential for installing solar panels on the college campus including cost-benefit analysis and feasibility study.
- Analyse the energy consumption patterns of the college campus and propose sustainable alternatives to reduce consumption - What gadgets are being used? How can we reduce demand using energy-saving gadgets?
- Analyse a local infrastructure project for its climate resilience and suggest improvements.
- Analyse a specific environmental regulation in India (e.g., Coastal Regulation Zone) and its impact on local communities and ecosystems.
- Research and present a case study of a successful sustainable engineering project in Kerala/India (e.g., sustainable building design, water management project, infrastructure project).
- Research and present a case study of an unsustainable engineering project in Kerala/India highlighting design and implementation faults and possible corrections/alternatives (e.g., a housing complex with water logging, a water management project causing frequent floods, infrastructure project that affects surrounding landscapes or ecosystems).

SEMESTER S3

CIRCUITS AND MEASUREMENTS LAB

Course Code	PCEEL307	CIE Marks	50
Teaching Hours/Week (L: T:P: R)	0:0:0:3	ESE Marks	50
Credits	2	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	Nil	Course Type	Lab

Course Objectives:

1. To train the students to familiarize and practice various measuring instruments and different transducers for measurement of physical parameters.
2. Students will also be introduced to a team working environment where they develop the necessary skills for planning, preparing and implementing basic instrumentation systems

Expt. No.	Experiments
1	Verification of Superposition theorem. *
2	Verification of (a) Thevenin's theorem and Maximum Power Transfer theorem.* (b) Calculation of Norton's equivalent circuit (calculation only).
3	Determination of impedance, admittance and power factor in RLC series/ parallel circuit and to study the effect of reactive components on power factor.
4	Measurement of two port network parameters.
5	Step response of RLC circuit (suggested to use DSO).
6	3-phase power measurement using one-wattmeter and two-wattmeter methods, and determination of reactive/apparent power drawn.*
7	Resistance measurement using Wheatstone's bridge and extension of range of voltmeters.
8	Resistance measurement using Wheatstone's bridge and extension of range of voltmeters.
9	Extension of instrument range using instrument transformers (CT and PT).
10	Calibration of 1-phase Energy meter at various power factors and phantom loading (minimum 3 conditions) *.
11	Calibration of 3-phase Energy meter using standard wattmeter
12	Determination of B-H curve, μ-H curve and μ-B curve of a magnetic specimen.

13	Measurement of self inductance, Mutual inductance and Coupling coefficient of a 1-phase transformer.
14	Measurement of Capacitance/ Inductance/ frequency using AC bridges.
15	Determination of characteristics of Thermal sensors: Thermistor, Thermocouple and RTD*.
16	Determination of P-V characteristics of solar PV array and determination of fill factor (study of partial shading may be included).
17	Determination of insulation resistance and earth resistance.
18	Calibration of meters (Ammeter/Voltmeter) using Potentiometers.
19	Determination of characteristics of transducers: LVDT, Strain gauge, and Load-cell
20	Simulation of circuits using software platforms like PSpice/LT spice / MATLAB / Multisim etc.*
21	Implementation of IoT-based data acquisition system
22	Demo Experiments: (a) Measurement of energy using TOD meter / Digital meters/ Bidirectional meter (b) Measurement of electrical variables and frequency using CRO and DSO (c) Harmonic analysers (d) Instrumentation systems for Gas / Fire/ Smoke Detection Systems. (e) Virtual instrumentation experiments using LABVIEW

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	Analyse voltage current phasor relations of RLC circuits	**K3**
CO2	Verify DC network theorems by setting up various electric circuits	**K3**
CO3	Measure power in single and three phase circuits by various methods	**K3**
CO4	Determine the calibration characteristics of various meters used in electrical systems	**K3**
CO5	Determine magnetic characteristics of different electrical devices	**K3**
CO6	Analyse the characteristics of various types of transducer systems	**K3**
CO7	Determine electrical parameters using various bridges	**K3**
CO8	Develop simulation models of electric circuits using modern simulation tools.	**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
CO2	3	3	2	-	-	-	-	-	2	-	-	3
CO3	3	3	-	-	-	-	-	-	2	-	-	3
CO4	3	3	-	-	-	-	-	-	2	-	-	3
CO5	3	3	-	-	-	-	-	-	2	-	-	3
CO6	3	3	2	-	3	-	-	-	2	-	-	3
CO7	3	3	-	-	-	-	-	-	2	-	-	3
CO8	3	3	2	-	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	A course in Electrical and Electronic Measurements & Instrumentation,	A. K. Sawhney:	Dhanpat Rai Publishers	
2	A course in Electrical & Electronic Measurement & Instrumentation	J. B. Gupta:	S. K. Kataria & Sons Publishers	
3	Electronic Instrumentation	Kalsi H. S.:	Tata McGraw Hill, New Delhi.	3

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 S3

ANALOG ELECTRONICS LAB

Course Code	**PCEEL308**	**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)	Nil	**Course Type**	Lab

Course Objectives:

1. Design of Transistor and Op amp Circuits
2. Simulation and hardware implementation of the circuits

Expt. No.	Experiments
Pre Lab Assignment	Measurement of current, voltage, frequency and phase shift of signal in a RC network using oscilloscope.
	Introduction to circuit simulation using any circuit simulation software.
1	Clipping and clamping circuits using diodes.
2	Basic RC circuits- High pass and Low pass filters
3	RC coupled amplifier using BJT in CE configuration-Measurement of gain, BW and plotting of frequency response.
4	Emitter Follower Amplifier
5	JFET amplifier-Measurement of gain, BW and plotting of frequency response.
6	MOSFET amplifier
7	Design and testing of voltage regulators – Zener and series
8	Design and set up of inverting and non-inverting amplifier.
9	Op-amps circuits – Scale changer, adder, integrator, and differentiator.
10	Precision rectifier using Op-amp.
11	Op- Amp Oscillators – RC Phase shift and Wien Bridge Oscillator
12	Op Amp Oscillator - LC Oscillators- Colpitts or Hartley Oscillator
13	Waveform generation– Square, triangular and saw tooth waveform generation using OPAMPs.

14	Basic comparator and Schmitt trigger circuits using Op-amp (Use comparator ICs such as LM311).
15	Active Filters (High Pass and Low pass-one each)
16	Instrumentation Amplifier
17	Astable and Monostable circuit using 555IC.
18	Introduction to PCB layout software.

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	Use the various electronic instruments and for conducting experiments.	**K1**
CO2	Design and develop various electronic circuits using diodes and Zener diodes.	**K3**
CO3	Design and implement amplifier and oscillator circuits using BJT and JFET.	**K3**
CO4	Design and implement basic circuits using IC (OPAMP and 555 timers).	**K3**
CO5	Simulate electronic circuits using any circuit simulation software.	**K3**
CO6	Use PCB layout software for circuit design	**K2**

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											
CO2	2	3	3	3	3				3	3		
CO3	2	3	3	3	3				3	3		
CO4	2	3	3	3	3				3	3		
CO5	2	3	3	3	3				3	3		
CO6	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	Introductory Electronic Devices and Circuits	Robert T Paynter	Pearson Education	
2	Electronic devices and Circuit Theory	Boylestad R. L. and L. Nashelsky	Pearson Education	
3	Electronic Circuits : Analysis and Design	Donald A Neaman	McGraw Hill Companies	

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 4

ELECTRICAL AND ELECTRONICS ENGINEERING

SEMESTER S4

MATHEMATICS FOR ELECTRICAL SCIENCE– 4

(B Group)

Course Code	**GBMAT401**	**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)	Basic calculus	**Course Type**	Theory

Course Objectives:

1. To familiarize students with the foundations of probabilistic and statistical analysis mostly used in varied applications in engineering and science.
2. To expose the students to the basics of random processes essential for their subsequent study of analog and digital communication.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Random variables, Discrete random variables and their probability distributions, Cumulative distribution function, Expectation, Mean and variance, Binomial distribution, Poisson distribution, Poisson distribution as a limit of the binomial distribution, Joint pmf of two discrete random variables, Marginal pmf, Independent random variables, Expected value of a function of two discrete variables. **[Text 1: Relevant topics from sections 3.1 to 3.4, 3.6, 5.1, 5.2]**	9
2	Continuous random variables and their probability distributions, Cumulative distribution function, Expectation, Mean and variance, Uniform, Normal and Exponential distributions, Joint pdf of two Continuous random variables, Marginal pdf, Independent random variables, Expectation value of a function of two continuous variables. **[Text 1: Relevant topics from sections 3.1, 4.1, 4.2, 4.3, 4.4, 5.1, 5.2]**	9

3	Confidence Intervals, Confidence Level, Confidence Intervals and One-side confidence intervals for a Population Mean for large and small samples (normal distribution and *t*-distribution), Hypotheses and Test Procedures, Type I and Type II error, *z* Tests for Hypotheses about a Population Mean (for large sample), *t* Test for Hypotheses about a Population Mean (for small sample), Tests concerning a population proportion for large and small samples. **[Text 1: Relevant topics from 7.1, 7.2, 7.3, 8.1, 8.2, 8.3, 8.4]**	**9**
4	Random process concept, classification of process, Methods of Description of Random process, Special classes, Average Values of Random Process, Stationarity- SSS, WSS, Autocorrelation functions and its properties, Ergodicity, Mean-Ergodic Process, Mean-Ergodic Theorem, Correlation Ergodic Process, Distribution Ergodic Process. **[Text 2: Relevant topics from Chapter 6]**	**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	Understand the concept, properties and important models of discrete random variables and to apply in suitable random phenomena.	**K3**
CO2	Understand the concept, properties and important models of continuous random variables and to apply in suitable random phenomena.	**K3**
CO3	Estimate population parameters, assess their certainty with confidence intervals, and test hypotheses about population means and proportions using z-tests and the one-sample t-test.	**K3**
CO4	Analyze random processes by classifying them, describing their properties, utilizing autocorrelation functions, and understanding their applications in areas like signal processing and communication systems.	**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	2	2	-	-	-	-	-	-	-	2
CO2	3	3	2	2	-	-	-	-	-	-	-	2
CO3	3	3	2	2	-	-	-	-	-	-	-	2
CO4	3	3	2	2	-	-	-	-	-	-	-	2

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Probability and Statistics for Engineering and the Sciences	Devore J. L	Cengage Learning	9th edition, 2016
2	Probability, Statistics and Random Processes	T Veerarajan	The McGraw-Hill	3rd edition, 2008

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Probability, Random Variables and Stochastic Processes,	Papoulis, A. & Pillai, S.U.,	McGraw Hill.	4th edition, 2002
2	Introduction to Probability and Statistics for Engineers and Scientists	Ross, S. M.	Academic Press	6th edition, 2020
3	Probability and Random Processes	Palaniammal, S.	PHI Learning Private Limited	3rd edition, 2015
4	Introduction to Probability	David F. Anderson, Timo, Benedek	Cambridge	1st edition, 2017

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/117/105/117105085/
2	https://archive.nptel.ac.in/courses/117/105/117105085/
4	https://archive.nptel.ac.in/courses/117/105/117105085/

SEMESTER S4

SYNCHRONOUS & INDUCTION MACHINES

Course Code	**PCEET402**	**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)	PCEET303	**Course Type**	Theory

Course Objectives:

1. Describe the constructional details, working and analyse the performance of synchronous machines and induction machines under various load conditions.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Principle of Operation of 3-phase alternators – classification - constructional features - types of armature windings – winding diagram of a 3-phase, 12 slot, 2-pole, single layer full-pitched armature winding (winding diagram not for evaluation) – coil-span factor and distribution factor (sinusoidal flux distribution only) - EMF equation – numerical problems Cylindrical-rotor type synchronous generator on no-load – open circuit characteristics - Synchronous generator on load – armature reaction – effect of armature reaction - synchronous impedance - Equivalent circuit - phasor diagram – numerical problems Voltage regulation – OC and SC tests – emf and mmf methods – ZPF test - Potier method – numerical problems	**12**

2	Power flow equations in cylindrical-rotor type synchronous generator – numerical problems Parallel operation - synchronous generator on infinite bus-bar – conditions – methods of synchronisation – effect of change of mechanical input – effect of change of excitation - V-curves and inverted V curves – numerical problems Salient-pole synchronous generator - two reaction theory – phasor diagram – slip test for determination of X_d and X_q - numerical problems Synchronous motor – rotating magnetic field - principle of operation – starting methods Power developed (both cylindrical rotor type and salient-pole type) – excitation power & reluctance power – power angle characteristics - losses and efficiency – numerical problems V-curves and inverted V curves	**12**
3	3-phase Induction motor – principle of operation - classification - constructional features – torque equation - torque-slip characteristics – relation between starting torque, maximum torque and full-load torque - numerical problems Phasor diagram - equivalent circuit Power flow diagram - losses and efficiency – numerical problems No-load and blocked-rotor tests – circle diagram – numerical problems Starting of induction motors – types of starters – DOL starter, autotransformer starter, star-delta starter – numerical problems - rotor resistance starter (no design)	**11**
4	Braking of Induction motors – plugging, dynamic braking, regenerative braking (concepts only) Speed control – stator voltage control, V/f control, rotor resistance control Induction generator – line excited and self-excited induction generators (principle of operation only) – torque-slip characteristics for braking, motoring and regeneration Single-phase induction motors – double revolving field theory – equivalent circuit – torque slip characteristics Types of 1-phase inductions motors – split-phase, capacitor-start induction-run, permanent capacitor types – 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	Describe the constructional details and analyse the performance of synchronous generators under various load conditions.	**K3**
CO2	Analyse the performance of synchronous motors under various load conditions	**K3**
CO3	Describe the constructional details and analyse the steady-state performance of induction motors under various load conditions	**K3**
CO4	Analyse the various starting, braking and speed control methods of 3-phase induction motors.	**K3**
CO5	Explain the construction details and working of various types of single-phase induction motors.	**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										3
CO2	3	2										3
CO3	3	2										3
CO4	3	2										3
CO5	3	2										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 Machinery	P.S. Bhimbra	Khanna	7^{th} edition 2021
2	Performance & Design of AC Machines	M.G. Say	CBS	3^{rd} edition 2002
3	Electric Machines	Kothari & Nagrath	Tata McGraw-Hill	5^{th} edition 2017
4	Induction & Synchronous Machines	K Murugesh Kumar	Vikas	11^{th} edition 2000
5	Theory & Performance of Electrical Machines	J.B. Gupta	S.K. Kataria	15^{th} edition 2022

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/108/105/108105131/

SEMESTER S4

POWER ELECTRONICS AND DRIVES

Course Code	**PCEET403**	**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)	PCEET303, PCEET304	**Course Type**	Theory

Course Objectives:

1. To give a strong foundation on power converters, power quality and electric drives
2. To enable the students to select suitable power devices and passive components for target applications
3. To motivate students to design and implement power electronic converters having high efficiency, small size, high reliability and low cost

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Role of Power Electronics, Motivation, Objectives and Challenges, Power Electronics Vs Linear Electronics, Ideal and real switches- Static and dynamic Performance – Power losses- Temperature rise- Thermal Analogy- Use of Heat sinks- Need for high efficiency, small size, high reliability and low cost- Overview of Applications Uncontrolled Switch: Power Diodes – Types- Characteristics (Static and Dynamic) –Effects of Reverse Recovery Transient- Ratings-Schottky Diodes – Features & Applications Semi-controlled switch: SCR (Thyristor) – Symbol, Structure, Characteristics (Static and dynamic) – Turn-on and Turn-off phenomena – Ratings- Gate control of SCR – Gate pulse magnitude and duration requirements- Typical gate drive circuits – Gate synchronisation – Isolated gate drives	11

	Fully-controlled switches: MOSFETS and IGBTs: Symbol, Structure, Characteristics (Static and Dynamic) -Device ratings -Gate drive requirements–Typical gate drive circuits Modern power devices: Introduction to Wide Bandgap Devices – SiC MOSFET and GaN HEMT – Features and advantages **Suggestions:** Reading and interpreting datasheets are to be encouraged [To be tested through assignments] –Possibility of simulation assignments/homework may be explored- Design of MOSFET/IGBT gate drives – need/requirement of isolation in certain circuits- Use of pulse transformers/opto-isolators – sample circuits [Design assignments may be given using popular driver ICs for MOSFETs/SCRs – not to be tested in ESE]	
2	Controlled Rectifiers (Single Phase) – Fully controlled and half-controlled rectifiers (semi-converter)with RL and RLE loads- Rectifier and inverter modes of operation- waveforms (continuous & discontinuous conduction)– Output voltage, Input line current, Real Power, Power factor and THD(Continuous conduction, ripple free current)- Effect of source inductance(Full converter in continuous conduction, ripple free current) Controlled Rectifiers (3-Phase) - Fully controlled & Half-controlled bridge converter with RLE load (continuous conduction, ripple free current)– Waveforms- Output voltage equation AC voltage controllers (ACVC) – 1-phase full-wave ACVC with R & RL loads – waveforms – RMS output voltage - applications DC-DC Switching Regulators- Buck, Boost & Buck-Boost– Operation with Continuous conduction Waveforms– Effect of non-idealities such as capacitor ESR and inductor resistance (qualitative treatment only)- Design of filter inductance and capacitance- Selection of power devices	**12**
3	Switch mode DC-AC Voltage Source Inverters (VSI)- Single phase Half-Bridge and Full-Bridge configurations- Sinusoidal Pulse Width Modulation (PWM) - Control of Fundamental output voltage- Harmonic spectrum- Bipolar and Unipolar PWM- Linear, Over Modulation and Square wave modes -Merits and demerits- Need for blanking time (dead-time) Three-Phase Pulse Width Modulated VSI - Fundamental Output voltage- Linear, Over Modulation and Square wave modes – Third harmonic Injection PWM Single phase current regulated VSI –Tolerance band current control- Fixed	**11**

	frequency operation - Single phase current source Inverters (IGBT based)- Comparison Need for improved utility interface- Generation of current harmonics- Power factor- Harmonics and IEEE 519 standard- Active shaping of the input line current- Single-phase front end boost converter(circuit diagram, operation, block diagram of the control scheme)	
4	Introduction to Electric Drives– Advantages of adjustable speed electric drives –Block diagram, Types of loads – Classification of load torque- Motor torque-load combination: characteristics and dynamic equation- Steady state stability DC Drives- Chopper control of Separately Excited DC drives (SEDC) –One quadrant, Two quadrant and four quadrant Chopper fed drives(Continuous conduction only)- Motoring and Regenerative braking – Speed-Torque characteristics – Speed control- Controlled rectifier fed separately excited DC motor drive- Single phase and three phase (Continuous conduction only)- Speed-Torque characteristics- Speed control –Dual converter drives (single phase) - Circulating current Type and Non-circulating current - Static four-quadrant operation with SEDC Three-phase VSI fed induction motor drives: Stator Voltage control - V/F speed control– Speed-Torque characteristics- Speed control – operation below and above base speed – Braking: dynamic and regenerative	**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	Understand the operation of modern power semiconductor devices, its characteristics and select suitable gate driver circuits & heatsinks	**K3**
CO2	Understand the features of phase-controlled rectifiers, AC voltage Controllers &Switching Regulators and analyse the operation	**K3**
CO3	Understand the features of different types of switch mode DC-AC Inverters and analyse the operation	**K3**
CO4	Understand the need for improved efficiency, improved reliability, improved load &source waveforms and improved utility interface	**K2**
CO5	Understand the features of adjustable speed drives and analyse the Basic drive schemes for DC motors and Induction Motors	**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									2
CO2	3	1	3									2
CO3	3	1	3									2
CO4	3	1	3									2
CO5	3	1	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	Power Electronics- Converters, Applications and Design, 3ed(Indian Adaptation) by Mohan, Undeland, Robbins, Wiley India, 2022	Ned Mohan, Undeland, Robbins	Wiley-India	2022
2	Power Electronics- Principles and Applications	Joseph Vithayathil	Tata McgrawHill	2010
3	Power Electronics	Cyril W Lander	McGrawHill	1993
4	Power Electronics – Circuits, Devices and Applications	Muhammad H. Rashid	Pearson Education	2014
5	Power Electronics	D.W. Hart	McGrawHill	2010
6	Power Electronics – Essentials & Applications	L. Umanand	Wiley-India	2009
7	Fundamentals of Electric Drives	G K Dubey	Narosa	2001

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Elements of Power Electronics	Philip T Krein	Oxford	2017
2	Power Electronics Handbook-5e	Muhammad H. Rashid	Butterworth	2024

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	Lecture Series on Power Electronics **by Prof. G. Bhuvaneswari**, IIT Delhi https://www.youtube.com/watch?v=Z2CORFayCv0&list=PLp6ek2hDcoND7i5-DAD9mPmYF1Wg6ROdO&index=3
2	NPTEL Lecture Series on Power Electronics by **Prof. L. Umanand**, IISc Bangalore https://www.youtube.com/watch?v=eLIdqiPMjBs&list=PLgMDNELGJ1CaXa4sX6QSrkhu-yP_Wu2EN&index=26
3	NPTEL Lecture Series by**Prof.ShabariNath**, IIT Guwahati https://www.youtube.com/watch?v=S_UXW2UzAi8&list=PLwdnzlV3ogoWVgA9fHBV36L_bxWZlpa7X&index=7

SEMESTER S4

DIGITAL ELECTRONICS

Course Code	**PBEET404**	**CIE Marks**	60
Teaching Hours/Week (L: T:P: R)	3:0:0:1	**ESE Marks**	40
Credits	4	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. Explain the various number systems, Digital logic gates and Boolean expressions
2. Design and implement different types of combinational and sequential logic circuits
3. Design and implement digital circuits using Hardware Descriptive Language.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Number Systems and Codes** – binary, octal and hexadecimal – conversions – ASCII code, Excess – 3 code, Gray code, BCD code **Signed numbers** – 1's complement and 2's complement – addition and subtraction **Basic logic gates** – universal gates – TTL – CMOS – Internal diagram of TTL NAND gate and CMOS NOR gate – comparison of CMOS and TTL performance. **Boolean laws and theorems** – Sum of products and Product of sums forms – K map representation and simplification (up to four variables) – pairs, quads, octets – don't care conditions.	**9**
2	**Combinational circuits** – half adder and full adder, half subtractor and full subtractor – 4-bit parallel binary adder/subtractor. **Comparators** – parity generators and checkers – encoders – decoders – BCD to seven segment decoder. **Multiplexers** – implementation of boolean expressions using multiplexers – demultiplexers.	**9**

3	**Flip-Flops** – SR, JK, D and T flip-flops – characteristic table and excitation table – JK Master Slave Flip-flop – Conversion of flip- flops – SR to JK and JK to SR only. **Up/Down counters** – asynchronous counters – mod-6 and mod-10 counters. Synchronous counters – design of synchronous counters – Ring counter – Johnson Counter. **Shift registers -** SISO, SIPO, PISO, PIPO.	**10**
4	**State Machines** – state transition diagram – Moore and Mealy machines. **Digital to Analog converter** –weighted resistor type, R-2R Ladder type. **Analog to Digital Converter** – flash type, successive approximation type. **Introduction to Verilog** – Implementation of AND, OR, half adder and full adder.	**8**

Suggestion on Project Topics

Course Assessment Method

(CIE: 60 marks, ESE: 40 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Project	Internal Ex-1	Internal Ex-2	Total
5	30	12.5	12.5	60

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 2 marks • **(8x2 =16 marks)**	• 2 questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 2 sub divisions. • Each question carries 6 marks. **(4x6 = 24 marks)**	**40**

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Identify various number systems, binary codes and formulate digital functions using Boolean algebra.	**K2**
CO2	Design combinational logic circuits.	**K3**
CO3	Design sequential logic circuits.	**K3**
CO4	Describe the operation of various analog to digital and digital to analog conversion circuits.	**K2**
CO5	Explain the basic concepts of programming using Verilog HDL	**K2**
CO6	Design and realize medium complexity practical digital hardware circuits.	**K6**

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	2										3
CO2	3	2		2	2			2	2			3
CO3	3	2		2	2			2	2			3
CO4	3	2										3
CO5	3	2		2	2			2	2			3
CO6	3	3	3	3	3	2	2	3	3		2	3

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Digital Fundamentals	Floyd T.L	Pearson Education	11/e, 2017
2	Digital Principles and Applications	Albert Paul Malvino & Donald P. Leach	Mc-GRAW Hill International Editions	4/e, 2018
3	Digital Design: With an Introduction to the Verilog HDL, VHDL, and System Verilog	M. Morris Mano, Michael D. Ciletti	Pearson Education	6/e, 2018
4	Digital Integrated Electronics	Herbert Taub and Donald Schilling	McGraw Hill Education	2017

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Fundamentals of Digital Logic with Verilog Design	Stephen Brown	McGraw Hill Education	2^{nd} Edition
2	Fundamental of Digital Circuits	A Anand Kumar	Prentice Hall	4/e, 2023
3	Digital Circuits and Design	S. Salivahanan	Oxford University Press	2018
4	Digital Design Verilog HDL and Fundamentals	Joseph Cavanagh	CRC Press	1^{st} Edition, 2008

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/108/105/108105132/ https://archive.nptel.ac.in/courses/18/106/108106177/
2	https://archive.nptel.ac.in/courses/108/105/108105132/ https://archive.nptel.ac.in/courses/108/106/108106177/
3	https://archive.nptel.ac.in/courses/108/105/108105132/ https://archive.nptel.ac.in/courses/108/106/108106177/
4	https://archive.nptel.ac.in/courses/108/105/108105132/ https://archive.nptel.ac.in/courses/108/106/108106177/

PBL Course Elements

L: Lecture (3 Hrs.)	R: Project (1 Hr.), 2 Faculty Members		
	Tutorial	**Practical**	**Presentation**
Lecture delivery	Project identification	Simulation/ Laboratory Work/ Workshops	Presentation (Progress and Final Presentations)
Group discussion	Project Analysis	Data Collection	Evaluation
Question answer Sessions/ Brainstorming Sessions	Analytical thinking and self-learning	Testing	Project Milestone Reviews, Feedback, Project reformation (If required)
Guest Speakers (Industry Experts)	Case Study/ Field Survey Report	Prototyping	Poster Presentation/ Video Presentation: Students present their results in a 2 to 5 minutes video

Assessment and Evaluation for Project Activity

Sl. No	Evaluation for	Allotted Marks
1	Project Planning and Proposal	5
2	Contribution in Progress Presentations and Question Answer Sessions	4
3	Involvement in the project work and Team Work	3
4	Execution and Implementation	10
5	Final Presentations	5
6	Project Quality, Innovation and Creativity	3
Total		**30**

1. **Project Planning and Proposal (5 Marks)**

    - Clarity and feasibility of the project plan
    - Research and background understanding
    - Defined objectives and methodology

2. **Contribution in Progress Presentation and Question Answer Sessions (4 Marks)**

    - Individual contribution to the presentation
    - Effectiveness in answering questions and handling feedback

3. **Involvement in the Project Work and Team Work (3 Marks)**

    - Active participation and individual contribution
    - Teamwork and collaboration

4. **Execution and Implementation (10 Marks)**

    - Adherence to the project timeline and milestones
    - Application of theoretical knowledge and problem-solving
    - Final Result

5. **Final Presentation (5 Marks)**

    - Quality and clarity of the overall presentation
    - Individual contribution to the presentation
    - Effectiveness in answering questions

6. **Project Quality, Innovation, and Creativity (3 Marks)**
    - Overall quality and technical excellence of the project
    - Innovation and originality in the project
    - Creativity in solutions and approaches

SEMESTER S4

ELECTRONIC INSTRUMENTATION

Course Code	**PEEET411**	**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)	PCEET205	**Course Type**	Theory

Course Objectives:

1. The objective of this course is to impart comprehensive understanding in the field of electronic instrumentation, industrial instrumentation and communication systems.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Functional elements of electronic instrumentation system – Calibration methods: Static, Dynamic, Field, Traceable, Master. Transducers- Classification-Criteria for selection- Static and dynamic characteristics- Zeroth and first order instruments and time responses. Resistive transducers for liquid level and humidity Inductive transducers- types and basic principles- LVDT- synchro Capacitive transducers- types and basic principles- Thickness measurement Piezoelectric transducers- Hall effect transducers-Basic principle and applications Electronic IC for sensor applications, Micro Electromechanical system (MEMS) Advantages and Applications, MEMS micro sensors and actuators, MEMS accelerometers	10

2	Signal conditioning for instrumentation systems: Voltage to Current Converter, Transducer bridges: null type and deflection bridges, AC bridges using push pull transducers Amplifiers: Instrumentation amplifiers- charge amplifiers- isolation amplifier Role of filters: Low pass, high pass, band pass and band rejection filters, Introduction to digital filters Data Transmission- Types of Telemetry System- Modulation methods: Pulse modulation, Pulse amplitude modulation, Pulse code modulation General telemetry systems- Cable transmission of analog and digital data- Fibre optic data transmission Principles of time division and frequency division multiplexing- Radio-wireless communication, WLAN architecture. Protocols: Field Bus, Profibus , HART	**10**
3	Display methods and devices: Different types of display –display system building blocks. Data Presentation Element: Recorders-Strip Chart Recorder, Potentiometric Recorder, X-Y Recorder. Magnetic recorder, Digital recorders- Data logger Experiments and statistical analysis: Performance of experiment-characteristics of experimental data- description of dispensed data- type of probability distribution-probability error	**9**

4	Introduction to Process Control - Block diagram of the process control loop. Analog and Digital DAS: Programmable logic controllers (PLC), Organization- Hardware details- I/O- Power supply- CPU- Standards Programming aspects- Ladder programming- realization of AND, OR, NAND, NOR and XOR logic, the concept of latching, Introduction to Timer/Counters, Numerical Exercises based on Timers and Counters. SCADA and DCS systems: SCADA: Introduction, SCADA Architecture, Common System Components, Supervision and Control, HMI, RTU and Supervisory Stations, Protocols-IEC 60870-5-101 and DNP3. Distributed Control System: Introduction, DCS Architecture, Control modes.	**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	Identify the sensors/transducers suitable for industrial applications.	**K3**
CO2	Design the signal conditioning circuits for industrial instrumentation and automation.	**K3**
CO3	Understand the concepts of data transmission methods applicable to electronic instrumentation systems.	**K2**
CO4	Develop the logic for the process control applications using PLC programming	**K3**
CO5	Analyze the performance of measurement systems using statistical methods	**K4**
CO6	Describe the fundamental concepts of DCS and SCADA systems	**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
CO2	3	3	-	-	-	2	-	-	-	-	-	2
CO3	3	3	-	-	-	-	-	-	-	-	-	2
CO4	3	2	-	-	2	-	-	-	-	-	-	2
CO5	3	2	-	-	2	-	-	-	-	-	-	2
CO6	3	2	3	-	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	A course in Electrical and Electronic Measurements & Instrumentation	A. K. Sawhney	Dhanpat Rai & Co.	2011
2	A course in Electrical & Electronic Measurement & Instrumentation	J. B. Gupta	S K Kataria & Sons	14th Ed., 2014
3	Electrical Measurements & Measuring Instruments	Golding E.W and Widdis	Wheeler Pub.	
4	Electronic Instrumentation	H. S. Kalsi	McGraw Hill, New Delhi	4th Ed., 2019
5	Principles of Electrical Measurement	S Tumanski	Taylor & Francis.	
6	Electronic Instrumentation and Measurements	David A Bel	Oxford	
7	Programmable Logic Controllers	William Bolton	Elsevier India Pvt. Ltd	5th edition,
8	SCADA: Supervisory Control and Data Acquisition	Stuart A. Boyer,	International Society of Automation,	4th edition, 2010

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Modern Electronics Instrumentation	Cooper W.D	Prentice Hall of India	
2	Basic Electrical Measurements	Stout M.B	Prentice Hall	
3	Electronic Measurements & Instrumentation	Oliver & Cage	McGraw Hill	
4	Doebelin's Measurements Systems	E.O Doebelin and D.N Manik	McGraw Hill Education (India) Pvt. Ltd.	6th Ed.
5	Electrical and Electronics Measurements and Instrumentation	P.Purkait, B.Biswas, S.Das and C. Koley	McGraw Hill Education (India) Pvt. Ltd.,	2013

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/108/105/108105153/ https://archive.nptel.ac.in/courses/108/108/108108147/
2	https://archive.nptel.ac.in/courses/108/105/108105153/
3	https://archive.nptel.ac.in/courses/108/105/108105153/
4	https://archive.nptel.ac.in/courses/108/108/108108147/ https://archive.nptel.ac.in/courses/106/105/106105166/

SEMESTER S4

RENEWABLE ENERGY SOURCES

Course Code	PEEET412	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 – Classification of PV system - Principle of Solar cell, advantages, disadvantages and applications of solar photovoltaic system.	9
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	4^{th} 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 S4

MATHEMATICS FOR MACHINE LEARNING

Course Code	PEEET413	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. The purpose of this course is to introduce mathematical foundations of basic Machine Learning concepts among learners, on which Machine Learning systems are built.
2. Concepts in this course help the learners to understand the mathematical principles in Machine Learning and aid in the creation of new Machine Learning solutions, understand and debug existing ones, and learn about the inherent assumptions and limitations of the current methodologies.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	LINEAR ALGEBRA: Systems of Linear Equations – Matrices, Solving Systems of Linear Equations. Vector Spaces –Vector Spaces, Linear Independence, Basis and Rank. Linear Mappings – Matrix Representation of Linear Mappings, Basis Change, Image and Kernel.	9
2	ANALYTIC GEOMETRY, MATRIX DECOMPOSITIONS: Norms, Inner Products, Lengths and Distances, Angles and Orthogonality, Orthonormal Basis, Orthogonal Complement, Orthogonal Projections – Projection into One Dimensional Subspaces, Projection onto General Subspaces, Gram-Schmidt Orthogonalization. Determinant and Trace, Eigenvalues and Eigenvectors, Cholesky	9

	Decomposition, Eigen decomposition and Diagonalization, Singular Value Decomposition, Matrix Approximation.	
3	VECTOR CALCULUS: Differentiation of Univariate Functions - Partial Differentiation and Gradients, Gradients of Vector Valued Functions, Gradients of Matrices, Useful Identities for Computing Gradients. Back propagation and Automatic Differentiation – Gradients in Deep Network, Automatic Differentiation. Higher Order Derivatives- Linearization and Multivariate Taylor Series.	**9**
4	Probability and Distributions: Construction of a Probability Space - Discrete and Continuous Probabilities, Bayes' Theorem. Summary Statistics and Independence – Gaussian Distribution - Conjugacy and the Exponential Family - Change of Variables/Inverse Transform. Optimization: Optimization Using Gradient Descent - Gradient Descent With Momentum. Constrained Optimization and Lagrange Multipliers - Convex Optimization - Linear Programming - Quadratic Programming.	**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	Make use of the concepts, rules and results about linear equations, matrix algebra, vector spaces, eigenvalues & eigenvectors and orthogonality & diagonalization to solve computational problems	**K3**
CO2	Perform calculus operations on functions of several variables and matrices, including partial derivatives and gradients	**K3**
CO3	Utilize the concepts, rules and results about probability, random variables, additive & multiplicative rules, conditional probability, probability distributions and Bayes' theorem to find solutions of computational problems	**K3**
CO4	Train Machine Learning Models using unconstrained and constrained optimization methods	**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
CO2	3	2										2
CO3	3	2	1									2
CO4	3	2										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, and Cheng Soon Ong	Cambridge University Press (freely available at https:// mml - book.github.io)	

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Linear Algebra and Its Applications,	Gilbert Strang		4th Edition
2	Linear Algebra Done Right	Axler, Sheldon	Springer	2015
3	Introduction to Applied Linear Algebra	Stephen Boyd and Lieven Vandenberghe	Cambridge University Press	2018
4	Pattern Recognition and Machine Learning	Christopher M Bishop	Springer	2006
5	Convex Optimization	Stephen Boyd and Lieven Vandenberghe	Cambridge University Press	2004
6	Learning with Kernels – Support Vector Machines, Regularization, Optimization, and Beyond	Bernhard Scholkopf and Smola, Alexander J Smola	MIT Press	2002
7	Information Theory, Inference, and Learning Algorithms	David J. C MacKay	Cambridge University Press	2003
8	Machine Learning: A Probabilistic Perspective	Kevin P Murphy	MIT Press	2012
9	The Nature of Statistical Learning Theory	Vladimir N Vapnik	Springer	2000

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	archive.nptel.ac.in/courses/111/107/111107137 onlinecourses.nptel.ac.in/noc24_cs38/
2	archive.nptel.ac.in/courses/111/107/111107137 onlinecourses.nptel.ac.in/noc24_cs38/
3	archive.nptel.ac.in/courses/111/107/111107137 onlinecourses.nptel.ac.in/noc24_cs38/
4	archive.nptel.ac.in/courses/111/107/111107137 onlinecourses.nptel.ac.in/noc24_cs38/

SEMESTER S4

THEORY OF COMPUTATION

Course Code	PEEET414	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. Introduce the concept of formal languages
2. Discuss the Chomsky classification of formal languages with discussion on grammar and automata for regular, context-free, context sensitive and unrestricted languages.
3. Discuss the notions of decidability and halting problem

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to formal language theory– Alphabets, Strings, Concatenation of strings, Languages. Regular Languages - Deterministic Finite State Automata (DFA) (Proof of correctness of construction not required), Nondeterministic Finite State Automata (NFA), Equivalence of DFA and NFA, Regular Grammar (RG), Equivalence of RGs and DFA.	9
2	Regular Languages -Regular Expression (RE), Equivalence of REs and DFA, Homomorphisms, Necessary conditions for regular languages, Closure Properties of Regular Languages, DFA state minimization (No proof required).Context Free Grammar (CFG)- CFG representation of Context Free Languages (proof of correctness is required), derivation trees and ambiguity, Normal forms for CFGs	9

3	Context-Free Languages -Nondeterministic Pushdown Automata (PDA), Deterministic Pushdown Automata (DPDA), Equivalence of PDAs and CFGs (Proof not required), Pumping Lemma for Context-Free Languages (Proof not required), Closure Properties of Context Free Languages	**9**
4	Context Sensitive Languages - Context Sensitive Grammar (CSG), Linear Bounded Automata. Turing Machines - Standard Turing Machine, Robustness of Turing Machine, Universal Turing Machine, Halting Problem, Recursive and Recursively Enumerable Languages. Chomsky classification of formal languages	**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	Classify a given formal language into Regular, Context-Free, Context Sensitive, Recursive or Recursively Enumerable	**K2**
CO2	Design finite state automata, regular grammar, and regular representations for regular languages.	**K3**
CO3	Design push-down automata and context-free grammar representations for given context-free languages.	**K3**
CO4	Design Turing machines as language acceptors or transducers.	**K3**
CO5	Explain the notion of decidability.	**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	2	-	-	-	-	-	-	-	-	3
CO2	3	3	3	2	-	-	-	-	-	-	-	3
CO3	3	3	3	2	-	-	-	-	-	-	-	3
CO4	3	3	3	2	-	-	-	-	-	-	-	3
CO5	3	3	3	2	-	-	-	-	-	-	-	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	Automata and Computability,	Dexter C. Kozen	Springer	1999

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Introduction to Automata Theory, Languages, and Computation	John E Hopcroft, Rajeev Motwani and Jeffrey D Ullman,	Pearson Education	3/e, 2007
2	Introduction To Theory of Computation,	Michael Sipser	Cengage Publishers	2013

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://www.youtube.com/watch?v=77nkSUsQqJk
2	https://www.youtube.com/watch?v=77nkSUsQqJk
3	https://www.youtube.com/watch?v=77nkSUsQqJk
4	https://www.youtube.com/watch?v=77nkSUsQqJk

SEMESTER S4

COMPUTER ORGANIZATION

Course Code	PEEET416	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. The course introduces the principles of computer organization and the basic architectural concepts.
2. To be understand memory systems in digital computer.
3. To better with IO devices communication with processor.
4. To understand control logic design.
5. To be clear with pipeline concepts.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Basic Structure of computers** –functional units - basic operational concepts - bus structures. Memory locations and addresses -memory operations, Instructions and instruction sequencing, addressing modes. **Basic processing unit** – fundamental concepts – instruction cycle – execution of a complete instruction -single bus and multiple bus organization.	9
2	**Register transfer logic:** Inter register transfer – arithmetic, logic and shift micro-operations. **Processor logic design:** - processor organization – Arithmetic logic unit - design of arithmetic circuit - design of logic circuit – Design of arithmetic logic unit - status register – design of shifter - processor unit – design of accumulator(Basic Concept Only).	9

3	**Control Logic Design:**Hardwired control-microprogrammed control-Microinstructions, Microprogram Sequencing. **Arithmetic algorithms:** Signed-Operand multiplication, Booth Algorithm, fast multiplication-bit pair recoding of multipliers. **Pipelining:** Basic principles, classification of pipeline processors, instruction and arithmetic pipelines (Design examples not required), hazard detection and resolution.	9
4	**Memory system:** Types of memory(**Concepts only),**Virtual memory, Content addressable memory, cache memories - mapping functions. **I/O organization:** Characteristics of I/O devices, Data transfer schemes - Programmed controlled I/O transfer, Interrupt controlled I/O transfer. Organization of interrupts - vectored interrupts – Servicing of multiple input/output devices – Polling and daisy chaining schemes. Direct memory accessing (DMA)	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 relevance of functional units, memory locations and addressing modes in a digital computer.	**K2**
CO2	Illustrate the register transfer logic,Processor logic design.	**K2**
CO3	Explain the implementation aspects of arithmetic algorithms and pipelining concept in a digital computer.	**K3**
CO4	Demonstrate the control signals required for the execution of a given instruction.	**K3**
CO5	Illustrate the organization of different types of memories and I/O organization.	**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	1						2		3
CO2	3	2	2	1						2		3
CO3	3	2	2	1						2		3
CO4	3	2	2	1						2		3
CO5	3	2	2	1						2		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	Computer Organization	Hamacher C., Z. Vranesic and S. Zaky,	McGraw Hill	5/e,2011
2	Digital Logic & Computer Design	Mano M. M	PHI	2004
3	Computer System Architecture	Mano M. M	PHI	2007

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Computer Organization and Design	Patterson D.A. and J. L. Hennessy	Morgan Kaufmann Publishers	5/e,2013
2	Computer Organization and Architecture: Designing for Performance	William Stallings	Pearson,	9/e, 2013.
3	Computer Organization and Design	Chaudhuri P	Prentice Hall	2/e, 2008.

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://www.youtube.com/watch?v=msqxkEKFg8I&list=PLgHucKw979AvcnTpPNZMZyORdL5HvTr9m,, https://www.youtube.com/watch?v=k_QgyvsqtwA&list=PLgHucKw979AvcnTpPNZMZyORdL5HvTr9m&index=12
2	https://www.youtube.com/watch?v=0B-y1RPDXjs&list=PL59E5B57A04EAE09C&index=17
3	https://www.youtube.com/watch?v=AgoC0mlL6eQ&list=PLdS3u59E0DKjUKPcnCYxVxssEkX2zo-kV&index=8 https://www.youtube.com/watch?v=6CCwWCstDGc&list=PL1A5A6AE8AFC187B7&index=9https://www.youtube.com/watch?v=IQql2ojVzsU&list=PLEAYkSg4uSQ3dmkbCah82ek0KJnpz_DxL&index=5
4	https:/www.youtube.com/watch?v=Wfau1WC5m4c

SEMESTER S4

SOLID STATE DEVICES

Course Code	PEEET417	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)	GYEST104	Course Type	Theory

Course Objectives:

1. To design and analyze different electronic circuits for various applications.
2. To design various analog circuits using discrete electronic devices.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Wave shaping circuits**: First order RC low pass and high pass filters, Differentiator and Integrator, Diode clipping circuits, Diode clamping circuits, Voltage multipliers **Transistor biasing: Concept** of DC and AC load lines, Types -Fixed bias circuit, Self-bias, voltage divider bias, Bias stabilization. **Switching Circuits:** Astable, Bistable and Monostable multivibrators, Schmitt Trigger.	**11**
2	**BJT amplifiers:** RC coupled amplifier –Design, Voltage gain and frequency response. Small signal analysis of CE configuration - small signal hybrid-pi model for mid and low frequency (Gain, Input and output impedance). High frequency equivalent circuits of BJT, Miller effect, Analysis of high frequency response of CE amplifier. **Multistage amplifiers** - Cascade and Cascode amplifiers: Design, Effect on gain and bandwidth.	**11**
3	**MOSFETs** - MOSFET as an amplifier, Biasing of p-channel and n-channel MOSFET circuits, Small signal equivalent circuit, Small signal Voltage gain, current gain, input and output impedances of CS configuration, CS stage with diode connected load. **Feedback topologies:** Effect of positive and negative feedback on gain, frequency response and distortion, Feedback topologies and its effect on input and output impedance, Feedback amplifier circuits using BJT in	**11**

	each feedback topologies (Analysis of only Voltage series feedback circuit is required)	
4	**Oscillators:** Introduction, Barkhausen criterion, Classification of oscillators - RC phase shift, Wien bridge, Hartley, Colpitts and Crystal oscillators (working principle and design equations of the circuits only). Analysis of RC phase shift oscillator. **Power amplifiers:** Classification, Transformer coupled class A power amplifier, push pull class B and class AB power amplifiers, complementary symmetry class B and class AB power amplifiers, Class C power amplifier efficiency and distortion (no analysis required). **Regulated power supplies:** Load and line regulation, Series voltage regulator, shunt voltage regulator, Short circuit protection and fold back protection.	**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	Design and analyze the RC circuits and BJT biasing circuits	**K4**
CO2	Perform small signal and high frequency analysis of BJT amplifier circuits using equivalent models	**K3**
CO3	Design and analyze MOSFET amplifier circuits	**K4**
CO4	Design and analyze feedback amplifiers and oscillators	**K4**
CO5	Design power amplifiers and voltage regulator circuits	**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
CO2	3	3										3
CO3	3	3	2									3
CO4	3	3	2									3
CO5	3	1	2									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	Electronic Devices and Circuit Theory	Robert Boylested and L. Nashelsky	Pearson	11/e,2017.
2	Microelectronic circuits	Sedra A S. and K. C. Smith	Oxford University Press	6/e,2013
3	Electronic Devices and Circuits	David A Bell	Oxford University Press	5/e,2008

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Electronic circuits, Analysis and Design	Neamen D.	McGraw Hill	3/e,2007
2	Microelectronic Circuits – Analysis and Design	Rashid M. H	Cengage Learning	2/e,2011
3	Fundamentals of Microelectronics	Razavi B.	Wiley	2015
4	Integrated Electronics	Millman J. and C. Halkias	McGraw Hill	2/e, 2010

SEMESTER S4

ILLUMINATION TECHNOLOGY

Course Code	**PEEET418**	**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)	GBPHT121, GYEST104	**Course Type**	Theory

Course Objectives:

1. Understand the principles of light, including electromagnetic radiation, human eye perception, and the properties and types of lighting, both natural and artificial.
2. Develop the ability to measure and quantify light using various units and laws and apply these measurements to practical lighting scenarios.
3. Acquire the skills to design efficient and effective interior lighting systems, considering factors such as maintenance, uniformity, and the specific lighting needs of different environments.
4. Learn to design and implement outdoor lighting solutions, including street lighting, flood lighting, and special aesthetic lighting, with a focus on energy efficiency and safety.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to Light: Electromagnetic radiation, Visible spectrum, Human eye and light perception, Visible light production by black body radiation and emission spectrum, Day lighting, Artificial lighting. Qualities of good lighting, Factor affecting the lighting – Glare (Discomfort and disability glare), Visual comfort probability (VCP) and Unified glare rating (UGR) to measure glare, Shadow, Colour rendering and Colour rendering index (CRI), Stroboscopic effect and method to reduce it. Methods of artificial lighting schemes – Direct, indirect, semi -direct, semi-indirect and diffused lighting, General lighting and task lighting, Areas of usage of such lighting schemes Definition of lamp and luminaire, Working of Incandescent and Halogen lamps, fluorescent lamps, Vapour lamps (LPSV, HPSV, Mercury), metal	9

	halide lamps, LED lamps.	
2	Measurements of Light : Definitions and units – Luminous flux & Lumen, luminous intensity & Candela, illuminance& Lux, Luminance &Candela/m^2, luminous efficacy, colour temperature, Candle power. M.H.C.P., M.S.C.P. and M.H.S.C.P. of lamp, Efficiency of a lamp, Concept of CIE 1931 colour space Laws of illumination – Inverse square law of illumination, Lambert's cosine law of illumination, Numerical problems based of laws of illumination, Practical application of the laws, Polar curve in illumination, Rousseau's construction Calculation of luminance and illumination in case of linear source, round source and flat source. Measuring apparatus- Goniophotometer, Integrating sphere, luxmeter	**10**
3	Design of Interior Lighting: Definitions of maintenance factor, Uniformity ratio, Direct ratio, Coefficients of utilisation and factors affecting it, Illumination required for various work planes, Types of fixtures and relative terms used for interior illumination such as DLOR and ULOR, Selection of lamp and luminance, Selection of utilisation factor, reflection factor and maintenance factor. Calculation of wattage of each lamp and no of lamps needed, Layout of lamp luminaire, Calculation of space to mounting height ratio, Indian standard recommendation and standard practices for illumination levels in various areas, Numerical problems from design of interior lighting. Installation aspects for lighting (mechanical and electrical) Special feature for entrance, staircase, corridor lighting, industrial building and hospital lighting, Emergency lighting, Lighting maintenance	**9**
4	Design of Outdoor Lighting: Street Lighting - Types of street and their level of illumination required, Terms related to street lighting, Types of fixtures used and their suitable application, Various arrangements in street lighting, Requirements of good street lighting , Selection of lamp and luminaire, Calculation of illumination level available on road. Flood Lighting: Terms related to flood lighting, Types of fixtures and their suitable applications, Selection of lamp and projector, recommended method for aiming of lamp, Calculation of their wattage and number and their arrangement. Tunnel lighting zones and schemes, Special Features of aesthetic lighting - decorative lighting of monuments, parks and streets, Safety considerations in public lighting, Sports lighting, lighting for hazardous area.	**9**

	Energy efficient lighting systems strategies and controls like dimmers, motion and occupancy sensors, photo sensors and timers. Introduction to software used for lighting design, DIALux and Relux(Self study)	

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 fundamental principles of light, including electromagnetic radiation, visible spectrum, and human eye perception and to analyse qualities of good lighting and factors affecting lighting such as glare, shadow, colour rendering, and stroboscopic effects.	**K4**
CO2	Apply methods of artificial lighting schemes and understand the working principles of various lamps and luminaires.	**K3**
CO3	Evaluate measurements of light using definitions, units, laws of illumination, and measurement apparatus.	**K5**
CO4	Design and implement efficient interior lighting systems that enhance visual comfort, optimize energy usage, and comply with standard practices and recommendations for various environments, including residential, commercial, and industrial spaces.	**K6**
CO5	Develop the ability to design and implement comprehensive outdoor lighting solutions, including street lighting, flood lighting, tunnel lighting, and aesthetic lighting for public spaces, ensuring energy efficiency, safety, and adherence to industry standards and practices.	**K6**

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	2	2	2	1	1	1	1	1	1
CO2	3	3	3	2	2	2	1	1	1	1	1	1
CO3	3	3	3	2	2	2	1	1	1	1	1	1
CO4	3	3	3	2	2	2	1	1	1	1	1	1
CO5	3	3	3	2	2	2	1	1	1	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	Applied Illumination Engineering	Jack L. Lindsey	PHI, 1991	1991
2	Lighting	D.C. Pritchard	Routledge	2016
3	The Lighting Handbook, Zumtobel Lighting GmbH, Austria July 2017			

Reference Books	
Sl. No	**Title of the Book**
1	National Lighting Code 2010 (SP72:2010), Bureau of Indian Standards
2	M.A. Cayless, Lamps and Lighting , Routledge, 1996
3	Lighting Engineering Applied calculations R. H. Simons and A. R. Bean, Routledge; 1st edition, 2020
4	Craig DiLouie, Advanced Lighting Controls: Energy Savings, Productivity, Technology and Applications, CRC Press, 2005.
5	Sask Power, SEP4, Roadway lighting Design guide
6	IS Codes : IS:1944-1970, IS:10322-1982, IS:3646-1992, IS:2440-1975, IS:6665-1972

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
Module – I to IV	https://archive.nptel.ac.in/courses/108/105/108105060/
Module – I to IV	http://www.nptelvideos.com/course.php?id=482
Module -III	https://www.youtube.com/watch?v=PZo4G12MbO4

SEMESTER S4

OBJECT ORIENTED PROGRAMMING

Course Code	PEEET419	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)	GBEST204 Programming in C	**Course Type**	Theory

Course Objectives:

1. To introduce the basic concepts of object-oriented design techniques.
2. To give a thorough understanding of basics of Java programming.
3. To provide basic exposure to the Exception handling and Multithreaded programming etc.
4. To impart the techniques of Swing in Java and database connectivity.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction:** **Approaches to Software Design -** Functional Oriented Design, Object Oriented Design, Case Study of Automated Fire Alarm System. **Object Modeling Using Unified Modeling Language (UML)** – Basic Object-Oriented concepts, UML diagrams, Use case Diagram, Class diagram. **Introduction to Java -** Java Buzzwords, Java program structure, Java compiler, Bytecode, Java Virtual Machine (JVM), Comments, Lexical Issues.	**9**

2	**Core Java Fundamentals:** **Primitive Data types -** Integers, Floating Point Types, Characters, Boolean. Type Conversion and Casting, Variables, Arrays, Strings. **Operators -** Arithmetic Operators, Bitwise Operators, Relational Operators, Boolean Logical Operators, Assignment Operator, Conditional (Ternary) Operator, Operator Precedence. **Control Statements -** Selection Statements, Iteration Statements and Jump Statements. **Object Oriented Programming in Java -** Class Fundamentals, Declaring Objects, Object Reference, Introduction to Methods, Constructors, this Keyword, Method Overloading. Inheritance - Super Class, Sub Class, Method Overriding-super Keyword. **Input/Output** - I/O Basics, Reading Console Input, Writing Console Output.	9
3	**More features of Java:** **Packages -** Defining Package, Importing Packages. **Access Control-**public, private, protected. **Exception Handling -** Checked Exceptions, Unchecked Exceptions, try Block and catch Clause, Multiple catch Clauses, Nested try Statements, throw, throws and finally. **Multithreaded programming-**Thread model, Creating threads, Creating multiple threads, thread synchronization.	9
4	**Graphical User Interface and Database support of Java:** **Swings fundamentals -** Swing Key Features, Model View Controller (MVC), Components and Containers, Swing Packages, Swing Layout Managers. **Event Handling in Swings:** Delegation event model, event handling using swing components-JFrame, JLabel, JButton, JTextField. **Java DataBase Connectivity (JDBC)-** JDBC architecture, Creating and Executing Queries – create table, delete, insert, select.	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	Write Java programs using the object-oriented concepts - classes, objects, constructors, data hiding, inheritance and polymorphism.	**K2**
CO2	Utilise datatypes, operators, control statements, object-oriented class, concepts, I/O basics in Java to develop programs.	**K3**
CO3	Illustrate how robust programs can be written in Java using packages, exception handling mechanism and Multithreaded programming.	**K3**
CO4	Write Graphical User Interface based application programs by utilising Swing in Java and database connectivity.	**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	3	-	-	-	-	-	-	-	-	-
CO2	3	3	2	-	-	-	-	-	-	-		-
CO3	3	3	3	2	2	-	-	-	-	-	-	-
CO4	2	3	3	3	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	Java: The Complete Reference.	Herbert Schildt	Tata McGraw Hill	8th edition, 2011
2	Fundamentals of Software Engineering	Rajib Mall	PHI	4th edition, 2014
3	Java How to Program, Early Objects	Paul Deitel, Harvey Deitel	Pearson	11th Edition, 2018

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Programming JAVA a Primer	BalagurusamyE	McGraw Hill	5/e, 2014.
2	Object Oriented Systems Development using the Unified Modeling Language	Ali Bahrami	McGraw-Hill Int.	2017
3	Introduction to Java Programming	Y. Daniel Liang	Pearson	7/e, 2013.
4	Core Java: An Integrated Approach	Nageswararao R.	Dreamtech Press	2008
5	Java in A Nutshell	Flanagan D	O'Reilly	5/e, 2005.
6	Object Oriented Design with UML and Java	Barclay K.J. Savage,	Elsevier	2004
7	Head First Java	Sierra K.	O'Reilly	2/e, 2005.

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/106105191
2	https://onlinecourses.nptel.ac.in/noc20_cs08/preview

SEMESTER S3/S4

ECONOMICS FOR ENGINEERS

Course Code	**UCHUT346**	**CIE Marks**	50
Teaching Hours/Week (L: T:P: R)	2:0:0:0	**ESE Marks**	50
Credits	2	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. To provide students with an understanding of fundamental economic principles essential for effective decision-making in engineering contexts.
2. To enable students to apply economic analysis to production decisions, cost management, and market strategies in engineering practice.
3. To equip students with the ability to evaluate macroeconomic scenarios, financial methods, and investment decisions relevant to engineering projects.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Basic economic problems – Production Possibility Curve – Utility – Law of diminishing marginal utility –Demand: Factors determining demand – Law of Demand – Demand curve- Price elasticity of demand- measurement of price elasticity and its applications – Supply: factors determining supply - Law of supply – Supply curve- Equilibrium price determination- Changes in demand and supply and its effects on equilibrium price and quantity Production: Production function - Law of variable proportion –Returns to scale- Cobb-Douglas Production Function	**6**
2	Cost: Cost concepts – Private cost and social cost – Sunk cost – Opportunity cost -Explicit and implicit cost –Short run cost curves –Long run average cost curve -Revenue concepts – Break-even point Market: Perfect Competition – Monopoly - Monopolistic Competition (features and equilibrium of a firm) - Oligopoly – Features – Kinked demand model	**6**

3	National income: Concepts (GDP, GNP and NNP)– Final goods and Intermediate goods - Methods of Estimation –output method – expenditure method-- Difficulties in the measurement of national income. Inflation: Causes and Effects – Measures to Control Inflation - Monetary and Fiscal policies – Repo and reverse repo rate	**6**
4	Value Analysis and value Engineering: Cost Value, Exchange Value, Use Value, Esteem Value - Aims, Advantages and Application areas of Value Engineering - Value Engineering Procedure Capital Budgeting: Time value of money - Net Present Value Method - Benefit Cost Ratio – Internal Rate of Return –- Payback – Accounting Rate of Return.	**6**

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

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/Case Study/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
10	15	12.5	12.5	50

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
• Minimum 1 and Maximum 2 Questions from each module. • Total of 6 Questions, each carrying 3 marks (6x3 =18 marks)	2 questions will be given from each module, out of which 1 question should be answered. Each question can have a maximum of 2 sub divisions. Each question carries 8 marks. (4x8 = 32 marks)	50

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the fundamentals of various economic issues using laws and learn the concepts of demand, supply, elasticity and production function.	**K2**
CO2	Develop decision making capability by applying concepts relating to costs and revenue, and acquire knowledge regarding the functioning of firms in different market situations.	**K3**
CO3	Outline the macroeconomic principles of monetary and fiscal systems and national income.	**K2**
CO4	Make use of the possibilities of value analysis and engineering, and take investment decisions through capital budgeting techniques.	**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	-	-	-	-	-	1	-	-	-	-	1	-
CO2	-	-	-	-	-	1	1	-	-	-	1	-
CO3	-	-	-	-	1	-	-	-	-	-	2	-
CO4	-	-	-	-	1	1	-	-	-	-	2	-

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Managerial Economics	Geetika, Piyali Ghosh and Chodhury	Tata McGraw Hill,	2015
2	Engineering Economy	H. G. Thuesen, W. J. Fabrycky	PHI	1966
3	Engineering Economics	R. Paneerselvam	PHI	2012
4	Financial Management	I M Pandey	Vikas Publishing House	2015

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Engineering Economy	Leland Blank P.E, Anthony Tarquin P. E.	Mc Graw Hill	7^{TH} Edition
2	Indian Financial System	Khan M. Y.	Tata McGraw Hill	2011
3	Engineering Economics and analysis	Donald G. Newman, Jerome P. Lavelle	Engg. Press, Texas	2002
4	Contemporary Engineering Economics	Chan S. Park	Prentice Hall of India Ltd	2001
5	Financial Management: Theory and Practice	Prasanna Chandra	Mc Graw Hill	2007

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD SEMESTER B. TECH DEGREE EXAMINATION, MONTH AND YEAR

Course Code: UCHUT346

Course Name: Economics for Engineers

Max. Marks: 50		Duration: 2 hours 30 minutes

PART A

		Answer all questions. Each question carries 3 marks	CO	Marks
1		What are the central problems of an economy?	CO1	(3)
2		Point out any three applications of price elasticity of demand.	CO1	(3)
3		What is the social cost of production?	CO2	(3)
4		What is repo rate?	CO3	(3)
5		What is esteem value?	CO4	(3)
6		Write a short note on time value of money.	CO4	(3)

PART B

Answer any one full question from each module. Each question carries 8 marks

Module 1

9	a)	Suppose a country is producing at a point inside the production possibility curve. Draw a PPC and examine this situation.	CO1	(5)
	b)	State the law of demand. Point out any two exceptions of this law.	CO1	(3)
10	a)	A consumer purchases 10 units of a commodity when its price is Rs.100. Later when its price falls to Rs.90, he purchases 8 units only. Estimate price elasticity. What type of a commodity is this?	CO1	(5)
	b)	State the law of variable proportion.	CO1	(3)

Module 2				
11	a)	What is oligopoly? Why price is rigid under oligopoly?	CO2	(5)
	b)	The cost function of a firm is given as $TC=1000+10Q-6Q^2+Q^3$.. Calculate fixed cost, variable cost and marginal cost when output is 10 units.	CO2	(3)
12	a)	Suppose a firm is earning super normal profit under monopolistic market condition. Explain this situation by drawing a diagram.	CO2	(5)
	b)	Suppose a firm sells its product at a price of Rs.10 per unit and its average variable cost is Rs.6. If the firm spend Ra.10000 as rent and pay Rs. 6000 as interest every month, estimate its break-even level of output.	CO2	(3)
Module 3				
13	a)	What is inflation? How does inflation affect investment and production.	CO3	(5)
	b)	How will you obtain NNPfc from GDPmp.	CO3	(3)
14	a)	From the data given below (In Rs. Crores) estimate GDPmp and national income. Private final consumption expenditure = 1000, Government expenditure = 500, Invest expenditure = 700, Net exports = 300, Depreciation = 200, NFIA=(-200) and Net indirect tax = 100	CO3	(5)
	b)	What is bank rate? Examine the bank rate policy of the government during inflation.	CO3	(3)
Module 4				
15	a)	Examine the procedures of value engineering.	CO4	(5)
	b)	Examine the application areas of value engineering	CO4	(3)

16	a)	1. Suppose the initial investment of a project is Rs. 3000 (Crores) and the cost of capital or the opportunity cost of capital is 10 percent. Calculate NPV of the project based on the cash flows given below. Year 1 2 3 4 5 Cash flow 1000 900 800 700 600 (In Crores)	CO4	(5)
	b)	Point out any three merits of NPV method.	CO4	(3)
*****				

SEMESTER S3/S4

ENGINEERING ETHICS AND SUSTAINABLE DEVELOPMENT

Course Code	**UCHUT347**	**CIE Marks**	50
Teaching Hours/Week (L: T:P: R)	2:0:0:0	**ESE Marks**	50
Credits	2	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. Equip with the knowledge and skills to make ethical decisions and implement gender-sensitive practices in their professional lives.
2. Develop a holistic and comprehensive interdisciplinary approach to understanding engineering ethics principles from a perspective of environment protection and sustainable development.
3. Develop the ability to find strategies for implementing sustainable engineering solutions.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Fundamentals of ethics -** Personal vs. professional ethics, Civic Virtue, Respect for others, **Profession and Professionalism,** Ingenuity, diligence and responsibility, Integrity in design, development, and research domains, Plagiarism, a balanced outlook on law - challenges - case studies, **Technology and digital revolution-**Data, information, and knowledge, Cybertrust and cybersecurity, Data collection & management, **High technologies: connecting people and places-**accessibility and social impacts, **Managing conflict**, Collective bargaining, **Confidentiality**, Role of confidentiality in moral integrity, **Codes of Ethics**. **Basic concepts in Gender Studies -** sex, gender, sexuality, gender spectrum: beyond the binary, gender identity, gender expression, gender stereotypes, **Gender disparity and discrimination in education**, employment and everyday life, History of women in Science & Technology,	6

	Gendered technologies & innovations**, Ethical values and practices in connection with gender -** equity, diversity & gender justice, **Gender policy and women/transgender empowerment initiatives.**	
2	**Introduction to Environmental Ethics:** Definition, importance and historical development of environmental ethics, key philosophical theories (anthropocentrism, biocentrism, ecocentrism). **Sustainable Engineering Principles:** Definition and scope, triple bottom line (economic, social and environmental sustainability), life cycle analysis and sustainability metrics. **Ecosystems and Biodiversity:** Basics of ecosystems and their functions, Importance of biodiversity and its conservation, Human impact on ecosystems and biodiversity loss, An overview of various ecosystems in Kerala/India, and its significance. **Landscape and Urban Ecology:** Principles of landscape ecology, Urbanization and its environmental impact, Sustainable urban planning and green infrastructure.	**6**
3	**Hydrology and Water Management:** Basics of hydrology and water cycle, Water scarcity and pollution issues, Sustainable water management practices, Environmental flow, disruptions and disasters. **Zero Waste Concepts and Practices:** Definition of zero waste and its principles, Strategies for waste reduction, reuse, reduce and recycling, Case studies of successful zero waste initiatives. **Circular Economy and Degrowth:** Introduction to the circular economy model, Differences between linear and circular economies, degrowth principles, Strategies for implementing circular economy practices and degrowth principles in engineering. **Mobility and Sustainable Transportation:** Impacts of transportation on the environment and climate, Basic tenets of a Sustainable Transportation design, Sustainable urban mobility solutions, Integrated mobility systems, E-Mobility, Existing and upcoming models of sustainable mobility solutions.	**6**
4	**Renewable Energy and Sustainable Technologies:** Overview of renewable energy sources (solar, wind, hydro, biomass), Sustainable technologies in energy production and consumption, Challenges and opportunities in renewable energy adoption. **Climate Change and Engineering Solutions:** Basics of climate change science, Impact of climate change on natural and human systems, Kerala/India and the Climate crisis, Engineering solutions to mitigate, adapt and build resilience to climate change. **Environmental Policies and Regulations:** Overview of key environmental policies and regulations (national and international), Role of engineers in policy	**6**

	implementation and compliance, Ethical considerations in environmental policy-making. **Case Studies and Future Directions:** Analysis of real-world case studies, Emerging trends and future directions in environmental ethics and sustainability, Discussion on the role of engineers in promoting a sustainable future.	

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

Continuous Internal Evaluation Marks (CIE):

Continuous internal evaluation will be based on individual and group activities undertaken throughout the course and the portfolio created documenting their work and learning. The portfolio will include reflections, project reports, case studies, and all other relevant materials.

- The students should be grouped into groups of size 4 to 6 at the beginning of the semester. These groups can be the same ones they have formed in the previous semester.
- Activities are to be distributed between 2 class hours and 3 Self-study hours.
- The portfolio and reflective journal should be carried forward and displayed during the 7th Semester Seminar course as a part of the experience sharing regarding the skills developed through various courses.

Sl. No.	Item	Particulars	Group/ Individual (G/I)	Marks
1	Reflective Journal	Weekly entries reflecting on what was learned, personal insights, and how it can be applied to local contexts.	I	5
2	Micro project (Detailed documentation of the project, including methodologies, findings, and reflections)	1 a) Perform an Engineering Ethics Case Study analysis and prepare a report 1 b) Conduct a literature survey on 'Code of Ethics for Engineers' and prepare a sample code of ethics	G	8
		2. Listen to a TED talk on a Gender-related topic, do a literature survey on that topic and make a report citing the relevant papers with a specific analysis of the Kerala context	G	5
		3. Undertake a project study based on the concepts of sustainable development* - Module II, Module III & Module IV	G	12
3	Activities	2. One activity* each from Module II, Module III & Module IV	G	15
4	Final Presentation	A comprehensive presentation summarising the key takeaways from the course, personal reflections, and proposed future actions based on the learnings.	G	5
		Total Marks		**50**

*Can be taken from the given sample activities/projects

Evaluation Criteria:

- **Depth of Analysis**: Quality and depth of reflections and analysis in project reports and case studies.
- **Application of Concepts**: Ability to apply course concepts to real-world problems and local contexts.
- **Creativity**: Innovative approaches and creative solutions proposed in projects and reflections.
- **Presentation Skills**: Clarity, coherence, and professionalism in the final presentation.

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Develop the ability to apply the principles of engineering ethics in their professional life.	**K3**
CO2	Develop the ability to exercise gender-sensitive practices in their professional lives	**K4**
CO3	Develop the ability to explore contemporary environmental issues and sustainable practices.	**K5**
CO4	Develop the ability to analyse the role of engineers in promoting sustainability and climate resilience.	**K4**
CO5	Develop interest and skills in addressing pertinent environmental and climate-related challenges through a sustainable engineering approach.	**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	2	3	3	2		2
CO2		1				3	2	3	3	2		2
CO3						3	3	2	3	2		2
CO4		1				3	3	2	3	2		2
CO5						3	3	2	3	2		2

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Ethics in Engineering Practice and Research	Caroline Whitbeck	Cambridge University Press & Assessment	2nd edition & August 2011
2	Virtue Ethics and Professional Roles	Justin Oakley	Cambridge University Press & Assessment	November 2006
3	Sustainability Science	Bert J. M. de Vries	Cambridge University Press & Assessment	2nd edition &

				December 2023
4	Sustainable Engineering Principles and Practice	Bhavik R. Bakshi,	Cambridge University Press & Assessmen	2019
5	Engineering Ethics	M Govindarajan, S Natarajan and V S Senthil Kumar	PHI Learning Private Ltd, New Delhi	2012
6	Professional ethics and human values	RS Naagarazan	New age international (P) limited New Delhi	2006.
7	Ethics in Engineering	Mike W Martin and Roland Schinzinger,	Tata McGraw Hill Publishing Company Pvt Ltd, New Delhi	4" edition, 2014

Suggested Activities/Projects:
Module-II

- Write a reflection on a local environmental issue (e.g., plastic waste in Kerala backwaters or oceans) from different ethical perspectives (anthropocentric, biocentric, ecocentric).
- Write a life cycle analysis report of a common product used in Kerala (e.g., a coconut, bamboo or rubber-based product) and present findings on its sustainability.
- Create a sustainability report for a local business, assessing its environmental, social, and economic impacts
- Presentation on biodiversity in a nearby area (e.g., a local park, a wetland, mangroves, college campus etc) and propose conservation strategies to protect it.
- Develop a conservation plan for an endangered species found in Kerala.
- Analyze the green spaces in a local urban area and propose a plan to enhance urban ecology using native plants and sustainable design.
- Create a model of a sustainable urban landscape for a chosen locality in Kerala.

Module-III

- Study a local water body (e.g., a river or lake) for signs of pollution or natural flow disruption and suggest sustainable management and restoration practices.
- Analyse the effectiveness of water management in the college campus and propose improvements - calculate the water footprint, how to reduce the footprint, how to increase supply through rainwater harvesting, and how to decrease the supply-demand ratio
- Implement a zero waste initiative on the college campus for one week and document the challenges and outcomes.
- Develop a waste audit report for the campus. Suggest a plan for a zero-waste approach.
- Create a circular economy model for a common product used in Kerala (e.g., coconut oil, cloth etc).
- Design a product or service based on circular economy and degrowth principles and present a business plan.
- Develop a plan to improve pedestrian and cycling infrastructure in a chosen locality in Kerala

Module-IV

- Evaluate the potential for installing solar panels on the college campus including cost-benefit analysis and feasibility study.
- Analyse the energy consumption patterns of the college campus and propose sustainable alternatives to reduce consumption - What gadgets are being used? How can we reduce demand using energy-saving gadgets?

- Analyse a local infrastructure project for its climate resilience and suggest improvements.
- Analyse a specific environmental regulation in India (e.g., Coastal Regulation Zone) and its impact on local communities and ecosystems.
- Research and present a case study of a successful sustainable engineering project in Kerala/India (e.g., sustainable building design, water management project, infrastructure project).
- Research and present a case study of an unsustainable engineering project in Kerala/India highlighting design and implementation faults and possible corrections/alternatives (e.g., a housing complex with water logging, a water management project causing frequent floods, infrastructure project that affects surrounding landscapes or ecosystems).

SEMESTER S4

DC MACHINES & TRANSFORMERS LAB

Course Code	**PCEEL407**	**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)	PCEET303	**Course Type**	Lab

Course Objectives:

1. Provide practical experience in operation and testing of DC machines and transformers

Expt. No.	Experiments
PART A – DC MACHINES	
1	**Open circuit characteristics of DC shunt generator (CO1)** Objectives: a. Predetermine the OCC at different speeds b. Determine the critical field resistance c. Determine the maximum voltage built up with given shunt field resistance d. Determine the critical speed for a given shunt field resistance
2	**Load test on DC shunt generator (CO1)** Objectives: Determine the external and internal characteristics
3	**Brake test on DC shunt motor (CO2)** Objectives: Plot the following characteristics a. Performance characteristics b. Electrical characteristics c. Mechanical characteristics

4	**Brake test on DC series motor (CO2)** Objectives: Plot the following characteristics a. Performance characteristics b. Electrical characteristics c. Mechanical characteristics
5	**Load test on DC compound generator (CO1)** Objectives: a. Plot the load characteristics when cumulatively compounded b. Plot the load characteristics when differentially compounded
6	**Swinburne's test on a DC shunt machine (CO3)** Objectives: a. Predetermine the efficiency while DC machine is acting as generator and motor b. Plot the efficiency curves while DC machine is acting as generator and motor
7	**Hopkinson's test on a pair of DC machines (CO3)** Objectives: Determine the efficiency the DC machine while working as a motor and generator under various load conditions
8	**Retardation test on a DC machine (CO3)** Objectives: a. Separate the hysteresis, eddy current, friction and windage losses b. Find the moment of inertia of the rotating system
9	**Separation of losses in a DC shunt motor (CO3)** Objectives: Separate the hysteresis, eddy current, friction and windage losses by conducting no-load tests at different excitations.
PART B - TRANSFORMERS	
10	**OC and SC tests on single-phase transformer (CO4)** Objectives: 1. Predetermine the voltage regulation and efficiency at different loads and power factors. 2. Determine the equivalent circuit referred to LV side and HV side 3. Plot the voltage regulation vs power factor curves at full-load and half full-load. 4. Plot the efficiency curve at unity p.f. and 0.5 p.f. 5. Determine the power factor at which the voltage regulation is zero 6. Determine the load at which maximum efficiency occurs and the maximum

	efficiency.
11	**Load test on single-phase transformer (CO4)** Objectives: Determine the voltage regulation and efficiency at different loads and at unity power factor.
12	**Separation of losses in a single-phase transformer (CO4)** Objectives: a. Separate the hysteresis and eddy current losses using voltage and frequency control. b. Plot losses Vs frequency curves at normal voltage and different frequencies c. Plot losses Vs frequency curves at different frequencies keeping V/f constant
13	**Sumpner's test (CO4)** Objectives: a. Predetermine the voltage regulation and efficiency at different loads (full-load and half full-load) and power factors (unity, 0.8 lag and lead) b. Determine the equivalent circuit referred to LV side and HV side
14	**Parallel operation of two dissimilar single-phase transformers (CO4)** Objectives: a. Determine the load sharing while two dissimilar transformers are operating in parallel b. Verify the load sharing by using the impedances of the two transformers
15	**OC and SC tests on 3-phase transformer (CO5)** Objectives: a. Predetermine the voltage regulation and efficiency at different loads (full-load and half full-load) and power factors (unity, 0.8 lag and lead) b. Determine the per phase equivalent circuit
16	**Scott Connections (CO4)** Objectives: Convert 3-phase AC supply into 2-phase AC by means of Scott connection and to conduct the load test for finding the performance
NOTE: A minimum of TWELVE experiments are mandatory out of the sixteen 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 DC generators by conducting load/no-load tests	**K3**
CO2	Sketch the performance characteristics of DC shunt and series motors	**K3**
CO3	Investigate the losses and efficiency in DC machines by conducting no-load tests	**K3**
CO4	Examine the performance of individual and parallel connected single-phase transformers by conducting load/no-load tests	**K3**
CO5	Determine the voltage regulation and efficiency of 3-phase transformer by conducting no-load tests.	**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

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	7^{th} edition 2021
2	Electric Machines	D P Kothari & I J Nagrath	Tata McGraw Hill	5^{th} 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 S4

POWER ELECTRONICS AND DRIVES LAB

Course Code	**PCEEL408**	**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)	PCEET403	**Course Type**	Lab

Course Objectives:

1. To motivate students to design and implement power electronic converters having high efficiency, small size, high reliability and low cost
2. To enable the students to select suitable power devices and passive components
3. To compare simulation results and hardware results and do iterative design

Expt. No.	Experiments
	Suggestions: *Students are encouraged to do the simulations associated with the experiments before the corresponding lab session so that more emphasis can be given to the hardware part in the lab (Simulations can be done off-lab) and the simulation results need to be correlated with the hardware results. For experiments where the effects of device parasitics cannot be neglected and circuit-level simulations are needed, SPICE based simulation software such as LTSpice^{TM}, OrCAD^{TM}, PSpice^{TM}, Proteus^{TM} etc. may be used. In other cases, software like MATLAB Simulink^{TM}, SciLab^{TM}, SEQUEL^{TM}, PSIM^{TM}, PLECS^{TM} etc. may be used if required.*
	Preliminary work-1 *(Mandatory)* (a) Testing and Troubleshooting- Power diodes, SCR, Power Transistors, MOSFETS, IGBTS, OP-Amps, MOSFET drivers etc – Use of Multimeter, DSO, and Data sheets (b) Simulation of any Power Electronic circuit using a SPICE based software such as LTSpice, ORCAD, PSpice, and Proteus

	Preliminary work -2 *(Mandatory)* (a) PCB routing using any standard PCB layout software such as ORCAD, Proteus, KiCAD, Altium, Eagle etc. ensuring good PCB routing practices (b) Soldering and desoldering Practice – Through-Hole/SMD (It is recommended to select any one of the experiments for the PCB practice)
1	**Static VI characteristics of Power Devices** **Aim:** To simulate the static VI characteristics of (a) Power Diode (b) SCR (b) MOSFET (c) IGBT using any suitable simulation software and compare with datasheet values
2	**High frequency diode - Measurement of power loss and reverse recovery time Aim:** To measure the power losses & reverse recovery time of a high frequency diode, compare with theoretical estimate and to compare with a schottky diode of similar ratings (Hardware/Simulation).
3	**Single-Phase half-wave-controlled rectifier feeding R/RL load** **Aim:** To simulate and set up a half-wave-controlled rectifier with line synchronized R and RC firing circuits and plot relevant waveforms such as voltage waveform across the load and thyristor, gate voltage and gate current for different firing angles. The need for line synchronization to be emphasized. (Any suitable simulation software may be used for the simulation)
4	**Single-Phase half-controlled(semi-converter)/fully-controlled rectifier feeding R/RL loads** **Aim:** To simulate and set up any type of line synchronized Triggering circuit such as UJT firing, Ramp firing, Digital firing etc. for single-phase half-controlled/full controlled rectifier feeding R and RL loads and observe relevant waveforms. The need for line synchronization to be emphasized (Any suitable simulation software may be used for the simulation).
5	**Effect of source inductance in single-phase controlled rectifier feeding highly inductive loads** **Aim:** To set up a single-phase full controlled rectifier with source inductance, for highly inductive loads, observe relevant waveforms and calculate the source power factor, line current THD and the average voltage lost due to the effect of source inductance (Simulation may be used to get more insights).
6	**Single-Phase half-controlled/fully-controlled Rectifier fed PMDC/Separately excited DC motor drive** **Aim:** To simulate and set up a single-phase half-controlled/full controlled rectifier feeding a PMDC/SEDC motor (additional inductor may be included in the armature circuit to get continuous conduction) and observe relevant waveforms (Any suitable simulation

	software may be used for the simulation)
7	**AC Voltage controller feeding R/RL loads** **Aim:** To set up a single-phase AC voltage controller using TRIAC/SCR and to observe relevant waveforms such as voltage waveforms across the load (R/RL Load) & TRIAC/SCR, gate voltage, gate current etc. for different firing angles (Simulation may be used to get more insights).
8	**Isolated Gate Driver Circuit for Single-phase half-Bridge IGBT/MOSFET Inverter** **Aim:** (a) To identify the gate current and voltage requirement to drive the MOSFET/IGBT in a half-bridge configuration for a certain switching frequency with galvanic isolation, to select suitable industry-standard IGBT/MOSFET driver ICs and to test the driver circuit both for floating and ground-referenced configurations, and to observe relevant waveforms (b) To simulate and set up a circuit for dead-time generation for use with the half- bridge inverter
9	**Gate drive using Bootstrap technique** **Aim:** To identify the gate current and voltage requirement to drive the MOSFET/IGBT with boot-strap technique for a certain switching frequency, understand the merits & pertinent limitations of the bootstrapping circuit and to explore dead-time and shutdown/over current protection options
10	**Single-phase half-bridge/full-bridge IGBT/MOSFET inverter feeding RL load** **Aim:** To simulate and set up a single-phase half-bridge inverter with L/LC filter for square wave and sine-triangle PWM, observe relevant waveforms and obtain THD (Any suitable simulation software may be used for the simulation)
11	**Inductor design and Fabrication** **Aim:** To design and fabricate an inductor to be used in a high frequency switching application and measure the inductance value using time constant measurement/LCR meter **Note:** The inductor may be designed taking into account the requirement in expt #12
12	**Design and set-up a buck/ boost /buck-boost converter** ***(Mandatory Experiment)*** **Aim:** (a) Design, simulate and set up a buck/boost/buck-boost converter (continuous conduction mode) and observe relevant waveforms (b) Compare the measured quantities such as capacitor voltage ripple and inductor current ripple with the designed values (c) Calculate power loss in power devices and select heat sink (and snubbers) needed if any (d) Overall efficiency computation and measurement of temperature of the heatsink and passive components (e) Explore performance improvement opportunities

	(Any suitable simulation software may be used for the simulation)
13	**Speed control of Permanent Magnet/Separately-Excited DC motor using chopper drive** **Aim:** To simulate and set up a One-quadrant/Two-quadrant DC chopper to control the speed of a PMDC/SEDC motor for operation in continuous conduction and observe relevant waveforms (Any suitable simulation software may be used for the simulation)
14	**Three-phase IGBT/MOSFET inverter feeding RL Load** **Aim:** To simulate and set up (Demo is sufficient) a three-phase inverter for (a) sine-triangle PWM (b) third-harmonic (or triple-n harmonic) injection PWM and observe relevant waveforms & THD. Influence of various parameters such as switching frequency, amplitude & frequency modulation indices, dead-time etc. on the performance may be studied (Any suitable simulation software may be used for the simulation).
15	**Stator Voltage control of Three-Phase Induction Motor** **Aim:** To set up (Demo is sufficient) a three-phase induction motor drive using stator voltage control and observe relevant waveforms & THD (Simulation may be used to get more insights).
16	**Single phase unidirectional/bidirectional interface – boost PWM rectifier Aim:** To set up (Demo is sufficient) a single-phase PWM rectifier with near unity power, observe relevant waveforms and obtain the line current THD/PF (Simulation may be used to get more insights).
17	**V/F control of Three-Phase Induction Motor** **Aim:** To simulate and set up (Demo is sufficient) a three-phase induction motor drive using V/F control and observe relevant waveforms & THD for different speeds of operation (Any suitable simulation software may be used for the simulation).

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	Understand the operation of modern power semiconductor devices, its characteristics and Design & Select suitable gate driver circuits & heatsinks	**K5**
CO2	Understand the features of phase-controlled rectifiers, AC voltage Controllers & Switching Regulators and Analyse the operation	**K4**
CO3	Understand the features of different types of switch mode DC-AC Inverters and Analyse the operation	**K3**
CO4	Understand the need for improved efficiency, improved reliability, improved load & source waveforms and improved utility interface	**K3**
CO5	Understand the features of adjustable speed drives and Analyse the basic drive schemes for DC motors and Induction Motors	**K4**

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									
CO2	3	1	3									
CO3	3	1	3									
CO4	3	1	3									
CO5	3	1	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	Power Electronics- Essentials and Applications	L. Umanand	John Wiley	2009
2	Power Electronic Systems- Theory and Design	Jai P Agrawal	Pearson	2006
3	Power Electronics- Converters, Applications and Design, 3e (Indian Adaptation)	Ned Mohan, Undeland, Robbins	Wiley India	2022
4	Power electronics: principles and applications	Joseph Vithayathil	Tata McGraw Hill	2010
5	Power Electronics	D.W. Hart	McGraw Hill	2010

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Elements of Power Electronics	Philip T Krein	Oxford	2017
2	Power Electronics- Devices, Circuits and Applications	Muhammad H. Rashid,	Pearson	2014
3	Power Electronics	Cyril W Lander	McGrawHill	1993
4	Power Electronics- A first course: Simulations and Laboratory Implementations	Ned Mohan, Siddharth Raju	Wiley	2023
5	Power Electronics Step by Step- Design, Modeling, Simulation and Control	Weidong Xiao	McGrawHill	2021

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	Lecture Series on Power Electronics **by Prof. G. Bhuvaneswari**, IIT Delhi https://www.youtube.com/watch?v=Z2CORFayCv0&list=PLp6ek2hDcoND7i5-DAD9mPmYF1Wg6ROdO&index=3
2	NPTEL Lecture Series on Power Electronics by **Prof. L. Umanand**, IISc Bangalore https://www.youtube.com/watch?v=eLIdqiPMjBs&list=PLgMDNELGJ1CaXa4sX6QSrkhu-yP_Wu2EN&index=26
3	NPTEL Lecture Series by **Prof. Shabari Nath**, IIT Guwahati https://www.youtube.com/watch?v=S_UXW2UzAi8&list=PLwdnzlV3ogoWVgA9fHBV36L_bxWZlpa7X&index=7

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 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	8^{th} edition 2023
2	Principles of Power System	V. K. Mehta and Rohit Mehta	S. Chand	4^{th} edition reprint 2020
3	Power System Protection and Switchgear	Badri Ramand D.N.Viswakarma	Tata McGraw Hill	2^{nd} edition, 2011
4	Non-conventional energy sources	B. H. Khan	Tata McGraw Hill	3^{rd} 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	2^{nd}Edn, 2012
2	Chemical and Process Thermodynamics	Kyle B.G.	Pearson	3^{rd}Edn, 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	Tota l
• 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):

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 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.
- 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 7

ELECTRICAL AND ELECTRONICS ENGINEERING

SEMESTER S7

POWER SYSTEM OPERATION AND CONTROL

Course Code	PEEET741	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	PE -Theory

Course Objectives:

1. To introduce analysis techniques for the operation and control of power system.
2. To discuss load scheduling and scheduling of energy.
3. To study power system security and state estimation.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction- Optimum load dispatch - First order gradient method base point and participation factors. Economic dispatch versus unit commitment. Unit Commitment Solution Methods - Priority-List Methods – Security Constrained Unit Commitment.	9
2	Generation with limited supply-Take or pay fuel supply contract-Introduction to Hydrothermal coordination-Long range and short range scheduling Hydro-electric plant models-scheduling energy problems - types of scheduling problems. Scheduling energy - The Hydrothermal Scheduling Problem - Hydro scheduling with storage limitation - Introduction to Pumped storage hydro plants.	9
3	Inter change evaluation and power pools- Interchange contracts – Energy interchange between utilities - Interchange evaluation with unit commitment - Energy banking- power pools. Power system security- Factors Affecting Power System Security - Contingency Analysis: Detection of Network Problems - Generation Outages - Transmission Outages - An Overview of Security Analysis.	9
4	Introduction to State estimation in power system, Maximum Likelihood Weighted Least Squares Estimation - State Estimation of an AC Network - Sources of Error in State Estimation - Detection and Identification of Bad	9

	Measurements - Estimation of Quantities Not Being Measured - Network Observability and Pseudo-measurements - The Use of Phasor Measurement Units (PMUs) - Application of Power Systems State Estimation - Importance of Data Verification and Validation.	

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 various methods of generation scheduling.	**K4**
CO2	Formulate hydro-thermal scheduling problems.	**K5**
CO3	Evaluate power exchange in interconnected power systems.	**K5**
CO4	Analyse security issues in power system networks.	**K3**
CO5	Analyse various state estimation methods.	**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	3	3	3	3	3					3
CO2	3	3	3	3	3	3	3					3
CO3	3	3	3	3	3	3	3					3
CO4	3	3	3	3	3	3	3					3
CO5	3	3	3	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	Power Generation Operation and Control	Allen J. Wood & Bruce F. Wollenberg	John Wiley & Sons	3rd edition 2023
2	Power System Analysis	John Graigner & William Stevenson	McGraw Hill	1994
3	Power System State Estimation: Theory and Implementation	Ali Abur, Antonio Gomez	CRC Press	2004

SEMESTER S7

ENERGY MANAGEMENT AND AUDITING

Course Code	**PEEET742**	**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 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. **Ancillary services:** Introduction of ancillary services – Types of Ancillary services	**9**

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 S7

SPECIAL ELECTRICAL MACHINES

Course Code	PEEET743	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. Describe the constructional details, working and drive circuits of various types of special electrical machines

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Stepper motors – basic principle - types - variable reluctance, permanent magnet, hybrid types – constructional features - principle of operation – comparison - modes of operation – monofilar and bifilar windings – modes of excitation – one phase ON mode, two phase ON mode, half-step mode – micro-stepping - static and dynamic characteristics – open-loop and closed loop control - applications – numerical problems.	9
2	Synchronous Reluctance Motor – Constructional details - principle of operation - phasor diagram - torque equation - applications. Switched reluctance motors – constructional details - principle of operation - torque equation – characteristics - power converter circuits - control of SRM - rotor position sensors- torque pulsations – sources of noise - noise mitigation techniques - applications.	9
3	PM Brushless DC motor- constructional details - permanent magnets – different types - demagnetization characteristics – arrangement of permanent magnets – magnetization of permanent magnets – axial and parallel magnetizations- principle of operation – Control of BLDC motor - applications. Permanent Magnet Synchronous Motors - construction - principle of operation – Control of PMSM – self-control – sensor-less control– applications - comparison with BLDC motors	9

4	Linear Electric Machines: Linear motors – different types – linear reluctance motor - linear synchronous motors – construction – comparison. Linear Induction Motor – Construction- Thrust Equation, Transverse edge and end effects- Equivalent Circuit, Thrust-Speed characteristics, Applications. Single Phase Special Electrical Machines- AC series Motor, Repulsion Motor, Hysteresis Motor, Universal Motor- Construction - principle of operation - 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	Explain the constructional details, working and drive circuits for various types of stepper motor.	**K2**
CO2	Explain the constructional details, working and drive circuits for switched and synchronous reluctance motor.	**K2**
CO3	Explain the constructional details, working and drive circuits for brushless DC motor and permanent magnet synchronous motor.	**K2**
CO4	Explain the constructional details and working of linear induction motor	**K2**
CO5	Explain the constructional details and working of single-phase special electrical machines.	**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										3
CO2	3	3										3
CO3	3	3										3
CO4	3	3										3
CO5	3	2										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	Special Electrical Machines	E. G. Janardhanan	PHI Learning Private Limited	Ist edition 2014
2	Special Electrical Machines	K. Venkataratnam	Universities Press	Ist edition, 2008
3	A detailed study on Special Electrical Machines	V. Vedanarayanan	Notion Press	Ist edition, 2021
4	Brushless PM and Reluctance Motor Drives	T. J. E. Miller	Clarendon Press, Oxford	1989
5	Permanent magnet synchronous and Brushless DC motor Drives	R. Krishnan	CRC Press.	Ist edition 2016

SEMESTER S7

DISCRETE TIME CONTROL SYSTEMS

Course Code	**PEEET744**	**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**	Theory

Course Objectives:

1. To provide a strong foundation on the analysis and design techniques on classical and modern control theory in discrete domain

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Analysis of Sampled Data Systems:** Review of Z Transforms; Sampling Theorem, Impulse Sampling, Sampling Rate Selection, Data Hold – ZOH, FOH, Pulse Transfer Function, Control configurations. Mapping between the s-plane and the z-plane. Stability analysis of closed-loop system in the z-plane, Jury's test, Schur-Cohn test, Bilinear Transformation, Routh-Hurwitz method in w-plane.	**9**
2	**Design of Compensators:** Direct design based on root locus: Design of Lag Compensator, Design of Lead Compensator, Design of Lead-Lag Compensator. Digital Controller Design in Frequency Domain: Direct design based on frequency response, Design of Lag Compensator, Design of Lead Compensator, Design of Lag-Lead Compensator, Realization of digital controllers.	**11**
3	**Discrete-time State Space System:** State variable model of discrete data systems with S/H devices - State transition equations, state diagrams. Relationship between state space representation and pulse transfer function, Transformation to canonical forms and phase variable form. Solution of state equation, Computation of state transition matrix using	**9**

	Cayley-Hamilton theorem and z-transform method.	
4	**Design using State Space approach:** Discretization of continuous time state-space equations, Controllability, Observability. State feedback controller design via Pole Placement. State Observer Design: Full order observers and Reduced order observers.	**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	Model and analyse discrete-time system using pulse transfer function approach.	**K3**
CO2	Design digital compensators for linear systems.	**K3**
CO3	Model and analyse discrete-time system using state space approach.	**K3**
CO4	Design discrete-time state feedback controllers and observers for a linear system.	**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	2	2	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 control system analysis and design	Philips and Nagle	Prentice Hall	1984
2	Discrete Time Control Systems	K. Ogata	PHI Learning Private Limited, New Delhi	2009.
3	Digital control and State Variable methods	M. Gopal	Tata McGraw –Hill	1997

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Digital Control Systems	B C Kuo	2nd Ed., Oxford University Press	1992
2	Digital control systems Theory, hardware software.	Constantine H. Houpis and Gary B. Lamont	McGraw Hill Book Company	1985
3	Digital control systems Volume I, Fundamentals , Deterministic control	Isermann	Springer Verlag	2nd revised edition 1989
4	Digital Control of Dynamic Systems	G.F.Franklin, J. David Powell and M. Workman		3rd Ed.

SEMESTER S7

DIGITAL IMAGE PROCESSING

Course Code	**PEEET746**	**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. To introduce the fundamental concepts of Digital Image Processing and study the various transforms required for image processing.
2. To study spatial and frequency domain image enhancement and image restoration methods.
3. To understand image compression and segmentation techniques.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Digital Image Fundamentals: Image representation, Types of images, Elements of DIP system, Basic relationship between pixels, Distance Measures, Simple image formation model. Brightness, contrast, hue, saturation, Mach band effect. Colour image fundamentals-RGB, CMY, HIS models, 2D sampling and quantization.	9
2	2D Image transforms: DFT, Properties, Walsh transform, Hadamard transform, Haar transform, DCT, KL transform and Singular Value Decomposition. Image Compression: Image compression model, Lossy, lossless compression, Concept of transform coding, JPEG Image compression standard.	9
3	Image Enhancement: Spatial domain methods: Basic Gray Level Transformations, Histogram Processing, Enhancement Using Arithmetic/Logic Operations, Basics of Spatial Filtering, Smoothing spatial Filters, Sharpening spatial Filters. Frequency domain methods: low pass filtering, high pass filtering,	9

	homomorphic filtering.	
4	Image Restoration: Degradation model, Inverse filtering- removal of blur caused by uniform linear motion, Minimum Mean Square Error (Wiener) Filtering. Image segmentation: Region based approach, clustering , Segmentation based on thresholding, edge based segmentation, Hough Transform.	**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 =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	Understand different components of image processing system	**K2**
CO2	Analyse the various concepts and mathematical transforms necessary for image processing	**K3**
CO3	Illustrate the various schemes of image compression	**K3**
CO4	Analyze the filtering and restoration of images	**K3**
CO5	Understand the basic image segmentation techniques	**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	3	3	3		1							2
CO2	3	3	3		1							2
CO3	3	3	3		1							2
CO4	3	3	3		1							2
CO5	3	3	3		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	Digital Image Processing	Gonzalez Rafel C	PEARSON	4TH
2	Digital Image Processing	S Jayaraman, S Esakkirajan, T Veerakumar	McGraw Hill	Ist

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Digital Image Processing	Kenneth R Castleman	Pearson Education	2/e,2003
2	Fundamentals of digital image processing	Anil K Jain	PHI	1988
3	Digital Image Processing	Pratt William K	John Wiley	4/e,2007

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc24_ee133/preview
2	https://nptel.ac.in/courses/117105135
3	https://www.youtube.com/watch?v=KiJo4-IijL4
4	https://archive.nptel.ac.in/courses/117/105/117105135/

SEMESTER S7

POWER QUALITY

Course Code	**PEEET751**	**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. To introduce the fundamental concepts of power quality, different power quality issues and its mitigation methods.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Power quality phenomenon** - Sources and effects of power quality problems, Need for concern of Power quality **Types of power quality disturbances** –Transients – classification and origin, Short duration voltage variation – interruption, sag, swell, Long duration voltage variation, voltage unbalance, waveform distortion - notching, harmonics and voltage flicker **Power Quality issues of Grid connected Renewable Energy Systems** – operating conflicts	9
2	**Harmonics** - mechanism of harmonic generation, Triplen harmonics, **Harmonic sources** – switching devices, arcing devices and saturable devices, Effects of harmonics on power system equipment and loads – transformers, capacitor banks, motors and telecommunication systems, Effect of triplen harmonics on neutral current, line and phase voltages. **Harmonic analysis using Fourier series and Fourier transforms** – simple numerical problems	9
3	**Harmonic indices** (CF, DF, THD, TDD, TIF, DIN, C – message weights), Displacement and total power factor **Overview of power quality standards**: IEEE 519, IEEE 1433 and IEC 61000 **Power quality Monitoring:** Objectives and measurement issues, different monitoring instruments – Power quality analyzer, harmonic spectrum analyzer, flicker meters	9

4	**Mitigation of Power quality problems** - Harmonic elimination - Design simple problems and analysis of passive filters to reduce harmonic distortion – demerits of passive filters – description of active filters - shunt, series, hybrid filters, sag and swell correction using DVR Power quality conditioners - DSTATCOM and UPQC - Configuration and working **Power factor correction** – Single phase active power factor converter – circuit schematic and control block diagram **Grounding and wiring**– reasons for grounding – wiring and grounding problems - solutions to these problems	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 sources and effects of power quality problems.	**K2**
CO2	Apply Fourier concepts for harmonic analysis.	**K3**
CO3	Explain the important aspects of power quality monitoring.	**K2**
CO4	Examine power quality mitigation techniques.	**K2**
CO5	Discuss power quality issues in grid connected renewable energy systems.	**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		1				2
CO2	3	3										2
CO3	3	3			3							2
CO4	3	3	2					1				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	Electrical Power System Quality	R. C. Dugan, M. F. Me Granaghen, H. W. Beaty	McGraw-Hill	2012
2	Power Quality	C. Sankaran	CRC Press	2002
3	Understanding Power Quality Problems	Math H. Bollen	Wiley-IEEE Press	1999
4	Power Quality problems and mitigation techniques	Bhim Singh, Ambrish Chandra and Kamal Al-Haddad	John Wiley and Sons Ltd	2015

SEMESTER S7

NONLINEAR CONTROL SYSTEMS

Course Code	**PEEET752**	**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**	Theory

Course Objectives:

1. To introduce the concept of nonlinear systems
2. To impart knowledge about different strategies adopted in the analysis of nonlinear systems
3. To familiarize with the design of different types of nonlinear controllers

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to nonlinear systems:** Basic characteristics of nonlinear systems. Examples. State-space representation of nonlinear systems. Classification of nonlinearities. Phase plane analysis: Concept of phase plane, singular points. Definition of stability – asymptotic stability, instability; Construction using isocline method. Classification of equilibrium points; Systems with multiple equilibria. Periodic orbits - limit cycles.	10
2	**Lyapunov Stability Theory:** Lyapunov's direct method - Definite functions - Stability theorems; - Variable gradient method – La-Salle theorems. Stability of linear systems - Lyapunov equation for time-invariant systems - Lyapunov's linearization (indirect) method - Region of attraction (concept only).	7
3	**Frequency domain Analysis of Feedback systems:** Describing function method: Analysis through harmonic linearization-Determination of describing function of nonlinearities. Application of describing function for stability analysis of autonomous system with	10

	single nonlinearity (relay, dead zone and saturation only). Feedback Stabilisation, Kalman-Yakubovitch-Popov lemma (Concept only); Stability Analysis of feedback systems, Circle Criterion.	
4	**Nonlinear Control Design:** Lie Derivatives and Lie Brackets; Feedback linearization, Input state linearization and input – output linearization of SISO systems. (3 hours) Design via linearization - regulation via integral control; gain scheduling, tracking. Concepts of other nonlinear controllers – sliding mode, backstepping.	**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 qualitative behaviour of nonlinear systems about their equilibrium points.	**K3**
CO2	Analyse the stability of nonlinear systems.	**K3**
CO3	Analyse the behaviour of nonlinear systems using frequency domain analysis.	**K2**
CO4	Design feedback controller for nonlinear systems.	**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	2	2	3	3	3			3	2
CO2	3	3	2	2	2	3	3	3			3	2
CO3	3	2	1	2	1	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	Nonlinear Systems	Hassan K Khalil	Prentice - Hall International (UK)	2002
2	Applied Nonlinear Control	Jean-Jacques E. Slotine and Weiping Li	Prentice-Hall, NJ	1991

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Nonlinear Control Systems: An Introduction	Alberto Isidori	Springer-Verlag	1985
2	Nonlinear System Analysis, Stability and Control	M. Vidyasagar	Prentice-Hall, India	1991

SEMESTER S7

DEEP LEARNING

Course Code	PEEET753	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)	Basic understanding of probability theory, linear algebra and machine learning	Course Type	Theory

Course Objectives:

1. To introduce the building blocks used in deep learning like neural networks, deep neural networks, convolutional neural networks and recurrent neural networks
2. To learn and understand various learning and optimization techniques such as Gradient Descent, Adam
3. To solve a wide range of problems in Computer Vision and Natural Language Processing

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Neural Network:** Introduction to neural networks -Single layer perceptrons, Multi Layer Perceptrons (MLPs), Activation functions - Sigmoid, Tanh, ReLU, Softmax, Risk minimization, Loss function, Training MLPs with Backpropagation, Practical issues in neural network training - The problem of Overfitting, Vanishing and Exploding gradient problems, Difficulties in convergence, Local and spurious Optima, Computational challenges. Applications of neural networks	9
2	**Deep Learning:** Introduction to Deep Learning, Deep Feed Forward network, Training deep learning models, Optimization techniques - Gradient Descent (GD), GD with momentum, Nesterov accelerated GD, Batch, Mini-batch and Stochastic GD, AdaGrad, RMSProp, Adam	9
3	**Convolutional Neural Network (CNN):** Introduction to CNN - Convolution and Pooling, Convolution and Pooling as	9

	an infinitely strong prior, variants of convolution functions, Efficient convolution algorithms, Applications - Computer Vision	
4	**Recurrent Neural Network (RNN):** Introduction to RNN - Computational graphs, RNN design, Encoder-decoder sequence to sequence architectures, Deep RNNs, Modern RNN - LSTM and GRU, Applications - Natural Language Processing (NLP),	**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 =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 subdivisions. **(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	Illustrate the basic concepts of neural networks and its practical issues	**K2**
CO2	Outline the standard regularization and optimization techniques for deep neural network	**K2**
CO3	Implement the foundation layers of convolutional neural networks, pooling and convolution	**K2**
CO4	Implement sequence model using recurrent neural networks	**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				2						3
CO2	3	3				2						3
CO3	3	3				2						3
CO4	3	3	3	2	3	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	Neural Networks and Deep Learning	Charu C. Aggarwal	Springer	2018
2	Fundamentals of Deep Learning: Designing Next-Generation Machine Intelligence Algorithms	Nikhil Buduma and Nicholas Locascio	O'Reilly Media	2017
3	Deep Learning	Ian Goodfellow, Yoshua Bengio,Aaron Courville	MIT Press	2016

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Neural Networks and Deep Learning	Michael Nielsen	http://neuralnetworksanddeeplearning.com/	2018
2	Neural Networks: A Classroom Approach	Satish Kumar	Tata McGraw-Hill Education	2014
3	Artificial Neural Networks	Yegnanarayana, B	PHI Learning Pvt. Ltd	2009

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/106/105/106105215/
2	https://archive.nptel.ac.in/courses/106/106/106106184/
3	https://archive.nptel.ac.in/courses/106106201/
4	https://archive.nptel.ac.in/courses/106106224/

SEMESTER S7

COMPUTER VISION

Course Code	**PEEET754**	**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. To develop the knowledge of various methods, algorithms and applications of Computer Vision.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Review of image processing techniques: Digital filters, linear filters- Homomorphic filtering, Point operators- Histogram, neighbourhood operators, thresholding Mathematical morphology, Binary shape analysis, Binary shape analysis, Erosion, Dilation, Opening and Closing, Hit-or-Miss Transform ,connectedness, object labelling and counting, Boundary descriptors – Chain codes. Properties of Binary Regions, Geometric Features, Statistical Shape Properties	**9**
2	Feature Detection and Image Synthesis,Edge detection – edges, lines, active contours, Split and merge, Mean shift and mode finding, Normalized cuts, Graph cuts, energy- based methods- Cranny’s Algorithm, Corner detection, Harris corner detection algorithm. Hough transform-Line and curve detection.	**9**
3	Shape from X - Shape from shading, Photometric stereo, Texture Occluding contour detection. Motion Analysis- Regularization theory,Optical Flow: brightness constancy equation, aperture problem, Horn-Shunck method, Lucas-Kanade method. Structure from motion	**9**
4	Object recognition-Shape correspondence and shape matching PCA,SVM, LDA, Bayes rule andML methods. Eigen faces,Face detection, Face recognition, Application: Scene analysis Examples of real time applications: In-vehicle vision system.	**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	Understand digital filtering operations for CV applications.	**K2**
CO2	Apply basic morphological and boundary operators for Computer vision applications	**K3**
CO3	Apply edge, corner detection algorithms to locate objects in an image.	**K3**
CO4	Apply optical flow algorithms to detect moving objects in a video.	**K3**
CO5	Analyse a given scene using appropriate computer vision algorithms to detect/recognize objects and to implement it in real time practical applications.	**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		2						2	3
CO2	3	3	2		2						2	3
CO3	3	3	3		2						2	3
CO4	3	3	3		2						2	3
CO5	3	3	3		2						2	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	Computer and Machine Vision -Theory Algorithm and Practicalities	E. R .Davies	Academic Press,	2012.
2	Computer Vision: Algorithms and Applications	Richard Szeliski	ISBN 978-1- 84882-935-0, Springer	2011
3	Computer Vision: A Modern Approach	David Forsyth and Jean Ponce	Pearson India	2002

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Deep Learning,	Goodfellow, Bengio, and Courville,	MIT Press,.	2006
2	Mastering OpenCV with Practical Computer Vision Projects	Daniel Lelis Baggio, et al	Packt Publishing Limited,	2012
3	Computer Vision: Models, Learning, and Inference,	Simon J D Prince	Cambridge University Press	2012
4	Digital Image Processing and Computer Vision,	R. J. Schalkoff	John Wiley,	2004
5	Programming Computer Vision with Python: Tools and algorithms for analyzing images	Jan Erik Solem,	O'Reilly Media,	2012

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc19_cs58/preview
2	https://onlinecourses.nptel.ac.in/noc21_cs93/preview
3	https://onlinecourses.nptel.ac.in/noc24_ee38/preview

SEMESTER S7

DESIGN OF SOLAR PV SYSTEMS

Course Code	**OEEET721**	**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**	OE -Theory

Course Objectives:

1. To introduce a solar PV system and its grid integration aspects.
2. To give insight to basic knowhow for the implementation of Solar PV system

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction** - Basic Concept of Energy -Source of Solar Energy -Formation of the Atmosphere - Solar Spectrum. Solar Constant -Air Mass -Solar Time-Sun–Earth Angles-Solar Radiation-Instruments to Measure Solar Radiation-Pyrheliometer –Pyranometer - Sunshine Recorder -Solar Radiation on a Horizontal Surface - Extra-terrestrial Region.- Terrestrial Region -Solar Radiation on an Inclined Surface -Conversion Factors -Total Solar Radiation on an Inclined/Tilted Surface -Monthly Average Daily Solar Radiation on Inclined Surfaces .	9
2	**Solar Thermal system**-Principle of Conversion of Solar Radiation into Heat, –Solar thermal collectors –General description and characteristics –Flat plate collectors –Heat transfer processes –Solar concentrators (parabolic trough, parabolic dish, Central Tower Collector) – performance evaluation. Applications -Solar heating system, Air conditioning and Refrigeration system, Pumping system, solar cooker, Solar Furnace, Solar Greenhouse - Design of solar water heater	9
3	**Solar PV Systems**-Introduction -Fundamentals of Semiconductor and Solar Cells - Photovoltaic Effect -Solar Cell (Photovoltaic) Materials - Basic Parameters of the Solar Cell - Generation of Solar Cell (Photovoltaic) Materials-.Photovoltaic (PV) Module and PV Array - Single-Crystal Solar	9

	Cell Module, Thin-Film PV Modules, III–V Single Junction and Multifunction PV Modules-Emerging and New PV Systems -Packing Factor of the PV Module - Efficiency of the PV Module -Energy Balance Equations for PV Modules -Series and Parallel Combination of PV Modules.- Effect of shadowing-MPPT Techniques-P&O , incremental conductance method- Maximum Power Point Tracker (MPPT) using buck-boost converter.	
4	**Solar PV Systems** –stand-alone and grid connected -Design steps for a Stand-Alone system – Storage batteries and Ultra capacitors. Design PV powered DC fan and pump without battery-Design of Standalone System with Battery and AC or DC Load. Life cycle costing, Growth models, Annual payment and present worth factor, payback period, LCC with examples. Introduction to simulation software for solar PV system design	**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 the basics of solar energy conversion systems.	**K1**
CO2	Design a standalone PV system.	**K3**
CO3	Demonstrate the operation of a grid interactive PV system.	**K2**
CO4	Utilize life cycle cost analysis in the planning of Solar PV 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	1										1
CO2	3	3	3									2
CO3	3	3	2									2
CO4	3	3	2	1	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	Solar Photovoltaics: Fundamentals, Technologies And Applications	Chetan Singh Solanki	PHI	3rd Edition
2	Solar Energy-Fundamentals, Design, Modelling and Applications	G.N. Tiwari:	Narosa Publishers	2002
3	Grid Integration of Solar Photovoltaic Systems,	D.P. Kothari, M Jamil.	CRC Press	2018
4	Solar Photovoltaics: Fundamentals, Technologies And Applications	Chetan Singh Solanki	PHI	3rd Edition

SEMESTER: S7

HYBRID AND ELECTRIC VEHICLES

Course Code	**OEEET722**	**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**	OE -Theory

Course Objectives:

1. Familiarise with the hybrid and electric vehicles and its drive train topologies
2. Discuss the propulsion unit for electric vehicles
3. Choose proper energy storage system for electric vehicles.
4. Selection of battery management strategy and study of various communication protocols for EV

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to Hybrid and Electric Vehicles**: History of hybrid and electric vehicles, Social and environmental importance of hybrid and electric vehicles. **Vehicle Dynamics & Load Forces :** mathematical models to describe vehicle performance, vehicle load forces (concept only): aerodynamic drag ,rolling resistance , grading resistance, vehicle acceleration, calculation of motor power from traction torque. **Hybrid Electric Drive-trains**: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies (Block diagram only), power flow control in various hybrid drive-train topologies (Block diagram only). **Electric Drive-trains**: Basic concept of electric traction, introduction to various electric drive-train topologies (Block diagram only), power flow control in electric drive-train topologies (Block diagram only).	**10**
2	**Electric Drives:** Block diagram, Introduction to electric motors used in hybrid and electric vehicles.	**8**

	DC Motor Drives: Introduction, Configuration and control of separately excited DC motors Motoring using a PM DC Machine - DC motor drive using DC-DC converter - Generating/Braking using a PM DC Machine (concept only) **Induction Motor Drives**: Introduction, Speed control of induction motor, V/f control of induction motor (block diagram only)	
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 **Other storage topologies (Basics only)**: Fuel Cell based energy storage systems- Supercapacitors- flywheel- Hybridization of different energy storage devices **Types of charging stations** (Basics only)- AC Level 1 & 2, DC - Level 3 (block diagram only) -Types of Connectors - CHAdeMO, CCS Type1 and 2, GB/T - PIN diagrams and differences	**10**
4	**Battery management system**: Introduction to energy management strategies, Classification of Battery management system (concept only) **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 **Autonomous Vehicles**: Levels of automation, significance & effects of automation in vehicles	**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	Familiarise with the hybrid and electric vehicles and its drive train topologies	**K2**
CO2	Discuss the propulsion unit for electric vehicles	**K3**
CO3	Choose proper energy storage system for electric vehicles	**K3**
CO4	Selection of battery management strategy and study of various communication protocols for EV	**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
CO2	3											3
CO3	3											3
CO4	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 and Hybrid Vehicles: Design Fundamentals, 2003	Iqbal Hussein	CRC Press,	2003
2	Elementary Concepts of Power Electronic Drives:	K Sundareswaran,	CRC Press, Taylor & Francis Group	
3	Electric Drives	Krishnan	PHA	

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Electrical Engineering – Introduction to Hybrid and Electric Vehicles	NPTEL (notes)		

SEMESTER S7

INTRODUCTION TO ENERGY STORAGE SYSTEMS

Course Code	OEEET723	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	OE - 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)

CO	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	TheInstitution of Engineering and Technology (IET) Publication, UK,	Second Edition, 2011
2	Energy Storagein Power Systems	Francisco Díaz-González, Andreas Sumper, Oriol Gomis-Bellmunt	Wiley Publication	2016.
1	Energy Storage for Power Systems	A.G.Ter- Gazarian	TheInstitution of Engineering and Technology (IET) Publication, UK,	Second Edition, 2011
2	Energy Storagein 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 8

ELECTRICAL AND ELECTRONICS ENGINEERING

SEMESTER S8

SMART GRID TECHNOLOGIES

Course Code	**PEEET861**	**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. To introduce various advancements in the area of smart grid.
2. To introduce distributed energy resources and micro-grid.
3. To introduce cloud computing, cyber security and power quality issues in smart grids.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to Smart Grid:** Evolution of electric grid, Definitions, Need for smart grid, Smart grid drivers, Functions of smart grid, Opportunities and barriers of smart grid, Difference between conventional grid and smart grid, Concept of resilient and self- healing grid. Components and architecture, Inter-operability, Impacts of smart grid on system reliability, Present development and international policies in smart grid, Smart grid standards. **Information and Communication Technology in Smart Grid:** Wired and wireless communication -radio mesh, ZIGBEE, 3G, 4G and 5G. Digital PLC, DSL, Wi-Max, LAN, NAN, HAN, Wi-Fi, Bluetooth, Bluetooth Low Energy (BLE), Li-Fi. Communication Protocols in Smart grid, Introduction to IEC 61850 standard and benefits, IEC Generic Object-Oriented Substation Event - GOOSE, Substation model.	9
2	**Smart grid Technologies Part I:** Introduction to smart meters, Electricity tariff, Real Time Pricing- Automatic Meter Reading (AMR) - System, Services and Functions, Components of AMR Systems, Advanced Metering Infrastructure (AMI). Plug in Hybrid Electric Vehicles (PHEV), Vehicle to Grid (V2G), Grid to Vehicle (G2V), Smart Sensors, Smart energy efficient end use devices, Home & Building Automation. Intelligent Electronic	9

	Devices (IED) and their application for monitoring & protection: Digital Fault Recorder (DFR), Digital Protective Relay (DPR), Circuit Breaker Monitor (CBM), Phasor Measurement Unit (PMU), Standards for PMU. Time synchronization techniques, Wide Area Monitoring System (WAMS), control and protection systems (Architecture, components of WAMS, and applications: Voltage stability assessment, frequency stability assessment, power oscillation assessment, communication needs of WAMS, remedial action scheme).	
3	**Smart grid Technologies Part II:** Smart substations, Substation automation, Feeder automation, Fault detection, Isolation, and Service Restoration (FDISR), Geographic Information System (GIS), Outage Management System (OMS). Introduction to Smart distributed energy resources and their grid integration, Smart inverters, Concepts of microgrid, Need and application of microgrid – Energy Management- Role of technology in demand response- Demand side management, Demand side Ancillary Services, Dynamic line rating.	**9**
4	**Cloud computing in smart grid:** Private, Public and hybrid cloud. Types of cloud computing services- Software as a Service (SaaS), Platform as a service (PaaS), Infrastructure as a service (IaaS), Data as a service (DaaS), Cloud architecture for smart grid. **Cyber Security** - Cyber security challenges and solutions in smart grid, Cyber security risk assessment, Security index computation. **Power Quality Management in Smart Grid**- Fundamentals, Power Quality (PQ) & Electromagnetic Compatibility (EMC) in smart grid, Power quality conditioners for smart grid. Case study of smart grid.	**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 the basic concept of distributed energy resources, micro-grid and smart grid	**K2**
CO2	Choose appropriate Information and Communication Technology (ICT) in smart grid	**K2**
CO3	Select infrastructure and technologies for consumer domain of smart grid	**K2**
CO4	Select infrastructure and technologies for smart substation and distribution automation	**K2**
CO5	Formulate cloud computing infrastructure for smart grid considering cyber security	**K3**
CO6	Categorize power quality issues and appraise it in smart grid context	**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	3	3	3	2							
CO3	3	3	3	3	2							
CO4	3	3	3	3								
CO5	3	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	Smart Grid Infrastructure Technology and Solutions	Stuart Borlase	CRC Press	2nd edition
2	Smart Grid: Fundamentals of Design and Analysis	James Momoh	Wiley	2012
3	Microgrids and Active Distribution Networks	S. Chowdhury	Institution of Engineering and Technology	2009
4	Smart Grids Technology and Applications	Janaka Ekanayake, Kythira Liyanage, Jianzhong Wu, Akihiko Yokohama, Nick Jenkins-	Wiley	2012
5	Smart Grids Technology and Applications	Janaka Ekanayake, Kythira Liyanage, Jianzhong Wu, Akihiko Yokohama, Nick Jenkins	Wiley	2012
6	Cybersecurity for the Electric Smart Grid: Elements and Considerations	Barker, Preston, Price, Rudy F	Nova Science Publishers Inc	2012

SEMESTER S8

HVDC AND FACTS

Course Code	PEEET862	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)	PCEET403	Course Type	PE - Theory

Course Objectives:

1. To introduce HVDC concepts and analysis of HVDC systems.
2. To provide a detailed study of FACTS devices.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to HVDC System:** Comparison of AC and DC Transmission - Types of HVDC system - Current Source Converters - Analysis without and with overlap period. Voltage Source Converters (VSC) - VSC with AC current control and VSC with AC voltage control **HVDC Controls** - Functions of HVDC Controls - Equivalent circuit for a two terminal DC Link - Control Basics for a two terminal DC Link - Current Margin Control Method - Current Control at the Rectifier - Inverter Extinction Angle Control - Hierarchy of Controls	9
2	**Introduction to FACTS:** Power flow in Power Systems – Voltage regulation and reactive power flow control in Power Systems - Power flow control -Constraints of maximum transmission line loading - Needs and emergence of FACTS - Types of FACTS controllers-Advantages and disadvantages Transmission line compensation- Uncompensated line -shunt compensation - Series compensation -Phase angle control.	9
3	**Shunt and Series Facts Devices:** Static shunt Compensator - Objectives of shunt compensations - Variable impedance type VAR Generators -TCR, TSR, TSC, FC-TCR (Principle of operation and schematic) and - STATCOM (Principle of operation and schematic). Static Series compensator - Objectives of series compensations-Variable impedance type series compen-	9

	sators - GCSC. TCSC, TSSC (Principle of operation and schematic) Switching converter type Series Compensators-(SSSC) (Principle of operation and schematic)	
4	**UPFC AND IPFC:** Unified Power Flow Controller: Circuit Arrangement, Operation of UPFC- Basic principle of P and Q control- independent real and reactive power flow control- Applications Introduction to interline power flow controller (IPFC) (Principle of operation and schematic) Thyristor controlled Voltage and Phase angle Regulators (Principle of operation and schematic)	**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 current source and voltage source converters for HVDC systems	**K4**
CO2	Describe the control schemes for HVDC systems	**K2**
CO3	Explain the need for FACTS devices	**K2**
CO4	Classify reactive power compensators in power system	**K2**
CO5	Interpret series and shunt connected FACTS devices for power system applications	**K2**
CO6	Explain the dynamic interconnection mechanisms of FACTS devices	**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			2							
CO2	3	3			2							
CO3	3	3			2							
CO4	3	3			2							
CO5	3	3			2							
CO6	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	HVDC and FACTS Controllers	Vijay K Sood	Springer	2004
2	Understanding FACTS	N.G. Hingorani and L.Gyugyi	IEEE Press	2000
3	High Voltage DC Transmission	K.R.Padiyar	Wiley	1993
4	FACTS Controllers in Power Transmission and distribution	K.R.Padiyar	New age international Publishers	2007
5	Flexible AC Transmission systems (FACTS)	Y.H. Song and A.T.Jones	IEEE Press	1999
6	Reactive Power control in Power systems	T.J.E. Miller	John Wiley	1982

SEMESTER S8

MECHATRONIC SYSTEMS

Course Code	PEEET863	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	PE - Theory

Course Objectives:

1. To familiarise mechatronic systems with fundamental knowledge in sensors and actuators achieve conceptual understanding of mechatronic systems
2. To enhance the fundamental knowledge in microprocessors and microcontrollers
3. To learn the fundamentals of system models and controllers
4. To understand control actions such as Proportional, derivative and integral and study its significance in industrial applications

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to Mechatronics: Introduction, Examples of Mechatronic systems, Electric circuits and components, Semiconductor Electronics, Transistor Applications Sensors and transducers: Performance terminology of sensors, Displacement, Position & Proximity Sensors-I, Displacement, Position & Proximity Sensors-II, Force, Fluid pressure, Liquid flow sensors, temperature, light sensor, Acceleration and Vibration measurement, Semiconductor sensor and MEMS, SAW	3 3 3
2	Actuators and mechanisms: Mechanical Actuation System, Hydraulic & Pneumatic Actuation System, Electrical Actuation System-I, Electrical Actuation System-II, Data Presentation system Signal conditioning: Introduction to signal processing & Op-Amp, Op-Amp as signal conditioner, Analogue to Digital Converter, Digital to Analogue Converter, Artificial intelligence	5 5
3	Microprocessors and microcontrollers: Digital circuits-I, Digital circuits-II,	5

	Microprocessor Micro Controller, Programming of Microcontrollers Modeling and system response: Mechanical system model, Electrical system model, Fluid system model, Dynamic response of systems, Transfer function and frequency response.	**5**
4	Closed loop controllers: P, I, PID Controllers, Digital Controllers, Program Logic Controllers, Input/output & Communication systems, Fault findings Mechatronics designs, examples and case studies	**5** **2**

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	Comprehend the importance of sensors and actuators with application to mechatronic systems	**K2**
CO2	Identify actuator mechanisms and signal conditioning processes	**K2**
CO3	Select microprocessors and microcontrollers for the implementation in mechatronic system	**K2**
CO4	Analyse the models and responses of different 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					1						1
CO2	3					1						1
CO3	3					1						1
CO4	3	3	3	2	3	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	Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering	W. Bolton	Pearson Education	4th Edition 2010
2	Introduction to Mechatronics and Measurement Systems	Michael B. Histand, David G. Alciatore	McGraw-Hill Series in Mechanical Engineering	2003
3	Mechatronics system design. CL-Engineering	Shetty, Devdas, and Richard A. Kolk.		2010.
4	Mechatronics: an introduction.,	Bishop, Robert H.	CRC Press	2017.
5	Intelligent Mechatronic Systems: Modeling, Control and Diagnosis	R. Merzouki, A. K. Samantaray, P. M. Pathak, B. Ould Bouamama	Springer, London	2003

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/112/107/112107298/
2	https://archive.nptel.ac.in/courses/112/107/112107298/
3	https://archive.nptel.ac.in/courses/112/107/112107298/
4	https://archive.nptel.ac.in/courses/112/107/112107298/

SEMESTER S8

ELECTRONIC COMMUNICATION

Course Code	PEEET864	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:3:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	GYEST104, PBEET304	Course Type	PE - Theory

Course Objectives:

1. To acquire knowledge about analog and digital communication systems

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Analog Communication:** Introduction to communication systems, Classification of channels, Need for modulation. Amplitude modulation: Equation and frequency spectrum of AM signal, Double-side band suppressed carrier (DSB-SC) modulation, Single sideband modulation (SSB), comparison of spectrum, power and efficiency of all the three variants, Amplitude modulator circuits -balanced modulator, AM demodulators – Envelope detector.	9
2	**Angle Modulation:** Frequency and phase modulation, Narrow and wide band FM and their spectra, Modulation and demodulation techniques for FM, pre-emphasis and de-emphasis, FM transmitter and receiver, Noise in receivers, Noise figures, Performance of analog modulation schemes in AWGN: SNR and figure of merit for different schemes.	9
3	**Digital baseband communication:** Elements of digital communication system. Sources, channels and receivers, Sampling and Reconstruction of Analog Signals: Nyquist Sampling Theorem, Ideal Reconstruction Filter, Pulse Amplitude Modulation (PAM), Time division multiplexing with PAM, Pulse Code Modulation (PCM), A-law and mu-law quantization.	9
4	**Digital bandpass communication**: Digital bandpass communication system, Bandpass modulation techniques:	9

	Amplitude shift keying, Phase shift keying, Frequency shift keying, Methods of generation and detection, Signal constellations, M-ary digital modulation schemes, Quadrature phase shift keying, Minimum shift keying, Quadrature amplitude modulation.	

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

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examina-tion-1 (Written)	Internal Examina-tion- 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 mod-ule. • 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 divi-sions. **(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 working of Amplitude modulator and demodulator circuits using mathematical relations.	**K2**
CO2	Explain the characteristics of various analog modulation schemes in terms of spectra, power and efficiency.	**K3**
CO3	Understand the various processing blocks of a digital communication system.	**K2**
CO4	Apply the knowledge of digital modulation in digital transmission.	**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											
CO2	3	2										
CO3	3											1
CO4	3	2										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	Kennedy's Electronic Communication Systems	Kennedy, Davis and Prasanna	Tata McGraw Hill	6th Edition, 2018
2	Electronic Communication Systems – Fundamentals through Advanced	Wayne Tomasi	Pearson	5th edition, 2008
3	Communication Systems	Simon Haykin and Michael Mohre	Wiley	5th Edition,2021
4	Principles of Communication Systems	Taub& Schilling	McGraw-Hill	4th edition, 2017

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Principles of Communications	Rodger E. Ziemer& William H. Tranter	Wiley	7the edition, 2014
2	Communication System Engineering	J. G. Proakis and M. Salehi	Pearson Education	2nd Edition, 2018.
3	Digital and Analog Communication Systems	Leon W. Couch	Prentice Hall	8th edition, 2012
4	Modern Digital and Analog Communication Systems	B. P. Lathi, Zhi Ding	Oxford University Press	4th edition, 2011

SEMESTER S8

INTRODUCTION TO ROBOTICS

Course Code	OEEET831	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	OE - Theory

Course Objectives:

1. To familiarise mechatronic systems with fundamental knowledge in sensors and actuators achieve conceptual understanding of mechatronic systems
2. To enhance the fundamental knowledge in microprocessors and microcontrollers
3. To learn the fundamentals of system models and controllers
4. To understand control actions such as Proportional, derivative and integral and study its significance in industrial applications

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Definitions-** Robots, Robotics; Types of Robots- Manipulators, Mobile Robots-wheeled & Legged Robots, Aerial Robots; Anatomy of a robotic manipulator-links, joints, actuators, sensors, controller; open kinematic vs closed kinematic chain; degrees of freedom; Robot considerations for an application- number of axes, work volume, capacity & speed, stroke &reach, Repeatability, Precision and Accuracy, Operating environment, point to point control or continuous path control	7
2	**Sensors and Actuators** Sensor classification- touch, force, proximity, vision sensors. Internal sensors-Position sensors, velocity sensors, acceleration sensors, Force sensors; External sensors-contact type, noncontact type Actuators for robots- classification-Electric, Hydraulic, Pneumatic actuators; their advantages and disadvantages; Electric actuators- Stepper motors, DC motors, DC servo motors and their drivers, AC motors, Linear actuators, selection of motors **Robotic configurations and end effectors** Robot configurations-PPP, RPP,	10

	RRP, RRR; features of SCARA, PUMA Robots; Classification of robots based on motion control methods and drive technologies; 3R concurrent wrist; Classification of End effectors - mechanical grippers, special tools, Magnetic grippers, Vacuum grippers, adhesive grippers, Active and passive grippers, selection and design considerations of grippers in robot.	
3	**Kinematics and Motion Planning** Robot Coordinate Systems- Fundamental and composite rotations, homogeneous co-ordinates and transformations, Kinematic parameters, D-H representation, Direct Kinematics. The Arm equation- forward Kinematic analysis of a typical robots upto 3 DOF. Motion Planning- joint space trajectory planning-cubic polynomial, linear trajectory with parabolic blends; Cartesian space planning, Point to point vs continuous path planning.	**9**
4	**Dynamics and Control of Robots** Building of a servo controlled robot – 1R two link chain, construction of link and joint and mounting of encoder, actuator, etc. Dynamics- Dynamic model of a robot using Lagrange's equation, dynamic modelling of 1DOF robot, including motor and gearbox, 2R planar manipulator. Control Techniques- Transfer function and state space representation, Performance and stability of feedback control, PID control of a single link manipulator, selection of PID controller gains; nonlinear nature of manipulators, and need for nonlinear control techniques.	**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	Familiarise with anatomy, specifications and applications of Robots	**K2**
CO2	Choose the appropriate sensors and actuators for robots	**K2**
CO3	Choose appropriate Robotic configuration and gripper for a particular application	**K2**
CO4	Obtain kinematic model of robotic manipulators	**K3**
CO5	Plan trajectories in joint space and Cartesian space	**K3**
CO6	Develop dynamic model and design the controller for robotic manipulators	**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										3
CO2	2	1										3
CO3	2	1										3
CO4	3	2	2									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	Introduction to Robotics	S K Saha	McGraw Hill Education (India) Private Limited	2014
2	Fundamentals of robotics – Analysis and control	Robert. J. Schilling	Prentice Hall of India	1996.
3	Robotics and Control	R K Mittal and I J Nagrath	Tata McGraw Hill, New Delhi	2003
4	Introduction to Robotics: Mechanics and control	John. J. Craig	Pearson Education Asia	4^{th} Edition, 2018
5	Robotics-Fundamental concepts and analysis	Ashitava Ghosal	Oxford University press.	2006
6	Robotics Technology and Flexible Automation	S. R. Deb	McGraw-Hill Education LLC	Second Edition,

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/107/106/107106090/
2	https://archive.nptel.ac.in/courses/107/106/107106090/
3	https://archive.nptel.ac.in/courses/107/106/107106090/
4	https://archive.nptel.ac.in/courses/107/106/107106090/

SEMESTER S8

PLC AND AUTOMATION

Course Code	OEEET832	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:1:0	**ESE Marks**	60
Credits	4	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. Learn the roles, architectures, and interfacing techniques of computer-based measurement and control systems, including HMI and hardware integration.
2. Gain hands-on experience with PLC programming and simulation, and understand the functionalities and interfacing of Distributed Control Systems for process control.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to computer based control system** -Role of computers in measurement and (process) control Basic components of computer based measurement and control systems Architecture – computer based process control system –Centralised, Distributed and Hierarchical. Human Machine Interface (HMI) Hardware for computer based process control system, Interfacing computer system with process. Architecture of DDC, SCADA and DCS. **Programmable logic Controller (PLC**): Introduction, Evolution, Relay VS PLC VS Computer	9
2	PLC- Hardware and Internal Architecture-Input –output devices .Basics of Ladder Programming, on/off instructions, internal relay, jump instructions, data handling instruction, data manipulation instructions, Arithmetic and Comparison ,PID and other important instructions	9
3	Timers and Counters in PLC. Problems. Design Development and Simulation of PLC Programme Program on Temperature control Valve sequencing, Conveyor belt control and Control of a process.	9

	PLC Installation, trouble shooting and maintenance, Design of Alarms and Interlocks, Networks of PLC Distributed Control System- DCS - Evolution– Various Architectures – Comparison – Local control unit	
4	DCS -LCU Languages-Process interfacing issues-communication facilities-Operator interface-Low level and High level Operator interface- Displays - Engineering interfaces – Low level and high level engineering interfaces – Factors to be considered in selecting DCS – Other key issues in DCS – Packaging and Power system issues.	**9**

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

Continuous Internal Evaluation Marks (CIE):

Attendance	***Internal Ex***	***Evaluate***	***Analyse***	***Total***
5	**15**	**10**	**10**	**40**

Criteria for Evaluation (Evaluate and Analyse): 20 marks

Micro projects on automation using PLC and DCS for student group comprising of 3 students.
Report – 5 marks
Working Model – 15 Marks

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 students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the basic architecture and components of computer-based measurement and control systems.	**K2**
CO2	Understand the human-machine interfaces (HMI) and learn the hardware and interfacing techniques needed to integrate computer systems with process controls.	**K2**
CO3	Create and troubleshoot PLC programs using ladder logic for various applications.	**K5**
CO4	Understand and apply the architecture and interfaces of Distributed Control Systems in various process control settings.	**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											
CO2	3											
CO3	3				2							
CO4	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	Instrument Engineer's Handbook – Process Control,	B G Liptak	CRC Press	4th edtion
2	Understanding Distributed Processor Systems for Control,	Samel M. Herb	ISA Publication	1st edition 1999
3	Programmable Logic Controllers – Principles and Applications.	John W.Webb & Ronald A. Reiss,	PHI	5th edition
4	Computer Control of Processes,	M. Chidambaram	Alpha Science International Ltd	1st edition 2002

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Process Software and Digital Networks, CRC Press.	B G Liptak	CRC	3rd edition
2	Programmable Logic Controllers – Programming Methods and Applications, Pearson Education.	John R. Hackworth & Frederick D. Hackworth Jr	Pearson	1st edition 2003

Video Links (NPTEL, SWAYAM…)	
Module No.	Link ID
1	https://onlinecourses.nptel.ac.in/noc21_me67/preview
2	https://onlinecourses.nptel.ac.in/noc21_me67/preview
3	https://onlinecourses.nptel.ac.in/noc21_me67/preview
4	https://onlinecourses.nptel.ac.in/noc21_me67/preview

SEMESTER S8

MECHATRONIC SYSTEMS AND CONTROL

Course Code	OEEET833	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	OE - Theory

Course Objectives:

1. To familiarise mechatronic systems with fundamental knowledge in sensors and actuators achieve conceptual understanding of mechatronic systems
2. To enhance the fundamental knowledge in microprocessors and microcontrollers
3. To learn the fundamentals of system models and controllers
4. To understand control actions such as Proportional, derivative and integral and study its significance in industrial applications

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to Mechatronics: Introduction, Examples of Mechatronic systems, Electric circuits and components, Semiconductor Electronics, Transistor Applications Sensors and transducers: Performance terminology of sensors, Displacement, Position & Proximity Sensors-I, Displacement, Position & Proximity Sensors-II, Force, Fluid pressure, Liquid flow sensors, temperature, light sensor, Acceleration and Vibration measurement, Semiconductor sensor and MEMS, SAW	3 3 3
2	Actuators and mechanisms: Mechanical Actuation System, Hydraulic & Pneumatic Actuation System, Electrical Actuation System-I, Electrical Actuation System-II, Data Presentation system Signal conditioning: Introduction to signal processing & Op-Amp, Op-Amp as signal conditioner, Analogue to Digital Converter, Digital to Analogue Converter, Artificial intelligence	5 5

3	Microprocessors and microcontrollers: Digital circuits-I, Digital circuits-II, Microprocessor Micro Controller, Programming of Microcontrollers Modeling and system response: Mechanical system model, Electrical system model, Fluid system model, Dynamic response of systems, Transfer function and frequency response.	5 5
4	Closed loop controllers: P, I, PID Controllers, Digital Controllers, Program Logic Controllers, Input/output & Communication systems, Fault findings Mechatronics designs and case studies	5 2

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	Comprehend the importance of sensors and actuators with application to mechatronic systems	**K2**
CO2	Identify actuator mechanisms and signal conditioning processes	**K2**
CO3	Select microprocessors and microcontrollers for the implementation in mechatronic system	**K2**
CO4	Analyse the models and responses of different 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					1						1
CO2	3					1						1
CO3	3					1						1
CO4	3	3	3	2	3	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	Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering	W. Bolton	Pearson Education	4^{th} Edition 2010
2	Introduction to Mechatronics and Measurement Systems	Michael B. Histand, David G. Alciatore	McGraw-Hill Series in Mechanical Engineering	2003
3	Mechatronics system design. CL-Engineering,	Shetty, Devdas, and Richard A. Kolk.		2010
4	Mechatronics: an introduction.,	Bishop, Robert H.	CRC Press	2017
5	Intelligent Mechatronic Systems: Modeling, Control and Diagnosis	R. Merzouki, A. K. Samantaray, P. M. Pathak, B. Ould Bouamama	Springer, London	2003

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/112/107/112107298/
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3	https://archive.nptel.ac.in/courses/112/107/112107298/
4	https://archive.nptel.ac.in/courses/112/107/112107298/