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	3
	Sensors and transducers: Performance terminology of sensors, Displacement, Position & Proximity Sensors-I, Displacement, Position & Proximity Sensors-II,	3
	Force, Fluid pressure, Liquid flow sensors, temperature, light sensor, Acceleration and Vibration measurement, Semiconductor sensor and MEMS, SAW	3
2	Actuators and mechanisms: Mechanical Actuation System, Hydraulic & Pneumatic Actuation System, Electrical Actuation System-I, Electrical Actuation System-II, Data Presentation system	5
	Signal conditioning: Introduction to signal processing & Op-Amp, Op-Amp as signal conditioner, Analogue to Digital Converter, Digital to Analogue Converter, Artificial intelligence	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 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 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	4th 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	3
	Sensors and transducers: Performance terminology of sensors, Displacement, Position & Proximity Sensors-I, Displacement, Position & Proximity Sensors-II,	3
	Force, Fluid pressure, Liquid flow sensors, temperature, light sensor, Acceleration and Vibration measurement, Semiconductor sensor and MEMS, SAW	3
2	Actuators and mechanisms: Mechanical Actuation System, Hydraulic & Pneumatic Actuation System, Electrical Actuation System-I, Electrical Actuation System-II, Data Presentation system	5
	Signal conditioning: Introduction to signal processing & Op-Amp, Op-Amp as signal conditioner, Analogue to Digital Converter, Digital to Analogue Converter, Artificial intelligence	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	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/