SEMESTER S6

ELECTRICAL AND COMPUTER ENGINEERING

SEMESTER S6

LINEAR CONTROL SYSTEMS

Course Code	PCEOT601	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)	Core Math Courses	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, 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) Characteristic equation. Routh stability criterion. (3 hours) *Root locus technique:* Construction of Root locus - stability analysis-	**13**

	effect of addition of poles and zeros; Effect of positive feedback systems on Root locus. (5 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). (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	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 and frequency response.	**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	2	1	2	1	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

COMPUTER COMMUNICATION & NETWORK SECURITY

Course Code	PCEOT602	CIE Marks	60
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	40
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	Program Core Theory

Course Objectives:

1.The syllabus is prepared with a view to equip the Engineering Graduates to learn basic concepts in data communication and network security.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Data Transmission and Encoding Techniques** Digital-To-Digital Conversion: Line Coding Schemes: Unipolar, Polar, Bipolar - Block Coding, Scrambling, Analog-To-Digital Conversion: Pulse Code Modulation, Delta Modulation - Digital-To-Analog Conversion: ASK, FSK, PSK. Transmission Modes: Parallel and Serial Transmission, Asynchronous, Synchronous, Isochronous Transmission, Multiplexing - TDM, FDM, WDM	9
2	**Overview of Computer Communication** Introduction: - Types of Computer Networks, Network Software - Protocol Hierarchies, Connection oriented and Connection less hierarchies, Reference Models - ISO-OSI Reference Model, TCP/IP Reference Model – Comparison of OSI and TCP/IP reference models. **Physical Layer:** - Guided Transmission Media– Twisted Pair, Coaxial and Fiber Optics **Data Link Layer:** – design issues - Error Detection: Parity Check, Checksum, CRC, Error Correction: Hamming code - Flow Control: Stop-and-Wait, Go-Back-N, and Selective- Repeat. Multiple Access Protocols: ALOHA, CSMA, CSMA/CD, Collision free protocols	10

3	**Network Layer and Transport Layer** Network Layer Design Issues, Routing Algorithm – Optimality principle - Flooding - Distance vector routing – Link state routing –Congestion Control Algorithms – General principles – Congestion prevention policies – Choke packets – Random Early Detection. Transport layer – transport services, elements of transport protocols, introduction to UDP, introduction to TCP – TCP service model, TCP segment header, TCP connection establishment and release	**9**
4	**Network Security** Introduction to network security, principles of cryptography – symmetric key cryptography, public key cryptography, message integrity and digital signatures, securing e-mail, securing TCP connections, IPSec, VPN, Firewalls and Intrusion detection systems	**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	Identify the concepts of data transmission and apply signal encoding techniques and multiplexing in data transmission (**Cognitive Knowledge**:**Apply**)	**K3**
CO2	Discuss the basic concepts used in data communication and computer (**Cognitive Knowledge: Understand**)	**K2**
CO3	networking Describe the design issues and protocols in data link layer (**Cognitive Knowledge**: **Understand**)	**K2**
CO4	Familiarize with routing algorithms and transport layer protocols **(Cognitive Knowledge: Understand)**	**K2**
CO5	Understand the basics of network **(Cognitive Knowledge: Understand)**	**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	1	2							2
CO2	3	2	1									2
CO3	2	3	1	2	2							2
CO4	2	3	3	2	1							2
CO5	2	2	2	1	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	Computer Networks	Andrew S. Tanenbaum and David J. Wetheral	Pearson	5/e,2019
2	Computer Networking: A Top Down Approach	James F. Kurose and Keith W. Ross	Pearson	6/e,2013

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Behrouz A. Forouzan	Data Communications and Networking	Tata McGraw Hill	5/e,2017
2	William Stallings	Computer Networking with Internet Protocols	Prentice-Hall	2004
3	Fred Halsall	Computer Networking and the Internet		5/e
4	F. Kurose and K. W. Ross	Computer Networking: A Top-Down Approach Featuring Internet	Pearson Education	6/e,2012

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://youtu.be/ifgs0uypC78?si=OQSgLGJFfDYJsfcd
2	https://youtu.be/sG6WGvzmVaw?si=KyjOYVY9I7VADL1n
3	https://youtu.be/O--rkQNKqls?si=Ag8Sf3kBDkstci-9
4	https://youtu.be/iTVyKbDCJrA?si=97T6ZfFdlUyC6ttt

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

SEMESTER S6

R-PROGRAMMING

Course Code	PEEOT631	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2Hrs. 30 Min.
Prerequisites (if any)	GBEST204, PEEET413	Course Type	PE - Theory

Course Objectives:

1. Illustrate uses of conditional and iterative statements in R programs.
2. Write, test and debug R programs
3. Illustrate the use of Probability distributions and basic statistical functions.
4. Visualize different types of data
5. Comprehend regression modelling using R

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to R and Data Structures** The R Environment: Command Line Interface and Batch processing, R Packages, Basic Concepts: Variables, Data Types. Data Structures: Vectors (vector operations and factor vectors), Lists and their operations, Data Frames, Matrices and arrays, Control Statements: Branching and looping (for loops, while loops, controlling loops), Functions: Function as arguments, Named arguments	9
2	**Data Handling and Transformation** Reading and Writing Data: Importing data from Text files and other software, exporting data, importing data from databases (Database Connection packages), Handling Missing Data: NA, NULL Data Manipulation: Combining data sets, Transformations, Binning Data, Subsets, summarizing functions, Data Cleaning (Finding and removing duplicates, Sorting)	9

3	**Statistical Analysis with R** **Analysing Data:** Summary statistics, **Statistical Tests:** Continuous Data, Discrete Data, Power Probability Distributions: Common distributions (type arguments), Probability distributions, Normal distributions	**9**
4	**Data Visualization and Regression Models** Data Visualization: R Graphics (Overview, Customizing Charts, Graphical parameters, Basic Graphics functions), Lattice Graphics (Lattice functions, Customizing Lattice Graphics), Ggplot Introduction to Regression Models: Building linear models (model fitting, predict values using models, analysing the fit), Refining the model, Generalized linear models (Logistic Regression, Poisson Regression)	**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	Illustrate uses of conditional and iterative statements in R programs.	**K3**
CO2	Write, test and debug R programs	**K3**
CO3	Illustrate the use of Probability distributions and basic statistical functions.	**K3**
CO4	Visualize different types of data	**K3**
CO5	Comprehend regression modelling using R	**K2**

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	2	-	3	-	-	-	-	-	-	2
CO2	3	3	3	-	3	-	-	-	-	-	-	3
CO3	3	2	1	1	1	-	-	-	-	-	-	1
CO4	3	2	2	2	2	-	-	-	-	-	-	2
CO5	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	R in a Nutshell	Joseph Adler	O'reilly	Second edition,2012

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	R for Everyone- Advanced analytics and graphics	Jared P Lander	Addison Wesley data analytics series, Pearson	
2	The art of R programming, A Tour of Statistical, Software Design	Norman matloff	O'reilly	
3	R in action, Data analysis and graphics with R	Robert Kabacoff	Manning	
4	Hands-on programming with R, Write your own functions and simulations,	Garret Grolemund	O'reilly	

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.swayam2.ac.in/aic20_sp35/preview
2	https://onlinecourses.swayam2.ac.in/aic20_sp35/preview
3	https://archive.nptel.ac.in/courses/111/104/111104100/
4	https://archive.nptel.ac.in/courses/111/104/111104100/

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 acand 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,	9

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

Course Assessment Method

(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

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

End Semester Examination Marks (ESE)

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

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

Course Outcomes (COs)

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

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

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

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

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

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

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

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

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

SEMESTER S6

DIGITAL SIGNAL PROCESSING

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

Course Objectives:

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

SYLLABUS

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

	Structures, Lattice Structure. Linear Phase FIR filters. Signal Flow Graphs and Transposed Structures.	
3	**Design of Digital Filters:** General considerations, Causality and its implications, characteristics of practical frequency selective filters. 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.	**10**
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. Basics of Network Virtualization, Storage Virtualization and Desktop Virtualization.	8

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, S. Thamarai Selvi	McGraw Hill Education	2017
3	Cloud Computing	Sandeep Bhowmik	Cambridge University Press	2017

Reference Books			
Title of the Book	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
Cloud Computing: Theory and Practice	Dan C. Marinescu	Morgan Kaufmann publications	2018
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 S6

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	11
	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	
	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	
2	Formulation of linear programming models, Graphical solution in two variables, Standard form	9
	Simplex method, Duality, Dual simplex method - Karmarkar's method	
3	Equality constrained problems - Lagrange multipliers - Kuhn Tucker conditions - Kuhn Tucker theorems - Saddlepoint conditions - Second order optimality conditions - Generalized Lagrangian multiplier method	10

	Transformation methods - Concept of penalty - penalty functions - Method of Multipliers	
4	Constrained direct search - simple direct search method - Complex method - Random search methods	**9**
	Linearization methods for constrained Problems - Successive linear problems - Separable programming - Method of feasible directions - Simplex extensions for linearly constrained problems - Generalized reduced gradient method	

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

MACHINE LEARNING

Course Code	PBEOT604	CIE Marks	60
Teaching Hours/Week (L: T:P: R)	3:0:0:1	ESE Marks	40
Credits	4	Exam Hours	2 Hrs. 30Min.
Prerequisites (if any)	GYEST305, UCEST105	Course Type	PBL

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	9

	– 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: 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	**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, preprocess, and visualize data sets, preparing data for machine learning applications.	**K3**
CO4	**Implement** machine learning algorithms (such as linear regression, logistic regression, k-Nearest Neighbors, 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:

	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

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 VanderPlas	O'Reilly Media	1st Edition, 2016
4	Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow	AurélienGéron	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

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc23_cs18/preview
2	https://onlinecourses.nptel.ac.in/noc23_cs18/preview
3	https://nptel.ac.in/courses/106105152
4	https://nptel.ac.in/courses/106105152

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 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)	–	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**

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

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**	OE

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.	**9**

	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.	
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	OE - 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	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

ELECTRICAL SIMULATION LAB

Course Code	PCEOL607	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)	Power systems/Linear Control systems (PCEOT503,PCEOT601)	Course Type	Lab

Course Objectives:

1. To provide students with hands-on experience in simulating and analyzing various aspects of power systems through digital simulation
2. To bridge the gap between theoretical knowledge and practical application of control system analysis and design techniques using digital simulation

Expt. No.	Experiments
	POWER SYSTEMS
1	Plot the IV and PV characteristics of a solar photovoltaic module and determine Maximum Power Point under uniform and partial shaded conditions
2	Load Flow Analysis –Gauss-Siedel Method /Newton-Raphson Method/Fast Decoupled Method
3	Reactive Power Compensation and power factor correction using capacitor bank
4	Short Circuit Analysis – Symmetrical Faults and Unsymmetrical Faults
5	Transmission Line Modelling (Basic Programming): ABCD constants
6	Modelling of Over current relay for Power system protection
	CONTROL SYSTEMS
7	Determination of transfer function from block diagram of closed loop system and plot pole zero graph .
8	Observe the performance of Step response of a second order system. Objective: Design a second order system (eg: RLC network) to analyse thefollowing:

	A. The effect of damping factor (ξ: 0, <1,=1,>1) on the unit stepresponse using simulation study B. Verification of the delay time, rise time, peak overshoot and settlingtime with the theoretical values.
9	Stability Analysis by Frequency Response Methods. Objective: Plot Bode plot or Nyquist plot of the given transferfunctions to analyse the following using simulation: A. Determination of Gain Margin and Phase Margin B. Verification of GM and PM with the theoretical values C. The effect of controller gain K on the stability, D. The effect of the addition of poles and zeros on the given system
10	Performance Analysis using Root-Locus Method. Objective: Plot the root locus of the given transfer function to analyse thefollowing using simulation: A. Verification of the critical gain, wo with the theoretical values B. The effect of controller gain K on the stability C. The sensitivity analysis by giving small perturbations in given polesand zeros D. The effect of the addition of poles and zeros on the given system.
11	Design of lead/lag/lead lag compensator
12	Design of PI /PID controller and its effects on the feedback loop response

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	Estimate various parameter of a power system network using different load flow techniques and fault analysis.	**K3**
CO2	Examine the performance of transmission lines and relays	**K4**
CO3	Examine the Time Domain and frequency domain response analysis of second order control systemsfor assessing the system stability and control action.	**K4**
CO4	Design compensator for unstable control systems in order to enhance the system response and stability.	**K3**
CO5	Design P, PI and PID controllers for continuous process control	**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	2	3	3	1	1	1	3			
CO2	3	2	1	3		1	1	1	3			
CO3	3	2	1	3			1	1	3			
CO4	3	3	3	2		2	2		3	2		2
CO5	3	3	3	2		2	2		3	2		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	Power System Analysis	HadiSaadat	McGraw Hill	2/e,2002.
2	Modern Power System Analysis	Kothari D. P. and I. J. Nagrath	TMH	2/e ,2009
3	Modern Control Systems,,	Richard C. Dorf and Robert H. Bishop	Pearson Education	Eleventh Edition,2009.
4	Control System Engineering,.	Nagarath I. J. and Gopal M.,	Wiley Eastern	, 2008

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 records