MAJOR DEGREE COURSES

EEF-471: Special Electrical Machines

L	T	P	Credit	Assessment:	Type of course	Total No. of Teaching Hours
3	0	0	3	Mid Sem.40%+ End Sem.60% =100%	HDC	42

Pedagogy: Classrooms lecture, Tutorial, Case studies, Group discussion, Seminar & field work etc.

Pre requisites: DC Machines, Synchronous Machines and Induction Machines.

COURSE OBJECTIVES & COURSE DESCRIPTION: This subject course objective is to introduce students about the core concepts, explanation of different phenomenon and governing equations related to Special Machines. This course along with Electrical machines develops a comprehensive understanding of special machines.

COURSE OUTCOMES: After successfully completing the course, students should be able to

CO1	Describe construction, working principle and characteristics of Switched Reluctance Motor (SRM).
CO2	Understand the open loop and closed loop systems for Servo Motors and Stepper Motors.
CO3	Analyze the torque speed characteristics and transfer function of Permanents Magnet Synchronous Motors (PMSM).
CO4	Describe construction, working principle and characteristics of Permanents Magnet Brush less DC (BLDC) Motor.
CO5	Understand the dynamic characteristics, drive system, open loop systems for Linear motors.

UNIT-I: SWITCHED RELUCTANCE MOTORS (SRM): Introduction, Constructional features, Principle of operation. Torque equation,Characteristics, Control Techniques and Drive – Concept, Mathematical model and analysis.

UNIT-II: SERVOMOTORS & STEPPER MOTORS: Introduction, Constructional features, Principle of operation, Modes of excitation, Torque production in Variable Reluctance (VR) motor, dynamic characteristics, Drive system and circuit for open loop control, closed loop control, Stability and areas of applications.

UNIT III: PERMANENT MAGNET SYNCHRONOUS MOTORS (PMSM): Introduction, Permanent magnet materials and motors, Principle of operation, EMF and torque equation, Torque speed characteristics,Power Controllers, Comparisons of conventional and PM synchronous motor, Transfer function of PMSM and control Schemes of PMSM.

UNIT-IV: PERMANENT MAGNET BRUSHLESS DC (BLDC) MOTORS: Introduction, Constructional features, Principle of operation, Commutation in DC motors, Difference between mechanical and electronic commutators, Hall sensors, Optical sensors, Types of BLDC motors, EMF and torque equation, Torque-speed characteristics, Drives - concept and Control of BLDC motors.

UNIT-V: LINEAR MOTOR:Linear Induction Motor (LIM), Construction features, Principle of operation, Thrust equation, Concept of Current sheet, Goodness factor, Equivalent circuit, Performance characteristics, Control strategies. Linear Synchronous Motors (LSM) Construction features, Principle of operation, Thrust equation, Control strategies, Applications. Linear Levitation Machines (LLM), Principle of operation, Attraction and repulsion types of LLM, Goodness factor and Levitation stiffness. Introduction to IoT based machine control system.

TEXTBOOKS:

[T1] K. Venkataratnam, "Special Electrical Machines", Universities Press (India) Private Limited, Hyderabad, First Edition reprinted in 2013.
[T2] E.G. Janardanan, "Special Electrical Machines", PHI Learning Private Limited, Delhi First Edition reprinted in 2014.

REFERENCE BOOKS:

[R1] R. S. Krishnan, "Switched Reluctance Motor Drives: Modeling Simulation Analysis, Design and Application" CRC press2001.
[R2] Miller, T.J.E. "Brushless Permanent Magnet and Reluctance Motor Drives", Clarendon Press, Oxford, 1989.
[R3] R.S.Krishnan, "Permanent Magnet Synchronous Motor and Brushless DC Motor Drives",RC press,2002.
[R4] NaserA and Boldea I, "Linear Electric Motors: Theory, Design and Practical Application",Prentice Hall Inc., New Jersey, 1987.
[R5] Kenjo T, " Stepping Motor and their Microprocessor control", Clarendon press Oxford,1989

WEB RESOURCE :

[W1] http://nptel.ac.in/courses/electricalmachines

Computer Usage / Software required: Simulink / Matlab

EEF-571: Electric Vehicle & Energy Management System (EMS)

L	T	P	Credit	Assessment:	Type of course	Total No. of Teaching Hours
3	0	0	3	Mid Sem.40%+ End Sem.60% =100%	HDC	42

Pedagogy: Classrooms lecture, Tutorial, Case studies.

Pre requisites:

COURSE OBJECTIVES&COURSE DESCRIPTION: The course objectives for a course on "Electric Vehicle and Energy Management System" aims to provide students with a strong foundation in the principles, technologies, and practical applications of electric vehicle (EV) and related Energy Management System. This includes the basic to advance knowledge of EV and EMS requirements and design.

COURSE OUTCOMES: After successfully completing the course, students should be able to

CO1	Explain basics of electric vehicle and its architecture.
CO2	Analyze the fundamentals of power electronics and control technology for EVs
CO3	Apply the knowledge todesign the EV charging infrastructure
CO4	Understand the Energy Management system for EV along with basics of optimization techniques
CO5	Discuss advance topics like BMS, Reliability of EV converters.

UNIT-I: History and evolution of Electric vehicles. Overview of Electric Vehicles and their types. Environmental and economic considerations. Electric Vehicle Architecture and components. Government policies and Industry specifications. Market trends.

UNIT-II: Power Electronics and control systems for charging of EVs (Battery, Battery with Supercapacitors etc). Charging cables and connectors, Safety standards and protocols. Charging station design and installation -A case study. Battery Management System, Power Electronics for EC drive.

UNIT III: Electric Vehicle charging infrastructure: Types of EV chargers (Level 1, Level 2, DC Fast Chargers), Charging standards (ChadeMo, CCS, Tesla supercharges) , Charging infrastructure deployment and challenges, Smart Charging and Vehicle to Grid, Grid to vehicle charging concepts. Wireless charging

UNIT-IV: Introduction to Energy Management System (EMS), Energy Optimization Techniques, Vehicle to Grid, Grid to Vehicle, Vehicle to home concept. EMS with in EV.

UNIT-V: Battery state of charge and state of health monitoring, thermal management in EVs, Reliability analysis of EV converters (with Advance techniques – Image Processing, AI etc). Autonomous EV, Future trend of EV. Industry solutions for reliability of EVs/Battery, Smart parking with EMS.

TEXTBOOKS:

[T1] Advanced Electric Drive Vehicles Editor: Ali Emadi CRC Press
[T2] Smart Charging Solutions for Hybrid and Electric Vehicles, Sulabh Sachan, P. Sanjeevi Kumar, Sanchari Deb, Wiley Press.

REFERNCEBOOKS:

[R1] Electric Vehicle Integration into Modern Power Network: R Garcia, Springer

WEB RESOURCE :

[W1] www.nptel.ac.in

EEL-571: Electric Vehicle & Energy Management System (EMS) Lab

COURSE OUTCOMES: After successfully completing the course, students should be able to

S. NO	DESCRIPTION
CO1:	Explain basics of operation various converters used in Electric Vehicle (EV) .
CO2:	Analyze the operation of different motors used in EV drive.
CO3:	Apply the knowledge todesign EMS for EV.

LIST OF EXPERIMENTS:

1. To Study the design and operation of DC-DC converter for EV.
2. To Study the design and operation of DC-AC converter for EV.
3. To Study the design and operation of charging converters for EV.
4. To Study the operation of PMSM motor for EV.
5. To Study the operation of three phase induction motor for EV.
6. To Study the operation of DC charging of EV.
7. To Study the operation of AC charging of EV.
8. To Study the Energy management system with in EV.
9. To Study the Vehicle to Grid operation of EV.
10. To Study the Grid to vehicle operation of EV.

EEF-671: Robotics and Automation

L	T	P	Credit	Assessment:	Type of course	Total No. of Teaching Hours
3	0	0	3	Mid Sem.40%+ End Sem.60% =100%	HDC	42

Pedagogy: Classrooms lecture, Tutorial, Case studies, Group discussion, Seminar & field work etc.

Pre requisites: Should know basic control system

COURSE OBJECTIVES & COURSE DESCRIPTION: The course offers a comprehensive exploration of robotic mechanisms, kinematics, dynamics, and control. Students will gain a deep understanding of fundamental components, kinematic arrangements, and the classification of robots. The curriculum covers trajectory generation, linear feedback control, and two-stage control, enabling students to design controllers for precise and stable robotic movements. Additionally, the course delves into dynamic equations, inertia tensors, and Newton-Euler formulation for modeling and analyzing robotic system dynamics. Force control techniques, including impedance control and hybrid control, are addressed, providing students with the skills to manipulate and interact with the environment effectively. Overall, the course emphasizes practical applications, ensuring graduates are well-equipped to tackle real-world challenges in the dynamic field of robotics.

COURSE OUTCOMES: After successfully completing the course, students should possess proficiency in

CO1	Robotics encompassing classification, selection criteria, and understanding of industrial robot components and performance characteristics crucial for various applications.
CO2	Sensor selection and understanding of drive types, advantages, and suitability for robotic applications, facilitating optimal sensor and drive integration in robotic systems.
CO3	Manipulator kinematics, including DH transformation, direct and inverse kinematics for industrial robots, and differential kinematics for planar serial robots.
CO4	Controllers, grippers, and mobile robotics, including kinematics and dynamics of various types of robots, facilitating comprehensive expertise in robotics systems.
CO5	Robot applications, programming methods, and languages, along with an understanding of AI's relevance to robotics, ensuring comprehensive expertise in robotic systems.

UNIT-I: Robotics-Introduction-classification with respect to geometrical configuration (Anatomy), Industrial robots specifications. Selection based on the Application. Controlled system & chain type: Serial manipulator & Parallel Manipulator. Components of Industrial robotics-precession of movement-resolution, accuracy & repeatability-Dynamic characteristics- speed of motion, payload capacity & speed of response, safety measures.

UNIT-II:Kinematics-Manipulators Kinematics, Rotation Matrix, Homogenous Transformation Matrix, D-H transformation matrix, D-H method of assignment of frames. Direct and Inverse Kinematics for industrial robots. Differential Kinematics for planar serial robots

UNIT III Sensors – Characteristics of sensing devices, Criterion for selections of sensors, Classification, & applications of sensors. Internal sensors: Position sensors, & Velocity sensors, External sensors: Proximity sensors, Tactile Sensors, Grippers and its application, Force or Torque sensors.
Drives – Basic types of drives. Advantages and Disadvantages of each type. Selection / suitability of drives for Robotic application.

UNIT-IV: Controllers: - Types of Controllers and introduction to Close loop controller, Grippers – Mechanical Gripper-Grasping force--mechanisms for actuation, Magnetic gripper vacuum cup gripper-considerations in gripper selection & design.
Introduction to Mobile Robotics - Tasks of mobile robots, robots manufacturers, type of obstacles and challenges, tele-robotics, philosophy of robotics, service robotics, types of environment representation. Ground Robots: Wheeled and Legged Robots, Aerial Robots, Underwater Robots and Surface Robots. Kinematics and Dynamics of Wheeled Mobile Robots (two, three, four - wheeled robots, omni-directional and macanum wheeled robots).

UNIT-V: Robot Applications: Material transfer and machine loading/unloading, processing operations assembly and inspection. Concepts of safety in robotics, social factors in use of robots, economics of robots.

Programming and Languages: - Methods of robot programming, Introduction to various languages such as RAIL and VAL II, Features of each type and development of languages for recent robot systems.

Introduction to AI, relevance of AI with robotics.

TEXTBOOKS:

1. John J. Craig, Introduction to Robotics, Pearson Education Inc., Asia, 3rd Edition, 2005
2. S. K. Saha, Introduction to Robotics 2e, TATA McGraw Hills Education (2014)
3. Asitava Ghoshal, Robotics: Fundamental concepts and analysis, Oxford University Press (2006)
4. Dilip Kumar Pratihar, Fundamentals of Robotics, Narosa Publishing House, (2019)
5. R. K. Mittal, I. J. Nagrath, Robotics and Control, TATA McGraw Hill Publishing Co Ltd, New Delhi (2003)
6. S. B. Niku, Introduction to Robotics – Analysis, Contro, Applications, 3rd edition, John Wiley & Sons Ltd., (2020)
7. Mikell Groover, Mitchell Weiss, Roger N. Nagel, Nicholas Odrey, Ashish Dutta, Industrial Robotics 2nd edition, SIE, McGraw Hill Education (India) Pvt Ltd (2012)
8. R. D. Klafter, Thomas A. Chmielewski, and Mechael Negin, Robotic Engineering – An Integrated Approach, EEE, Prentice Hall India, Pearson Education Inc. (2009)
9. Norman S. Nise, "Control System Engineering", 7th Edition, Wiley
10. Richard C Drof, Robert H. Bishop, "Modern Control Systems, Pearson, 13th Edition
11. Siegwart, IR Nourbakhsh, D Scaramuzza, Introduction to Autonomous Mobile Robots, The MIT Press, USA, 2011,
12. SG Tzafestas, Introduction to Mobile Robot Control, Elsevier, USA, 2014,
13. A Kelly, Mobile Robotics, Mathematics, Models, and Methods, Cambridge University

ALTERNATIVE NPTEL/SWAYAM COURSE:

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Advanced Robotics	By Prof. Ashish Dutta	IIT Kanpur
2	Robotics: Basics and Selected Advanced Concepts	By Prof. Ashitava Ghosal	IISc Bangalore

Computer Usage / Software required: ROS, Matlab/Simulink

EEL-671: Robotics & Automation Lab

Course Outcomes: After successfully completing the course, **t**he student will be able to:

S. NO	DESCRIPTION
CO1:	Interface different actuators with autonomous mobile robots
CO2:	Learn working of touch sensors and their interfacing and feedback
CO3:	formulate obstacle avoidance algorithms
CO4:	detect the object and path tracing using vision sensor

LIST OF EXPERIMENTS:

1. Trajectory tracking and analysis of autonomous mobile robots
2. obstacle avoidance for autonomous mobile robots
3. Line follower autonomous mobile robots
4. Line following autonomous mobile robots
5. Interface of BLDC and stepper motor for autonomous robots
6. Pick and place operation for two link manipulator
7. Touch sensor interfacing and feedback system
8. Object detection and Image processing using vision sensors in robots
9. Virtual robotics lab experiments on MATLAB
10. Virtual robotics lab experiments on MATLAB/Simulink
11. Virtual robotics lab experiments on MATLAB Robotics Systems Toolbox

EEF-771: IoT & Transducers Technology

L	T	P	Credit	Assessment:	Type of course	Total No. of Teaching Hours
3	0	0	3	Mid Sem.40%+ End Sem.60% =100%	HDC	42

Pedagogy: Classrooms lecture, Tutorial, etc.

Pre requisites:

COURSE OBJECTIVES & COURSE DESCRIPTION: The aim of this course is to provide a thorough understanding of Sensor based Instrumentation systems, Detection electronics and fundamental of IoT.

COURSE OUTCOMES: After successfully completing the course, students should be able to

CO1	Understand static and dynamic characteristics of measuring instruments and to develop mathematical model of Instrumentation Systems
CO2	Understand functioning of optical and other type of special transducers.
CO3	Design and implement signal conditioning circuit for different transducers
CO4	Select appropriate sensor and design instrumentations system for industrial applications.
CO5	Design and implement IoT systems.

UNIT-I: General concepts and terminology of measurement systems: Transfer Function, Span (Full-Scale Input), Full-Scale Output, Accuracy, Calibration, Calibration Error, Hysteresis, Nonlinearity, Saturation, Repeatability, Dead Band, Resolution, Excitation. Standards and calibration of measurement Systems, First order instruments: time and frequency response characteristics Second order instruments: time and frequency response characteristics

UNIT-II:Voltage and current transducers, Hall effect transducers, optical transducers, Semiconductor, Piezoelectric, Ultrasonic transducers and their applications. Tactile, Magnetostrictive, Magneto resistive, Electromagnetic and Thermoelectric transducers and their applications.

UNIT III: Design of detection electronics and signal conditioning circuits for various resistive, capacitive, inductive transducers. Active filters, Impedance matching, loading effect. Introduction to electromagnetic interference (EMI), and Radiofrequency interference (RFI), shielding and filtering etc. Concepts of interface with digital devices like PC, μc, μp.

UNIT-IV: Thermal Transducers, LVDT, Strain gauge and their applications. Application of the different traducers for industrial parameters measurement; flow, pressure, rotational speed, liquid level, chemical sensing etc., commercial sensors to measure industrial process parameters, Transducers activated RFID tags.

UNIT-V: IoT Fundamentals, Different IoT Architectures, Design of IoT, Overview of IoT protocols, IoT levels and deployment templates, Challenges for IoT, Interdependencies of IoT and cloud computing, Web of things. Sensors and actuators for IoT applications, IoT components and implementation, Programming of Node MCU and Raspberry PI, Implementation of IoT with Edge devices, Reading sensor data and transmit to cloud, Controlling devices through cloud using mobile application and web application. Broad categories of IoT applications: Consumer IoT, Commercial IoT, Industrial IoT, Infrastructure IoT, Military Things (IoMT)

TEXTBOOKS/REFERENCE BOOK(S) :

1. Curtis D Johnson, Process Control Instrumentation Technology, Eighth Edition, PHI- 2006.
2. Doeblin E.O. Measurement Systems-Application and Design, Fourth Edition, McGraw Hill International Edition, New York-1992.
3. Rahul Dubey, “An Introduction to Internet of Things: Connecting Devices, Edge Gateway, and Cloud with Applications”, Cengage India Publication.
4. Adeel Javed, “Building Arduino projects for Internet of Things”, A press publication
5. Donald Noris, “The Internet of Things: Do it yourself Projects with Arduino, Raspberry PI and Beagle Bone Black” Mc Graw Hill Publication

EEL-771: IoT & Transducers Technology Lab

Course Outcomes: After successfully completing the course, **t**he student will be able to:

LIST OF EXPERIMENTS:

1. To study the measurement of linear displacement using Linear Variable Differential Transformer (LVDT).
2. To study the measurement and control of temperature using Resistance Temperature Detector (RTD).
3. To study the measurement and control of temperature using Thermocouple.
4. To study the measurement and control of temperature using Thermistor.
5. To study the measurement of flow using Ultrasonic Flow meter.
6. To study the measurement of force using Piezoelectric transducer.
7. Getting started with Node MCU, Arduino with ESP8266 and ESP32 in the Arduino IDE.
8. IoT based home automation.
9. IoT based mini project.
10. Controlling devices remotely using Bluetooth link, WiFi link.
11. Smart energy experiments.

EEF-472: Introduction to Computer Networks & Cyber Security

L	T	P	Credit	Assessment:	Type of course	Total No. of Teaching Hours
3	0	0	3	Mid Sem.40%+ End Sem.60% =100%	HDC	42

Pedagogy: Classrooms lecture, Tutorial, Case studies, Group discussion

Pre requisites: Programming (C/C++, MATLAB, Python, etc.)

COURSE OBJECTIVES&COURSE DESCRIPTION: The objective of this course is to provide introduction to fundamental concepts in the design and implementation of computer networks, their protocols, and applications as well as an insight to information coding techniques, error correction mechanism for cyber security.

COURSE OUTCOMES: After successfully completing the course, students should be able to

CO1	Understand the concept of networking foundation.
CO2	Understand the different methods of internetworking.
CO3	Understand the concept of error MAC protocol and Ethernet switches.
CO4	Introduce the principles and applications of information theory.
CO5	Understand the concept of Cyber security and issues and challenges associated with it.

UNIT-I: Networking Foundations: Network elements and architectures, packet and circuit switching, performance measures (delay, throughput), OSI and TCP/IP protocol suites, layering.

UNIT-II: Internetworking: Internet protocol (IP), IP addressing, sub-netting, forwarding, routing algorithms (Dijkstra, Bellman-Ford), distance-vector routing, link-state routing.

UNIT III: Link Layer, LANs, and MAC Protocols: Framing, error detection and correction, multiple access protocols, Aloha, CSMA, Ethernet (IEEE 802.3), Ethernet switches, address resolution protocol (ARP).

UNIT-IV: Shannon's foundation of Information theory, Probability distribution factors, Uncertainty/entropy information measures, Leakage, Quantifying Leakage and Partitions, Lower bounds on key size: secrecy, authentication and secret sharing. Information-theoretic security and cryptograph, basic introduction to Diffie-Hellman, AES, and side-channel attacks.

UNIT-V: Defining Cyberspace and Overview of Computer and Web-technology, Architecture of cyberspace, Communication and web technology, Internet, World wide web, Advent of internet, Internet infrastructure for data transfer and governance, Internet society, Regulation of cyberspace, Concept of cyber security, Issues and challenges of cyber security. Brief introduction to IT Act, 2000. Role of ICERT, Infrastructure Security, CCMP.

TEXTBOOKS:

[T1] J. Kurose and K. Ross, Computer Networking: A Top-Down Approach (7th edition), Pearson, 2017
[T2] Fundamentals of Network Security by E. Maiwald, McGraw Hill

REFERENCE BOOKS:

[R1] Network Security Bible, Eric Cole, Ronald Krutz, James W. Conley, 2nd Edition, Wiley India Pvt. Ltd.
[R2] Cyber Security Understanding Cyber Crimes, Computer Forensics and Legal Perspectives by Sumit Belapure and Nina Godbole, Wiley India Pvt. Ltd. (First Edition, 2011).

ALTERNATIVE NPTEL/SWAYAM COURSE:

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Computer Networks	Prof. S. K Ghosh	IIT Kharagpur
2.	Cyber Security	Prof. S. K. Mathew	IIT Madras

EEF-572: Introduction to AI & Machine Learning

L	T	P	Credit	Assessment:	Type of course	Total No. of Teaching Hours
3	0	0	3	Mid Sem.40%+ End Sem.60% =100%	HDC	42

Pedagogy: Classrooms lecture, Tutorial, Case studies, Group discussion

Pre requisites: Computer & Programming Fundamentals, Python, C/C++ etc.

COURSE OBJECTIVES&COURSE DESCRIPTION: To review and strengthen important mathematical concepts required for AI & ML. Introduce the concept of learning patterns from data and develop a strong theoretical foundation for understanding state of the art Machine Learning algorithms.

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COURSE OUTCOMES: After successfully completing the course, students should be able to

CO1	Explain the basics of Artificial Intelligence and techniques. Discuss the mathematical foundation.
CO2	Understand the concepts of knowledge representation and methods in AI
CO3	Design and implement machine learning solutions to classification and regression problems.
CO4	Evaluate and interpret the results of the different ML techniques.
CO5	Design and implement various machine learning algorithms in a range of Real-world applications.

UNIT-I:Introduction to AI, Control strategies, Search strategies, Production system characteristics - Specialized production system- Problem solving methods - Problem graphs, Matching, Indexing and Heuristic functions -Hill Climbing, Depth first and Breadth first, Constraint's satisfaction Problem.

UNIT-II: Game playing - Knowledge representation, Knowledge representation using Predicate logic, Introduction to predicate calculus, Resolution, use of predicate calculus, Knowledge representation using other logic: Structured representation of knowledge, First order logic: Syntax and Semantics, Knowledge Engineering in First Order Logic ,Inference in First Order Logic

UNIT III: Introduction to Machine Learning Process, Supervised Learning, Regression, Linear Regression, Predicting, Polynomial Regression, Classification: Feature Engineering, Logistic Regression, kNN classification, SVM, Naive bayes, Decision tree and Random Forest classifier, Unsupervised Learning, Clustering techniques

UNIT-IV:Model representation, decision boundary, cost function, gradient descent, regularization, evaluating a hypothesis (Model selection), training/validation/testing procedures, bias/variance, learning curves, Accuracy and Error measures, evaluating the accuracy of a classifier or predictor, Confusion metric, precision, recall, ROC curve and AUC score, Parameter Tuning.

UNIT-V:Ensemble methods: Ensemble strategies, boosting and bagging; Sequence Models: Hidden Markov Models, Probabilistic Suffix Trees; Applications and Case studies.

TEXTBOOKS:

[T1] Saroj Kaushik, Artificial Intelligence, Cengage Learning, 1st Edition 2011.
[T2] Anindita Das Bhattacharjee, "Practical Workbook Artificial Intelligence and Soft Computing for beginners, Shroff Publisher-X team Publisher.
[T3] Tom Mitchell, Machine Learning, McGraw Hill, 2017

REFERENCE BOOKS:

[R1] Yuxi (Hayden) Liu, "Python Machine Learning by Example", Packet Publishing Limited, 2017.
[R2] Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer, 2011.
[R3] T. Hastie, R. Tibshirani, J. Friedman. The Elements of Statistical Learning, 2e, 2011.

WEB RESOURCE:

[W1] https://swayam.gov.in/nd2_cec20_cs10/preview.

ALTERNATIVE NPTEL/SWAYAM COURSE:

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Introduction to Artificial Intelligence	Prof. Mausam	IIT Delhi
2.	Introduction to Machine Learning	Prof. S Sarkar	IIT Kharagpur

EEL-572: Introduction to AI & Machine Learning Lab

COURSE OUTCOMES: After successfully completing the course, students should be able to

LIST OF EXPERIMENTS:

1. Implementation of logical rules in Python.
2. Using any data apply the concept of:
    a. Linear regression
    b. Gradient decent
    c. Logistic regression 6
3. To add the missing value in any data set.
4. Perform and plot under fitting and over fitting in a data set.
5. Implementation of clustering and classification algorithms.

EEF-672: Deep Learning & ANN

L	T	P	Credit	Assessment:	Type of course	Total No. of Teaching Hours
3	0	0	3	Mid Sem.40%+ End Sem.60% =100%	HDC	42

Pedagogy: Classrooms lecture, Tutorial, Case studies, Group discussion

Pre requisites: Computer network, Programming (Python, Java etc.)

COURSE OBJECTIVES&COURSE DESCRIPTION: To strengthen important Mathematical concepts required for Deep learning and neural network.To get a detailed insight of advanced algorithms of ML.

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COURSE OUTCOMES: After successfully completing the course, students should be able to

CO1	Explain the foundation of the artificial neural network and concept.
CO2	Understand the learning methods of the neural network
CO3	To design and implement CNN.
CO4	To understand RNN.
CO5	Understand the deep unsupervised learning and GAN.

UNIT-I: Information flow in a neural network: Human Brain, Model of an artificial Neuron, Basic concepts of Neural Networks, Fundamentals of Biological Neural Network, understanding basic structure and ANN: Evolution of Neural Networks, Characteristics of Neural Networks.

UNIT-II: Training a Neural network: Learning Methods – supervised, unsupervised and reinforcement, Taxonomy of Neural Network Architectures, Terminologies – weights, bias, threshold, learning rate, Applications of Neural Networks, how to determine hidden layers, recurrent neural network

UNIT III: Basic structure of Convolutional Network, Convolutions for Images, Padding and Stride, Multiple Input and Multiple Output Channels, Pooling, FCNN Case study: Image classification using CNN.

UNIT-IV: Recurrent Neural Networks: Architectural Overview, Bidirectional RNNs – Encoder-decoder sequence to sequence architectures – Back-propagation Through Time for training RNN, Vanishing and Exploding Gradients, Long Short-Term Memory Networks, Gated recurrent Unit.

UNIT-V: Deep Unsupervised Learning: Auto-encoders, De-noising auto-encoders, Sparse auto-encoders, Variational Autoencoder. Generative Adversarial Networks(GANs) Introduction of GANs (Generative Modeling) , Different Types of GANs, Components of GANs, Training and Prediction of GANs, Brief on GAN Loss Function, Challenges Faced by GANs, Application of GANs.

TEXTBOOKS:

[T1]John Paul Mueller, Luca Massaron, Deep Learning for Dummies, John Wiley & Sons.
[T2] Christopher M. Bishop, Neural Networks for Pattern Recognition, Oxford.

REFERENCE BOOKS:

[R1] Adam Gibson, Josh Patterson, Deep Learning, A Practitioner's Approach, Shroff Publisher /O'Reilly Publisher Media.
[R2]Russell Reed, Robert J MarksII, Neural Smithing: Supervised Learning in Feedforward Artificial Neural Networks, Bradford Book Publishers.

WEB RESOURCE:

[W1]https://swayam.gov.in/nd1_noc20_ge09/preview.

ALTERNATIVE NPTEL/SWAYAM COURSE:

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Deep Learning	Prof. Mitesh Kapra	IIT Madras

EEL-672: Deep Learning Lab

COURSE OUTCOMES: After successfully completing the course, students should be able to

LIST OF EXPERIMENTS:

1. Introduction to Kaggle and how it can be used to enhance visibility.
2. Build general features to build a model for text analytics.
3. Build and deploy your own deep neural network on a website using tensor flow

EEF-772: Cryptography and Network Security

L	T	P	Credit	Assessment:	Type of course	Total No. of Teaching Hours
3	0	0	3	Mid Sem.40%+ End Sem.60% =100%	HDC	42

Pedagogy: Classrooms lecture, Tutorial, Case studies, Group discussion

Pre requisites: Computer network

COURSE OBJECTIVES&COURSE DESCRIPTION: To understand basics of Cryptography and Network Security and able to secure a message over insecure channel by various means. To learn about how to maintain the Confidentiality, Integrity and Availability of a data.To understand various protocols for network security to protect against the threats in the networks.

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COURSE OUTCOMES: After successfully completing the course, students should be able to

CO1	Acquire fundamental knowledge on the concepts of finite fields, number theory and cryptography.
CO2	To be able to secure a message over insecure channel by various means.
CO3	To learn about how to maintain the Confidentiality, Integrity and Availability of a data
CO4	Understand the various authentication mechanisms
CO5	Acquire the knowledge on firewall and security applications for networks.

UNIT-I: Introduction to security attacks, services and mechanism, introduction to cryptography, Conventional Encryption: Conventional encryption model, classical encryption techniques, substitution ciphers and transposition ciphers, cryptanalysis – steganography, stream and block ciphers, Modern Block Ciphers: Block ciphers principals, Shannon's theory of confusion and diffusion, fiestal structure, data encryption standard(DES), strength of DES, differential and linearcrypt analysis of DES, block cipher modes of operations, triple DES – AES

UNIT-II: Confidentiality using conventional encryption, traffic confidentiality, key distribution, random number generation, Introduction to graph, ring and field, prime and relative prime numbers, modular arithmetic, Fermat's and Euler's theorem, primality testing, Euclid's Algorithm, Chinese Remainder theorem, discrete algorithms.

UNI-III: Principles of public key crypto systems, RSA algorithm, security of RSA, key management – Diffle, Hellman key exchange algorithm, introductory idea of Elliptic curve cryptography – Elgamel encryption, Message Authentication and Hash Function: Authentication requirements, authentication functions, message authentication code, hash functions, birthday attacks – security of hash functions and MACS.

UNIT-IV: MD5 message digest algorithm, Secure hash algorithm (SHA) Digital Signatures: Digital Signatures, authentication protocols, digital signature standards (DSS), proof of digital signature algorithm, Authentication Applications: Kerberos and X.509, directory authentication service, electronic mail security, pretty good privacy (PGP), S/MIME.

UNIT-V: IP Security: Architecture, Authentication header, Encapsulating security payloads, combining security associations, key management. Web Security: Secure socket layer and transport layer security, secure electronic transaction (SET), System Security: Intruders, Viruses and related threads, firewall design principals – trusted systems.

TEXTBOOKS:

[T1] William Stallings, "Cryptography and Network Security", 3rd Edition, Pearson Education, 2003
[T2] Charlie Kaufman, Radia Perlman, Mike Speciner, "Network Security", Prentice Hall, 2nd edition, ISBN10: 0130460192, ISBN,13: 978,013046

REFERENCE BOOKS:

[R1] Charles Pfleeger," Security in Computing", Prentice Hall, 4th Edition, ISBN,10: 0132390779, ISBN,13: 978, 01323907744, 2006.
[R2] Earl Gose, Richard Johnsonbaugh, Steve Jost, "Pattern Recognition and Image Analysis", Prentice Hall of India Private Ltd., New Delhi – 110001, 1999.

WEB RESOURCE:

[W1]http://nptel.ac.in/courses/106105031/
[W2] https://ocw.mit.edu/courses/electrical,engineering,and,computer,science/6,033, computer,system,engineering,spring,2009/video,lectures/

ALERNATIVE NPTEL/SWAYAM COURSE:

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Cryptography and Network Security	Prof. D. Mukhopadhyay	IIT Kharagpur
2.	Cryptography and Network Security	Prof. S. Mukhopadhyay	IITKharagpur

EEL-772: Network Security Lab

COURSE OUTCOMES: After successfully completing the course, students should be able to

LIST OF EXPERIMENTS:

1. Substitution techniques. Number Theory: Groups, Rings, Fields, Modular Arithmetic – Euclidean Theorem– Galois Field.
2. Implement Euclid. Prime Numbers – Fermat's Theorem, Euler's totient function, Euler's Theorem, Chinese Remainder theorem, Primitive roots, Discrete Logarithms.
3. Implement Chinese Remainder Theorem.
4. Implement SDES, Modes of operation. Public Key Cryptosystems RSA Algorithm.
5. Implement Diffie, Hellman Key exchange algorithm.
6. Implement MD5, Secure Hash Algorithm.
7. Implement SHA, Digital signatures: Digital signature requirements, Digital Signature scheme, Elgamal Digital signature scheme, Schnoor Digital signature scheme, User Authentication protocol.
8. Implement Elgamal Digital signature scheme.
9. Discussions on network layer attacks, Introduction to Firewall– Firewall Generations.
10. Firewall configurations, Intrusion Detection System – Types of IDS – Intrusion Prevention System – Wireless LAN – Wireless LAN Security – Network Access Control and Cloud Security.
11. Discussions on Email security, IP security – IPSEC protocol suite–functionalities–Transport mode Authentication Header – Introduction to Encapsulation Security Payload, Virtual Private Network (VPN).
12. Discussions on VPN, Web Security – Secure Socket Layer (SSL) –Transport Layer Security – Secure Electronic Transaction (SET).

EEF-473: Energy Conservation and Management

L	T	P	Credit	Assessment:	Type of course	Total No. of Teaching Hours
2	1	0	3	Mid Sem.40%+ End Sem.60% =100%	Core	42

Pedagogy: Classrooms lecture, Tutorial, Case studies, Group discussion, Seminar & field work etc.

Pre requisites: Power Generation, SCADA System, Smart Grid, Electrical Power System

COURSE OBJECTIVES & COURSE DESCRIPTION: Energy Management has been identified as a key instrument to reduce greenhouse gas emissions, besides increasing the cost competitiveness of the entity/ facility while enhancing the energy security of the nation. Policy makers and technology providers have been working towards the cause of energy efficiency and its overall management. This course is designed to educate students on the various dimensions of energy management across the entire value chain.

COURSE OUTCOMES: After successfully completing the course, students should be able to

CO1	Analyse energy systems from a supply and demand perspective
CO2	Impart knowledge in the domain of energy conservation.
CO3	Bring out Energy Conservation Potential and Business opportunities across different user segments.
CO4	Develop innovative energy efficiency solutions and demand management strategies

UNIT-I:Introduction to Energy Conservation:
Overview - Global & Indian Energy Scenario Energy Sources, Supply & Demand Overview of Electrical and Thermal Energy Imperative for Energy Conservation, Policy & Regulations for Energy Conservation.

UNIT-II: Energy Conservation Requirements:
Global EE Programmes India - Energy Conservation Policies, Energy Conservation Opportunities – Electrical Buildings & Lighting Systems Motors, Pumps, Transformers Power Transmission & Distribution System

UNIT III:Energy Conservation Opportunities:
Thermal Boilers, Furnaces & Waste Heat Recovery Systems Cogeneration Systems HVAC, Cooling Towers & DG Systems, Energy Data Analysis IT Tools and Applications Smart Energy Systems.

UNIT-IV:Case Studies:
Industrial Use Cases, Business Approaches Market Opportunities Overview on EE Financing ESCO Business Models Case studies

TEXTBOOKS:

[T1] LC Witte, PS Schmidt and DR Brown: Industrial Energy Management and Utilization (Hemisphere Publishing Corporation, Washington, 1998)

REFERENCE BOOKS:

[R1] WC Turner and Steve Doty: Energy Management Handbook, Seventh Edition, (Fairmont Press Inc., 2007)
[R2] Sumper Andreas and Baggini Angelo: Electrical Energy Efficiency: Technologies and Applications (John Wiley 2012)
[R3] Frank Kreith: Handbook on Energy Efficiency and Renewable Energy (CRC Press, 2007)
[R4] George Polimeros: Energy Cogeneration Handbook (Industrial Press, Inc., New York, 1981)

Websites:

[W1] National Productivity Council (http://www.npcindia.gov.in)
[W2] Bureau of Energy Efficiency (https://www.beeindia.gov.in)
[W3] Petroleum Conservation Research Association (http://www.pcra.org)

EEF-573: Energy Economics and Auditing

L	T	P	Credit	Assessment:	Type of course	Total No. of Teaching Hours
3	0	0	3	Mid Sem.40%+ End Sem.60% =100%	HDC	42

Pedagogy: Classrooms lecture, Tutorial, Case studies, Group discussion, Seminar etc.

Pre requisites: Fundamentals of Power systems

COURSE OBJECTIVES & COURSE DESCRIPTION: This course aims to provide students an understanding of the economic fundamentals and principles of decision making involved in energy projects. The course also sensitize the students on the mechanism of energy audit and the technologies/ tools typically employed to undertake an audit exercise, supported by case study.

COURSE OUTCOMES: After successfully completing the course, students should be able to:

CO1	Understand the basics of engineering economics
CO2	Understand the structure of energy markets and methods used for pricing electricity and other forms of energy.
CO3	Evaluate the cost effectiveness of individual renewable energy projects.
CO4	Gain knowledge on tools and techniques employed in energy auditing
CO5	Comprehend an energy audit report, including economic parameters

UNIT-I: Basics of engineering economics: Role of engineering economics in the decision-making process, Economic decisions versus design decisions, discount rate and economic equivalence, worth analysis, rate-of-return analysis, depreciation, and taxation, developing project cash flows, social cost benefit analysis, origins of renewable energy project risks, sensitivity and, break-even analysis, expected value decisions.

UNIT-II: Energy Modelling: Review of Energy Prices and Markets, review of various energy sector models, energy demand analysis and forecasting, energy supply assessment and evaluation, energy demand – supply balancing, energy modelling in the context of climate change

UNIT-III: Techno-economic evaluation of Renewable Energy Technologies: Technology dissemination models, dynamics of fuel substitution by renewable energy systems and quantification of benefits, fiscal, financial and other incentives for promotion of renewable energy systems and their effect on financial viability, case studies on financial feasibility evaluation of renewable energy devices and systems.

UNIT-IV: Energy Audit Basics: Definition and Objectives, types, Energy Profiling, Energy Flow diagram, Types of Energy Audit, Duties of Energy Auditor & Manager.

UNIT-V: Energy Audit Procedure: Energy Audit Procedure Tools/Techniques/Equipment, Energy Audit Report, Financing EEC Activities. Case study on energy audit in Power Distribution Utilities.

TEXTBOOKS:

[T1] G. J. Thuesen and W. J. Fabrycky, “Engineering economy”. Prentice Hall of India.
[T2] T.C. Kandpal and H.P. Garg, “Financial Evaluation of Renewable Energy Technologies”, Macmillan India.
[T3] LC Witte, PS Schmidt and DR Brown,” Industrial Energy Management and Utilization”, Hemisphere Publishing Corporation, Washington, 1998.

REFERENCE BOOKS:

[R1] C. Dahl, “International Energy Markets: Understanding Pricing, Policies, & Profits”. PennWell Books.
[R2] S. Kaplan, “Energy economics: quantitative methods for energy and environmental decisions”. McGraw-Hill College.
[R3] YP Abbi and Shashank Jain, “Handbook on Energy Audit and Environment Management”, TERI Press, 2006.
[R4] WC Turner, “Energy Management Handbook”, Seventh Edition, Fairmont Press Inc., 2007.

WEB RESOURCE:

[W1] https://onlinecourses.swayam2.ac.in/nou23_es05/preview
[W2] Bureau of Energy Efficiency (https://www.beeindia.gov.in/)
[W3] National Productivity Council (http://www.npcindia.gov.in/)

ALTERNATIVE NPTEL/SWAYAM COURSE:

S. No.	NPTEL/SWAYAM Course Name	Instructor	Host Institute
1.	Basic Principles of Energy Management & Energy Audit	Dr. R. N. Patel & Mr. Akhilesh Kumar Tiwari	Chhattisgarh Swami Vivekanand Technical University

EEF-673: Green and Sustainable Building Technologies

L	T	P	Credit	Assessment:	Type of course	Total No. of Teaching Hours
3	0	0	3	Mid Sem.40%+ End Sem.60% =100%	HDC	42

Pedagogy: Classrooms lecture, Tutorial, Case studies, Group discussion, Seminar etc.

Pre requisites: Energy Conservation and Management, Renewable Energy

COURSE OBJECTIVES & COURSE DESCRIPTION: This course aims to provide the students an understanding of the concepts of green and sustainable buildings and their different rating systems. This course familiarizes the students with best practices for green and sustainable buildings as well as various renewable energy technologies used in green and sustainable buildings.

COURSE OUTCOMES: After successfully completing the course, students should be able to:

CO1	Understand the basics of green and sustainable buildings
CO2	Familiarize with renewable energy sources for green and sustainable buildings and evaluate the carbon credits.
CO3	Understand the energy management system for green and sustainable buildings.
CO4	Gain knowledge on equipments/appliances for green and sustainable buildings.
CO5	Familiarize with energy efficiency ratings for buildings.

UNIT-I: Green Building: Design Strategies and Building codes, Energy use in buildings, factors affecting energy use, Energy conservation options, External Factors consideration- Climate, Building Orientation, Shading.

UNIT-II: Renewable Energy Sources for Buildings. Rooftop PV plant: design consideration, types of mounting structures, standards, Performance parameter: Losses in solar PV power plant, Yield, Capacity Utilization Factor and Performance Ratio, Design exercises using PVsyst for ground mounted and rooftop plants with shadow analysis. Assessment of carbon footprints and carbon credit calculation, estimating CO_2 mitigation potential, Green building practices to integrate renewable energy sources.

UNIT-III: Energy Management Systems in Building: Introduction, Advantages, Basic Design Criteria, Components used in EMS, Future markets and opportunities, System Architecture, Concept of Green & Smart Design.

UNIT-IV: Equipments/Appliances: Electric drives, sensors, HVAC system, Illumination system, smart home appliances, smart meters, modern equipments.

UNIT-V: Energy Efficiency Rating: Rating systems in different countries. Green building rating systems such as LEED and GRIHA. ECBC and Eco-Niwas Samhita (ECBC-Residential).

TEXTBOOKS:

[T1] M. S Sodha, N. K. Bansal, P.K. Bansal, A. Kumar, M.A.S. Malik, "Solar, Passive Building: Science and design", Pergamon Press, Oxford, 1986.
[T2] S. Kubba, "Handbook of Green Building Design and Construction" Elsevier, 2012.

REFERENCE BOOKS:

[R1] S. Attia, "Net Zero Energy Buildings (NZEB): Concepts, Frameworks and Roadmap for Project Analysis and Implementation". Elsevier, 2018.
[R2] A. Sayigh, "Sustainability, Energy and Architecture: Case Studies in Realizing Green Buildings, Elsevier, 2013.
[R3] A. Krishnan, N. Baker, S. Yannas, S. Szokolay, "Climate Responsive Architecture- A Design Handbook for Energy Efficient Buildings", Tata McGraw-Hill, New Delhi, 2001.
[R4] M. Karlen and J. Benya, "Lighting Design Basics", John Wiley & Sons Inc., New York, 2004.

WEB RESOURCE:

[W1] https://archive.nptel.ac.in/courses/124/107/124107011/
[W2] Indian Green Building Council LEED India: www.igbc.in,
[W3] GRIHA Websi http://www.grihaindia.org/ ,

ALTERNATIVE NPTEL/SWAYAM COURSE:

S. No.	NPTEL/SWAYAM Course Name	Instructor	Host Institute
1.	Sustainable Architecture	Prof. Avlokita Agrawal	IIT Roorkee

EEF-773: Grid Integration of Renewable Energy

L	T	P	Credit	Assessment:	Type of course	Total No. of Teaching Hours
2	1	0	3	Mid Sem.40%+ End Sem.60% =100%	HDC	34

Pedagogy: Classroom instruction will consist of interactive lectures, class discussions, PowerPoint presentations, and video illustrations.

Pre requisites: Basic understanding of Power System and Power Electronics Engineering.

COURSE OBJECTIVES & COURSE DESCRIPTION:

The characteristics and behaviour of power systems changes when the share of variable energy increase in the total mix. With the increase in penetration from renewable energy sources, the dynamics of the existing electricity infrastructure must be understood. This course provides a platform for strong understanding related to the phenomenon of integrating renewable energy sources. The course is focussed on causes, effects and recovery measures when power from renewable energy sources are injected to the grid.

COURSE OUTCOMES: After successfully completing the course, students should be able to:

CO1	Acquire a strong understanding of power systems, their operation and control focussed on the issues related to the integration of distributed renewable generation into the network.
CO2	Apply advanced knowledge of electrical power system operations and control to analyse the challenges and opportunities for distributed renewable generation in both large interconnected grid and microgrid settings.
CO3	Describe the principles and requirements of the next generation future power network, incorporating distributed generation and storage and demand management
CO4	Understand the principles, power and limitations of complex power networks incorporating distributed generation and storage

UNIT-I: Introduction of various techniques of utilizing power from renewable energy sources, concept of nano/micro/mini grid. Need of integrating large renewable energy sources, issues related to integration of large renewable energy sources, rooftop plants. Concept of VPP.

UNIT-II: Power system equipment for grid integration Synchronous generator: synchronization/integration to existing grid, load sharing during parallel operation, stability (swing equation and solution) Induction Generator: working principle, classification, stability due to variable speed and counter measures Power Electronics: need of power electronic equipment in grid integration, converter, inverter, chopper, ac regulator and cyclo-converters for AC/DC conversion

UNIT-III: Power quality and management Importance of power quality and corresponding standards, THD, voltage sag, voltage swell, frequency change and its effects, network voltage management, frequency management, system protection, grid codes

UNIT-IV: Grid stabilization Scheduling and dispatch, Forecasting, reactive power and voltage control, frequency control, operating reserve, storage systems, electric vehicles Ancillary services in Indian Electricity Market (regulatory aspect),CERC and CEA orders (technical and safety standards)

UNIT-V: Integration of alternate sources of energy Introduction, principles of power injection: converting technologies, power flow; instantaneous active and reactive power control approach; integrating multiple renewable energy sources; DC link integration; AC link integration; HFAC link integration; islanding and interconnection, Case studies based on synchronous/induction generator for peak demand reduction, grid connected PV system.

TEXTBOOKS/REFERENCE BOOKS:

1. Integration of Alternative sources of Energy, IEEE Press –Wiley-Interscience publication, 2006.
2. Grid integration of solar photovoltaic systems, M. Jamil, M. Rizwan, D.P. Kothari, CRC Press(Taylor & Francis group), 2017
3. Renewable Energy Grid Integration, Marco H. Balderas, Nova Science Publishers, New York, 2009.
4. Wind Power Integration connection and system operational aspects, B. Fox, D. Flynn L. Bryans, N. Jenkins, M. O' Malley, R. Watson and D. Milborrow, IET Power and Energy Series 50 (IET digital library), 2007
5. Power Generation, Operation, and Control, Allen J. Wood, Bruce F. Wollenberg, Gerald B. Sheblé, John Wiley & Sons, New York, 2013 (3rd edition)
6. Power Electronics: Circuits, Devices, and Applications. M. H. Rashid, Pearson Education India, 2013
7. Advanced power system analysis and dynamics, L.P. Singh, New age international publishers,2017

MINOR DEGREE COURSES

EED-411: Power Electronics for Electric Vehicle

L	T	P	Credit	Assessment:	Type of course	Total No. of Teaching Hours
3	0	0	3	Mid Sem.40%+ End Sem.60% =100%	PCC	42

Pedagogy: Classrooms lecture, Tutorial, Case studies.

Pre requisites:

COURSE OBJECTIVES & COURSE DESCRIPTION: The course objectives for an undergraduate (UG) Power Electronics course typically aim to provide students with a fundamental understanding of power electronics and its applications. These objectives include the following topics to be taught : Introduction of Power Electronics, Semiconductor devices, Power semiconductor switching, Converter topologies, control techniques etc.

COURSE OUTCOMES: After successfully completing the course, students should be able to

S. NO	DESCRIPTION
CO1:	Explain basics of Power electronics, device operation and its control.
CO2:	Analyze the operation of uncontrolled and fully control rectifiers along with expressions of fourier series
CO3:	Apply the circuit topology to get the operation of DC-AC converters and AC-AC converters and its application
CO4:	Understand the process of operation of DC-DC converters along with its control
CO5:	Discuss various control techniques and few advance topics with understanding of related simulation software.

UNIT-I:

Introduction, Devices: Diodes-silicon, fast recovery, Schottky diode, SCR,TRIAC, SCS, GTO, PUT, SUS, CUJT, LASCR, Mosfet, IGBT with their V-I characteristics. SCR: Operating principle, Gate Characteristics, Two transistor model, over-current and over voltage protection, snubber circuits, methods of turning on (triggering) and turning off (commutation).

UNIT-II:

Half-wave and full-wave controlled rectifiers with resistive and reactive load, battery load Freewheeling diode. Detailed derivation of rms, average value, harmonic factor, displacement factor, THD, crest factor. Three phase half wave and full wave controlled rectifiers. Effect of Source impedance.

UNIT III:

Voltage-driven inverter, current-driven inverter, Single-phase inverter with resistive load, inductive load, Zero current switching (ZCS), Zero voltage Switching (ZVS). Introduction of resonant inverters. Three phase bridge inverter, 120-180 degree conduction. Multi level inverter, AC Voltage Controllers: Single and three phase ac voltage controllers. Cycloconverters: Single phase to single-phase, three-phase to single-phase, three-phase to three-phase cycloconverter circuit and their operation.

UNIT-IV

Principle of chopper, Step down-Step up chopper, Step down chopper with RL load withoutlinear approximation, Chopper classification: First Quadrant, Second Quadrant, Third and Fourth Quadrant, Fourth Quadrant, All Four Quadrant Chopper. Buck, Boost, Buck-boost DC-DC converters. Bidirectional DC-DC converter.

UNIT-V:

Various control techniques for power electronics converters: Various PWM Techniques, Advance applications: Power Factor correction, Solar PV technology, Motor drive, Electric Vehicle, FACTS, AI for power electronics, Simulation software: PSIM, Real time HIL. UPS, Energy harvesting WSN.

TEXTBOOKS:

[T1] M. H. Rashid, “Introduction to Power Electronics- Circuits, devices and application”, Pearson Education India, New Delhi.

[T2] A Haque, M A Khan, K V S Bharath, “Design and Control of Grid connected PV System” CRC Press, USA.

REFERENCE BOOKS:

[R1] P. C. Sen, “Power Electronics” Tata McGraw Hill Book Co., New Delhi.
[R2] G. K. Dubey, S.R. Doradla, A.Joshi and R.M.K. Sinha, “Thyristorised Power Controllers” ,Wiley Eastern Ltd., New Delhi.

WEB RESOURCE:

[W1] www.nptel.ac.in

EED-511 Electric Vehicle Control Systems

L	T	P	Credit	Assessment:	Type of course	Total No. of Teaching Hours
3	0	0	3	Mid Sem.40%+ End Sem.60% =100%	PCC	42

Pedagogy: Classrooms lecture, Tutorial, Case studies, Group discussion, Seminar etc.

Prerequisites:

To understand this course, the student must have idea of:

Sl. No.	Subject	Description	Level of Study
01	Mathematics	Linear Differential Equations, Laplace Transform	Class XII, 2nd Sem
02	Physics	Rotational Motion	Class XI
03	Circuit Theory	Network Theory	3rd Sem

COURSE OBJECTIVES & COURSE DESCRIPTION:

- To introduce different types of system and identify a set of algebraic equations to represent and model a complicated system into a more simplified form to interpret different physical and mechanical systems in terms of electrical system to construct equivalent electrical models for analysis.
- To employ time domain analysis to predict and diagnose transient performance parameters of the system for standard input functions and identify the needs of different types of controllers and compensator to ascertain the required dynamic response from the system
- Formulate different types of analysis in frequency domain to explain the nature of stabilityof the system.

COURSE OUTCOMES: After successfully completing the course, students should be able to

S. NO	DESCRIPTION
CO1:	Categorize different types of system and identify a set of algebraic equations to represent and model a complicated system into a more simplified form.
CO2:	Characterize any system in Laplace domain to illustrate different specification of the system using transfer function concept.
CO3:	Interpret different physical and mechanical systems in terms of electrical system to construct equivalent electrical models for analysis.
CO4:	Employ time domain analysis to predict and diagnose transient performance parameters of the system for standard input functions.
CO5:	Formulate different types of analysis in frequency domain to explain the nature of stability of the system.

UNIT-I: Introduction: Concept of feedback and Automatic control, Effects of feedback, Objectives of control system. Types of control systems. Merits and demerits of open and closed loop control systems, Transfer function concept.
Mathematical modeling of dynamic systems: Translational systems, Rotational systems, Mechanical coupling, Liquid level systems, Electrical analogy of Spring– Mass-Dashpot system. Mathematical modelling of electrical systems. Analogous systems, Force-current analogy, Force –voltage analogy. Mathematical modelling of electromechanical systems. Mathematical modeling of mechanical, electrical, thermal, hydraulic and pneumatic systems.

UNIT-II: Block diagram representation of control systems. Block diagram algebra. Block diagram reduction rules. Overall transfer function of complex block diagrams. Signal flow graph. Mason's gain formula.
Control system components: Potentiometer, Synchros, Resolvers, Position encoders. DC and AC tacho-generators. Actuators. Block diagram level description of feedback control systems for position control, speed control of DC motors, temperature control, liquid level control, Servomechanisms and regulators.

UNIT-III: Time domain analysis: Time domain analysis of a first and standard second order closed loop system. Time Response Specifications, Dependence of time domain performance parameters on natural frequency and damping ratio. Step and Impulse response of first and second order systems.
Error Analysis: Steady state errors in control systems due to step, ramp and parabolic inputs. Concepts of system types and error constants.

UNIT-IV: Stability Analysis in Time Domain: Stability concept, Necessary conditions for stability. Routh-Hurwitz's stability criterion, Root locus techniques, construction of Root Loci for simple systems. analysis of control system by root loci. Sensitivity of the roots of the characteristic equation. Relative stability analysis. Effects of gain on the movement of Pole and Zeros.

UNIT-V: **Frequency domain analysis of linear system**: Relationship between time and frequency response, Procedure to plot Polar plot, Bode plots, Determination of margin of stability in Bode plot, Concept of resonance frequency of peak magnification. Nyquist criteria, measure of relative stability, phase and gain margin.

TEXTBOOKS:

1) I. J. Nagrath and M. Gopal, "Control Systems Engineering" New Age International Ltd , New Delhi, 7th Edition
2) Norman S. Nise, "Control System Engineering", 7th Edition, Wiley
3) Richard C Drof, Robert H. Bishop, "Modern Control Systems, Pearson, 13th Edition
4) Gopal, M., "Control Systems: Principles and Design", Tata McGraw Hill Book Co., New Delhi.
5) Gopal, M., "Digital Control Systems and State Variable techniques", Tata McGraw Hill Book Co., New Delhi.
6) Kou, B.C., "Automatic Control System", Prentice Hall of India Pvt. Ltd., New Delhi.
7) Ogata, K., "Modern Control Engineering", Prentice Hall of India Pvt. Ltd., New Delhi.

WEB RESOURCE :

1. https://www.controleng.com
2. https://www.mathworks.com
3. https://nptel.ac.in/courses/108/102/108102043/

EEL-501 Control Systems Lab

COURSE OUTCOMES: After successfully completing the course, students should be able to

S. NO	DESCRIPTION
CO1:	Demonstrate the use of potentiometer as an error detector system
CO2:	Learn to simulate transfer function, differentiator, integrator, and dead time for first order and second order systems
CO3:	formulate the mathematical model of DC position and speed control system, and verify their characteristics on the oscilloscope
CO4:	Learn about proportional, derivative and integral controllers and their gain scheduling schemes
CO5:	Design the mathematical model light intensity control system and magnetic amplifier system.

EED-711: Electric Vehicle Drives

L	T	P	Credit	Assessment:	Type of course	Total No. of Teaching Hours
3	0	0	3	Mid Sem.40%+ End Sem.60% =100%	Core	42

Pedagogy: Classrooms lecture, Tutorial, Case studies, Group discussion, Seminar & field work etc.

Pre requisites: Electric machines

COURSE OBJECTIVES&COURSE DESCRIPTION: This course aims to provide the students with a comprehensive understanding of Electric drives and its control involved in starting, speed regulation, braking, and reversal. It also aims to provide the students with an understanding of the application of power electronic converters for controlling the electric drives

COURSE OUTCOMES: After the completion of the course;

S. NO	DESCRIPTION
CO1:	Student will be able to demonstrate the knowledge of particular type of AC/DC drives.
CO2:	Student will use the knowledge for the analysis the DC drive system.
CO3:	Student will be able to analyze the AC drive systems.
CO4:	Students will be able to effectively apply the knowledge of drives for closed-loop systems.
CO5:	Student will be able to analyze and suggest microprocessor-based system for electric drives.

UNIT-I: Introduction, concept of electric drives classification and components, characteristic, starting, speed control and braking of electric motors (dc and ac), Electro-mechanical transients during starting and braking, time energy calculation, load equalization.

UNIT-II: Converters for feeding electric motors – line commutated converters, choppers, inverters, cycloconverters, ac voltage controllers.

UNIT III: Induction motor drive system, scalar control, vector control, sensor less control.

UNIT-IV: Permanent magnet motor drive system, number of phases, radial and axial field, closed loop control, sensor elimination and reduction, Energy conservation in Electric drives. Switched Reluctance Motor Drive Systems.

UNIT-V: Solar and battery powered drives Solar powered pumps, Traction drives, mainline and suburban train configurations, Application of polyphase ac motors in traction drives. Drives for vehicular and aircraft applications.

TEXTBOOKS:

[T1] G K Dubey, Power Semiconductor Controlled Drives, Prentice Hall Englewood Cliffs, New Jersey.

REFERENCE BOOKS:

[R1] S. K. Pillai, A First Course in Electric Drives, New Age Publications, New Delhi.
[R2] P C Sen, Principles of Electric Machines and Power Electronics, John Wiley.
[R3] M. H. Rashid, “Introduction to Power Electronics”, Pearson Education India, New Delhi.
[R4] G. K. Dubey, Fundamentals of Electric Drives, Narosa Publications, New Delhi.

WEB RESOURCE :

[W1] https://archive.nptel.ac.in/courses/108/104/108104140/

ALTERNATIVE NPTEL/SWAYAM COURSE:

S. No.	NPTEL Course Name	Instructor	Host Institute
1.	Industrial Drives	Dr. K .R. Rajagopal	IIT Delhi
2.	Advanced Electric Drives	Dr. S.P. Das	IIT Kanpur
3.	Fundamentals of Electric Drives	Prof. Shyama Prasad Das	IIT Kanpur

4.	Industrial Drives - Power Electronics	Prof. K. Gopakumar	IISc Bangalore