School of Electrical, Electronics & Communication Engineering
Department of Electrical Engineering

B. Tech (Electrical & Electronics Engineering) Syllabus

(Applicable for the students admitted in Academic Year 2019-20 & onwards)

THIRD SEMESTER

BB0025: VALUE EHICS & GOVERNANCE [2 0 0 2]

Relevance of Value Education in day-to-day life. Mantra for success - Value, Moral and Ethics. Determinants of human nature (Three Gunas) and its impact on human life. Relevance of Personality, Attitude, Behavior, Ego, Character, introspection, Motivation, Leadership and 4 Qs with relevant Case Studies*. Governance: Understanding of Public and Private sector Governance systems; Courts & CAG. Public Sector Governance: Need, relevance, stakeholders. Private Sector Governance: Proprietary, Partnership, Company (Pvt Ltd & Ltd), Company' Act 2013, Board of Directors; its Roles and Responsivities. Regulatory bodies; its role in ethical governance. Projects on PPP mode-relevance & prospects. CSR: Relationship with Society, Philanthropy and Business strategy, CSR Policy, Triple Bottom Line. Suggestive Case Studies: Uphar Theatre Tragedy- Engineering Ethics, Bhopal Gas Tragedy- Operational Engineering Ethics, Satyam Case- Financial Reporting Ethics, Enron Case- Business Ethics, Navin Modi Case- Financial Fraudulence.

References:

1. Professional Module of ICSI.
2. B. N. Ghosh, *Business Ethics & Corporate Governance*, (1e) McGraw Hill, 2011.
3. S. K. Mandal, *Ethics in Business & Corporate Governance*, (2e), McGraw Hill, 2012.
4. C. K. Ray, *Corporate Governance, Value & Ethics*, Vaya Education of India, 2012.
5. A. Chatterjee, *Professional Ethics*, (2e) Oxford Publications.

MA2103: ENGINEERING MATHEMATICS – III [2 1 0 3]

Functions of complex variable. Analytic function, C-R equations, differentiation, Integration of complex function, Cauchy's integral formula. Taylor's and Laurent Series, Singular points, Residues, Cauchy's residue theorem. Periodic function, Fourier series expansion. Even and odd functions, functions with arbitrary periods, half range expansions, Fourier transform, Parseval's identity, PDE-Solution by method of separation of variables and by indicated transformations. One dimensional wave equation, one dimensional heat equation and their solutions. Vector differential operator, gradient divergence and curl. Line, surface and volume integrals. Green's theorem, Divergence and Stoke's theorem.

References:

1. B. S. Grewal, *Higher Engineering Mathematics*, (43e), Khanna Publishers, 2014.
2. E. Kreyszig, *Advanced Engineering Mathematics*, (7e), John Wiley & Sons, Inc., 2015.
3. C. F. Gerald and P. O. Wheatley, *Applied Numerical Analysis*, (7e), Pearson Education, 2007
4. R. Spiegel Murray, *Vector Analysis*, (2e), Schaum Publishing Co., 2009.

EE2101: ANALOG & DIGITAL SYSTEM DESIGN [3 1 0 4]

Semiconductor Devices MOSFET Characteristics, structure, biasing, current mirrors, basic amplifier configurations, CS, CD, CG configurations, small signal model, frequency response, OPAMP configuration, OPAMP in linear Mode, OPAMP with positive and negative feedback, Linear applications of OPAMP, Nonlinear applications of OPAMP, Overview of Algebraic simplification of Boolean expressions, realization using logic gates, minimization using Karnaugh map, Combinational circuit design, Arithmetic circuits, Sequential logic circuits: Overview of flip-flops, Counters, shift registers.

References:

1. D. S. William, *Operational Amplifiers with Linear Integrated Circuits*, Pearson Education, 2004.
2. Boylestad and Nashelsky, *Electronic Devices and Circuit Theory* (10e), Pearson Education 2009.
3. R. A. Gayakwad, *Op-Amps and Linear Integrated Circuits* (4e), Pearson Education 2015.
4. D. D. Givone, *Digital Principles & Design*, TMH Publications, 2003.

5. J. F. Wakerly, *Digital Design Principles & Practices*, Pearson Education, 2002

EE2102: ELECTROMAGNETIC FIELD THEORY [2 1 0 3]

Vector analysis: Vector algebra, Rectangular, Cylindrical and Spherical Coordinates, Electrostatics: Field intensity, Flux density, Electric scalar potential, Potential gradient, Energy density in an electric field, Boundary conditions, Capacitance, Laplace's and Poisson's equations. Magnetostatics: Field intensity, Flux density, Boundary conditions, Magnetic forces, Inductance, Time varying fields: Maxwell's equations, Uniform Plane wave: Wave equation and its solution, Wave propagation in different media, Poynting's theorem.

References:

1. W. Hayt, *Engineering Electromagnetics*, TMH, 2012.
2. M. Sadiku, *Elements of Electromagnetics*, Oxford University Press, 2014.
3. N. Rao, *Elements of Engineering Electromagnetics*, Pearson Education, 2006.

EE2103: ELECTRICAL CIRCUIT ANALYSIS [3 1 0 4]

Introduction to Graph Theory, Graph of a network, Matrix representation of a graph, Cut- set and Tie set Matrix. Network Theorems with controlled sources: Superposition, Thevenin's, Norton's, Maximum power transfer, Reciprocity, Substitution, Compensation, Millman's, Tellegen's theorems. Signals and waveforms: Classification of Signals, elementary signals, characteristics, representation of waveforms. Time domain analysis: Initial and final conditions, Transients analysis of RL, RC and RLC circuits. Frequency domain analysis: Laplace domain analysis, Laplace Transforms of signals, Transformed circuits, Analysis of networks using Laplace Transforms, Frequency domain analysis: Network Function, poles and zeros, convolution integral. Two port networks: Z, Y, T and h parameters, Relation between parameters, Series, parallel and cascade connections.

References:

1. W. H. Hayt, J. E. Kemmerly & S. M. Durbin, *Engineering Circuit Analysis*(7e), TMH, 2010.
2. V. Valkenberg, *Network Analysis* (3e), PHI, 2009.
3. J. W. Nilsson & S. A. Reidel, *Electric Circuits* (9e), PHI, 2011.
4. R. R. Singh, *Network Analysis and Synthesis*, McGraw Hill Education 2013

EE 2104: ELECTRICAL MACHINES – I [3 1 0 4]

Transformers: Types of transformers; Single phase transformers - working principle, construction, phasor diagram, equivalent circuit, voltage regulation, losses and efficiency, All day efficiency, testing, parallel operation, inrush current, harmonics, tap changing, auto transformer. Three phase transformers: Connections: star-star, star-delta, delta-star, delta-delta, zigzag, open delta; three winding transformer. DC Machines: DC generators- working principle, construction, types, armature winding, Magnetization characteristics, armature reaction, commutation, load characteristics, DC Motors – working principle, types, torque-speed characteristics, starting, braking, speed control, losses, efficiency, and testing. BLDC motors – working principle and control.

References:

1. A. E. Clayton & N. N. Hancock, *Performance and Design of Direct Current Machines*, CBS, 2004.
2. Fitzarald & Kingslay, *Electric Machinery*, TMH, 2011
3. P. S. Bhimbra, *Electrical Machinery*, Khanna Publication, 2011
4. D. P. Kothari & I. J. Nagrath, *Electric Machines* (4e), TMH, 2013.

EE2130: ANALOG SYSTEM DESIGN LAB [0 0 2 1]

Module I: Design, Simulate and Test basic analog electronic circuits using diodes, Rectifiers without and with capacitor filter, Fixed and variable voltage power supplies, Zener diodes, voltage regulators, MOSFET biasing and current mirror circuits, Frequency response of Amplifier Circuits, Power amplifiers, Differential amplifier circuit. Module II: Design, Simulation and Testing of operational amplifier based circuits in linear and nonlinear mode, Timer based Mono-stable and Astable-Multivibrators circuits.

References:

1. B. Razavi, *Fundamentals of Microelectronics* (2e), Wiley Publishers, 2013.
2. S. Franco, *Design with Operational Amplifiers and Analog Integrated Circuits* (4e), McGraw-Hill, 2014.
3. A. S. Sedra, Kenneth C. Smith, Arun N. Chandorkar, *Microelectronic Circuits: Theory and Application* (6e), Oxford, 2017.

EE2131: DIGITAL SYSTEM DESIGN LAB [0 0 2 1]

Design and Testing of combinational circuits using gates, multiplexers, decoders, arithmetic circuits etc., Design and Testing of sequential digital electronic circuits such as counters, shift registers & sequence generators, sequence detectors etc. HDL and Digital Circuit Implementation on FPGA.

References:

1. Givone, *Digital Principles & Design*, TMH, 2011.
2. Wakerly, *Digital Design Principles & Practices*, Pearson, 2003.
3. C. H. Roth, *Fundamentals of Logic Design*, Jaico, 2007.
4. S. Brown and Z. Vranesic, *Fundamentals of Digital logic with Verilog design*, TMH, 2008.

EE2132: ELECTRICAL MACHINERY LAB – I [0 0 2 1]

Transformers: OC and SC tests on single phase transformer, Sumpner's test, Polarity tests, connection of single phase transformers as three phase bank, Scott-connection of transformer, Parallel operation of single phase transformers. DC Machines: Magnetisation characteristics of DC generator, Load test on dc machines, speed control of D.C. shunt motor. Testing of DC Machines. BLDC motors – operation and control.

References:

1. E. H. Langsdorf, *Theory of Alternating Current Machinery* (2e), TMH, 2004.
2. A. E. Clayton & N. N. Hancock, *Performance and Design of Direct Current Machines*, CBS, 2004.
3. Fitzarald & Kingslay, *Electric Machinery*, TMH, 2011
4. P. S. Bhimbra, *Electrical Machinery*, Khanna Publication, 2011
5. D. P. Kothari & I. J. Nagrath, *Electric Machines* (4e), TMH, 2013.

FOURTH SEMESTER

EO2001: ECONOMICS – IV [3 0 0 3]

Introduction: Definition, nature and scope of economics, introduction to micro and macroeconomics; Microeconomics: Consumer behaviour, cardinal and ordinal approaches of utility, law of diminishing marginal utility, theory of demand and supply, law of demand, exceptions to the law of demand, change in demand and change in quantity demanded, elasticity of demand and supply, Indifference curve, properties, consumer equilibrium, Price and income effect; Production: Law of production, production function, SR and LR production function, law of returns, Isoquant curve, characteristics, Isocost, producer's equilibrium; Cost and revenue analysis: Cost concepts, short run and long- run cost curves, TR, AR, MR; Various market situations: Characteristics and types, Break-even analysis; Macro Economics: National Income, Monetary and Fiscal Policies, Inflation, demand and supply of money, consumption function and business cycle.

References:

1. H. L. Ahuja, *Macroeconomics Theory and Policy*, (20e), S. Chand Publication.
2. H. C. Peterson, *Managerial Economics*, (9e), 2012.
3. P. L. Mehta, *Managerial Economics*, Sultan Chand & Sons.
4. G. J. Tuesen and H.G. Tuesen, *Engineering Economics*, PHI.
5. J. L. Riggs, D. D. Bedworth and S. U. Randhawa, *Engineering Economics*, Tata McGraw Hill.

MA2206: ENGINEERING MATHEMATICS – IV [2 1 0 3]

Statistics: Mean, Median, Mode measures of dispersion. Finite sample spaces, conditional probability and independence, Bayes' theorem, one dimensional random variable, mean, variance, Chebyshev's inequality. Two and higher dimensional random variables, covariance, correlation coefficient, curve fitting. Binomial, Poisson, uniform, normal, gamma, Chi-square and exponential distributions. Moment generating function, Functions of one and two dimensional random variables, Sampling theory, Central limit theorem. Difference equations with constant coefficients, solutions. Z-Transforms and Inverse Z-transforms. Solutions of Difference equations using Z-transforms. Solution of boundary value problems, Numerical solutions of Laplace and Poisson equations, heat and wave equations by explicit methods.

References:

1. E. Kreyszig, *Advanced Engineering Mathematics*, 7(e), John Wiley & Sons, Inc., 2015.
2. A. V. Openheim & R. W. Schafer, *Discrete Signal Processing*, Prentice Hall, 2009.
3. R.V. Hogg and A.T. Craig, *Introduction to Mathematical Statistics* (4e), MacMillan, 2012.

4. R. Narayanan and M. Pillay, *Advanced Engineering Mathematics*, Vol 2 and 3, Vishwanthan Publishers Pvt Ltd, 2006.

EE2201 Electrical Machinery – II [3 1 0 4]

Induction Machines: Three phase Induction motor- construction and working principle, equivalent circuit and phasor diagram, losses and efficiency, torque-slip characteristics, no load & blocked rotor tests, starting, braking, speed control, Induction generator, Single phase induction motor - types, double field revolving theory, torque-slip characteristics. Synchronous Machines: Alternators– construction and working principle, EMF equation, Equivalent circuit of non-salient pole alternator, Phasor diagrams, voltage regulation, Synchronization, Synchronizing power and torque, power angle characteristics, Load sharing, Alternator connected to infinite bus, Equivalent circuit of salient pole alternator - Two reaction theory, Phasor diagrams, slip test. Synchronizing power and torque, power angle characteristics. Synchronous motors: working principle, Starting methods, Synchronizing power and torque, Performance characteristics, Hunting, Synchronous condenser.

References:

1. E. H. Langsdorf, *Theory of Alternating Current Machinery* (2e), TMH, 2004.
2. A. E. Clayton & N. N. Hancock, *Performance and Design of Direct Current Machines*, CBS, 2004.
3. D. P. Kothari & I. J. Nagrath, *Electric Machines* (4e), TMH, 2013.
4. Fitzarald & Kingslay, *Electric Machinery*, TMH, 2011
5. P. S. Bhimbra, *Electrical Machinery*, Khanna Publication, 2011

EE2202: GENERATION TRANSMISSION & DISTRIBUTION [3 1 0 4]

Generation of Electric Power: Hydro Electric Power Plants, Thermal and Nuclear Power Plants, Diesel Power Plant, Typical AC transmission and distribution scheme: Effect of system voltage and regulation, Distribution network elements, distribution schemes, Transmission Line Parameter Calculations, Transmission Line Performance, Ferranti effect, receiving end power circle diagram, regulated system of transmission by reactive power control, power factor improvement, Mechanical characteristics of Overhead lines: Line Insulators, Corona, Underground cables.

References:

1. J. Duncan Glover, Mulukutla S Sarma and Thomas J Overbye, *Power System Analysis and Design*, (5e), Cengage Learning, 2012.
2. S. N. Singh, *Electric Power Generation, Transmission & Distribution* (6e), PHI, 2011.
3. D. P. Kothari & I. J. Nagrath, *Power System Engineering* (2e), TMH, 2010.
4. C. L. Wadhwa, *Electrical Power System* (3e), New Age Intl, 2013.
5. B. R. Gupta, *Power System Analysis and Design* (7e), S. Chand Publications, 2014.

EE2203: MICROCONTROLLERS [2 1 0 3]

Introduction to microprocessors and microcontrollers, general purpose and embedded systems, CISC and RISC architectures, AT89C51 (8051) microcontroller: Architecture, pin diagram, addressing modes, instruction set, programming, stack, subroutines, GPIO, timers, serial port, interrupts. Interfacing keyboard, LCD, ADC and DAC to 8051. Embedded software development in 'C'. Programming 8051 in 'C'. ARM7 based NXPLPC21XX microcontroller: architecture, programming and interfacing.

References:

1. M. A. Mazidi and G. Mazidi, *The 8051 Microcontroller and embedded systems, using assembly and 'C'*, Pearson education, 2013.
2. K. Ayala, *The 8051 Microcontroller and embedded systems, using assembly and 'C'*, Cengage Learning, 2009.
3. S. Furber, *ARM System - on – Chip Architecture* (2e), Pearson, 2015.
4. W. Hohl and H. Christopher, *ARM Assembly Language*, CRC Press, 2016.

EE2230: ELECTRICAL MACHINERY LAB – II [0 0 2 1]

Induction machines: No load and blocked rotor tests, Load test on three phase squirrel cage & Slip ring Induction motor, Load test on induction generator. Load test on Single Phase Induction Motor. Synchronous Machines: V- and inverted V-curves of synchronous machines, Measurement of Xd and Xq of a salient pole synchronous machine, Predetermination of regulation of alternator. Synchronization of alternator, Design of Electrical machines.

References:

1. E. H. Langsdorf, *Theory of Alternating Current Machinery* (2e), TMH, 2004.
2. A. E. Clayton & N. N. Hancock, *Performance and Design of Direct Current Machines*, CBS, 2004.
3. Fitzarald & Kingslay, *Electric Machinery*, TMH, 2011
4. P. S. Bhimbra, *Electrical Machinery*, Khanna Publication, 2011
5. D. P. Kothari & I. J. Nagrath, *Electric Machines* (4e), TMH, 2013.

EE2231: MICROCONTROLLER LAB [0 0 2 1]

Module I: Experiments using 8051 Microcontroller simulator. Module II: Interfacing exercises using 8051 microcontroller, Module III: Experiments using ARM7 processor based microcontroller.

References:

1. M. A. Mazidi and G. E. Mazidi, *The 8051 Microcontroller and embedded systems, using assembly and 'C'*, Pearson education, 2013.
2. K. J. Ayala, *The 8051 Microcontroller and embedded systems, using assembly and 'C'*, Cengage Learning, 2009.
3. S. Furber, *ARM System - on -Chip Architecture* (2e), Pearson, 2016.

EE2232: MATLAB & SYSTEM SIMULATION LAB [0 0 2 1]

Introduction to MATLAB, Basics of MATLAB matrices and vectors, matrix and array operations, Saving and loading data, plotting simple graphs, scripts and functions, Script files, Function files, Global Variables, Loops, Branches, Control flow, Advanced data objects, Multi-dimensional matrices, Structures, Electric circuit simulation using MATLAB, data visualization, functions, file I/O and GUI, Introduction to SIMULINK, Steady state analysis of circuits, Transient analysis of RL, RC, and RLC circuits, Circuit simulation using Simscape. Simulation of basic electrical systems: PV System, Distribution System, Electrical vehicle system.

References:

1. D. Hanselman, *Mastering MATLAB 7*, Pearson Education, 2005.
2. S. J. Chapman, *Essentials of MATLAB Programming*, BAE Systems (3e), Cengage Learning, 2008.
3. A. Gilat, *MATLAB: An Introduction with Applications*, Wiley India Ltd., 2004
4. S. L. Eshkavilov, *MATLAB & Simulink Essentials: MATLAB & Simulink for Engineering Problem Solving and Numerical Analysis*, Lulu Publishing, 2017.

FIFTH SEMESTER

BB0026: ORGANISATION AND MANAGEMENT [3 0 0 3]

Meaning and definition of an organization, Necessity of Organization, Principles of Organization, Formal and Informal Organizations. Management: Functions of Management, Levels of Management, Managerial Skills, Importance of Management, Models of Management, Scientific Management, Forms of Ownership, Organizational Structures, Purchasing and Marketing Management, Functions of Purchasing Department, Methods of Purchasing, Marketing, Functions of Marketing, Advertising. Introduction, Functions of Personal Management, Development of Personal Policy, Manpower Planning, Recruitment and Selection of manpower. Motivation – Introduction, Human needs, Maslow's Hierarchy of needs, Types of Motivation, Techniques of Motivation, Motivation Theories, McGregor's Theory, Herzberg's Hygiene Maintenance Theory. Leadership - Introduction Qualities of a good Leader, Leadership Styles, Leadership Approach, Leadership Theories. Entrepreneurship-Introduction, Entrepreneurship Development, Entrepreneurial Characteristics, Need for Promotion of Entrepreneurship, Steps for establishing small scale unit. Data and Information; Need, function and Importance of MIS; Evolution of MIS; Organizational Structure and MIS, Computers and MIS, Classification of Information Systems, Information Support for functional areas of management.

References:

1. Koontz, Harold, Cyril O'Donnell, and Heinz Weihrich, Essentials of Management (1e), Tata McGraw-Hill, New Delhi, 1978.
2. Robbins, P. Stephen, and Mary Coulter, Management, Prentice Hall, (2e) New Delhi, 1997.
3. E. S. Buffa and R. K. Sarin, Modern Production / Operations Management, (8e), Wiley, 1987

4. H. J. Arnold and D. C. Feldman, Organizational Behavior, McGraw – Hill, 1986.
5. K. Aswathappa, Human Resource and Personnel Management, Tata McGraw Hill, 2005.
6. W. Wether & K. Davis, Human Resource and Personnel Management, McGraw Hill, 1986.

EE3101: COMMUNICATION SYSTEMS [2 1 0 3]

Elements of communication systems; Analog Communication techniques : Amplitude modulation Schemes, Angle (Non-Linear) Modulation; Pulse Modulation schemes ; Data transmission using analog carriers- Shift Keying techniques ; Channel Encoding & decoding technologies; Conceptual idea of encryption & decryption; Communication Protocols& Networking; Internet of Things; Wireless sensor actuator networks, Applications: Spread Spectrum & Mobile Communications - Optical fiber communication, Basic principles of Digital TV Broadcasting.

References:

1. S. Haykin, and Michael Moher, *Introduction to analog & digital communications*, John Wiley & Sons. 2007.
2. S. Haykin, *Communication systems*, John Wiley & Sons, 2008.
3. W. Stallings, *Cryptography and network security: principles and practices*, Pearson Education India, 2006.
4. D. Torrieri, *Principles of spread-spectrum communication systems*, Springer, 2015.

EE3102: DIGITAL SIGNAL PROCESSING [3 1 0 4]

Time domain analysis of discrete-time signals & systems: linear-time invariant systems, impulse response, convolution, causality and stability, representation of LTI systems, Frequency domain analysis of discrete-time signals and systems: Discrete-time Fourier series, Discrete-time Fourier transform, properties and applications, Z transform representation of discrete time signals and systems, properties and applications. Sampling in time and frequency domain. Discrete Fourier Transform-Linear convolution using DFT. Computation of DFT-Fast Fourier Transform, Decimation in time and Decimation in frequency FFT algorithms. Digital Filters-Digital filter structures, FIR and IIR filters. FIR filter design- FIR design by Fourier approximation, Window method, Frequency sampling method, Optimal FIR design. IIR filter design: Classical filter design using Butterworth and Chebyshev approximations, Impulse invariant and bilinear transformation methods, Frequency transformation technique for HP, BP and BS filter design. Direct design of IIR filters. Applications of DSP.

References:

1. S. Haykin, *Signals and Systems*, Wiley, 2007.
2. A. V. Oppenheim, Alan S. Willsky, and S. Hamid Nawab, *Signals and Systems* (2e), PHI, 2014.
3. J. G. Proakis and D.G. Manolakis, *Introduction to Digital Signal Processing*, PHI, 2009.
4. A. V. Oppenheim and R.W. Schafer, *Discrete time signal processing*, Pearson, 2009.
5. S. K. Mitra, DSP: A computer based approach (2e), TMH, 2006.

EE3103: MEASUREMENTS & INSTRUMENTATION [3 1 0 4]

Electrical instrumentation, characteristics, electromagnetic interference, instrumentation transformers, Moving Coil and Moving Iron Instruments, Bridge circuits for R, L and C measurements, Modern Transducers for R, L and C measurements, Signal Isolation (Magnetic and Optical), Charge amplifiers, Instrumentation amplifiers, Active filters, Sallen Key Topology, State Variable Filters, Sample & Hold circuits, Successive Approximation, Flash A/D Converter, PWMD/A converter, R 2R and Binary weighted D/A converter, Net metering concepts, Phasor Measurement Unit.

References:

1. K. Sawhney, *A course in electrical & electronic measurement and instrumentation*, Dhanpat Rai & Sons, 2014.
2. S. Franco, *Design with Operational Amplifiers and Analog Integrated Circuits*, McGraw Hill, 2014.
3. R. B. Northrop, *Introduction to Instrumentation & Measurements*, CRC Press, 2005.
4. H. Zumbahlen, *Linear Circuit Design Handbook: Analog Devices*, Elsevier, 2008.

EE3104: POWER SYSTEM ANALYSIS [3 1 0 4]

Single line diagram, per unit concept, selection and change of base quantities, three winding transformer in power system, symmetrical short circuit current calculation, current limiting reactors, selection of circuit breakers, symmetrical components, sequence networks, unsymmetrical fault analysis in loaded and unloaded system involving transformers, admittance model of power system, load flow solution by numerical method, stability studies, equal area criterion.

References:

1. J. J. Grainger and W. D. Stevenson, *Elements of Power System Analysis* (4e), TMH, 2015.
2. D. P. Kothari and I. J. Nagrath, *Modern Power System Analysis* (2e), TMH, 2013.
3. H. Saadat, *Power System Analysis* (3e), PSA Pub., 2010.
4. Elgerd Olle I., Electric Energy System Theory, TMH, 2011.

EE3130: DSP LAB [0 0 2 1]

Generation of waveforms, Sample and reconstruct analog signals, time and frequency response of LTI systems, Convolution, analysis of DTFT, DFT, Z transforms, pole zero diagrams, Spectrogram analysis of nonstationary signals, digital filter structures, Analysis of various classical discrete-time filters such as LP, HP, BP, BS, comb, notch, multi-notch, sinusoidal oscillators, all pass filters, FIR filter design, IIR filter design, simple applications of DSP in communication systems, speech processing, image processing, and electrical power.

References:

1. J.G. Proakis and D.G. Manolakis, *Introduction to Digital Signal Processing*, PHI, 2009.
2. A.V. Oppenheim and R.W. Schafer, *Discrete time signal processing*, Pearson, 2009.
3. S. K. Mitra, DSP: *A computer based approach* (2e), TMH, 2006.

EE3131: MEASUREMENTS & INSTRUMENTATION LAB [0 0 2 1]

Module 1: Familiarization of LabVIEW: Introduction to LabVIEW, Sub VI's and Loops, Case Structure, Express VI, Module 2: Measurement of physical signal like temperature, pressure, displacement. Measurement of electrical parameter, Power Measurement, Smart Metering, Signal conditioning: Realization of Instrumentation Amplifier, Realization of Analog Filter using TI ASLKv2010 Starter Kit, Module 3: Realization of a Digital Instrumentation System using PC: Realization of Digital spectrum analyser & digital voltmeter using LabVIEW.

References:

1. J. Jerome, *Virtual Instrumentation Using LabVIEW*, PHI Learning Pvt. Ltd., 2010.
2. K. R. K. Rao & C. P Ravikumar, *Analog system lab pro kit manual*, Mikro Elektronika Ltd. 2012.
3. J. Travis & J. Kring, *LabVIEW for Everyone: Graphical Programming Made Easy and Fun* (3e), Prentice Hall Professional, 2016.

EE3132: PROJECT BASED LEARNING LAB [0 0 2 1]

Project based learning aims to build students' creative capacity to work through difficult or complex problems. It encompasses student's involvement in designing, developing, and constructing hands-on solutions to a problem, commonly in small teams. Typically, Project based learning takes students through the following phases or steps: Identifying a problem, agreeing on or devising a solution and potential solution path to the problem (i.e., how to achieve the solution), Designing and developing a prototype of the solution, refining the solution based on feedback from experts, instructors, and/or peers. Depending on the goals of the instructor, the size and scope of the project can vary greatly.

SIXTH SEMESTER

EE3201: LINEAR CONTROL THEORY [2 1 0 3]

Classification of control systems, Mathematical modelling of electrical circuits/mechanical systems (translational & rotary)/electro-mechanical systems/geared systems, reduction of sub-systems, signal flow graphs, Time domain response of 1st and 2nd order systems, RH criteria, Root Locus technique, Bode plots, Nyquist Plots, Frequency domain based compensator design and their realization through OPAMPS, Design/realization of active P, PI, PID controllers for LTI systems, State equation, state space modelling, Physical variable form State space models from transfer function, Solution of state equation for continuous time system, State transition matrix, Controllability criteria, Observability criteria. Pole-Placement Design, Ackermann's Formula, State Estimation & Reduced-Ordered Estimators & Observers. MATLAB & SIMULINK for Linear Control Theory.

References:

1. Norman S. Nise, *Control Systems Engineering*, John Wiley & Sons, 2010.
2. K Ogata, Modern *Control Engineering*, Englewood Cliffs, NJ: Prentice Hall, 2010.
3. M. Gopal, *Control Systems: Principles and Design*, McGraw Hill, 2008.
4. B. C. Kuo, *Automatic Control Systems*, John Wiley & Sons, 2014.

EE3202: POWER ELECTRONICS [3 1 0 4]

Introduction to Power Electronics devices and protection: Thyristor family devices, principle of operation, IGBT operation, principles and ratings. Snubber designs, selection and protection, AC-DC converters: uncontrolled, semi-controlled, fully controlled and dual converters in single-phase and three-phase configurations, harmonic analysis, firing circuits and their designs. Choppers: Introduction to dc-dc conversion, buck, boost, buck-boost converters and Type E chopper. Inverters: Basics of dc to ac conversion, inverter circuit configurations and principle of operation, VSI and CSI, single and three-phase configurations, Square wave and sinusoidal PWM control methods and harmonic control. AC voltage controllers: Introduction to ac to ac conversion, single-phase and three-phase ac voltage controller circuit configurations, harmonic analysis, control, Cyclo-converters: single-phase to single-phase, three-phase to single-phase, three-phase to three-phase.

References:

1. D. W. Hart, *Introduction to Power Electronics*, PHI, 2010.
2. N. Mohan, T. M. Undeland, W. P. Robbins, *Power Electronics, Converters, Applications & Design* (2e), Wiley, 2001.
3. B. K. Bose, *Modern Power Electronics and AC Drives*, Pearson, 2002.
4. M. H. Rashid, *Power Electronics, Circuits, Devices and Applications*, PHI, 2010.
5. P. S. Bimbhra, *Power Electronics*, Khanna Publication, 2013

EE3203 SWITCH GEAR & PROTECTION [3 1 0 4]

Circuit breakers: Arc phenomenon, arc interruption theories, Current chopping, CB types: Oil circuit breakers, Air circuit breakers, SF6 CB, Vacuum CB, MCB, MCCB and HVDC circuit breakers. CB rating, testing, operating mechanism, Autoreclosure, Isolators and earthing switches, Fuses, low & medium voltage switchgear-layout, construction & mechanical interlocks, Gas Insulated Switchgear, Neutral grounding. Protective Relaying: Functions, characteristics, standard definition of relay terminologies, classifications & operating principles. Protection schemes for bus zone, transformer, alternator, transmission Line- Carrier Current Protection and Induction Motor. Introduction to Static Relays & Numerical relay.

References:

1. S. S. Rao, *Switchgear Protection and Power systems*, Khanna Publishers, 2015.
2. B. Ram and D. N. Vishwakarma, *Power System Protection & Switchgear*, MGH, 2014.
3. B. Ravindranath and M. Chander, *Power System Protection and Switchgear*, New Age International, 2018.
4. R. P. Singh, *Digital Power System Protection*, PHI, 2007.

EE3230: POWER ELECTRONICS LAB [0 0 2 1]

Power electronic devices – characteristics, AC-DC converters and its harmonic analysis, AC-AC converters, Speed control of DC motor, induction motor, Realization of DC to DC converter, Power electronic circuit simulation using MATLAB: AC to DC converter, DC to DC converter, DC to AC converter, AC to AC converter.

References:

1. D. W. Hart, *Power Electronics*, Tata Mcgraw-Hill, 2011.
2. N. Mohan, *Power Electronics, Converters, Applications & Design* (2e), Wiley, 2010.
3. B. K. Bose, *Modern Power Electronics and AC Drives*, Pearson, 2010.
4. A. S. Hadeed, *Simulation of Power Electronics Circuits using SIMULINK*, LAP LAMBERT Academic Publishing, 2014.

EE3231: POWER SYSTEMS LAB [0 0 2 1]

Module-I (Software based): YBUS and ZBUS formulation, Load flow study Newton-Raphson (N-R) and Fast Decoupled Load Flow (FDLF) Methods, Short Circuit Study, Contingency analysis, Optimal system operation & Unit Commitment, Transient stability analysis, Reactive power control and voltage stability, Simulations on MATLAB and DIgSILENT – Power Factory Software. Module-II (Hardware based): Over current protection using numerical relay- high set & low set protection, relay

characteristics, over/under voltage protection, Motor protection feeder, Transformer protection, Generator protection, fault analysis: symmetrical and unsymmetrical faults, Transmission line performance evaluation, standalone and grid tied solar PV system.

References:

1. I. J. Nagrath and D. P. Kothari, *Modern Power System Analysis*, Tata Mc-Graw Hill, 2003
2. J. J. Grainger and W. D. Stevenson, *Elements of Power System Analysis* (4e), Tata McGraw Hill, 2003.
3. H. Saadat, *Power System Analysis*, McGraw Hill, 2011.
4. G. J. Duncan, *Power System: Analysis & Design*, Cengage Learning, 2012.

EE 3232: CONTROL & AUTOMATION LAB [0 0 2 1]

Basics of PLC and its Applications, Totally Integrated Automation, Human Machine Interface. Different applications of Home Automation, Industrial Automation. Real-time Production Line. Automation using Blockchain. Real-time Hardware Implementation & Hardware-In-Loop Simulation for different Control Applications with LabVIEW/MATLAB. Process Control Trainer Kits with DAQ Cards. Modeling & Simulation using MATLAB, Inverted Pendulum, PID Controller, Smart Systems, Internet-of-Things & Intelligent Systems.

References:

1. Frank D. Petruzella, *Programmable Logic Controllers* (4e), Mc Graw Hill Education, 2016.
2. John Essick, *Hands On Introduction to LabVIEW* (2e), Oxford, 2013.
3. Jerome Jovitha, *Virtual Instrumentation using LabVIEW* (2e), PHI, 2010.
4. D. K. Chaturvedi, *Modelling and Simulation of Systems Using MATLAB and Simulink*, CRC Press; 2010.

EE3270: MINOR PROJECT - I [0 0 2 1]

The project work may be carried out in institute laboratory. An interim project report on the progress of the work shall be submitted to the department during the mid-term evaluation. The final evaluation and viva-voce will be conducted after submission of the final project report in the prescribed form. Students have to make a presentation on the work carried out, as part of project evaluation.

SEVENTH SEMESTER

EE4170: MINOR PROJECT - II [0 0 4 2]

The project work may be carried out in institute laboratory. An interim project report on the progress of the work shall be submitted to the department during the mid-term evaluation. The final evaluation and viva-voce will be conducted after submission of the final project report in the prescribed form. Students have to make a presentation on the work carried out, as part of project evaluation.

EE4171: SEMINAR / INDUSTRIAL TRAINING [0 0 2 1]

Each student has to undergo industrial training for a minimum period of 4 weeks. This may be taken in a phased manner during the vacation starting from the end of sixth semester; the student has to submit to the department a training report in the prescribed format with a power point presentation followed by viva. The report should include the certificates issued by the industry.

EIGHTH SEMESTER

EE4270: PROJECT WORK / PRACTICE SCHOOL - II

The project work may be carried out in an institution/ industry/ research laboratory. The duration of the project work shall be a minimum of 16 weeks which may be extended up to 24 weeks. A mid-semester evaluation of the project work shall be done after about 8 weeks. An interim project report on the progress of the work shall be submitted to the department during the mid-semester evaluation. The final evaluation and viva-voce will be conducted after submission of the final project report in the prescribed form. Students have to make a presentation on the work carried out, before the departmental committee, as part of project evaluation.

MINOR SPECIALIZATION

I. ELECTRIC VEHICLE TECHNOLOGIES

EE3254: DYNAMICS OF ELECTRIC VEHICLES [3 0 0 3]

Introduction: Classification, Analysis, Basic Components of Electric Vehicles, Electric Vehicle Modelling: General description of vehicle movement Rolling resistance, Aerodynamic drag, grading resistance, Acceleration resistance, Dynamic equation, Adhesion, Consideration of Vehicle Mass Dynamic wheel radius and slip, Electric Vehicle Vibration, Noise and Control, Braking Efficiency and Braking Distance. Power Train & its Performance: Introduction of Drive power train Configuration, Classification of Power Train, selection of a Power Train, operating performance, Economy, Environmental effects, Compare characteristic curves of different Power Train, Drive train tractive effort and vehicle speed, Maximum Cruising Speed, Acceleration Performance, Traction control system, Anti-lock Braking system, Hydraulic unit for ABS and EPS. Overview on effect of safety system on Dynamics of Vehicle. Modelling and simulation of Vehicle Dynamics.

References:

1. Reza N. Jazar, *Vehicle Dynamics: Theory and Application*, Springer, 2017.
2. R. Rajamani, *Vehicle Dynamics and Control*, Springer, 2011.
3. A. F. Andreev, V. Kabanau and V. Vantsevich *Driveline Systems of Ground Vehicles: Theory and design*, CRC Publishers 2010.

ELE 4159: DESIGN & MODELLING OF SPECIAL ELECTRICAL MACHINES [3 0 0 3]

Permanent Magnets Machines, Introduction to Inverters and Their Control. Dynamic Modelling of Permanent Magnet Synchronous Machine, Control Strategies for a Permanent Magnet Synchronous Machine, Flux-Weakening Operation, Design of Current and Speed Controllers, Parameter Sensitivity and Compensation, Rotor Position Estimation and Position Sensor less Control, PM Brushless DC Machine, Commutation Torque Ripple and Phase Advancing, Half-Wave PMBDCM Drives, Design of Current and Speed Controllers, Sensorless Control of PMBDCM Drive.

References:

1. R. Krishnan, *Permanent Magnet Synchronous and Brushless DC Motor Drives*, CRC Press, 2009.
2. Md. Enamul Haque, Permanent Magnet Synchronous Motor Drives: Analysis, *Modeling and Control*, VDM Verlag, 2009.
3. Chang-liang Xia, *Permanent Magnet Brushless DC Motor Drives and Controls*, Wiley, 2012.

EE4160: Electric Vehicle Power Converters & Drives [3 0 0 3]

Power Electronics & its Control Circuits: Basic Power Electronic Devices, EV configuration based on power converters, DC–DC Converter Topologies, Soft-Switching DC–DC Converter, Four Quadrants control strategy, PWM Switching Inverters, Voltage Source Inverters, Current Source Inverters, Control Techniques, bidirectional power flow converters controlling approach, Electric Drives in Electric Vehicles: Brushed-DC Electric Machine for Automotive Applications, Induction Motor Drives, Basics of speed control of Induction Motors, regenerative braking operation, different transient operation of the induction motor drives, soft starting, variable frequency drives, Fundamentals of Scalar and Vector control for Induction Motors, Brushless DC Drives, Sensorless Brushless DC Drives, Testing of Electric Motors and power electronics controllers for Electric vehicle, Modelling & Simulation using Matlab/Simulink: DC to DC converter controlled BLDC motor based vehicle system, Variable frequency control of Induction motor vehicle system and PWM Inverter with its control circuit.

References:

1. K. T. Chau, *Electric Vehicle Machines and Drives*, Design, Analysis and Application, John Wiley & Sons Singapore P. Ltd, 2015.
2. S. Soylu, Electric Vehicles –*Modelling and Simulations*, In Tech, 2011
3. P. Krause, O. Wasynczuk, S. Sudhoff and S. Pekarek, *Analysis of Electric Machinery and Drive Systems*, Third Edition, IEEE Press, 2015.

EE4161: Charging Technologies for Electric Vehicle [3 0 0 3]

Charging Protocols national & international standards. Architecture of the charging station. Key equipment's, Fundamental of rechargeable batteries and capacitors. Batteries management systems its performance, charging and discharging of a battery, storage density, energy density, and safety issues. Types of Charger, Conductive charging, Inductive Charging, Level 1,2 & 3 Charging Scheme, charging modes: Converter topologies, Charging methods- constant current (CC), constant voltage (CV), constant power (CP), taper charging, trickle charging, constant current/constant voltage (CC/CV). Fast charging strategies: Pulse-charging and negative pulse-charging of an EV battery. Effects of fast charging on battery life, Grid-to-Vehicle, Vehicle-to-Grid, Sharing Electric Charge Points and Parking Spaces, Electric Vehicle Solar Charging Stations. Impact of Plug-in Charging Current and Temperature on the Power Distribution System. Optimal design of electric vehicle charging station. Wireless Charging System Structure, Technologies & its Regulation: Wireless Power Transfer for Electric Vehicles, Architecture of the wireless charging station, key equipment's and technologies for Wireless charging, Selection of Optimum Frequency and Optimization, Optimum Design of Wireless Power Transfer System, The Economics of Wireless Charging on the Road, Regulatory and Safety Issues.

References:

1. I. S. Bayram and Ali Tajer, *Plug-In Electric Vehicle Grid Integration*, Artech House, 2017.
2. Quiwei Wu, *Grid Integration of Electric Vehicles in Open Electricity Market*, Wiley, 2013
3. S. Rajkaruna and F. Shahnia, *Plug In Electric Vehicles in Smart Grids*, Springer, 2015
4. S. Dhameja, *Electric Vehicle Battery Systems*, Newnes, 2001.

II RENEWABLE ENERGY SYSTEMS

EE3255: RENEWABLE ENERGY SOURCES [3 0 0 3]

Energy sources and their availability, Solar Energy - Solar radiation and measurements, solar energy storage, Solar Photo-Voltaic systems design- Wind Energy- Estimation, Maximum power and power coefficient, wind energy conversion systems, design considerations and applications. Energy from Bio-Mass- Sources of bio-mass, Biomass conversion technologies, Thermo-chemical conversion and Biochemical conversions, Anaerobic digestion and Fermentation, Bio-gas generation Pyrolysis and Liquefaction, Classification of Gasifiers, Geo-Thermal Energy, Energy plantation- Energy from the Oceans, Ocean Thermal Energy Conversion, Open and Closed Cycle plants, Site selection considerations, Origin of tides, Tidal energy conversion systems, Wave energy conversion systems, Hybrid Energy Systems.

References:

1. B. H. Khan, *Non-conventional Energy Resources*, TMH, 2009.
2. J. W. Twidell & A. D. Weir, *Renewable Energy Resources*, ELBS, 2005.
3. D. Mukherjee & S. Chakrabarti, *Fundamentals of Renewable Energy Systems*, New Age Intl., 2004.
4. G. D. Rai, *Non-Conventional Energy Sources*, Khanna Publishers, 2004.

EE 4162: SOLAR PHOTOVOLTAIC SYSTEMS [3 0 0 3]

Solar Radiation: Spectrum, Terminologies, Measurement, Estimation; Sun-Earth Movement & Angles, Sun Tracking, PN Junction Diode & Characteristics, Solar Cell, Photovoltage, Light Generated Current, I-V equation & Characteristics: Short Circuit Current, Open Circuit Voltage, Maximum Power Point, Fill Factor, Efficiency, Losses, Equivalent Circuit, Effect of Series & Shunt Resistance, Solar Radiation, Temperature on Efficiency, Solar PV Modules: Series & Parallel connection, Hotspots, Bypass & Blocking Diodes, Power Output, Ratings, I-V & Power Curve, Effect of Solar Irradiation & Temperature, Balance of System (BOS): Batteries: Classification, Capacity, Voltage, Depth of Discharge, Life Cycle, Factors affecting Battery Performance; Charge Controllers, DC to DC Converters, DC to AC converters, Maximum Power Point Tracking (MPPT).

References:

1. C. Solanki, *Solar Photovoltaics: Fundamentals, Technologies and Application*, PHI New Delhi, 2009.
2. G. N. Tiwari, *Solar Energy: Fundamentals, Design, Modeling and Applications*, Narosa Publications New Delhi, 2013.

3. S. Deambi, *Photovoltaic System Design*, CRC Press USA, 2016.
4. F. Kreith and D. Y. Goswami, *Energy Management and Conservation Handbook* (2e), CRC Press USA, Fairmont Press, USA, 2017.
5. J. Balfour, M. Shaw and N. B. Nash, *Advanced Photovoltaic Installations*, Jones & Barlett Learning USA, 2013.

EE 4163: WIND ENERGY CONVERSION SYSTEMS [3 0 0 3]

Wind Energy Basics: Status, Advantages and disadvantages of wind energy systems, Types of wind energy converters, local Effects on wind, site selection: roughness length, wind shear, Wind Speed Variability, Obstacles to wind flow, Working principles of wind energy: Energy content in wind, Energy Conversion at the Blade, Wind variations: Weibull distribution. Components of a wind energy converter: Rotor Blades, Gearboxes, Synchronous or Asynchronous Generators, Towers, Miscellaneous components, Turbine Selection Operation and Control of Wind Energy Converters: grid requirements, Issue of Noise and Its Control, Power Curve and Capacity Factor, Pitch control, Stall Control, Yaw Control.

References:

1. B. H. Khan, *Non-conventional Energy Resources*, TMH, 2006.
2. T. Burton, D. Sharpe, N. Jenkins and E. Bossanyi, *Wind Energy Handbook*, John Wiley & Sons, (1e), 2001.
3. S. Mathew, Wind Energy, *Fundamentals, Resource Analysis and Economics*, Springer, 2006.
4. S. N. Bhadra, S Banerjee and D. Kastha, *'Wind Electrical Systems'*, Oxford University Press, (1e), 2005.

EE 4164: DISTRIBUTED GENERATION SYSTEMS [3 0 0 3]

Introduction to Distributed Generation Systems- Principle and Structure of DGS- Features of DGS, Distributed Generation Technologies Overview, Integrating Distributed Energy Resources with the Grid, Planned/non-planned DG, Micro Grid and it's features. DG- Technologies: Wind Energy Conversion System, Photovoltaic Systems PV grid tied systems and different configurations. Micro turbine Generation, Small Hydro Generation Systems, Fuel Cells. Energy Storage Technologies- Different Energy storage technologies-Overview, Design Issues and control of Distributed Generation Systems-General model of DGS, Technical Regulation of DG integration, DG Optimization and Energy Management.

References:

1. G. B. Gharehpetian and S. Mohammad Mousavi Agah, *Distributed Generation Systems: Design, Operation and Grid Integration*, Butterworth-Heinemann, 2017.
2. Mahmoud, S. Magdi, AL-Sunni, and M. Fouad *Control and Optimization of Distributed Generation Systems*, Springer International Publishing, 2015.
3. Bo Zhao, C. Wang, and X. Zhang, *Grid Integrated and Standalone Photovoltaic Distributed Generation Systems Analysis, Design and Control*, Wiley, 2017.

III CONTROL SYSTEMS

EE 3256: SYSTEM IDENTIFICATION [3 0 0 3]

Introduction to system modelling, Types of system models, Importance of system models, Model development techniques – first principle based and data driven based, Introduction to System Identification, Procedure for identification, Concept of Identifiability, Signal to Noise Ratio, Overfitting, LTI System Modelling using time and frequency, Direct impulse response identification, Direct step response identification, Impulse response Identification using step response, Empirical Transfer function Identification, Correlation Methods, Linear Regression, Least Square Estimation, Equation Error Models – ARX Models, ARMAX Models, ARIMAX Models, OE Models, Box Jenkins Model, Model Validation Techniques.

References:

1. A. K. Tangirala, *Principles of System Identification Theory and Practice*, CRC Press, 2016.
2. K. J. Keesman, *System Identification – An Introduction*, Springer, 2011.
3. L. Ljung, *System Identification: Theory for the User* (2e), Prentice Hall,1998.

EE 4165: ROBUST CONTROL [3 0 0 3]

Introduction, Issues in Control System Design, Norms for signals and systems, Input- Output Relationships, Computing the Norm by State-Space Methods, Condition for Internal stability, sensitivity and complementary sensitivity function, Asymptotic Tracking, Performance, Sources of Model Uncertainties, Plant Uncertainty Model, Small Gain Theorem, Robust Stability, Robust Performance, Existence of Stabilizing Controllers, Parameterization of All Stabilizing Controllers, Coprime Factorization. Loop shaping with C, Shaping S, T, or Q, P-1 Stable, P-1 Unstable, The Modified Problem, Spectral Factorization, Case Studies-Robust Control for Mass Damper Spring Systems, Spacecraft and Inverted Pendulum.

References:

1. J. C. Doyle, B. A. Francis and A. Tannenbaum, *Feedback Control Theory*, Macmillan publishing co.,1990.
2. K. Zhou, J. C. Doyle and K. Glover, *Robust and Optimal Control*, Prentice Hall, Inc New Jersey.1995.
3. W. A. Wolovich, *Automatic Control Systems*, Saunders college publishing.1994.
4. K. Zhou and J. C Doyle, *Essential of Robust Control*, Prentice Hall Inc, New Jersey.1998.
5. R. C. Dorf and H. R. Bishop, *Modern Control Systems*, Addison Wesly Longman. Inc, 1998.

EE4166: NON-LINEAR CONTROL SYSTEM [3 0 0 3]

Introduction, Lyapunov stability using Krasovskii's method, Variable Gradient method, L2 stability of state models, L2 gain, small gain theorem, Passivity, Memory less functions, L2 gain and Lyapunov stability, passivity theorems, passivity based control, Review of describing function method, Absolute Stability Circle criterions, Popov Criterion, stabilization via linearization and Integral control, Gain scheduling, Graphical Linearization Methods, Analytical Linearization Method, Evaluation of Linearization Coefficients by Least-Squares Method, Local linearization, Feedback linearization, Input-state linearization, Input-output linearization, Internal dynamics, Zero dynamics, Model Reference Adaptive Control (MRAC). Sliding Mode Control, sliding surfaces, continuous approximations of switching control laws, modeling performance trade off, Tracking regulation via Integral control, Lyapunov redesign, non-linear damping, Back Stepping.

References:

1. H.K. Khalil, *Nonlinear Systems* (3e), Prentice Hall, 2002.
2. R. Marino and P. Tomei, *Nonlinear Control Design - Geometric, Adaptive and Robust*, Prentice Hall, 1995.
3. J.J.E. Slotine and W.Li, *Applied Nonlinear control*, Prentice Hall, 1998.
4. Alberto Isidori, *Non-linear Control Systems*, Springer Verlag, 1999.

EE4167: OPTIMAL CONTROL [3 0 0 3]

Foundation of Optimization Technique: Necessary and sufficient conditions for optima; convex analysis; unconstrained optimization; descent methods; Introduction to optimal control, Calculus of Variations and Optimal Control: Linear Quadratic Optimal Control Systems: Linear Quadratic Tracking System: Finite-Time and Infinite Time Case, Discrete-Time Optimal Control Systems: Variational Calculus for Discrete-Time Systems, Fixed-Final State and Open-Loop Optimal Control, Free-Final State and Open-Loop Optimal Control, Discrete-Time Linear State Regulator System, Kalman filter and duality, Steady-State Regulator System, Pontryagin Minimum Principle: The Hamilton-Jacobi-Bellman Equation, LQR System Using H-J-B Equation, Time Optimal Control System, Fuel-Optimal Control Systems. Game Theoretic Optimal Control Design

Reference:

1. D. E. Kirk., *Optimal Control Theory: An Introduction*, Dover publication, 2012.
2. D. G. Hull., *Optimal Control Theory for Applications*, Springer International, 2003.
3. B. D. O. Anderson and J. B. Moore, *Optimal Control: Linear Quadratic Methods*, Dover publication, 2007
4. D. S. Naidu., *Optimal Control Systems*, 1st ed., CRC Press., 2003.

IV POWER & ENERGY SYSTEMS

EE3257: COMPUTATIONAL TECHNIQUES IN POWER SYSTEM ANALYSIS [3 0 0 3]

Review of Power System Components: Network Matrices, Bus Impedance matrix, admittance matrix formation and modification of bus impedance matrix in three phase networks, Short Circuit Studies, symmetrical and asymmetrical faults: ZBUS and YBUS matrices for short circuit studies, short circuit

calculations using ZBUS, symmetrical component analysis: calculation of currents and voltages, load Flow Studies: PQ, PV and slack buses, bus mismatch, Gauss-Seidal, Newton-Raphson and Fast Decoupled methods of load flow analysis, Stability Studies: Transient Stability, Swing equation, synchronous machine and induction machine equations, representation of load, modified Euler and Range-Kutta methods of transient stability analysis.

References:

1. M. A. Pai, *Computer Techniques in Power System Analysis*, (2e) Tata McGraw-Hill, New Delhi, 2005.
2. H. Saadat, *Power System Analysis*, TMH, 2004.
3. J. J. Grainger and W. D. Stevenson, *Elements of Power System Analysis* (4e), TMH, 2015.
4. E. V. Krishnamurthy and S. K. Sen, *Computer Based Numerical Algorithms*, East-West Press, New Delhi, 2008.

EE3258: POWER SYSTEM OPERATION & CONTROL [3 0 0 3]

Basic introduction to power system operations and control: The structure of modern electrical power system, Operating states of power system, Basic power system control and objectives - generating unit controls. Automatic Generation Control (AGC): Basic generator control loops, automatic load frequency control (ALFC), Mathematical modelling of turbine speed-governing system, steam turbine model and generator load model, complete block diagram representation, stead-state and dynamic analysis, Concept of control area- single and two area control, proportional-integral controller. Automatic Voltage Regulator (AVR): basic control loop, block diagram representation- exciter system, generator models, stability of excitation system. Reactive Power & Voltage Control: Necessity of voltage control, generation and absorption of reactive power, methods of reactive power/voltage control, reactive power flow and voltage collapse, concept of voltage stability, synchronous generator capability curve, reactive power compensation- series & shunt compensation. Economic Operations: Basics formulations of Economic Load Dispatch (ELD) and Unit Commitment (UC).

References:

1. P. Kundur, *Power System Stability Analysis & Control*, Tata Mc Graw Hill, 2006.
2. A. Wood & B. F. Woolenberg, *Power System Operation & Control*, John – Wiley, 2003.
3. S. Sivanagaraju & G. Sreenivasan, *Power System Operation and Control*, Pearson, 2013.
4. J. J. Grainger and W. D. Stevenson, *Elements of Power System Analysis* (4e), Tata McGraw Hill, 2003.
5. I. J. Nagrath & D. P. Kothari, *Modern Power System Analysis*, Tata Mc-Graw Hill, 2011.

EE4168: POWER SYSTEM RESTRUCTURING & DEREGULATION [3 0 0 3]

Introduction to Restructuring of Power Industry: Basic Terminology- Restructuring, Competition and Deregulation, Deregulation of power industry, Restructuring process, Issues involved in deregulation- Causes, Types and Effects of Restructuring, Deregulation of various power systems. Fundamentals of Economics: Consumer behaviour, Supplier behaviour, Market equilibrium, Short and long run costs, various costs of production, Types of Market Environments. Market models: Market models based on Contractual arrangements, Comparison of various market models, Electricity and other commodities, Market architecture, Role of the Independent System Operator (ISO), Operational planning activities of ISO- ISO in Pool markets, ISO in Bilateral markets, Transmission Congestion Management and Pricing: Power wheeling, Transmission open access, Transmission Pricing Schemes, Transmission Cost Allocation Methods of congestion management in deregulation. Ancillary Services Auction Market: General description of various ancillary services, ancillary services management in various countries, and reactive power management in the deregulated electricity markets.

References:

1. K. Bhattacharya, M. Bollen and J.C Daalder, *Operation of Restructured Power Systems*, Kluwer Academic Publishers, USA, 2001.
2. M. Shahidehpour, H. Yamin and Z. Li, *Market Operations in Electric Power Systems-Forecasting, Scheduling, and Risk Management*, John Wiley & Sons, Inc., New York; 2002.
3. D. Kirschen and G. Strbac, *Fundamentals of Power System economics*, John Wiley & Sons Ltd, 2004.
4. C. Harris, *Electricity Markets: Pricing, Structures and Economics*, John Wiley & Sons Ltd, 2006.

EE 4169 SMART GRID TECHNOLOGIES [3 0 0 3]

Smart Grid Overview- Smart Grid evolution, Definition of the Smart Grid, Key Characteristics of Smart Grid, Key Functions of a Smart Grid, Smart Grid Elements. Traditional Electric Grid Model, Generation, Transmission, Distribution, Energy Storage, Micro-grids, Integration of new technologies into the grid, Smart Grid vision and its realization in Urban/Rural, Smart Grid infrastructure, Functionality, Reliability, Cost/Tariff, Standards, Smart Grid cyber security, Smart Grid Operations-Electric Grid (power delivery), SCADA (supervisory control and data acquisition), Smart Grid Control Layer-fault detection and location, Data collection and management, Control Layer Infrastructure, Software-Define Networks (SDN), Control Algorithms, Volt-VAR control, Distribution automation, Grid storage systems, Intermittent renewable, Cooperative grids.

References:

1. J. Momoh, *Smart Grid: Fundamentals of Design and Analysis*, IEEE press, John Wiley & Sons, 2012.
2. T. Sato, Daniel M. Kammen, B. Duan, M. Macuha, Z. Zhou, and Jun Wu, *Smart Grid Standards: Specifications, Requirements, and Technologies*, Wiley-Blackwell, 2015.
3. J. Ekanayake, K. Liyanage, Jianzhong Wu, A. Yokoyama, and N. Jenkins, *Smart Grid: Technology and Applications*, Wiley, New Delhi, 2015.
4. L. T. Berger and K. Iniewski, *Smart Grid Applications, Communications, and Security*, Wiley, New Delhi, 2015.
5. K. Salman, *Introduction to the Smart Grid: Concepts, Technologies and Evolution*, The Institution of Engineering and Technology, United Kingdom, 2017.

V COMPUTER ENGINEERING

EE3240: DATA STRUCTURES & ALGORITHMS [3 0 0 3]

Pseudo-code, algorithm analysis, asymptotic notations, iterative and recursive algorithms. Data Structures, data structure operations, review of arrays, structures, Stacks and Queues, stack and queue operations, array representation of stacks and queues, queues and stacks using linked lists, applications of queues and stacks. Properties of Binary search trees, array and linked list representation of binary search trees, binary search tree traversals. Graphs and their representations, application of graphs. Searching and sorting methods. Algorithm design techniques – Greedy, Divide and Conquer, Dynamic programming and Backtracking. Addressing limitations of algorithmic power - P, NP, and NP-Complete Problems.

References:

1. Cormen, Leiserson and Rivest, *Introduction to algorithms*, (3e), MGH, 2009.
2. Aho, Hopcroft and Ulmann, *Design and Analysis of Algorithms*, (1e), Pearson 2002.
3. Aho, Hopcroft and Ulmann, *Data Structures & Algorithms*, (1e), Pearson 2002.
4. Horowitz and Sahni, *Fundamentals of computer algorithms*, (1e), Universities Press. 2008.
5. S. Lipschutz, *Data Structures with C*, Schaum's ouTlines, McGraw Hill Education, 2011

EE3245: COMPUTER NETWORKS [3 0 0 3]

Introduction to computer networks and Internet, network edge and core, delay and throughput in packet switched networks, Protocol layers and their service models. Session, Presentation, and Application Layers. Examples: DNS, SMTP, FTP, HTTP. Transport layer: UDP, TCP. Connection establishment and termination, flow and congestion control, timers. Network layer: Internet Protocol, IPv4, IPv6, ICMP, Network Address Translation. Routing algorithms: Distance vector, Link state, Metrics, Inter-domain routing. Link Layer: Error detection (Parity checks and CRC), Multiple Access Protocols - ALOHA, CSMA. Switched LANs addressing, ARP, Ethernet-Gigabit Ethernet, VLANs. Datacentre networking. Wireless LANs-Wi-Fi (802.11). Multimedia Networking - UDP and HTTP streaming, Voice-over-IP, Case studies- Skype, YouTube, Case study on Webpage request, Overview of Software defined Networks (SDN)

References:

1. A. S. Tanenbaum, DJ Wetherall, *Computer Networks* (5e), Prentice Hall, 2010.
2. L. L. Peterson, BS Davie, *Computer Networks: A Systems Approach* (5e), Morgan-Kauffman, 2011.
3. J. F. Kurose and K. W. Ross, *Computer Networking: A Top-Down Approach* (5e), Addison-Wesley, 2009.

4. W. Stallings, *Cryptography and Network Security, Principles and Practice* (5e), Prentice-Hall, 2010.

EE4142: MACHINE LEARNING [3 0 0 3]

Machine learning basics, Naïve Bayesian Model. Non-Parametric Techniques: Density Estimation, Parzen Windows, k- Nearest-Neighbour Estimation, K- nearest neighbour classification, Radial Basis Function Network, Learning Vector Quantization, Clustering, K-Means clustering, Competitive learning, Self-Organizing Maps, Recurrent Neural Network, Hopfield Neural Network, Adaptive Resonance Theory, Support vector machines, Statistical Hypothesis testing- t-test, ANOVA, feature selection methods – Filter based techniques and wrapper methods, Principal Component Analysis, Applications of PCA, PCA ,Independent component analysis, Voting, Error correcting output codes, Bagging, Boosting.

References:

1. E. Alpaydin, *Introduction to Machine Learning*, (2e), MIT Press. 2010.
2. R. O. Duda, Peter E. Hart, David G. Stork, *Pattern Classification*, (2e), Wiley, 2001.
3. P. Harrington, *Machine Learning in Action*, Manning Publications, 2012.
4. C. M. Bishop, *Pattern Recognition and Machine Learning*, Springer, 2007.
5. R. Jensen, Qiang, Shen *Computational Intelligence and Feature Selection: Rough and Fuzzy Approaches*, Vol. 8, IEEE Press Series on Computational Intelligence, John Wiley & Sons, 2008.

EE4143: DATA ANALYTICS [3 0 0 3]

Introduction to Data science, Data analytics. Similarity, sequencing, sampling and quantization. Data Pre-processing, Error types, Error handling, Filtering, Data transformation and Data integrations. Modelling with data and Data visualizations. Correlation and causality tests. Regression analysis, Forecasting, Classification and clustering techniques. Introduction to Python-programming for data analytics.

References:

1. T. A. Runkler, *Data Analytics Models and Algorithms for Intelligent Data Analysis* (2e) Springer Publications, 2016.
2. S. A. Pardo, *Empirical Modeling and Data Analysis for Engineers and Applied Scientists*, Springer International Publishing, 2016.
3. W. L. Woon, Z. Aung, O. Kramer, S. Madnick, *Data Analytics for Renewable Energy Integration*, Springer 2017.
4. R. I. Kabacoff, *R in action: Data analysis and graphics with R*, Manning Publications C, 2011

OTHER PROGRAMME ELECTIVES

EE3241: DATABASE MANAGEMENT SYSTEMS [3 0 0 3]

Data-base system applications, Data models, schemas and instances. Three-schema architecture and data independence. Entity-Relationship Model: Entity, Attribute, Constraints. Relational model Concepts, Relational algebra: SELECT, PROJECT and DIVISION. Relational database design using ER-to-Relational Mapping. Structured Query Language (SQL), Queries in SQL. Query processing and optimisation, Database design: Functional dependencies, normalisation. Transaction management: ACID properties, concurrency control, transactions and scheduling, locking. Data warehousing, datamining and data analytics. Applications and case studies.

References:

1. AviSilberschatz, Henry F. Korth, S. Sudarshan, *Database System Concepts* (6e), McGraw-Hill, 2016.
2. Ramez Elmasri, Shamkant B. Navathe, *Fundamentals of Database Systems* (7e), Pearson, 2016.

EE3242: OBJECT ORIENTED PROGRAMMING [3 0 0 3]

Introduction to fundamental concepts of programming language, Object Oriented Programming paradigm, Characteristics of object-oriented languages. Classes and Objects: Class specification, Class objects, Accessing Class Members, Static members, Constructors and Destructors, Parameterized constructors, Multiple Constructors, Friend function. Operator Overloading & Type

conversion: Defining operator overloading, Overloading Unary and Binary operators, Overloading using friend function, Type conversion: Basics to class type, class to basic type and class to another class type. Inheritance: Derived class and base class, Types of inheritance, Levels of Inheritance, Single inheritance, Multiple Inheritance, Hierarchical inheritance and Hybrid inheritance. Polymorphism: Virtual Functions: Pure function, Friend classes. Files and Exception Handling: Classes for file stream operation, Opening and closing a file, file modes, file pointers and manipulators. Exception handling mechanism: throwing, catching all the exceptions.

References:

1. J. Rumbaugh et. al, "Object Oriented Modeling and Design", PHI, 2004
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3. R. Lafore, "*Object Oriented Programming in Turbo C++*", (3e), Galgotia Publications Pvt. Ltd., New Delhi, 2006
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5. H. Schildt, "*The Complete Reference C++*", (4e), TMH, New Delhi, 2004

EE3243: ARTIFICIAL INTELLIGENCE [3 0 0 3]

Foundation and History of AI, State of the art, Fields of application , Performance measures, Rationality, Specification and properties of task environment, Structure of Agents, Problem solving by searching, Searching for solutions, uninformed search strategies, Informed search strategies, Heuristic functions, Local search algorithms, Online search agents, Knowledge based agents, The Wumpus World, Propositional logic – reasoning patterns, effective inference, First order logic - Syntax and semantics, Knowledge engineering, Inference rule, forward and backward chaining, Ontological engineering, categories and objects, Processes and intervals, reasoning systems, Truth maintenance systems, Uncertainty, Basic probability notation, Axioms, Baye's rule, Bayesian networks, Inference in Bayesian networks.

References:

1. S. Russell and P. Norvig, *Artificial Intelligence: A Modern Approach* (3e), Pearson, 2012.
2. E. Rich, K. Knight and Shivashankar B. Nair, *Artificial Intelligence* (3e), Tata McGraw Hill, 2012.
3. D. Poole and A. Mackworth, *Artificial Intelligence: Foundations of Computational Agents* (2e), Cambridge University Press, 2017

EE3244: SOFT COMPUTING TECHNIQUES [3 0 0 3]

Introduction to Soft computing, soft computing techniques, Artificial Neural Networks, Multilayer Perceptron, Gradient descent, Logistic discrimination, Single layer Perceptron, Training a perceptron, Multilayer perceptron, Back-Propagation Algorithm, Fuzzy Systems, Fuzzy Logic, Membership Functions, Fuzzy Controllers, Evolutionary Algorithms, Genetic Algorithms, Other Optimization Techniques, Metaheuristic Search, Traveling Salesman Problem, Introduction to hybrid systems, Adaptive Neuro-Fuzzy Inference Systems, Evolutionary Neural Networks, Evolving Fuzzy Logic, Fuzzy Artificial Neural Networks.

References:

1. J. M Zurada, *Introduction to Artificial Neural Systems*, Jaico publication. 2016
2. T. J. Ross, *Fuzzy Logic with Engineering Applications*, (Intl. e), McGraw Hill publication, 2012.
3. S. Haykin, *Neural Networks and Learning Machines*, PHI, 2008
4. Shivanandam & Deepa, *Principles of Soft Computing*, Wiley India edition, 2009.
5. Rajasekaran and G. A. Vijayalakshmi Pai, *Neural Networks, Fuzzy Logic and Genetic Algorithms*, PHI Learning,2003

EE3246: UTILIZATION OF ELECTRIC POWER [3 0 0 3]

Electric Drives: Type of electric drives, choice of motor, starting and running characteristics, speed control, temperature rise, Particular applications of electric drives, Types of industrial loads, continuous, Intermittent and variable loads, load Equalization. Electric Heating: Advantages and methods of electric heating, resistance heating, induction heating and dielectric heating. Electric Welding: Electric welding, resistance and arc welding, electric welding equipment, comparison between A.C. and D.C. Welding. Electric Traction: System of electric traction and track electrification. Review of existing electric traction systems in India. Special features of traction motor, methods of electric braking-plugging, rheostatic braking and regenerative braking, Mechanics of train movement. Speed-time curves for different services – trapezoidal and quadrilateral speed time curves. Calculations of tractive effort, Illuminations.

References:

1. C. L. Wadhwa, *Generation, Distribution and Utilization of electrical Energy* (3e), New Age International (P) Limited Publishers, 2010.
2. N. V. Surya Narayana, *Utilization of Electrical Power including Electric drives and Electric traction* (1e), New Age International Publishers, 1996.
3. A. K. Sawhney, *A course in Electronic Measurements and Instrumentation*, Dhanpat Rai & Co., 2015
4. H. Partab, *Modern Electric Traction*, Dhanpat Rai & Co., 2017

EE3247: INTRODUCTION TO ELECTRIC VEHICLE [3 0 0 3]

History of electric vehicles (EV) and hybrid electric vehicles (HEV), need and importance of EV and HEV, comparison between IC engine and Electric vehicle. Electric Vehicle: Configuration of Electric Vehicle, Electric Propulsion Unit- DC machines (BLDC & BDC), three phase A/c machines, Induction machines, switched reluctance machines. Power Convertor- DC to DC, DC to AC and AC to DC Convertors. Electric Vehicle Drive Train -Transmission configuration, Components – gears, differential, clutch, brakes regenerative braking, motor sizing. Sizing the drive system: Sizing the propulsion motor, power electronics, Energy Source System- Types of batteries, Parameters – Capacity, C-rate, SOC, DOD. Technical characteristics of Lithium Ion and Lead-Acid batteries. Battery pack Design, Thermal issues in batteries, Fuel Cell based energy storage, Super Capacitor based energy storage and Flywheel based energy storage and analysis. Battery Management System- functions and Topology. Hybrid Electric Vehicles: Hybrid Types – series, parallel and mild parallel configuration.

References:

1. I. Hussein, *Electric and Hybrid Vehicles: Design Fundamentals*, CRC Press, 2003.
2. M. Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, *Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design*, CRC Press, 2004.
3. J. Larminie, John Lowry, *Electric Vehicle Technology Explained*, Wiley, 2003.

EE3248: SEMICONDUCTOR DEVICE THEORY [3 0 0 3]

Energy Bands in Solids, Electron and Hole Densities in Equilibrium, Excess carriers—Non-equilibrium Situation, Junctions and Interfaces, Charge Transport in Semiconductors, P-N Junctions and its applications. Junction Field Effect Transistor and Metal-Semiconductor, MIS Junction/capacitor - ideal C-V characteristics and deviations due to interface states/charges and work function differences, threshold voltage. Field Effect Transistor, MOSFETs- operation and characteristics.

References:

1. M. K. Achuthan and K. N. Bhat, *Fundamentals of Semiconductor Devices*, Tata McGraw Hill, New Delhi, 2011.
2. B. G. Streetman and S. Banerjee, *Solid State Electronic Devices*, PHI, New Delhi, 2011.
3. N. D. Gupta and A. D. Gupta, *Semiconductor Devices. Modelling and Technology*, PHI, New Delhi, 2004.

EE3249: DIGITAL SYSTEM DESIGN USING HDL [3 0 0 3]

Digital implementation options, Digital system modeling: Domains, levels of abstraction. Introduction to Verilog AND VHDL: Behavioral, data-flow and Gate level modeling. Design case studies - combinational, sequential, FSM, Test Benches. Verilog HDL Synthesis, Interfacing Applications, Programmable ASICs, Programming Technologies.

References:

1. M. J. S. Smith, *Application Specific ICs*, Pearson, 2010.
2. S. Palnitkar, *Verilog HDL: A Guide to Digital design and Synthesis*, PHI, 2003.
3. S. Brown and Z. Vranesic, *Fundamentals of Digital Logic with Verilog*, Design, TMH 2013.
4. N. M. Botros, HDL Programming: VHDL and Verilog, Dreamtech, Press, 2009.

EE3250: DIGITAL IMAGE PROCESSING [3 0 0 3]

Introduction, components of image processing system, Spatial domain transformations, histogram processing, smoothing, sharpening spatial filters, Filtering in the frequency domain- Introduction to Fourier transform, image smoothing, image sharpening using frequency domain filters. Image restoration-Noise models, restoration using spatial filtering, periodic noise reduction by frequency domain filtering, Morphological image processing- Preliminaries, dilation and erosion, opening and

closing, hit-or-miss transformation, basic algorithms, extension to gray-scale images, Image segmentation- Point, line, and edge detection, Thresholding, Region Segmentation Using Clustering and Superpixels, Graph Cuts, morphological watersheds, motion in segmentation.

References:

1. R. C. Gonzalez, R. E. Woods, *Digital Image Processing*, (4e), Pearson, 2017.
2. M. Sonka, V. Hlavac and R. Boyle, *Image Processing, Analysis and Machine Vision*, (4e), CENGAGE Learning, 2014
3. R. C. Gonzalez, R. E. Woods and S. L. Eddins, *Digital Image Processing Using MATLAB*, (2e), Mc Graw Hill India, 2010
4. G. B. García, O. D. Suarez, José Luis Espinosa Aranda, J. S. Tercero, I. S. Gracia, and N. V. Enano, Learning Image Processing with OpenCV, (1e), Packt Publishing, 2015

EE3251: SPECIAL ELECTRICAL MACHINES [3 0 0 3]

Stepping motors :Constructional features , Principle of operation ,Variable reluctance motor, Hybrid motor , Single and multi-stack configurations ,Torque equations ,Modes of excitations, Characteristics , Drive circuits, Microprocessor control of stepping motors, Closed loop control. Switched reluctance motors : Constructional features , Rotary and Linear SRMs ,Principle of operation, Torque production ,Steady state performance prediction, Analytical method ,Power Converters and their controllers, Methods of Rotor position sensing, Sensor less operation, Closed loop control of SRM, Characteristics. Permanent magnet brushless D. C. motors: Permanent Magnet materials, Magnetic Characteristics, Permeance coefficient, Principle of operation, Types, Magnetic circuit analysis, EMF and torque equations, Commutation, Power controllers, Motor characteristics and control. Linear induction motor, Repulsion motor, Hysteresis motor, AC series motor, Servo motors.

References:

1. R. Krishnan, *Switched Reluctance Motor Drives – Modeling, Simulation, Analysis, Design and Application,* (2e), CRC Press, New York, 2001.
2. P. P. Aearnley, *Stepping Motors – A Guide to Motor Theory and Practice,* (2e), Peter Perengrinus, London, 2004.
3. T. Kenjo and S. Nagamori, *Permanent Magnet and Brushless DC Motors*, (2e), Clarendon Press, London, 2006
4. T. J. E. Miller, *Brushless Permanent Magnet and Reluctance Motor Drives*, (2e), Clarendon Press, Oxford, 2003.
5. T. Kenjo, *Stepping Motors and Their Microprocessor Control,* (2e), Clarendon Press London, 2002

EE3252: HIGH VOLTAGE ENGINEERING [3 0 0 3]

Generation and transmission of electric energy, Voltage Stresses, Testing voltages. Generation of High D.C.&A.C, Voltages and Currents, and Impulse currents & voltages: Half-wave rectifier circuit, Voltage doubler circuits, Cockroft-Walton Voltage multiplier circuit, Electrostatic Generator, Vande-Graff Generator, Cascaded Transformers, Impulse voltage Generator, Marx's multi stage voltage generator, Generation of switching surges, Measurement: High Voltage DC, AC and Impulse Currents & Voltages, Over view of the Breakdowns, Electrical Field distribution and stress control, Breakdown in gases, solid and liquid dielectrics, Corona discharges, Partial-discharge.

References:

1. M. S.Naidu, V. Kamaraju, *High Voltage Engineering* (3e), Tata McGraw Hill-2004.
2. C. L. Wadhwa, *High Voltage Engineering* (2e), New Age International-2007.
3. Zangel & Kuffel, *High Voltage Engineering* (2e), Newnes-2000.

EE3253: POWER SYSTEM ENGINEERING [3 0 0 3]

Economic Operation of Power Systems: Introduction, system constraints, optimal operation of power systems. Input output, heat rate and incremental rate curves of thermal generating units. Economic distribution of load between generating units within a plant. Economic distribution of load between power stations, transmission loss equation. Introduction to unit commitment and dynamic programming. Power System Stability-I: Power angle equations and power angle curves under steady state and transient conditions. Power System Stability-II: Introduction to transient stability. Equal area criterion and its application to transient stability studies under basic disturbances. Critical clearing angle and critical clearing time. Factors affecting stability and methods to improve stability. Excitation Systems: Introduction of excitation systems of synchronous machines, types of excitation systems, Elements of various excitation systems and their control (functional block diagrams and

their brief description)-DC excitation systems, AC excitation systems, brushless excitation system. Interconnected Power Systems: Introduction to isolated and interconnected powers systems. Reserve capacity of power stations, spinning and maintenance resaves. Advantages and problems of interconnected power systems.

References:

1. I. J. Nagrath and D.P. Kothari, *Power System Engineering* (2e), MGH. 2011
2. J. J. Grainger and W. D. Stevenson, *Power System Analysis*, MGH. 2003
3. W. D. Stevenson, *Element of Power System Analysis*, MGH. 1982.
4. B. R. Gupta, *Power System Analysis and Design* (3e), S. Chand & Co. 2008.
5. C. L. Wadhwa, *Electrical Power Systems* (3e), New age international Ltd., 2009.

EE4140: INTERNET OF THINGS [3 0 0 3]

Introduction to Internet of Things, Sensing, actuation, Basics of Networking, Sensor networks, Machine to Machine communication (M2M), IOT technologies and Architectures: Infrastructure and service discovery protocols for the IoT ecosystems; Realization of IoT ecosystem using wireless technologies; Interoperability in IoT, Data handling and analytics, cloud computing, Real world design constraints, IoT use Cases.

References:

1. P. Raj and A. C. Raman, *The Internet of Things: Enabling Technologies, Platforms & Use Cases*, CRC Press, 2017.
2. A. Bahga and Vijay Medisetti, *Internet of Things: A Hands-on Approach*, University Press, 2014
3. J. Holler, V. T Siatsis, C. Mulligan, S. Karnouskos, S. Avesand and D. Boyle, *From Machine to Machine to the Internet of Things: Introduction to a New Age of Intelligence*, Academic Press, 2014.
4. F. Vahid and Givargis *Embedded Systems Design: A Unified Hardware/Software Introduction*, Wiley Publications, 2000.

EE4141: BLOCKCHAIN TECHNOLOGY [3 0 0 3]

Blockchain Concepts: Evolution, Structure, Characteristics, Stack, Benefits & Challenges, Domain Specific Applications, Design Methodology for Applications; Smart Contracts: Structure, Compiling & Deploying a Contract, Transactions and Calls, Interacting with a Contract, Gas, Examples, Smart Contract Patterns; Mining: Consensus on Blockchain Network, Different Stages, Block Validation, Setting up Node; Whisper Protocol; Advanced Topics on Blockchain: Double-Spending Problem, Byzantine Fault Tolerance, Proof-of-Work vs Proof-of-Stake, CAP, GHOST, Sybil Attack, Mining Pools & Centralization, Smart Contracts Vulnerabilities, Blockchain Scalability; Understanding Decentralized Applications & How Ethereum Works.

References:

1. M. Swan, *Blockchain Blueprint for a New Economy*, O'Reilly Media, 2015.
2. A. Bahga and V. Madisetti, *Blockchain Applications: A Hands-On Approach*, A. Bahga & V. Madisetti, 2017.
3. N. Prusty, *Building Blockchain Projects*, Packt, 2017.

EE4144: MODERN OPTIMIZATION TECHNIQUES [3 0 03]

Intoduction to optimization problems, Tradional Methods: Linear programming, Newton's Method, Interior point method, Nonlinear programming, Quadratic Programming, Modern Techniques: Genetic Algorithm, Simulated Annealing algorithm, Particle Swarm Optimization, Tabu search method, Differential Evolution, Introduction to multi-objective optimization problem.

References:

1. K. Deb, Optimization for Engineering Design: Algorithms and Examples, PHI, 2012.
2. A. Ravindran, K. M. Ragsdell and G. V. Reklaitis, Engineering Optimization: Methods and Applications (2e), John Wiley & Sons, Inc., 2006.
3. K. Y. Lee and M. A. El-Sharkawi, Modern Heuristic Optimization Technique: Theory and Applications to Power Systems, IEEE Press, 2008.

EE4145: CONTROL SYSTEM DESIGN [3 0 0 3]

Control System performance objectives, Design of cascade & feedback compensation, Scalar and multivariable control systems, Industrial PID controllers, Continuous & Discrete PID control, PID tuning, Dead Beat Algorithm. Adaptive Control: Self tuning control; Model Reference Adaptive

Control; High gain observers; Practical aspects. Digital Control Systems: Introduction, Sampling, Data acquisition, Quantization, sample and hold, zero order hold, frequency domain consideration in sampling and reconstruction. Difference equations, pulse transfer function, Block diagram analysis of sample data systems, time response of discrete time control systems, Steady State error analysis, Stability, Jury's stability test, bilinear transformation, Root locus technique, W transformation, Bode Plot. Nyquist Stability analysis, Design of Lag, Lead, Lag-lead compensator using Root Locus & Bode plot. Control System Design Examples; MATLAB & SIMULINK for Control System Design.

References:

1. S. M. Shinners, *Advanced Modern Control System Theory and Design*, John Wiley & Sons, 1998.
2. M. A. Johnson and M. M. Moradi, *PID Control: New Identification and Design Methods*, Springer 2005.
3. K. Ogata, *Discrete Time Control Systems* (7e); PHI 2011.
4. G. F. Franklin, J. D. Powell, M. L. Workman, *Digital Control of Dynamic Systems* (2e), A-Wesley Publishing Company, 1997.

EE4146: ROBOTICS AND AUTOMATION [3 0 0 3]

Basic Concepts: Definition and origin of robotics, different types of robotics various generations of robots, degrees of freedom, Asimov's laws of robotics, dynamic stabilization of robots. Power Sources and Sensors: Hydraulic, pneumatic and electric drives, variable speed arrangements, path determination, micro machines in robotics, machine vision, ranging laser, acoustic, magnetic, fiber optic and tactile sensors. Manipulators, Actuators and Grippers. Kinematics and Path Planning: Solution of inverse kinematics problem, multiple solution Jacobian work envelop, hill climbing techniques, robot programming languages. Case Studies: Multiple robots, machine interface, robots in manufacturing and non- manufacturing applications, robot cell design, selection of robot.

References:

1. N Odrey, M. Weiss, M. Groover, R. Nagal and A Dutta, *Industrial Robotics- SIE: Technology-Programming and Applications*, McGraw-Hill Education, 2017.
2. B. K. Ghosh, T. J. Tarn and N Xi, *Control in Robotics and Automation: Sensor-Based Integration*, Academic Press, 2011
3. S. R. Deb and S. Deb, *Robotics technology and flexible Automation*, McGraw-Hill Education, 2017
4. N. S. Nise, *Control Systems Engineering* (5e), John Wiley & Sons Inc, 2010

EE4147: INDUSTRIAL AUTOMATION & CONTROL [3 0 0 3]

Data loggers, Data Acquisition Systems, Direct Digital Control, SCADA, Programmable Logic Controller, Ladder logic Programming, PID functions, analog PLC operation, Alternate Programming Languages, PLC Maintenance, Interface and Backplane Bus Standards, Field bus, HART protocol, Smart transmitters, Valves and Smart actuators, MODBUS, Profibus, IEC 1158-2 Transmission Technology, Distributed Control Systems, Local Control Unit, Communications for DCS, Displays - Engineering interfaces. Control Technologies in Automation: Industrial Control Systems Continuous Versus Discrete Control, Computer Process. Computer-Based Industrial Control: Introduction & Automatic Process Control, Building Blocks of Automation Systems Distributed Control System. Modelling and Simulation for Plant Automation need for system Modelling Modern Tools & Future Perspective. HMI Design.

References:

1. J. W. Webb and R. A. Reis, *Programmable Logic Controllers - Principles and Applications*, PHI, (4e). 2002.
2. M. P. Lukcas, *Distributed Control Systems*, Van Nostrand Reinhold Co., 1986.
3. F. D. Petruzella, *Programmable Logic Controllers*, MGH, (2e), 2016.

EE4148: MODERN DC-DC POWER CONVERTER [3 0 0 3]

Switched Mode Power converters: generalized comparison between switched mode and linear regulators, operation and steady state performance of buck, boost, buck-boost, Cuk, SEPIC ZETA: continuous conduction mode, discontinuous conduction mode; Performance analysis of converters using DC Transformer model; DC-DC converters with isolation- Fly back converter, Forward converter, push-pull converter, half bridge and full bridge DC-DC converters; Resonant Converters- series and parallel loaded converters in continuous and discontinuous mode of operation, zero current switch resonant converter (ZCS), zero voltage switch resonant converter (ZVS); Control techniques-

Voltage feed forward PWM control, current mode control, digital pulse width modulation control; Converter modelling- equivalent circuit modelling of converters using state space averaging technique; Closed loop converter design – PID design issues; Electromagnetic interference – input filter design and its effect on converter performance.

References:

1. R. W. Erickson, Dragan Maksimovic, *Fundamentals of Power Electronics* (2e), Springer, 2005.
2. D. W. Hart, *Introduction to Power Electronics*, PH, 2010.
3. N. Mohan et. al., *Power Electronics, Converters, Applications & Design* (2e), Wiley, 2001.

EE4149: ADVANCE POWER CONVERTER DESIGN [3 0 0 3]

Multilevel Inverters: - Multi-level inverters, advantages, configurations: Diode clamped, flying capacitor and cascade multi-level inverters, applications, Selective harmonics elimination technique (SHE), Application of SHE in symmetric and asymmetric multilevel inverter, evolution of multilevel inverter topologies, new upcoming multilevel inverter topologies. Advance Power electronics Converters for Wireless Power Transfer:-Introduction to wireless power transfer using power electronics converters, Wireless power transfer for vehicular applications, static and dynamic charging, inductive power transfer for static charging of electric vehicle, Series-Series (SS), Series-Parallel (SP), Parallel-Series (PS), Parallel-Parallel (PP) topologies for inductive power transfer charging of electric vehicle, derivation of efficiency, Derivation of design parameters for SS topology, Society of Automotive Engineers (SAEJ2954) standards for wireless power charging of Electric Vehicle. Case study for designing IPT based IPT charging.

References:

1. C. T. Rim and C. Mi, *Wireless power transfer for electric vehicles and mobile devices*, John Wiley & Sons; 2017.
2. K. K. Gupta and P. Bhatnagar, *Multilevel Inverters: Conventional and Emerging Topologies and Their Control,* Academic Press; 2017.

EE4150: MICROCONTROLLER IN POWER ELECTRONICS [3 0 0 3]

Evolution of micro-controllers: comparison between microprocessor and micro controllers, Microcontroller development systems: 8051, 8096 and PIC Series Microcontrollers, architecture, hardware description, Addressing modes, Terminology, Linear addressing, segmented addressing and stack addressing, Instruction set, arithmetic operations, logical operations, data transfer operations, control transfer operations, Interrupt structure and Timers, Assembly language programming: C program structure, data acquisition, Typical applications in the control of power electronic converters for power supplies and electric motor drives.

References:

1. D. V. Hall, *Microprocessors and Interfacing - Programming and Hardware* (11e), Tata McGraw-Hill, 2017.
2. K. J. Hintz and D. Tabak, *Microcontrollers - Architecture, Implementation and programming*, McGraw Hill, USA, 2005.
3. J. B. Peatman, *Design with microcontrollers*, McGraw Hill International Ltd, 2002.

EE4151: SOLID STATE DRIVE [3 0 0 3]

Fundamentals of Electric Drives: components, dynamics, multi-quadrant operation, equivalent moment of inertia and torque, nature and classification of load torque, steady state stability; classes of motor duty. DC Drives: single phase and three phase controlled rectifier fed dc drives controlled freewheeling, speed torque characteristics, waveforms, expressions for voltage, current, speed, torque and power. Chopper fed DC drives- quadrants of operation; AC drives: Induction Motor Drives stator voltage control, rotor resistance control, slip power recovery scheme, frequency control-control strategies, DQ model, principle vector control, direct and indirect vector control scheme; Synchronous Motor Drives- overview of scalar and vector control schemes of PMSM and BLDC motors, brushless DC excitation.

References:

1. G. K. Dubey, *Power Semiconductor Controlled Drives*, PHI, 1989.
2. G. K. Dubey, *Fundamentals of Electric Drives*, Narosa, 2010.
3. J. M. D. Murphy & F.G. Turnbull, *Power Electronic Control of AC motors*, Pergamon 1989.

4. B. K. Bose, *Modern Power Electronics and AC Drives*, Pearson, 2010.
5. R. Krishnan, *Electric Motor Drives: Modeling, Analysis, and Control*, Pearson, 2011

EE4152: SOLID STATE TRANSFORMER [3 0 0 3]

Solid- State Devices: Review of SCR, Driving circuits and protection, Modern semiconductor devices, MOSFET, GTO, IGBT, SIT, SITH, MCT, Their operating characteristics, Heat sink design. AC-AC Converters: Three-phase ac regulators, Operation with resistive load, Single phase and three phase cyclo-converters, Matrix converters, output voltage control techniques, Commutation methods. Multilevel Inverters: Review of three-phase voltage source inverters, Voltage and frequency control, Harmonic reduction techniques, PWM inverters, Space vector Modulation, Multilevel Inverters, Configuration: Diode clamped, Flying capacitor and cascaded multi-level inverters, application, Current source inverter, Commutation circuits, Transient voltage suppressing techniques, DC link resonant converters, Operation and control, Single-phase Transformer: Principle of operation, Equivalent circuit, Voltage regulation and efficiency, Parallel operation. Three-phase Transformer: Various Connections and their comparative features, Harmonics in emf and magnetizing current, Effect of connections and construction on harmonics, Parallel operation of three-phase transformer, Sharing of load, 3-phase to 2-phase conversion, 3-phase to 6-phase conversion. Autotransformers: Principle of operation and comparison with two winding transformer. Solid state Transformer: Advantages, Topologies, Features, Environmental Impact, Application and challenges, Methodology

References:

1. N. Mohan., T. M. Undelandand and W. P. Robbins, *Power Electronics Converters, Applications and Design*, 3rd Ed., Wiley India, 2007
2. M. H Rashid., *Power Electronics Circuits Devices and Applications*, 3rd Ed., Pearson Education, 2009
3. I. J. Nagrath and D. P. Kothari, *Electrical Machines*, 3rd Ed., Tata McGraw-Hill Publishing Company Limited, 2017
4. M. G. Say, *The Performance and Design of Alternating Current Machines*, CBS Publishers, 2005

EE4153: ENERGY AUDITING & MANAGEMENT [3 0 0 3]

Energy Types, Needs, Scenario, Energy Security, Environmental Impact, Energy Reforms, Material & Energy Balance, Consumption Pattern, Sankey Diagram, Energy Policy, Information Systems, Energy Conservation Act 2001, Electricity Act 2003, Energy Reforms, National Action Plan for Climate Change (NAPCC), Standards & Labels , Energy Audit Purpose & Scope, Types of Energy Audit & Methodologies, Audit Instruments, Energy Management principles, Benchmarking and Strategies, Performance assessment of Electrical utilities, Performance Assessment of Thermal Utilities, Energy Economic Analysis, Role of ESCOs.

References:

1. P. W. O'Callaghan, *Energy Management A comprehensive guide to reducing costs by efficient energy use*, McGraw Hill, England, 1992.
2. A. K. Tyagi, *Handbook on Energy Audits and Management*, TERI, 2000.
3. IEEE Std. 739-1995, *IEEE recommended practice for energy management in industrial and commercial facilities*, 2000.
4. S. Doty and W. C. Turner, *Energy Management Handbook* (7e), Fairmont Press, USA, 2009.

EE4154: HVDC & FACTS [3 0 0 3]

HVDC Transmission system, merits and demerits application and schemes of HVDC, equivalent circuit diagram of a two terminal HVDC link, HVDC control, grid firing units for converters, Power flow model of HVDC. Introduction to FACTS controllers- configuration and working principle of SVC, STATCOM, TCSC, SSSC, GCSC, Switching Converter based voltage and Phase angle regulator, and UPFC, IPFC- Steady state characteristics, effect of FACTS devices on transient stability, power flow, power oscillation damping and voltage stability, Introduction to steady state and dynamic model of FACTS controllers.

References:

1. K. R. Padiyar, *FACTS Controllers in power transmission and distribution systems*, New Age International publishers, New Delhi, 2007.
2. N. G. Hingorani& L. Gyugyi, *Understanding FACTS: Concepts and Technology of flexible AC transmission systems*, IEEE Press, 2000.

3. K. R. Padiyaar, *HVDC power transmission systems, Technology and System Interactions*, New Age International publishers, New Delhi, 1999.
4. V. K. Sood, *HVDC and FACTS Controller*, Kluwer Academic Publisher, 2004

EE4155: MICROGRID [3 0 0 3]

Concept and definition of microgrid, microgrid drivers and benefits, review of sources of microgrids, typical structure and configuration of a microgrid, AC and DC microgrids, Power Electronics interfaces in DC and AC microgrids, communication infrastructure, modes of operation and control of microgrid: grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes: passive, active and communication based techniques. Power quality issues in microgrids- Modelling and Stability analysis of Microgrid, regulatory standards, Microgrid economics, Introduction to smart microgrids.

References:

1. N. Hatziargyriou, Microgrids *Architectures and Control*, John Wiley and Sons Ltd, 2014.
2. S. Chowdhury, S. P. Chowdhury and P. Crossley, *Microgrids and Active Distribution Networks*, The Institution of Engineering and Technology, London, U.K, 2009.
3. M. Sechilariu and F. Locment, Urban DC Microgrid, Intelligent Control and Power Flow Optimization, Elsevier, 1st Edition, 2016.

EE4156: Power System Optimization [3 0 0 3]

Review of Power flow, DC power flow, DC Optimal power flow, Classical Economic dispatch - Thermal system economic dispatch, Hydro-thermal economic dispatch. Security constrained economic dipatch, Multiarea System economic dispatch, Unit Commitment, Optimal power flow, Reactive power optimization, Optimal load shedding, Uncertainty Analysis in power system.

References:

1. J. Zhu, Optimization of Power System Optimization, John Wiley & Sons, Inc., 2009.
2. D. P. Kothari & J. S. Dhillon, Power System Optimization, PHI, 2007.
3. J. A. Momoh, Electric Power System Applications of Optimization (2e), CRC Press, 2009.

EE4157: ENERGY STORAGE DEVICES [3 0 0 3]

Introduction to different forms of energy storage. Energy storage as a structural unit of a power system, applications of energy storage- utilities, transport, industry, house hold. Energy storage techniques: Electrochemical energy storage- Secondary batteries, battery charge controller design, Fuel cells. Case Study on Electrical Vehicle- System design Consideration. Thermal energy storage, Flywheel storage, Superconducting magnetic energy storage, pumped hydro storage, Compressed air energy storage, Capacitor bank storage, Power system considerations for energy storage: Integration of energy storage systems-Effect of energy storage on transient regimes in the power system.

References:

1. A.G. Ter-Gazarian, *Energy Storage for Power Systems* (2e), IET Power and Energy Series 63, The Institution of Engineering and Technology, United Kingdom, 2011.
2. Gregory L Plett, *Battery Management Systems*, Volume- 1, Battery Modeling, Artech House Publishers, 2015.
3. Gregory L Plett, Battery Management Systems, Volume- 1, Equivalent circuit methods, Artech House Publishers, 2015.
4. R. Bove and S. Ubertini, *Modeling Solid Oxide Fuel Cells*, Springer, 2008.

EE4158: POWER QUALITY ISSUES [3 0 0 3]

Power Quality Issues: Standards and indices, Voltage sags, swell, surges, spikes, Interruptions, Harmonics: harmonic distortion of fluorescent lamps, effect of power system harmonics on power system equipment and loads, Power factor improvement, Passive Compensation, Passive Filtering, Harmonic Resonance, Control Methods for Single Phase APFC, Three Phase APFC and Control Techniques, PFC Based on Bilateral Single Phase and Three Phase Converter-static var compensators, SVC and STATCOM, Active Harmonic Filtering: Shunt Injection Filter for single phase, three-phase three-wire and three-phase four-wire systems, UPS, constant voltage transformers, series active power filtering techniques for harmonic cancellation and isolation, Dynamic Voltage Restorers, Grounding and wiring, NEC grounding requirements, solutions to grounding and wiring problems.

References:

1. S. Santoso, H. W. Beaty, R. C. Dugan, M F. McGranaghan, *Electrical Power System Quality*, Second edition, McGraw Hill Pub, 2002.
2. H. B. Math, *Understanding Power Quality Problems*, IEEE Press, 1st Edition, 2001.
3. J. Arrillaga, *Power System Quality Assessment*, John Wiley, 2000.
4. A. Ghosh and G. Ledwich, *Power Quality Enhancement using Custom Power Devices*, Kluwer Academic Publication, 2002.
5. C. Shankran, *Power quality*, CRC Press, 2001.

OPEN ELECTIVES

EE2080: SOLAR PHOTOVOLTAICS [3 0 0 3]

Solar Radiation: Spectrum, Terminologies, Measurement, Estimation; Sun-Earth Movement & Angles, Sun Tracking, PN Junction Diode & Characteristics, Solar Cell, Photovoltage, Light Generated Current, I-V equation & Characteristics: Short Circuit Current, Open Circuit Voltage, Maximum Power Point, Fill Factor, Efficiency, Losses, Equivalent Circuit, Effect of Series & Shunt Resistance, Solar Radiation, Temperature on Efficiency, Solar PV Modules: Series & Parallel connection, Hotspots, Bypass & Blocking Diodes, Power Output, Ratings, I-V & Power Curve, Effect of Solar Irradiation & Temperature, Balance of System (BOS): Batteries: Classification, Capacity, Voltage, Depth of Discharge, Life Cycle, Factors affecting Battery Performance; Charge Controllers, DC to DC Converters, DC to AC converters, Maximum Power Point Tracking (MPPT).

References:

1. C. Solanki, *Solar Photovoltaics: Fundamentals, Technologies and Application*, PHI New Delhi, 2009.
2. G. N. Tiwari, *Solar Energy: Fundamentals, Design, Modeling and Applications*, Narosa Publications New Delhi, 2013.
3. S. Deambi, *Photovoltaic System Design*, CRC Press USA, 2016.
4. F. Kreith and D. Y. Goswami, *Energy Management and Conservation Handbook* (2e), CRC Press USA, Fairmont Press, USA, 2017.
5. J. Balfour, M. Shaw and N. B. Nash, *Advanced Photovoltaic Installations*, Jones & Barlett Learning USA, 2013.

EE2081: MATLAB FOR ENGINEERS [3 0 0 3]

MATLAB desktop, workspace variables and types, creating and calling functions, 2D & 3D plots, control flow statements, introduction to Cody Coursework platform, introduction to live script environment, interpolating & extrapolating set of data, generating, importing data from various data tools, introduction to Simulink, solving ordinary differential equations in Simulink, introduction to Simscape, development of graphical user interface with GUIDE tool.

References:

1. S. J. Chapman, *Essentials of MATLAB Programming*, BAE Systems (3e), Cengage Learning, 2008
2. C. Wilkins, *Exploring Mathematics with MuPAD*, University of Oxford, 2011
3. S. L. Eshkavilov, *MATLAB & Simulink Essentials: MATLAB & Simulink for Engineering Problem Solving and Numerical Analysis*, Lulu Publishing, 2016

EE2082: FUNDAMENTALS OF RENEWABLE ENERGY SOURCES [3 0 0 3]

Energy sources and their availability, Solar Energy - Solar radiation and measurements, solar energy storage, Solar Photo-Voltaic systems design- Wind Energy- Estimation, Maximum power and power coefficient, wind energy conversion systems, design considerations and applications. Energy from Bio-Mass- Sources of bio-mass, Biomass conversion technologies, Thermo-chemical conversion and Biochemical conversions, Anaerobic digestion and Fermentation, Bio-gas generation Pyrolysis and Liquefaction, Classification of Gasifiers, Geo-Thermal Energy, Energy plantation- Energy from the Oceans, Ocean Thermal Energy Conversion, Open and Closed Cycle plants, Site selection considerations, Origin of tides, Tidal energy conversion systems, Wave energy conversion systems, Hybrid Energy Systems.

References:

1. B. H. Khan, *Non-conventional Energy Resources*, TMH, 2009.
2. J. W. Twidell & A. D. Weir , *Renewable Energy Resources*, ELBS, 2005.

3. D. Mukherjee & S. Chakrabarti, *Fundamentals of Renewable Energy Systems*, New Age Intl., 2004.
4. G. D. Rai, *Non-Conventional Energy Sources*, Khanna Publishers, 2004.

EE3080: ELECTRIC VEHICLE TECHNOLOGY [3 0 0 3]

History of electric vehicles (EV) and hybrid electric vehicles (HEV), need and importance of EV and HEV, comparison between IC engine and Electric vehicle. Vehicle Fundamental: General description of vehicle movement Rolling resistance, Aerodynamic drag, grading resistance, Acceleration resistance, Dynamic equation. Electric Vehicle: Configuration of Electric Vehicle, Electric Propulsion Unit- DC machines (BLDC & BDC), Three phase A/c machines, Induction machines, switched reluctance machines. Power Convertor- DC to DC. DC to AC and AC to DC Convertors. Control Strategies for BLDC, BDC & Induction drives. Energy Source System- Types of batteries, Parameters, BMS. Types of Charger, Conductive charging, Inductive Charging, Level 1,2 & 3 Charging Scheme, charging technology for Electric vehicle charging station, Converter topologies. Charging methods- constant current (CC), constant voltage (CV), constant power (CP), Fast charging strategies of an EV battery

References:

1. S. Rajkaruna, F. Shahnia, *Plug In Electric Vehicles in Smart Grids*, Springer, 2015
2. S. Dhameja, *Electric Vehicle Battery Systems*, Newnes, 2001.
3. R. Krishnan, *Permanent Magnet Synchronous and Brushless DC Motor Drives*, CRC Press, 2009
4. R. N. Jazar, *Vehicle dynamics: theory and application*, Springer, 2017
5. P. Krause, Oleg Wasynczuk, S. D. Sudhoff and S. Pekarek, *Analysis of Electric Machinery and Drive Systems*, 3rd Edition, Wiley-IEEE Press, 2013

EE3081: INTRODUCTION TO LIGHTING DESIGN [3 0 0 3]

Visible spectrum- psychophysics of vision-photometric quantities- laws of illumination-point by point method of illuminance calcualtions -Light sources- luminaires- principles of light control elements- light Intensity distribution diagram-evaluation of total flux-illuminance and visual performance- Lumen method calculations-principles and general requirements of interior & exterior lighting for different applications- Lighting Design Examples- Energy and cost effectiveness of lighting schemes.

References:

1. IESNA New York, *Lighting Handbook* (10e), 2011.
2. J. L. Lindsey, *Applied Illumination Engineering* (2e), Fairmont Press, INC 1997.
3. D. W. Durrant, *Interior Lighting Design* (5e), Lighting Industry Federation Limited, London 1977.
4. J. B. de Boer and D. Fischer, *Interior Lighting* (2e), Philips Technical Library, 1981

EE3082: ENERGY AUDITING [3 0 0 3]

Energy Types, Needs, Scenario, Energy Security, Environmental Impact, Energy Reforms, Material & Energy Balance, Consumption Pattern, Sankey Diagram, Energy Policy, Information Systems, Energy Conservation Act 2001, Electricity Act 2003, Energy Reforms, National Action Plan for Climate Change (NAPCC), Standards & Labels , Energy Audit Purpose & Scope, Types of Energy Audit & Methodologies, Audit Instruments, Energy Management principles, Benchmarking and Strategies, Performance assessment of Electrical utilities, Performance Assessment of Thermal Utilities, Energy Economic Analysis, Role of ESCOs.

References:

1. P. W. O'Callaghan, *Energy Management A comprehensive guide to reducing costs by efficient energy use*, McGraw Hill, England, 1992.
2. A. K. Tyagi, *Handbook on Energy Audits and Management*, TERI, 2000.
3. IEEE Std. 739-1995, *IEEE recommended practice for energy management in industrial and commercial facilities*, 1995
4. S. Doty and Wayne C. Turner, *Energy Management Handbook* (7e), Fairmont Press, USA, 2009.

EE3083: ELECTRICAL ENERGY SYSTEMS [3 0 0 3]

Global Energy Scenario: Role of energy in economic development and social transformation: Energy & GDP, GNP and its dynamics. Indian Energy Scenario: Energy resources & Consumption: Commercial and non-commercial forms of energy, Fossil fuels, Renewable sources including Bio-fuels in India, their utilization pattern in the past, present and future projections of consumption

pattern, Sector wise energy consumption, Electrical Energy Sources: Diesel Power Plant, Hydro Electric Power Plants, Gas turbine power plant, Applications Combined operation of power plants, load division among different types of power plants, Renewable Energy: Solar, Wind, Biomass, Geothermal, tidal, Fuel Cell, Introduction to transmission and distribution systems, Protection of electrical systems.

References:

1. M. A. El-Sharkawi, *Electric Energy – An Introduction* (2e), CRC press, 2008.
2. J. B. Gupta, *A Course in Electrical Power*, S.K. Kataria and Sons, 2013.
3. C. L. Wadhwa, *Electrical Power System* (3e), New Age Intl., 2000