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

B. Tech. (Electrical & Computer Engineering) Syllabus

(Applicable for the students admitted in Academic Year 2021-22 & onwards)

THIRD SEMESTER

BB0025: VALUE ETHICS & 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. 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.

EL2101: COMPUTER ORGANIZATION & ARCHITECTURE [3 0 0 3]

Basic Structure of computers: Computer types, functional units, basic operational concepts, bus structures, software, performance; Machine Instructions and programs: Numbers, arithmetic operations and characters, Memory locations and addresses; Memory operations, Addressing modes; Arithmetic: Addition and subtraction of signed numbers, Adders, ALU design, Bit slice processor, Multiplication of positive numbers Signed operand multiplication, Booth's Algorithm, Fast multiplication, Integer division, Floating point numbers and operations; Memory Systems: Introduction, Basic concepts, Design methods; RAM memories, Read only memories, Speed size and cost, Cache memories, Performance considerations, Virtual memories, Memory, Management Requirements, Secondary storage; Input / Output organization: Accessing I/O devices, Interrupts, Direct memory access, Buses, Interface circuits; Introduction to Parallel Processing: Flynn Classification, Multi-Core Architecture, Pipelining.

References:

1. C. Hamacher & Z. Vranesic, *Computer Organization (5e)*, Tata McGraw Hill (TMH), 2011.
2. W. Stallings, *Computer Organization and Architecture –Designing for Performance*, PHI, 2009.
3. D. A. Patterson & J. L. Hennessy, *Computer Organization and Design: The Hardware/Software Interface*, Morgan Kaufmann, 2011.
4. J. P. Hayes, *Computer Architecture and Organization (3e0*, Tata McGraw Hill (TMH), 1998.

EL2102: OBJECT ORIENTED PROGRAMMING [3 1 0 4]

Object-Oriented Thinking: Different paradigms for problem solving, need for OOP paradigm, differences between OOP and Procedure oriented programming, Overview of OOP concepts-Abstraction, Encapsulation, Inheritance and Polymorphism. C++ Basics: Structure of a C++ program, Data types, Declaration of variables, Expressions, Operators, Operator Precedence, Evaluation of expressions, Type conversions, Pointers, Arrays, Pointers and Arrays, Strings, Structures, References. Flow control statement- if, switch, while, for, do, break, continue, goto statements. Functions - Scope of variables, Parameter passing, Default arguments, inline functions, Recursive functions, Pointers to functions. Dynamic memory allocation and de-allocation operators-new and delete, Preprocessor directives. C++ Classes and Data Abstraction: Class definition, Class structure, Class objects, Class scope, this pointer, Friends to a class, Static class members, Constant member functions, Constructors and Destructors, Dynamic creation and destruction of objects, Data abstraction, ADT and information hiding. Inheritance: Defining a class hierarchy, Different forms of inheritance, Defining the Base and Derived classes, Access to the base class members, Base and Derived class construction, Destructors, Virtual base class. Virtual Functions and Polymorphism: Static and Dynamic binding, virtual functions, Dynamic binding through virtual functions, Virtual function call mechanism, Pure virtual functions, Abstract classes, Implications of polymorphic use of classes, Virtual destructors. C++ I/O: I/O using C functions, Stream classes hierarchy, Stream I/O, File streams and String streams, Overloading operators, Error handling during file operations, Formatted I/O.

References:

1. E. Balagurusamy, *Object Oriented Programming with C++*, Tata McGraw Hill, 2017.

2. H. Schildt, *The Complete Reference C++*, Tata McGraw Hill, 2017.
3. W. Savitch, *Problem solving with C++: The Object of Programming*, Pearson Education, 2017.

EL2103: ANALOG & DIGITAL SYSTEMS [3 1 0 4]

Semiconductor Devices: MOSFET Characteristics, structure, biasing, current mirrors, basic amplifier configurations, CS, CD, CG configurations, small signal model, frequency response. Operational Amplifier 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. Finite state machines analysis and design.

References:

1. D. S. William, *Operational Amplifiers with Linear Integrated Circuits*, Pearson Education, 2004.
2. R. L. Boylestad & L. Nashelsky, *Electronic Devices and Circuit Theory (11e)*, Pearson Education India, 2015.
3. R. A. Gayakwad, *Op-Amps and Linear Integrated Circuits (4e)*, Pearson Education, 2015.
4. D. D. Givone, *Digital Principles & Design*, TMH Publications, 2017.

EL2104: SENSOR & SENSOR CIRCUITS [3 1 0 4]

Electrical Sensors: Hall effect sensor, CT, PT. Thermal Sensors: Thermistors, Resistance Temperature Detector, Thermocouples. Mechanical Sensors: Displacement LVDT, Pressure sensors, Flow sensors. Design of temperature indicator using IC sensors, Errors due to resistance drift, effects of Op amp offset voltage drift, offset current drift. Error budgeting. Practical design of 4-20 mA current transmitter for resistance sensors and LVDT sensor. Instrumentation amplifier, Practical designing of a capacitor measurement circuit. Ratio transformer technique, Differential capacitor measurement. Errors in the capacitance measurement. Phase sensitive detection and use of the same for lock in amplifier design. Analog and Digital Signal Conditioning: Principles of analog signal conditioning, Signal-Level and Bias Changes, Linearization, Conversions, Filtering and Impedance Matching, Concept of Loading. Sensor-to-Frequency Conversion, Data-Acquisition Systems: Hardware and Software of Data Acquisition System (DAS), Characteristics of digital data: Digitized Value, Sampled Data Systems.

References:

1. P. Horowitz & W. Hill, *The Art of Electonics (2e)*, Cambridge University Press, 1992.
2. C. D. Johnson, *Process Control Instrumentation Technology (6e)*, Prentice Hall International Edition, 1999.
3. J. G. Webster., *Measurement, Instrumentation, and Sensors Handbook*, CRC Press, Taylor & Francis Group, 2014.
4. R. B. Northrop, *Introduction to Instrumentation and Measurement (3e)*, CRC Press, Taylor & Francis Group, 2014.
5. M.K. Gunasekaran, *Circuits for Analog System Design*, NPTEL, IISc Bangalore.

EL2130: PROGRAMMING LAB-I [0 0 2 1]

Developing programming code on Linux/Unix and Windows operating system, Introduction to C language programming, Programming in C language using basic constructs, operators, strings, pointers, functions, structures and file handling and processing. Introduction to object-oriented programming language using C++: Basic programming construct, flow control, loops, data type and arrays. Introduction to classes and object: creating class and object, using object to access class members, declaring method in class, recursion, argument passing and returning, declaring constructor, constructor overloading and method overloading. Input-output: Basic technique for input and output, type casting, file handling. Inheritance: creating base class and derive class, use of different access modifier, overriding base class methods, creating abstract classes/interfaces. Exception handling: try catch construct, creating own exception, raising exception.

References:

1. W. Brain & K. and D. Ritchie, *C Programming Language*, PHI, 2015.
2. H. Schildt, *The Complete Reference C++ (4e)*, Mcgraw Hill, 2017.

EL2131: ANALOG & DIGITAL SYSTEM DESIGN LAB [0 0 2 1]

Design, Simulation and Testing of operational amplifier-based circuits in linear and nonlinear mode. Timer based mono-stable and astable Multivibrators circuits. Design and Testing of combinational circuits using gates, multiplexers, decoders, arithmetic circuits. Design and Testing of sequential digital electronic circuits such as counters, shift registers & sequence generators, sequence detectors.

References:

1. D. D. Givone, *Digital Principles & Design*, TMH Publications, 2017.
2. J. F. Wakerly, *Digital Design: Principles & Practices (4e)*, Pearson Education, 2008.
3. B. Razavi, *Fundamentals of Microelectronics (2e)*, Wiley Publishers, 2013.
4. S. Sedra, K. C. Smith & A. N. Chandorkar, *Microelectronic Circuits: Theory and Application (6e)*, Oxford, 2017.

EL2132: SYSTEM SIMULATION & VIRTUAL INSTRUMENTATION LAB [0 0 2 1]

Introduction to MATLAB: Basics of MATLAB matrices and vectors, variables, arrays, conditional statements, loops, functions, and plots. Mathematical modelling & time domain analysis of first order and second order electrical system. Modeling and Simulation with SIMULINK: Analysis of electrical circuits-based system: Half wave, full wave rectifier and armature voltage control of DC motors - Familiarization of graphical design tools. Review of Virtual Instrumentation, VI Programming Techniques- Concepts in graphical programming, VIs, Components of VI and sub-VIs, Data Acquisition Basics, Common Instrument Interfaces, Real time Control in VI.

References:

1. D. Hanselman, *Mastering MATLAB 7*, Pearson Education, 2012.
2. S. J. Chapman, *Essentials of MATLAB Programming*, BAE Systems (3e), Cengage Learning, 2017.

3. S. L. Eshkavilov, *MATLAB & Simulink Essentials: MATLAB & Simulink for Engineering Problem Solving and Numerical Analysis*, Lulu Publishing, 2017.
4. E. Nesimi, *LabVIEW for electric circuits, machines, drives, and laboratories*., Prentice Hall Professional, 2002.

FOURTH SEMESTER

EO2001: ECONOMICS [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, 2020.
2. H. C. Peterson, *Managerial Economics (9e)*, 2012.
3. P. L. Mehta, *Managerial Economics*, Sultan Chand & Sons, 2012.
4. G. J. Tuesen and H.G. Tuesen, *Engineering Economics*, PHI, 2008.
5. J. L. Riggs, D. D. Bedworth and S. U. Randhawa, *Engineering Economics*, Tata McGraw Hill, 2018.

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. 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.

EL2201: OPERATING SYSTEMS [3 1 0 4]

Introduction: Operating System Structure and Operations, Process Management, Memory Management, Storage Management, Operating System Services, User Operating System Interfaces, Types of System Calls, System Programs, Operating System Structure, System Boot ,Overview, Process Scheduling, Operations on Processes, Inter-process Communication, Multithreaded Models, Thread Libraries, Scheduling Algorithms, Thread Scheduling, Linux scheduling, Critical Section Problem, Peterson's Solution, Synchronization Hardware, Semaphores, Logical Versus Physical Address Space, Segmentation, Contiguous Memory Allocation, Paging, Structure of Page Table, Segmentation, Demand Paging, Copy-On-Write, Page Replacement, Allocation of Frames, Thrashing, Disk Scheduling, Swap-Space Management, System Model, Deadlock: Deadlock prevention, Avoidance, Detection, Recovery. File System Interface and Implementation: File Concept, Access Methods, Directory and Disk Structure, File System Mounting, File System Structure, Space Allocation Methods for Files, Free Space Management.

References:

1. Silberschatz, P. B. Galvin & G. Gagne, *Operating System Concepts*, Wiley, 2014.
2. S. Tanenbaum, *Modern Operating Systems*, Pearson, 2016.
3. W. Stallings, *Operating Systems*, Pearson, 2018.
4. W. R. Stevens & S. A. Rago, *Advanced Programming in the UNIX Environment*, Addison-Wesley, 2013.

EL2202: NETWORK ANALYSIS & SYNTHESIS [3 1 0 4]

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 Transformed circuits, Network Function, poles and zeros. Two port networks: Z, Y, T and h parameters, Relation between parameters, Series, parallel and cascade connections. Network Synthesis: Hurwitz polynomial, positive real functions, reactive networks, Foster and Cauer form of reactance networks.

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.
5. F. F. Kuo, *Network Analysis and Synthesis (5e)*, Wiley, 2012.

EL2203: ELECTRICAL MACHINES [3 1 0 4]

Transformers: Single phase & Three phase transformers - introduction, equivalent circuit, voltage regulation, parallel operation, DC Machines: - working principle, construction, types, armature reaction, commutation, characteristics, Starting & speed control methods of DC motor. BLDC motor: construction & working principle, Application in Electric Vehicle.

Induction Machines: single-phase & three-phase Induction machine, construction, type and working principle, equivalent circuit, losses and efficiency, torque-slip characteristics, no load & blocked rotor tests, starting, speed control, Induction generator, Synchronous Machines: construction and working principle, Synchronization, Two reaction theory, Starting methods of Synchronous motor. Active and Reactive power control.

References:

1. Fitzarald & Kingslay, *Electric Machinery*, TMH, 2011.
2. P. S. Bhimbra, *Electrical Machinery*, Khanna Publication, 2011.
3. D. P. Kothari & I. J. Nagrath, *Electric Machines* (4e), TMH, 2013.
4. E. H. Langsdorf, *Theory of Alternating Current Machinery* (2e), TMH, 2004.

EL2230: PROGRAMMING LAB II [0 0 2 1]

Programming in C: Psuedo Code development, input and output, pointer, file handling. Objective C: variables, functions, objects, data structure and memory. Advanced C programming: advanced constructs, algorithms, advanced pointer, and dynamic memory allocation.

References:

1. S. Kochan, *Programming in Objective – C,* Addison-Wesley Professional, 2013.
2. M. Siegesmund, *Embedded C Programming*, O'Reilly Media, 2014.
3. K. N. King, *C programming 2e: A modern approach*, W. W. Norton & Company, 2008.

EL2231: ELECTRICAL MACHINES LAB [0 0 2 1]

Open circuit and short circuit tests on single phase transformer, Polarity tests and connection of single phase transformers as three phase bank, Parallel operation of two single phase transformers, No load & blocked rotor tests on single phase IM, Load test on single phase IM, No load & blocked rotor tests on three phase IM, Load test on three phase IM, Study of torque-slip characteristics by varying rotor resistance, Load test on induction generator, Magnetization characteristics of DC generator, Characteristics of Compound generator, speed control of DC shunt motor, load test of DC shunt motor, OCC and SCC of Synchronous generator, synchronization of Synchronous generator. Study of BLDC Motor.

References:

1. D. P. Kothari & I. J. Nagrath, *Electric Machines* (4e), TMH, 2013.
2. E. H. Langsdorf, *Theory of Alternating Current Machinery* (2e), TMH, 2004.

EL2232: 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.

FIFTH SEMESTER

BB0026: ORGANISATION & 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 (2e)*, Prentice Hall, 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.

EL3101: DATA STRUCTURES & ALGORITHMS [3 1 0 4]

Introduction: Algorithm specification; Performance analysis: Time and Space Complexity, Asymptotic notation; pointer declaration and definition, memory allocation functions, array of pointers; The type definition, enumerated types, accessing structures, complex structures, arrays of structures, structures and functions; Recursive definition & processes, Recursion in C, writing recursive programs efficiency of recursion, Examples: Tower of Hanoi, GCD, Fibonacci Definition and examples, Representing Stacks in C, Evaluation of expressions, multiple stacks and queues; Applications: infix, postfix and prefix and their conversions. Linked lists representations, Singly, doubly, header node, circular, Applications: Linked stacks and queues, polynomial and long integer arithmetic, union, intersection, basic terminologies, binary tree representation, recursive/ non recursive, binary search tree, Applications: Expression trees, inserting, deleting, searching, height of BST terminology and representations, graph operations, spanning trees, minimum cost spanning tree, shortest

path and transitive closure, binary and linear search, insertion, quick, merge, heap, radix sort static hashing, divide and conquer, greedy, back tracking and case studies of programming paradigms.

References:

1. Augenstein, Tenenbaum Langsam, *Data Structure Using C & C++ (2e)*, Prentice Hall India Ltd. 2015
2. H. Schildt, *The Complete Reference C++ (4e)*, Mcgraw Hill, 2017.
3. Mark Allen Weiss, *Data structures and Algorithm Analysis in C (2e)*, Pearson, 2014.
4. Aaron M. Tenenbaum, Yedidyah Langsam, Moshe J. Augenstein, *Data Structures using C*, Pearson Education, 2019.
5. G.Ellis Horowitz, Sartaj Sahni and Susan Anderson-Freed, *Fundamentals of Data Structures in C*, University Press (India) Pvt. Ltd., 2014.
6. Alfred V. Aho, John E. Hopcroft and Jeffrey D. Ullman, *Data Structures and Algorithms*, Pearson Education, 2012.
7. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein, *Introduction to algorithms (3e)*, PHI, 2009.
8. Seymour Lipschutz, *Data Structures with C (Schaum's Outline Series)*, McGraw Hill Education Private Limited, 2011.

EL3102: MICROCONTROLLER BASED SYSTEM DESIGN [3 1 0 4]

Introduction to microprocessors and microcontrollers: comparison microprocessor and microcontroller, Types and specifications of microcontrollers; development tools: Simulator, debugger, cross compiler and emulator; Introduction to embedded controllers, Harvard vs. Von Neumann architecture. Architecture of 8051: Registers, Register Banks, PSW, CPU, PC, DPTR, SFRs, RAM, ROM, Stack); Programming model of 8051, Pin diagram & details, I/O Ports & details. 8051 Assembly Language Programming: Assembler Directives, Addressing Modes of 8051, Instruction set, calculation of delay, delay programs. Timers, Counters, Serial Communication, Interrupts, Programming examples. 8051 Programming in Embedded C: Data types in embedded C, arithmetic & logic operators, control statements and loops in embedded C, functions & arrays, I/O port programming, programming timers & counters, Interrupts & Serial communication program. Hardware Interfacing: Programmable I/O (8255); Memory Interfacing, Stepper Motor, DAC, ADC, Seven Segment Display, LCD, Relays & Opto-isolators. Contemporary micro-controller architecture: PIC micro-controllers, ARM processors and its variants.

References:

1. Muhammad Ali Mazidi, Janice Gillipse Mazidi, Rolin D. Mckinlay, *8051 Microcontroller and Embedded Systems Using Assembly and C*, Pearson Education, 2010.
2. Myke Predko, *Programming and Customizing the 8051 Microcontroller*, Tata McGraw Hill, 2007.
3. Kenneth J. Ayala, *8051 Microcontroller and Embedded Systems using Assembly and C*, Cengage Learning, 2010.
4. Ajay V. Deshmukh, *Micro controllers- Theory and Applications*, TMH, New Delhi, 2008.

EL3103: CONTROL SYSTEM [3 1 0 4]

Mathematical Modelling: Mathematical Models of electrical, mechanical, and electro-mechanical systems, block diagram, signal flow graphs and Mason's gain formula. Time Response Analysis**:** Transient response specifications of second order systems, system response with additional pole & zero, steady state error non- unity feedback systems.

Sensitivity Stability: Routh - Hurwitz criterion, frequency domain specifications, root locus plot and transient response design by gain adjustment. Frequency response plots**:** Polar plots, Nyquist stability criterion, stability analysis and Bode plots. Controller design: proportional, derivative, and integral controllers, PI, PD & PID controller. State Space Analysis: State model, electrical, mechanical, and electromechanical systems, physical variable form and phase variable form.

References:

1. K. Ogata, *Modern Control Engineering (5e),* Prentice Hall, 2010.
2. S. N. Norman, *Control Systems Engineering (8e)*, John Wiley & Sons, Inc, 2019.
3. K. R. Varmah, *Control Systems*, Tata Mc-Graw Hill, 2010.
4. B. Kuo*, Automatic Control Systems (8e),* Prentice-Hall 2014.
5. K Jairath, *Control Systems With Essential Theory (6e),* Cbs Publishers And Distributors Pvt Ltd, 2015.
6. I. J. Nagrath, M.Gopal, *Control Systems Engineering Paperback (6e)*, New Age International Publishers, 2017.

EL3130: DATA STRUCTURE LAB [0 0 2 1]

Implementation of array operations: insertion, deletion, linear search and binary search, matrix operation. Implementation of singly, doubly and circular linked lists: inserting, deleting, and inverting a linked list, Polynomial addition, subtraction and sparse matrix implementation by linked list, Stacks and Queues: adding, deleting elements. Circular Queue: Adding & deleting elements, conversion of infix to postfix and Evaluation of postfix expressions using stacks & queues, Implementation of stacks & queues using linked lists. Recursive and Non-recursive traversal of Trees: BST tree implementation. Implementation of sorting and searching algorithms: bubble sort, Insertion sort, selection sort, quick sort, heap sort, merge sort, radix sort, Hash table implementation.

References:

1. Augenstein, Tenenbaum Langsam, *Data Structure Using C & C++ (2e),* Prentice Hall India Ltd. 2015.
2. H. Schildt, *The Complete Reference C++*, (4e), Mcgraw Hill, 2017.
3. Mark Allen Weiss, *Data structures and Algorithm Analysis in C*, Pearson, Second edition, 2014.
4. S. Tannenbaum, J. Augenstein, *Data Structures using C*, Pearson India, 2018.
5. E. Horowitz, S. Sahni, *Fundamentals of Data Structures in C (2e)*, Universities Press, 2008.
6. Forouzan, R. F. Gilberg, *A Structured Programming Approach Using C (3e),* Cengage Learning, 2007.

EL3131: MICROCONTROLLER LAB [0 0 2 1]

Introduction to 8051 simulation software and familiarization of 8051 Microcontroller Kit; Assembly & C Programming for 8051: Data Transfer, Arithmetic and logical operation programs - Array handling and Code conversion, I/O ports programming, Timer/Counter programming, serial mode programming, interrupt programming; Hardware interfacing with 8051: Interfacing LCD display, keyboard interfacing, Interfacing peripherals – ADC, DAC &

Waveform generation, interfacing Stepper motor, Interfacing Elevator & traffic light with 8051; Study and basic programming for Arm processor.

References:

1. Muhammad Ali Mazidi, Janice Gillipse Mazidi, Rolin D. Mckinlay, *8051 Microcontroller and Embedded Systems Using Assembly and C*, Pearson Education, 2010.
2. Myke Predko, *Programming and Customizing the 8051 Microcontroller*, Tata McGraw Hill, 2007.
3. Kenneth J. Ayala, *8051 Microcontroller and Embedded Systems using Assembly and C*, Cengage Learning, 2010.
4. Ajay V. Deshmukh, *Micro controllers- Theory and Applications*, TMH, New Delhi, 2008.
5. Krishna Kant, *Microprocessors and Microcontrollers*, PHI, 2007

EL3132: CONTROL & AUTOMATION LAB [0 0 2 1]

Control system design: Open & closed loop design and analysis, time domain analysis, stability analysis using pole-zero plot, root-locus, nyquist plot, bode plot (lead, lag, lag-lead), PID controller, compensator design. Mathematical modelling & analysis using MATLAB: Inverted pendulum, ball & beam system. Real-time hardware implementation: Model based design, hardware-in-loop simulation for different control applications with LabVIEW/MATLAB. Process control systems trainer kits with DAQ cards. Totally integrated automation: PLC with S7 1200, human machine interface with KTP700, applications of home automation, industrial automation, real-time production line. Smart systems, internet-of-things & intelligent systems.

References

1. B. C. Kuo, *Automatic Control Systems*, John Wiley & Sons, 2014.
2. D. K. Chaturvedi, *Modelling and Simulation of Systems Using MATLAB and Simulink*, CRC Press, 2010.
3. John Essick, *Hands on Introduction to LabVIEW (2e)*, Oxford, 2013.
4. Frank D. Petruzella, *Programmable Logic Controllers (4e)*, Mc Graw Hill Education, 2016.

SIXTH SEMESTER

EL3201: COMPUTER NETWORKS [3 0 0 3]

Introduction to networks, internet, protocols and standards, the OSI model. Physical Layer: Digital transmission, multiplexing, transmission media, network topology, circuit switched networks, datagram networks, virtual circuit networks. Data link layer: Introduction, framing, physical addressing, flow control, error control, access control, switches and VLAN. Network Layer: Logical addressing, internetworking, routing algorithms, packetizing-internet protocol (IP), datagram format, network layer protocols. Transport Layer: Services, connectionless transport-UDP, principles of reliable data transfer, connection oriented transport-TCP, principles of congestion control, TCP congestion control, virtual circuit and datagram

networks. Application Layer: Principles of network applications, the web and HTTP, FTP, SMTP, DNS, peer-to-peer applications.

References:

1. Behrouz A. Forouzan, Firouz Mosharraf, *Computer Networks A top Down Approach*, Mc-Graw Hill, 2012.
2. James F. Kurose *Computer Networking: A top-down approach*, Pearson Education, 2017.
3. Andrew S. Tanenbaum & David J. Wetherall, *Computer Networks*, (5e), Pearson Education, 2013.
4. Larry L. Peterson and Bruce S. Davie, *Computer Networks- A Systems approach*, Elsevier, 2016.

EL3202: DATA BASE MANAGEMENT SYSTEM [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. Silberschatz, H. F. Korth, S. Sudarshan, *Database System Concepts*, TMH, 2016
2. R. Elmasri, S. B. Navathe, *Fundamentals of Database Systems*, Pearson, 2017
3. R. Ramakrishnan, *Database Management Systems*, McGraw Hill, 2014.
4. Bayross, *Introduction to SQL*, Tata McGraw, 2014.

EL3203: POWER ELECTRONICS & DRIVES [3 1 0 4]

Power Semiconductor devices: SCR, Triac, Power MOSFET, IGBT – characteristics. AC – DC Converters: Single phase converters-half wave, half controlled and fully controlled bridge converters, Three-phase controlled converters- half wave, full wave, Dual converter. DC – DC Converters: Step down and step up operation, buck-boost converters and Type E chopper. DC – AC Converters: Single phase and three phase bridge inverters, Pulse Width Modulation (PWM) control technique, Current Source Inverter. Electric drives: Components, dynamics, multi-quadrant operation, Steady state stability. DC Drives: Single-phase converter fed, Three-phase converter fed, Dual converter fed and Chopper fed DC drives. Induction motor drives: Constant torque, Constant power operation, Static rotor resistance control, Volt per Hertz control, Field-oriented control. Synchronous motor drives: Permanent magnet synchronous machine control, brushless DC motor excitation.

References:

1. D. W.Hart, *Introduction to Power Electronics*, PHI Learning Publications, 2010.
2. N. Mohan, Power Electronics, Converters, Applications & Design (3e), Wiley 2007.
3. M.H.Rashid, *Power Electronics, Circuits, Devices and Applications (4e)*, PHI, 2017.
4. G.K.Dubey, *Fundamentals of Electrical Drives Narosa (2e)*, 2010.

1. Chang-liang Xia, *Permanent Magnet Brushless DC Motor Drives and Controls*, Wiley, 2012.

EL3230: DATA BASE MANAGEMENT SYSTEM LAB [0 0 2 1]

DB application development with MS Access, Experiments on DDL and Basic SQL, Advanced SQL, ER diagrams using DIA tool, Data Integrity Constraints and Built-in Functions, Design and Implementing the data requirements of a simple DB application, Experiments on Basic PL/SQL, PL/SQL Exceptions and Transactions, PL/SQL Cursors, PL/SQL Procedures, Functions and Packages, DB application development with Oracle 19c.

References:

1. Ivan Bayross, *Teach yourself SQL & PL/SQL using Oracle 8i & 9i with SQLJ*, BPB Publications, 2010.
2. Raghu Ramakrishnan, *Database Management Systems*, McGraw Hill, 2014.
3. Ivan Bayross, *Introduction to SQL*, Tata McGraw, 2014.
4. Avi Silberschatz, Henry, F. Korth, S. Sudarshan, *Database System Concepts*, TMH, New Delhi, 2013.

EL3231: POWER ELECTRONICS & DRIVES LAB [0 0 2 1]

SCR characteristics: Measurement of latching and holding current, Implement the Single Phase Controlled Converter for R and RL load, Three phase half wave and full wave controlled converter with their harmonics analysis, Describe the operation of Buck, Boost DC – DC Converter. Open & Closed Loop Speed Control of Induction Motor Drives using Micro Controller, speed control of PMSM Motor Drives, Simulation of speed control of BLDC Motor Drive for Electric Vehicle Application, Simulation of configuration Plug in Hybrid Vehicle.

References:

1. D. W.Hart, *Introduction to Power Electronics*, PHI Learning Publications, 2010.
2. M.H.Rashid, *Power Electronics, Circuits, Devices and Applications (4e)*, PHI, 2017.
3. N. Mohan et. al., *Power Electronics, Converters, Applications & Design (2e)*, Wiley 2010.

EL3270: 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

EL4101: ELECTRICAL POWER SYSTEMS [3 1 0 4]

Representation of power system, Power System Faults: Types and classification, symmetrical three phase fault calculations, current limiting reactors, selection of circuit breakers, symmetrical components, sequence networks, unsymmetrical fault analysis. Load Flow Study:

Bus admittance model, mathematical problem formulation, static load flow equations and classification of buses. Power System Protection & Switch Gear: Protective Relaying- standard definition of relay terminologies, classifications & operating principles. Protection Schemes for Transmission Line- Over current protection, distance protection, pilot wire and carrier current protection, protection of bus, auto re-closing. protection of transformer, generator and motor. Circuit breakers- types and operating principles.

References:

1. J. J. Grainger and W. D. Stevenson, *Power System Analysis*, Tata Mc Graw–Hill Edition, 2003.
2. D. P. Kothari and I. J. Nagrath, *Modern Power System Analysis* (2e), TMH, 2013.
3. S. S. Rao, Switchgear *Protection and Power systems*, Khanna Publishers, 2015.
4. B. Ram and D. N. Vishwakarma, *Power System Protection & Switchgear*, MGH, 2014.

EL4130: POWER SYSTEM LAB [0 0 2 1]

Software based Experiments: YBUS and ZBUS formulation, load flow study using Gauss-Seidel (G-S), Newton-Raphson (N-R) and fast decoupled load flow (FDLF) methods, short circuit study, contingency analysis, optimal system operation, simulations on MATLAB and DIgSILENT – Power Factory Software. Hardware based Experiment: Study of 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. J. Nagrath and D. P. Kothari, *Modern Power System Analysis*, Tata Mc-Graw Hill, 2003.
2. H. Saadat, *Power System Analysis (3e)*, McGraw Hill, 2011.
3. Gmbh DIgSILENT. *DIgSILENT PowerFactory user manual*. DIgSILENT GmbH 2017;2017:1-1200. https://www.digsilent.de.
4. B. Ram and D. N. Vishwakarma, *Power System Protection & Switchgear*, MGH, 2014.
5. Ravindranath and M. Chander, *Power System Protection & Switchgear*, New Age International, 2018.

EL4170: 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.

EL4171: 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

EL4270: PROJECT WORK/PRACTICE SCHOOL [12]

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.

PROGRAMME ELECTIVES

PROGRAM ELECTIVE – I

EL3140: JAVA PROGRAMMING [3 0 0 3]

Java Basics: Compilation and Execution of a Java Program, Access Modifiers; Class and Objects: Class Definition, Creating Objects, Role of Constructors, Method Overloading, Argument Passing, Objects as Parameters, Access Control; I/O Basics: Reading Console Input, Writing Console Output; Array and Strings: Arrays in Java, 1-D, 2-D and Dynamic Arrays, String Basics, String Comparison and Manipulation; Inheritance: Inheritance and its Types, Abstract Class, Inner and Outer Class, Super, Final, Static Keywords; Package and Interface: In-Built Packages and User Define Packages, Role of Interface, Polymorphism via Inheritance; Collection Framework & Generics: List, Set, Map, Generic Classes; Exception Handling: Errors and Exceptions, Types of Exceptions, Handling Exceptions, Multithreading: Thread Class, Runnable, Thread Life Cycle, Synchronization, Thread Priority; Event Handling and GUI Programming: Events, Action Listener, Important Swing Package Classes.

References:

1. Schildt H, *Java: The Complete Reference*, (10e), Tata McGraw-Hill Education Group, 2017.
2. Balagurusamy E, *Programming with Java*, (5e), Tata McGraw Hill, 2017.
3. Daniel Liang Y, *Introduction to Java Programming*, (10e), Pearson Education, 2018.
4. Horstmann CS, *Big Java: Early Objects*, (5e), Wiley's Interactive Edition, 2015.

EL3141: DATA SCIENCE [3 0 0 3]

Descriptive Statistics: Introduction, Descriptive Statistics, Probability Distribution; Inferential Statistics: Inferential Statistics through Hypothesis Testing, Permutation and Randomization Test; Regression and ANOVA: regression analysis, analysis of variance; Machine Learning: Differentiating algorithmic and model based framework, OLS, RIDGE & LASSO regression, KNN & classification; Supervised Learning with regression and Classification technique: Bias-Variance Dichotomy, Logistic Regression, LDA, QDA, Regression and Classification Trees, SVM, Ensemble Methods, random Forest; Prescriptive Analysis: Creating Data through Designed Experiments, Active learning, Reinforcement Learning.

References:

1. C. Douglas and C. George, "*Applied Statistics and Probability for Engineers*", John Wiley and Sons, 2010.
2. H. Trevor et al., "*The elements of statistical learning*", Vol. 2. No.1.New York, Springer, 2009.

EL3142: RENEWABLE ENERGY SOURCES [3 0 0 3]

Energy sources and their availability across globe. Solar Energy - Solar radiation and measurements, solar energy storage, Solar Photo-Voltaic systems design, maximum power point tracking. Wind Energy- Estimation, Maximum power and power coefficient, wind energy conversion systems, design considerations and applications. Energy from Bio-Mass- Sources of biomass, 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, 2015.
3. D. Mukherjee & S. Chakrabarti, *Fundamentals of Renewable Energy Systems*, New Age Intl., 2014.
4. G. D. Rai, *Non-Conventional Energy Sources*, Khanna Publishers, 2012.

EL3143: MODERN OPTIMIZATION TECHNIQUES [3 0 0 3]

Introduction to optimization problems – Definitions, classification, mathematical problem formulation of objective functions and constraints, Traditional optimization methods: Linear programming, newton's method, interior point method, nonlinear programming, quadratic programming. Modern optimization algorithms: 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 (2e)*, PHI Learning, 2012.
2. 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 (1e)*, IEEE Press, 2008.

PROGRAM ELECTIVE – II

EL3240: LINUX PROGRAMMING [3 0 0 3]

Fundamentals: Processes in Linux, I/O system calls, select and poll functions, Filters and redirection, Linux file system navigation, Directory access, File system implementation, Hard

links and symbolic links. Asynchronous Events: Manipulating signal masks and signal sets, Catching and ignoring signals, Waiting for signals. Inter-Process Communication: Sockets, Remote procedure calls, Network file system. Concurrency: POSIX thread attributes, Synchronization functions, Mutex locks, Condition variables, Signal handling and threads. Character Device Driver Development: Driver concepts, Writing character drivers, Interrupt handling, Interfacing with hardware. Shell Scripting: Loops, Conditional statements, Command line arguments, test command, expr command. Advanced Scripting Techniques: Providing command line options to scripts, Exporting variables, Arrays, Remote shell execution, Connecting to MySQL using shell, Essential system administration.

References*:*

1. W. R. Stevens, S. A. Rago, *Advanced Programming in the UNIX Environment (3e)*, AddisonWesley, 2013.
2. R. Love, *Linux System Programming: Talking Directly to the Kernel and C Library*, O'Reilly, 2013.
3. S. Das, *Unix Concepts and Applications (4e)*, McGraw Hill, 2017.
4. W. R. Stevens, B. Fenner, *UNIX Network Programming, Volume 1: The Sockets Networking API (3e)*, Pearson, 2003.
5. K. A. Robbins, S. Robbins, *Unix Systems Programming: Communication, Concurrency, and Threads (2e)*, Prentice Hall, 2015.

EL3241: INTERNET OF THINGS [3 0 0 3]

Introduction to IoT: Definition and characteristics of IoT, Design of IOT: Physical design of IOT, Logical Design of IOT- Functional Blocks, communication models, communication APIs, Basics of Networking - Wireless Sensor Networks, Cloud computing, Sensor-Cloud. IoT Hardware and Software: Sensor and actuator, Humidity sensors, Ultrasonic sensor, Temperature Sensor, Arduino, Raspberry Pi, Communication Protocols, Sensor Networks, Integration of Sensors and Actuators with Arduino, Introduction to SDN, SDN for IoT, Data Handling and Analytics. Challenges in IoT- Design challenges, Development challenges, Security challenges, Other challenges. IOT and M2M: M2M, Difference and similarities between IOT and M2M, Software defined networks, network function virtualization, difference between SDN and NFV for IoT. IOT Applications. i) Lighting as a service (case study) ii) Intelligent Traffic systems (case study) iii) Smart Parking (case study) iv) Smart water management (case study).

References:

1. M. Miller, *The Internet of Things: How Smart TVs, Smart Cars, Smart Homes, and Smart Cities Are Changing the World(1e)*, Que, 2015.
2. R. Kamal, *Internet of Things: Architecture and Design Principles*, MacGra Hills, 2017.
3. H. David, *IoT Fundamentals | Networking Technologies, Protocols, and Use Cases for the Internet of Things*, Cisco Press,2017.

EL3242: DIGITAL SIGNAL PROCESSING [3 0 0 3]

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. IIR filter design: Classical filter design using Butterworth and Chebyshev approximations and bilinear transformation methods, Frequency transformation technique for HP, BP and BS filter design. Applications of DSP.

References:

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

EL3243: ENGINEERING SYSTEMS MODELING [3 0 0 3]

Basic Introduction to Systems: Definitions and Classification of Systems, Analysis and Synthesis, Linear and Nonlinear Systems, Time-Varying and Time-Invariant Systems, Continuous-Time and Discrete-Time Systems, Deterministic and Stochastic Systems. Systems Modeling: Classification of Models, Characteristics of Models, Fundamental Hypothesis and Component Postulate, Model Evaluation, Model Reduction, Generic Description of Two-Terminal Components. Mathematical Modeling of Physical Systems: Review of Transfer Function Approach and State Space Approach, Modeling Examples of Mechanical Systems - Translational and Rotational Motion Systems, Electrical Systems, Electromechanical Systems, Hydraulic Systems, Thermal Systems. Graph Theory: Basic Definitions - Planar and Directed Graphs, Paths and Circuits, Trees and Co-Trees, Fundamental Circuits and Cut-sets, Dual Graphs, Matrix representation of Graphs. Graph Theoretic Methods and Algorithms for Physical System Modeling Applications: Electrical Network Analysis by Graph Theory – Mesh Analysis and Nodal Analysis for AC/DC Circuits, Electronic Circuit Analysis, Mechanical System Analysis.

References:

1. K. Ogata, *System Dynamics*, Pearson Education India, 2014.
2. C. A. Kluever, *Dynamic Systems: Modeling, Simulation, and Control*, (2e), Wiley, 2019.
3. V. P. Singh, *System Modeling and Simulation*, New Age International, 2009.
4. D. K. Chaturvedi, *Modeling and Simulation of Systems using MATLAB and Simulink*, CRC Press, 2010.
5. N. Deo, Graph Theory with Applications to Engineering & Computer Science, PHI, 1979.

PROGRAM ELECTIVE – III

EL3250: BIG DATA ANALYSIS [3 0 0 3]

Introduction to big data, definition, need and evolution of BDA, Applications of Big Data. Analysing big data: Sources of big data, Characteristics of Big Data (4 V's), Drivers of BDA, Structured vs. Unstructured data, Data Marts, Differences between traditional DWDM and BDA. Data Processing: Data Wrangling, Data Munging, Data Jujitsu. Data Visualisation: Why to visualize data. Data Analytics Life Cycle. Advanced Analytics Algorithms: Introduction using R – Theory and Methods Overview: K-means clustering, Association Rules, Linear Regression, Logistic Regression, Naïve Bayesian Classifiers, Decision Trees, Time Series Analysis, Text Analytics; Statistics for Model Building and Evaluation: Statistics in the Analytic Lifecycle, Hypothesis Testing, Difference of means. Hadoop Framework: Introduction to Hadoop, HDFS - Hadoop Distributed File system, Map Reduce Programming, Pig. ETL & Batch Processing with Hadoop: ETL & Data Warehousing, Ingesting data into Big Data Platforms using Apache Sqoop & Flume, Big Data Analytics using Apache Hive, NoSQL databases for Big Data Storage Applications (HBase), Workflow management for Hadoop using Oozie Spark: Introduction to Spark, SparkSQL, MLLib: Regression, Clustering & Classification using Spark MLLib.

References:

1. B. Schmarzo, *Big Data: Understanding How Data Powers Big Business*, Wiley, 2013.
2. Jorgensen, J. Rowland-Jones, J. Welch, *Microsoft Big Data Solutions*, Wiley, 2014.
3. J. Thompson, S. P. Rogers, *Analytics: How to Win with Intelligence, Technics*, LLC Publications, 2017.

EL3251: INTELLIGENT AUTONOMOUS SYSTEMS [3 0 0 3]

Domain for Intelligent Autonomous Systems, Constructive Approach to Artificial Minds, Introduction to Absolute & Relative Visual Navigation. Advanced Control: Introduction to System Identification, Procedure for identification, Introduction to optimal control, Calculus of Variations and Optimal Control, Linear Quadratic Optimal Control, Linear Quadratic Tracking System, Finite-Time and Infinite Time Case, Robust Control, Control and Decision Making. 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. S. G. Tzafestas, *Advances in Intelligent Autonomous Systems (1e)*, Springer, 1999.
2. K. Nonami, M. Kartidjo, Kwang-Joon Yoon & A. Budiyono, *Autonomous Control Systems and Vehicles (1e)*, Springer, 2013.
3. J. W. Webb and R. A. Reis, *Programmable Logic Controllers - Principles and Applications (4e)*, PHI, 2002.
4. M. P. Lukcas, *Distributed Control Systems*, Van Nostrand Reinhold Co., 1986.
5. F. D. Petruzella, *Programmable Logic Controllers (2e)*, MGH, 2016.

EL3252: SOLAR PHOTOVOLTAIC SYSTEMS [3 0 0 3]

Renewable energy sources, global scenario, Sun-Earth movement & angles, solar energy potential. Solar cells and modules: types of solar cells, equivalent circuit, I-V and P-V characteristics, short circuit current, open circuit voltage, solar PV modules and arrays, series and parallel operation, solar energy storage, atmospheric, temperature and shading effects, maximum power point tracking, MPPT schemes. Solar PV concentrators. Solar radiation measurements, solar photo-voltaic system: off-grid & grid connected systems. Applications of photovoltaic for power generation, design of off-grid solar power plant.

References:

1. Chetan Singh Solanki, *Solar Photovoltaics: Fundamentals, Technologies and Application* (3e), PHI Learning, 2015.
2. Sundaravadivelu S., Suresh R. Norman, Johnsi Stella I. and Suresh Kumar A., *Solar Photovoltaic Power Systems*, Notion Press, 2017.
3. Arno Smets, Klaus Jäger, Olindo Isabella, René Van Swaaij and Miro Zeman, *Solar Energy: The Physics and Engineering of Photovoltaic Conversion, Technologies and Systems*, UIT Cambridge, 2016.
4. Suneel Deambi, *Photovoltaic System Design: Procedure, Tools and Applications (1e)*, CRC Press USA, 2016.

EL3253: ENERGY STORAGE DEVICES [3 0 0 3]

Energy Storage Systems & applications: utilities, transport, industry, household, total energy system – hybrid, combined, integrated; Introduction to different energy forms - Mechanical energy storage, Electromagnetic energy storage. Electro-chemical storage- Electro-chemical cell, fuel cells, batteries, Battery Technologies, Fuel cells, Supercapacitors, Pseudo-capacitors, Hydrogen as storage medium for renewable energy systems; Lithium-ion battery technologies, battery management systems, Equivalent circuit model and associated parameters; St of Charge, State of health, Remaining Useful Life, Algorithms for state estimation, State estimation using machine learning techniques.

References:

1. Xiong, Rui, *Battery Management Algorithm for Electric Vehicles(1e)*, Springer, 2020.
2. Korthauer, Reiner, *Lithium-Ion Batteries: Basics and Applications(1e*), Springer, 2018.
3. Zhengcheng Zhang and Sheng Shui Zhang, *Rechargeable Batteries -Materials, Technologies and New Trends(1e)*, Springer International Publishing,2015.
4. Hariharan, Krishnan S., Tagade, Piyush, Ramachandran, Sanoop, *Mathematical Modeling of Lithium Batteries -From Electrochemical Models to State Estimator Algorithms(1e)*, Springer International Publishing, 2018.
5. Johannes, Jensen and B. Sorensen, *Fundamentals of Energy Storage*, John Wiley, 1984.

EL3254: GENERATION, TRANSMISSION & DISTRIBUTION [3 0 0 3]

General layout of electrical power systems. Generation of Electric Power: Hydro-electric power plants, thermal and nuclear power plants, renewable energy generation- solar & wind power plants. Brief introduction to automatic generation control. Transmission & Distribution of Electrical Power: Typical AC transmission and distribution scheme, effect of system voltage and regulation, computation of line parameters, line performance of short, medium & long transmission line, Ferranti effect, power factor improvement, overhead insulators, underground

cables, corona. Power system representation: Single line diagram, per unit system, reactance diagram.

References:

1. C. L. Wadhwa, *Electrical Power System(3e)*, New Age Intl, 2013.
2. B. R. Gupta, *Generation of Electrical Energy (7e)*, S. Chand Publications, 2017.
3. D. P. Kothari and I. J. Nagrath, *Modern Power System Analysis (2e)*, TMH, 2013.
4. B. R. Gupta, *Power System Analysis and Design (7e)*, S. Chand Publications, 2014.

PROGRAM ELECTIVE – IV

EL4140: DESIGN & ANALYSIS OF ALGORITHMS [3 0 0 3]

Introduction: Fundamentals of Algorithms, Important Problem Types, Analysis of algorithm efficiency. Analysis Framework: Asymptotic Notations and Basic Efficiency Classes, Mathematical Analysis of Nonrecursive and Recursive Algorithms, Brute force Techniques, Divide and Conquer. Decrease and Conquer: Insertion Sort, Depth First Search, Breadth First Search, Topological Sorting. Transform and Conquer: Presorting, BST, Heapsort. Space and Time tradeoffs: Input Enhancement in String Matching. Dynamic Programming: Warshall's and Floyd's Algorithms, The Knapsack Problem. Greedy Techniques: Prim's, Kruskal's and Dijkstra's Algorithm, Huffman Trees, Coping with limitations of algorithmic power. Backtracking: nQueens problem, Hamiltonian Circuit Problem, SubsetSum Problem. BranchandBound: Assignment Problem, Knapsack Problem, TSP. Complexity Clasess: P, NP,and NPcomplete Problems.

References*:*

1. E. Horowitz, S. Sahni, S. Rajasekaran, *Fundamental of Computer Algorithms (2e)*, Universities Press, 2007.
2. T. H. Cormen, C. E. Leiserson, R.L. Rivest and C. Stein, *Introduction to Algorithms (3e)*, MIT press, 2009.

EL4141: WEB TECHNOLOGY [3 0 0 3]

Introduction: Web Development and Client Side Programming, Protocols Governing Web, Internet Services and Tools, ClientServer Computing; HTML: Basic Syntax, Standard HTML Document Structure, Basic Text Markup, Images, Hypertext Links, Lists, Tables, Forms, HTML5; CSS: Creating Style Sheets, Levels of Style Sheets, CSS Properties, Style Specification Formats, Selector Forms, The Box Model, Conflict Resolution; Javascript: Basic of Javascript, Variables, Arrays and Operators, Functions, Event Handlers, Built-in JS Objects, Form Validations, Conditional and Loops, Debugging and Testing; Introduction to AJAX: AJAX and Node.Js Server, The Xmlhttprequest Object, Handling The Response, Jquery, Passing Data; PHP Programming: Introduction to PHP, Creating PHP Script, Running PHP Script, Variables and Constants, Data Types, Operators, Conditional Statements, Control Statements, Arrays, Functions.

References:

1. *Web Technologies (Black Book)*, Kogent Learning Solutions Inc., Dreamtech Press, 2009.

2. Jackson, *Web Technologies: A Computer Science Perspective*, (1e), Pearson Education India, 2007.
3. Srinivasan, *Web Technology: Theory and Practice, (1e)*, Pearson Education India, 2012.
4. A. Godbole and A. Khate, *Web Technologies, (3e)*, McGraw Hill Education, 2017.
5. N. P. Gopalan and J. Akilandeswari, *Web Technology: A Developer's Perspective, (2e Revised)*, Prentice Hall India Learning, 2014.
6. U. K. Roy, *Web Technologies*, Oxford Press, 2010.

EL4142: ELECTRIC VEHICLE TECHNOLOGY [3 0 0 3]

Introduction to Electric Vehicles: History, social and environmental importance, overview of Electric Vehicles in India, impact of modern drive-trains; Vehicle Dynamics, Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, sizing the propulsion motor and power electronic converters. Power Electronics & its Control Circuits: EV configuration based on power converters, DC–DC Converter Topologies DC/DC converters, DC/AC Inverters. Electric Drive-trains - Basic concepts, power flow control, topologies, Introduction of drives, configuration and control of BLDC motor drives, Induction Motor drives, Permanent Magnet Synchronous Motor drives, Switch Reluctance Motor drives, Regenerative braking operation, Energy Storage - Introduction Charging technologies Fundamentals of EV Battery Pack design: Fuel Cell, Super Capacitor and Flywheel based energy storage and analysis, Supporting subsystems - Energy Management Strategies, Battery management systems, Case Studies - Design of a Battery Electric Vehicle (BEV). Modelling & Simulation using Matlab/Simulink: DC to DC converter controlled BLDC motor based vehicle system,

References:

1. M. Ehsani, Y. Gao, S. E. Gay, and A. Emadi, *Modern Electric, Hybrid Electric, and Fuel Cell Vehicles*, CRC Press, 2018.
2. C. Mi, M. and A. Masrur, *Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives*, Wiley 2017.
3. S. Rajkaruna, F. Shahnia, *Plug in Electric Vehicles in Smart Grids*, Springer, 2015.
4. R. Krishnan, *Permanent Magnet Synchronous and Brushless DC Motor Drives*, CRC Press, 2017.
5. K. T. Chau, *Electric Vehicle Machines and Drives, Design, Analysis and Application*, John Wiley & Sons Singapore P. Ltd, 2015.

EL4143: 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, (3e),* John Wiley & Sons, Ltd., 2010.
3. S. Haykin, *Neural Networks and Learning Machines (3e),* PHI, 2008
4. S. N. Sivanandam and S. N. Deepa, *Principles of Soft Computing (3e),* Wiley India edition, 2018.
5. S. Rajasekaran, G. A. Vijayalakshmi Pai, *Neural Networks, Fuzzy Logic and Genetic Algorithm, Synthesis and Applications*, PHI Learning Pvt. Ltd., 2017.
6. N. P. Padhy and S. P. Simon, *Soft Computing with MATLAB Programming*, Oxford University Press, 2015.

PROGRAM ELECTIVE – V

EL4150: ARTIFICIAL INTELLIGENCE & MACHINE LEARNING [3 0 0 3]

Artificial Intelligence: Overview and historical perspective, Agents, Search Algorithms: Heuristic Search, Greedy Search, Stochastic Search. Game playing: Minimax Algorithm, Alpha Beta Algorithm, Knowledge, reasoning, and planning. Uncertain knowlege and reasoning: probabilities and Bayesian networks. Machine Learning: Introduction, mathematical background, supervised learning, unsupervised learning, reinforcement learning, regression and classification, feature selection, dimensionality reduction, hyper parameter tuning regularization, artificial neural networks, clustering. Applications of Artificial Intelligence and Machine Learning.

References:

1. D. Khemani. *A First Course in Artificial Intelligence*, McGraw Hill Education (India), 2013.
2. S. Russell, P. Norvig. *Artificial Intelligence: A Modern Approach*, Prentice Hall, 2020.
3. K. Deb. *Optimization for Engineering Design Algorithms and Examples*, Prentice Hall of India, New Delhi, 2012.
4. C. M. Bishop. *Pattern Recognition and Machine Learning*, Springer, 2010.
5. P. McCorduck, *Machines Who Think: A Personal Inquiry into the History and Prospects of Artificial Intelligence*, A K Peters/CRC Press, 2019.

EL4151: 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

EL4152: ENERGY AUDIT & MANAGEMENT [3 0 0 3]

Energy: Types, Needs, Scenario, Energy Security, Environmental Impact, Energy Reforms, Energy Information Systems; Material & Energy Balance: Consumption Pattern, Sankey Diagram, Energy Policy, Optimization of energy utilization by proper planning; Energy Statute :Conservation Act 2001, Electricity Act 2003 and 2014 amendment, 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 and Thermal Utilities; Energy Economics: Analysis, Data-driven approach for decision making on Energy Savings and Energy conservation opportunities(ESCOs), Case study on Green building and Green technology using cradle-to-grave analysis.

References:

1. Paul W. O'Callaghan, *Energy Management A comprehensive guide to reducing costs by efficient energy use*, McGraw Hill, England, 1992.
2. "*IEEE Recommended Practice for Energy Management in Industrial and Commercial Facilities*," IEEE Std 739-1995 [The Bronze Book], 1996, doi: 10.1109/IEEESTD.1996.85948.
3. S. J. Hansen and J. W. Brown, *Investment Grade Energy Audit – Making Smart Energy Choices*, River Publishers, 2003.
4. A. Kumar, O. Prakash, P. S. Chauhan, S. Gautam, *Energy Management Conservation and Audits*, CRC Press, 2020.

EL4153: SMART GRID TECHNOLOGIES [3 0 0 3]

Philosophy of smart grid and smart distribution system: Key technology areas, smart grid architecture. Information and communication technologies: Data communication, communication technologies and protocol, information security. Smart metering and demand-side integration: Smart metering, communications infrastructure and protocols for smart metering, demand-side integration. Distribution automation equipment: Substation automation equipment, faults in the distribution system, voltage regulation. Distribution management systems: Data sources and associated external systems, modelling and analysis tools, decision support systems. Power electronics for bulk power flows: FACTS, HVDC, energy storage technologies.

References:

1. J. Momoh, *Smart Grid: Fundamentals of Design and Analysis*, IEEE press, John Wiley & Sons, 2012.
2. T. Sato, D. M. Kammen, B. Duan, M. Macuha, Z. Zhou, and J. Wu, *Smart Grid Standards: Specifications, Requirements, and Technologies*, Wiley-Blackwell, 2015.
3. J. Ekanayake, K. Liyanage, J. 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.

PROGRAM ELECTIVE – VI

EL4160: ROBOTICS & 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* (8e), John Wiley & Sons Inc, 2019.

EL4161: 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. Bahga and V. Madisetti, *Blockchain Applications: A Hands-On Approach*, A. Bahga & V. Madisetti, 2017.
3. N. Prusty, *Building Blockchain Projects*, Packt, 2017.

EL4162: 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: Battery management system, 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 methods- constant current (CC), constant voltage (CV), constant power (CP), taper charging, trickle charging, constant current constant voltage (CCCV). 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, Impact of Plug-in Charging Current and Temperature on the Power Distribution System. Wireless Power Transfer for Electric Vehicles, Architecture of the wireless charging station. Simulation of DC fast charging system.

References:

1. 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. M. Ehsani, Y. Gao, S. E. Gay, and A. Emadi, *Modern Electric, Hybrid Electric, and Fuel Cell Vehicles*, CRC Press, 2018.

EL4163: DISTRIBUTED ENERGY RESOURCES [3 0 0 3]

Overview of centralized generation and distributed generation: Definition and features of DGs. Distributed generation technologies: Fuel cells, reciprocating engines, gas turbines, photovoltaic systems, wind energy conversion system, solar thermal, geothermal, small hydro-turbines, biomass. Energy storage technologies: Battery energy storage system, flywheels, superconducting magnetic energy storage, compressed air energy storage, pumped storage. Integration of DERs with grid: Principles of power injection, integration of multiple DERs, DER control and power injection, islanding, interconnection technologies, advantages and disadvantages of DERs, integration issues. Standards and codes for interconnection, hybrid energy systems.

References:

1. G. B. Gharehpetian and S. M. M. Agah, *Distributed Generation Systems: Design, Operation and Grid Integration (1e)*, Butterworth-Heinemann, 2017.
2. M. S. Mahmoud and F. M. AL-Sunni, *Control and Optimization of Distributed Generation Systems (1e)*, 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.
4. M. H. Nehrir and C. Wang, *Modelling and Control of Fuel Cells: Distributed generaion Applicationse (1e)*, Wiley- IEEE Press, 2009.
5. T. Funabashi, *Integration of Distributed Energy Resources in Power Systems: Implementation Operation, and Control (1e)*, Academic Press-Elsevier, 2016.

PROGRAM ELECTIVE – VII

EL4170: CLOUD COMPUTING [3 0 0 3]

Introduction: Distributed Computing and Enabling Technologies, Cloud Fundamentals: Cloud Definition, Evolution, Architecture, Applications, deployment models, and service models. Virtualization: Issues with virtualization, virtualization technologies and architectures, Internals of virtual machine monitors/hypervisors, virtualization of data centers, and Issues

with Multi-tenancy. Implementation: Study of Cloud Computing Systems like Amazon EC2 and S3, Google App Engine, and Microsoft Azure, Build Private/Hybrid Cloud using open-source tools, Deployment of Web Services from Inside and Outside a Cloud Architecture. MapReduce and its extensions to Cloud Computing, HDFS, and GFS. Interoperability and Service Monitoring: Issues with interoperability, Vendor lock-in, Interoperability approaches. SLA Management, Metering Issues, and Report generation. Resource Management and Load Balancing: Distributed Management of Virtual Infrastructures, Server consolidation, Dynamic provisioning and resource management, Resource Optimization, Resource dynamic reconfiguration, Scheduling Techniques for Advance Reservation, Capacity Management to meet SLA Requirements, and Load Balancing, various load balancing techniques. Migration and Fault Tolerance: Broad Aspects of Migration into Cloud, Migration of virtual Machines and techniques. Fault Tolerance Mechanisms. Advances: Grid of Clouds, Green Cloud, Mobile Cloud Computing.

References:

1. R. Buyya, J. Broberg, A. Goscinski, *Cloud Computing Principles and Paradigms*, Wiley Publishers, 2013.
2. B. Sosinsky, *Cloud Computing Bible*, Wiley, 2011.
3. M. Miller, *Cloud Computing: Web-based Applications that change the way you work and collaborate online*, Pearson, 2008.
4. D. S. Linthicum, *Cloud Computing and SOA Convergence in Your Enterprise: A Step-by-Step Guide*, Addision Wesley Information Technology Series, 2010.

EL4171: DEEP LEARNING [3 0 0 3]

Introduction: Neural networks; Training a network: Loss functions, back propagation and stochastic gradient descent, neural networks as universal function; Convolutional Neural Networks: Introduction to Convnet, training a Convnet, weights initialization, batch normalization, pooling, padding, dropouts, hyper parameter optimization, CNN Architectures-AlexNet, VGG, Inception, ResNet; Recurrent neural network: Recurrent networks, long short-term memory(LSTM), gated recurrent units(GRU), recurrent neural network language models; Deep unsupervised learning: Auto encoders, variation auto encoders, generative adversarial networks(GAN), maximum entropy distributions; Applications: Deep learning applications to computer vision and natural language processing(NLP)

References:

1. L. Deng & D. Yu, Deep *Learning: Methods and Applications*, (1e), Now Publishers, 2014.
2. Goodfellow, Y. Bengio, A. Courville, *Deep Learning*, (1e), MIT Press, 2016.
3. M. Nielsen, *Neural Networks and Deep Learning*, (1e), Determination Press, 2015.
4. C. R. Shalizi, *Advanced Data Analysis from an Elementary Point of View*, (1e) Cambridge University Press, 2015.

EL4172: ELECTRICITY MARKETS & OPERATIONS [3 0 0 3]

Introduction to Restructuring of Power Industry: Basic Terminology- Restructuring, Competition and Deregulation, Deregulation of power industry. 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), Pool markets and Bilateral markets, Role of GENCOs in Pool and Bilateral markets, market participation issues, competitive bidding. 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, England, 2006.

EL4173: MODERN 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, D. Maksimovic, *Fundamentals of Power Electronics (2e)*, Springer, 2010.
2. D. W. Hart, *Introduction to Power Electronics*, PHI, 2010.
3. N. Mohan et. al., *Power Electronics, Converters, Applications & Design (2e)*, Wiley, 2014.
4. M. K. Kazimierczuk, *Pulse-Width Modulated DC-DC Power Converters (2e)*, Wiley, 2015.

OPEN ELECTIVES

EL2080: SOLAR PHOTOVOLTAIC [3 0 0 3]

Renewable energy sources, global scenario, Sun-Earth movement & angles, solar energy potential. Solar cells and modules: types of solar cells, equivalent circuit, I-V and P-V characteristics, short circuit current, open circuit voltage, solar PV modules and arrays, series and parallel operation, solar energy storage, atmospheric, temperature and shading effects, maximum power point tracking, MPPT schemes. Solar PV concentrators. Solar radiation measurements, solar photo-voltaic system: off-grid & grid connected systems. Applications of photovoltaic for power generation, design of off-grid solar power plant.

References:

1. C. S. Solanki, *Solar Photovoltaics: Fundamentals, Technologies and Application (3e)*, PHI Learning, 2015.
2. S. Sundaravadivelu, Suresh R. Norman, Johnsi Stella I. and Suresh Kumar A., *Solar Photovoltaic Power Systems*, Notion Press, 2017.
3. Arno Smets, Klaus Jäger, Olindo Isabella, René Van Swaaij and Miro Zeman, *Solar Energy: The Physics and Engineering of Photovoltaic Conversion, Technologies and Systems*, UIT Cambridge, 2016.
4. Suneel Deambi, Photovoltaic System Design: Procedure, Tools and Applications (1e), CRC Press USA, 2016.

EL2081: MATLAB FOR ENGINEERS [3 0 0 3]

MATLAB Fundamentals: Introduction and Installation of software, Arithmetic operations, Creating and working with arrays (or vectors), Creating, saving and executing script file, Creating, saving and executing function file, Working with files, directories and publishing reports, Use of input, fprintf and sscanf in MATLAB, The conditional control statements, Numerical Analysis: Finding roots of a polynomial and Matrix operations, Ordinary differential equations and solutions to transcendental equations, Polynomial curve fitting, and numerical integration, Gauss Jordan, Gauss Elimination, Gauss Seidel and Jacobi, Roots of non-linear equation - Newton Raphson, Electrical Engineering Applications: Simple programs to solve electrical engineering problems, Simple programs to solve unsteady state problems

References:

1. Rudra Pratap, *Getting Started with MATLAB 7: A Quick introduction for scientists and engineers*, Oxford University Press.
2. Kirani Singh Y. and Chaudhuri B.B., *MATLAB Programming*, Prentice-Hall of India, 2007.
3. Etter, Delores M., *Engineering Problem solving with MATLAB*, Prentice-Hall, 1993
4. Lindfield, George and John Penny, *Numerical Methods Using MATLAB*, Prentice-Hall, 2000.

EL3080: FUNDAMENTALS OF RENEWABLE ENERGY SOURCES [3 0 0 3]

Energy scenario: Global and national energy scenarios, Forms and characteristics of Renewable energy sources. Solar Energy: Introduction, solar radiation measurements, solar energy storage, fundamentals of solar photo-voltaic conversion, solar cells, photo-voltaic system design, solar PV applications. Wind Energy: Wind energy estimation, maximum power

and power coefficient, wind energy conversion system (WECS), Design considerations and applications. Biomass: Sources of biomass, biomass conversion technologies, thermo and biochemical conversions, anaerobic digestion and fermentation, bio-gas generation, pyrolysis and liquefaction, classification of gasifiers. Geo-Thermal Energy: Geothermal systems and classifications, geothermal based electric power generation. Ocean & Tidal Energy: 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: Introduction and applications.

References:

1. B. H. Khan, *Non-conventional Energy Resources (3e)*, TMH, 2017.
2. G. D. Rai, *Non-Conventional Energy Sources*, Khanna Publishers, 2004.
3. J. W. Twidell & A. D. Weir, *Renewable Energy Resources*, ELBS, 2019.
4. D. Mukherjee & S. Chakrabarti, *Fundamentals of Renewable Energy Systems*, New Age Intl., 2004.

EL3081: INTRODUCTION TO 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 induction machines, switched reluctance machines. 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, (1e)*, 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. J. Larminie, J. Lowry, *Electric Vehicle Technology Explained*, Wiley, 2003.
6. P. Krause, O. Wasynczuk, S. D. Sudhoff and S. Pekarek, *Analysis of Electric Machinery and Drive Systems (3e)*, Wiley-IEEE Press, 2013.

EL3082: INTRODUCTION TO ELECTRICITY MARKETS [3 0 0 3]

Introduction to Restructuring and Deregulation of power industry. 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), Pool markets and Bilateral markets, Operational planning activities of a GENCOs in Pool and Bilateral markets, market participation issues, competitive bidding. Transmission Pricing:

Transmission open access, Transmission Pricing Schemes, Transmission Cost Allocation. Ancillary Services Auction Market: General description of various ancillary services.

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, England, 2006.

EL3083: ENERGY AUDITING [3 0 0 3]

Energy: Types, Needs, Scenario, Energy Security, Environmental Impact, Energy Reforms, Energy Information Systems; Material & Energy Balance: Consumption Pattern, Sankey Diagram, Energy Policy, Optimization of energy utilization by proper planning; Energy Statute :Conservation Act 2001, Electricity Act 2003 and 2014 amendment, 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 and Thermal Utilities; Energy Economics: Analysis, Case study on Green building and Green technology using cradle-to-grave analysis.

References:

1. Paul W. O'Callaghan, *Energy Management A comprehensive guide to reducing costs by efficient energy use*, McGraw Hill, England, 1992.
2. *IEEE Recommended Practice for Energy Management in Industrial and Commercial Facilities*, IEEE Std 739-1995 [The Bronze Book], 1996, doi: 10.1109/IEEESTD.1996.85948.
3. S. J. Hansen and J. W. Brown, *Investment Grade Energy Audit – Making Smart Energy Choices*, River Publishers, 2003.
4. A. Kumar, O. Prakash, P. S. Chauhan, and S. Gautam, *Energy Management Conservation and Audits*, CRC Press, 2020.

***