PAKISTAN ENGINEERING COUNCIL

Syllabus for Engineering Practice Examination (EPE)

Electrical Engineering and Allied Disciplines
(Electrical/ Electronics/ Industrial Electronics/ Telecommunication/ Avionics/ Mechatronics/ Biomedical/ Computer Engineering)

Total Marks: 60

PART-II

This is an open book breadth and depth examination, comprising 60 Multiple Choice Questions (MCQs) of one mark each (total 60 marks) with a duration of three hours. There shall be two sections of Part-II for each major discipline of EPE. Qualifying Marks for this part shall be *sixty per cent*.

SECTION-A / BREADTH

This section will generally confirm to latest (updated) B.E./equivalent qualification of Electrical Engineering and allied disciplines. The examination of this section shall comprise 25 MCQs (total 25 marks).

1. Mathematics – 13%

   i. Calculus and Analytical Geometry
   ii. Linear Algebra
   iii. Differential Equations
   iv. Complex Variables and Transforms
   v. Probability and Statistics
   vi. Numerical Methods.

   Suggested Books:

   - Erwin Kreyszig, "Advanced Engineering Mathematics," Ninth Edition, 2005, International Edition, John Wiley & Sons.
   - Stephen Goode, "Differential Equations and Linear Algebra," Second Edition, 2000, Prentice Hall.
   - Susan Milton and Jesse C Arnold, "Introduction to Probability and Statistics: Principles and Applications for Engineering and the Computing Sciences," Fourth Edition, 2003, McGraw-Hill.

2. Electric Circuits – 20%

   i. Electrostatics
   ii. Electrodynamics
   iii. Electrical circuit elements
   iv. DC and AC electric circuits
   v. Magnetic circuits
   vi. Fundamental Circuit Laws
   vii. Circuit theorems

viii. Two-Port Networks
ix. Filters (passive)
x. Frequency response
xi. Transfer functions.

Suggested Books:

- William H. Hayt, Jack Kemmerly and Steven M. Durbin, "Engineering Circuit Analysis," Seventh Edition, 2006, McGraw-Hill.
- J. David Irwin and R. Mark Nelms, "Basic Engineering Circuit Analysis," Ninth Edition, 2008, John Wiley & Sons.

3. Electronics – 17%

i. Semiconductor materials
ii. Semiconductor devices
iii. Biasing circuits
iv. Rectifiers
v. Limiting and clamping circuits
vi. Power supplies
vii. Applications of transistors as switches and amplifiers
viii. Op Amp and its Applications (amplifiers, differentiators/integrators, oscillators/signal generators, active filters)
ix. 555 timer and its applications (monostable, bistable and astable multivibrators)
x. Transducers
xi. Lasers basics.

Suggested Books:

- Robert Boylestad and Louis Nashelsky, "Electronic Devices and Circuit Theory," Ninth Edition, 2006, Prentice Hall.
- Adel S. Sedra and Kenneth C. Smith, "Microelectronic Circuits," Fifth Edition, 2003, Oxford University Press.
- Thomas Floyd, "Electronics Fundamentals: Circuits, Devices, and Applications," Sixth Edition, 2004, Prentice Hall.

4. Control Systems/ Signal Processing – 20%

i. Control Systems (10%)

- Open-Loop and Closed-Loop Systems
- Signal flow graphs
- System modeling
- Transfer functions
- Stability criteria
- Feedforward and feedback control systems
- Gain and phase margins
- PID controllers
- State space analysis.

ii. Signal Processing (10%)

- Types of signals

- LTI Continuous and Discrete-Time signals and systems
- Convolution
- Sampling theorem
- Aliasing
- Z transform
- Difference equations
- DFT & FFT
- Digital filters.

Suggested Books:
- Norman S. Nise, "Control Systems Engineering," Fourth Edition, 2004, John Wiley and Sons.
- Katsuhiko Ogata, "Modern Control Engineering," Fourth Edition, 2002, Prentice Hall.
- Simon Haykin, "Signals and Systems," Second Edition, 2003, John Wiley & Sons.
- John G Proakis, "Digital Signal Processing," Fourth Edition, 2008, Prentice Hall.
- Allan V Oppenheim, "Discrete-time Signal Processing," Third Edition, 2006, Prentice Hall.

5. Electric Power (Basics) – 10%

- Single-Phase and Poly-Phase circuits
- Star delta transformation
- Power triangle and power factor corrections
- Phasor diagrams
- Voltage regulation
- Transformers
- DC and AC machines

Suggested Books:
- William D. Stevenson Jr., "Elements of Power System Analysis," Fourth Edition, 1982, McGraw-Hill.
- A. E. Fitzgerald, Charles Kingsley, Jr. and Stephen D. Umans, "Electric Machinery," Sixth Edition, 2003, McGraw-Hill.
- Stephen J. Chapman, "Electric Machinery Fundamentals," Fourth Edition, 2004, McGraw-Hill.

6. Computer Fundamentals– 10%

i. Computer organization
ii. Digital Logic Design
iii. Computer architecture
iv. Microprocessors & interfacing
v. Microcontrollers
vi. Structured and object-oriented programming

Suggested Books:
- William Stallings, "Computer Organization and Architecture: Designing for Performance," Seventh Edition, 2006, Prentice Hall.
- Robert Lafore, "Object-Oriented Programming in C++," Fourth Edition, 2002, Prentice Hall.

7. Analog and Digital Communication -10%

i. Basic Communication Model
ii. Analog and digital signal modulation/de-modulation techniques
iii. Electromagnetic theory
iv. Antennas fundamentals
v. Wave propagation
vi. Transmission lines

Suggested Books:
- Leon W. Couch, "Digital and Analog Communication Systems," Seventh Edition, 2007, Prentice Hall.
- B. P. Lathi, "Modern Digital and Analog Communication Systems," Third Edition, 1998, Oxford University Press.
- Warren Hioki, "Telecommunication," Fourth Edition, 2000, Prentice Hall.
- The ARRL (American Radio Relay League) Handbook.

PART-II

SECTION-B / DEPTH

This section shall be based on practical concepts framed to judge the practical experience and field based knowledge of Registered Engineers (REs). The examination of this section shall comprise 35 MCQs. Each candidate may attempt the only opted area of practice, among the followings.

1. ELECTRIC POWER

i. Power Transmission and Distribution

- Types of feeders
- Rehabilitation procedures for distribution system
- Power Factor improvement methods
- Bus-bar schemes for substations (single bus-bar, double bus-bar, breaker and a half bus-bar schemes)
- Comparison of AC and DC distribution
- Comparison of overhead and under-ground systems
- Cable sizing calculations
- Load flow, fault and stability analysis
- Substations types (conventional outdoor, GIS) and components including surge/lightening arresters
- Substation conventional controls and substation automation systems, SCADA system and Automatic Generation Control/ Automatic Load Frequency Control
- Power supplies, transmission line models
- Instrument transformers (ratio, accuracy class, VA burden, transient dimensioning, insulation, various type of constructions)
- Insulation coordination
- Parallel operation of transformers/ vector groups
- Grounding/earthing
- Compensation devices and systems (series and shunt reactors, static VAR compensators)
- Power system transients
- HVDC transmission lines
- Power quality standards and power system harmonics
- Testing of transformers, reactors
- Cables, and circuit breakers
- Single line diagrams, single line metering & relaying diagrams.

Suggested Books:

- William D. Stevenson, "Elements of Power System Analysis," Fourth Edition, 1982, McGraw Hill.
- B. M. Weedy and B. J. Cory, "Electric Power Systems," Fourth Edition, 1998, John Wiley & Sons.
- Leonard L. Grigsby, "The Electric Power Engineering Handbook", 2nd Edition, 2007.
- Suhail A. Qureshi, "Power Distribution System", First Edition, January, 2009.

ii. Power Generation

- Conventional and non-conventional resources of energy
- Types of power plants (hydro, steam, gas turbine, combined cycle, cogeneration, nuclear & diesel/gas engine)
- Efficient and economical operation of plants
- Renewable energy resources and processes of their utilization, types of generators (induction & synchronous), ratings, electrical parameters
- Generator characteristics (open-circuit, short-circuit, unbalanced load, over fluxing withstand)
- Generator capability diagram
- Generator excitation systems including Automatic Voltage Regulator (AVR) and Power System Stabilizer (static and brushless type)
- Field flashing and field forcing
- Paralleling of generating units/synchronization
- Generator circuit breaker application
- Types of generator neutral grounding
- Power plant station, auxiliary power supply systems
- Testing of generators.

Suggested Books:

- Arche W. Culp, "Principles of Energy Conversion", 2nd Ed.
- M. M. Wakel, "Power Plant Technology", McGraw Hill, (Latest Edition).

iii. High Voltage Engineering

- Types of ionizations and decay processes
- Cathode processes
- Positive and negative point corona
- Breakdown mechanism for gases
- Liquid and solid dielectrics
- Different types of high voltages
- Generation of high voltages
- International standards for testing electrical equipment (lighting impulse, switching impulse and chopped wave tests, results and interpretation), high voltage testing procedures
- Factors affecting break-down voltages
- Measurement of high voltages
- Non-destructive testing techniques.

Suggested Books:

- "High Voltage Engineering", M. Abdullah and Kuffel.
- "Advances in High Voltage Engineering", Alstom.

iv. Power System Protection

- Introduction to protection system, types of protection
- Types of faults
- Electrical switchgear (fuse, circuit breakers, electrical switchgear, CT, PT/VT, protective relays and their operational curves)

- Power system protection schemes (distance protection, bus-bar protection, breaker failure protection, over-current & earth fault protection, line differential protection)
- Generator protection schemes
- Motor protection and transformer protection
- Operating mechanisms and ratings of circuit breakers
- Types of power system transients, switching and lightening transients
- Testing of protective relays, CTs, PTs and CCVTs.

Suggested Books:

- J. Lewis Blackburn and Thomas J. Domin, "Protective Relaying: Principles and Applications," Third Edition, 2006, CRC Press.
- Switchgear and Protection, S. Rao, Khanna Publishers.
- Fundamentals of Power System Protection, Paithankar & Bhide, Prentice Hall.
- Suhail A. Qureshi, "Power Distribution System," First Edition, January 2009.

2. ELECTRONIC ENGINEERING

i. Circuit Analysis

- Circuit components
- Voltage and current sources
- Mesh analysis
- Node analysis
- Transient and steady-state analysis
- Quality factor, power factor improvement
- Network theorems
- Star-delta transformations
- Two-port networks, interconnection of two-port networks.

ii. Semiconductor Materials and Devices

- Semiconductor materials
- pn Junction
- Drift and diffusion of carriers
- Diode: structure, operation, characteristics, breakdown mechanisms, large-signal and small-signal operation, models, types
- Bipolar junction transistor and MOSFET: types, structure, operation, characteristics
- Transconductance
- Transfer characteristic
- Biasing
- Large-signal and small-signal models
- Early effect, channel-length modulation
- Fabrication of solid-state devices.

iii. Electronic Circuit Design

- Rectifiers, limiting and clamping circuits, precision rectifiers, voltage regulators

- Amplifiers: topologies, gain, input and output impedances, amplifier loading, single-stage and multi-stage amplifiers, frequency response, emitter follower, source follower
- Class A, Class B, Class AB, Class C, push-pull and complementary symmetry amplifiers
- RC-coupled, transformer-coupled, and direct-coupled amplifiers
- Audio-frequency, radio-frequency, and tuned amplifiers
- Feedback: properties of negative feedback, basic feedback topologies, effect of feedback on frequency response, loop gain, stability, compensation
- Oscillators: theory, tank circuit, damped and undamped oscillations, oscillator circuits, phase-shift, colpitt, hartley, wein bridge, and clapp oscillators.

iv. Digital Electronics

- Design of pulse and switching circuits
- Monostable, astable and bistable circuits
- Emitter-coupled flip-flop
- Noise margin, fan-out, propagation delay
- Schmitt trigger
- Saturating and non-saturating logic families (DTL, TTL, ECL, I2L, CMOS)
- Timer ICs and their applications
- Semiconductor memories
- Random-Access Memory cells
- Sense amplifiers and address decoders
- Read-Only Memory
- Design of combinational and sequential logic circuits
- Analogue and digital circuit interface with applications
- Simple Programmable Logic Devices (SPLDs)
- Field Programmable Logic Devices (FPLDs) / Field Programmable Gate Arrays (FPGAs)
- Verilog HDL (VHDL), gate-level and dataflow modeling, use of simulation software such as veriwell verilog simulator
- Impact of interconnect parasitics on circuit performance and approaches to cope with them.

v. Integrated Circuits

- Integrated Circuit Biasing: current sources, current mirrors, current steering circuits
- Amplifiers with active loads, high-frequency response of amplifiers with active loads
- Cascode amplifier
- MOS and BJT differential pair: operation with common-mode input voltage, operation with differential input voltage, small- and large-signal operation, high-frequency response
- Digital Microelectronics: PMOS, NMOS, CMOS, and BiCMOS circuits
- Operational Amplifier: CMOS and Bipolar Op Amps, Op Amp circuits, Effect of finite open-loop gain, offset voltage, input bias and offset currents, frequency response, DC and AC analysis of Op Amp ICs
- Fabrication of solid-state devices and integrated circuits

vi. Opto Electronics

- **Laser:** emission, absorption and stimulated emission, population Inversion and gain, threshold conditions, optical feedback, laser losses, classes of lasers, laser modes, single-mode operation, Q Switching
- Semiconductor light sources, light-emitting diodes, semiconductor laser diodes (types, construction, operation, characteristics, and applications)
- Optical transmitters and receivers.

- Semiconductor Light Sources
  - Light Emitting Diodes and Semiconductor Laser Diodes: types, construction, operation, characteristics, and applications
- Photo Detector
  - Operation of Photo Diode
  - PIN Photodiode: construction, operation, and performance parameters
  - Avalanche Photo Diode (APD): construction, operation, performance parameters
  - Phototransistors
- Optical Fiber: construction, advantages, material properties, light guiding mechanism, important parameters (V-Parameter, numerical aperture, modes, cut off wavelength, mode field diameter)
  - Refractive index
  - Nature of light (wavelength, frequency, propagation, polarization)
  - Basic Laws of light (reflection, refraction, diffraction, total internal reflection)
  - Types of optical fiber in terms of refractive index profile
  - Types of optical fiber in terms of light guiding (single mode, multimode)
  - Operating wavelength window
  - Optical fiber losses
  - Attenuation losses
  - Dispersion losses
  - Special optical fiber (dispersion shifted fiber, dispersion flattend fiber)
  - Link budget (power, rise time budget).

Suggested Books:

- John Senior "Optical Fiber Communications: Principles and Practice", 3rd Ed., 2009, Prentice Hall.
- Gerd Kaiser "Optical Fiber Communication," 3rd Ed., 1999, McGraw Hill.

vii. Control Systems

- Open-loop and closed-loop systems
- Transfer functions, block diagrams, signal flow graphs
- Modeling of systems
- Stability, routh's stability criterion, root locus, bode plots, nyquist stability criterion
- Gain and phase margins

- Steady-state and transient response of systems
- State-space concepts
- Formation and solution of state equations
- PID controllers and compensators.

viii. Digital Control Systems

- Digital control fundamentals
- Theory of sampling
- Discrete signals and sampling
- Difference equations
- Discrete transfer functions
- Z-transform analysis
- Time-discrete representation of time-continuous systems
- Discrete control algorithms
- Design methods of digital controllers
- Stability of digital control systems
- Discrete equivalents for continuous controllers
- Pulse transfer functions of feedback systems

Suggested Books:

- Adel S. Sedra and Kenneth C. Smith, "Microelectronic Circuits," Fifth Edition, 2003, Oxford University Press.
- Charles A. Harper, "Electronic Materials and Processes Handbook," Third Edition, 2004, McGraw-Hill.

3. AVIONICS ENGINEERING

i. Navigation, Guidance and Control

- Navigation basics
- Navigation technology used by moving platforms
- Automatic direction finder (ADF)
- VHF omni-directional range (VOR)
- Distance measuring equipment (DME)
- Tactical air navigation (TACAN)
- Long range navigation systems (LORAN), Area Navigation
- Global positioning system (GPS)
- Inertial navigation system (INS)
- Flight-deck audio systems
- Air traffic control (ATC) systems
- Traffic alert and collision avoidance systems (TACAS)
- Guidance basics
- Types of guidance sensors
- Missile guidance and homing radar

ii. Radar Systems Engineering

- Radar basics, Radar equation, radar cross-section and radar frequencies
- Pulse repetition frequency, staggered PRFs and radar blind speeds
- Radar range resolution and tracking in range
- Delay line cancellers, T/R switch, duplexer and diplexer

- Effects of noise, weather, sea and land backscatter on radar performance
- Radar antennas: parameters, parabolic reflector, scanning feed, Radomes
- Moving Target Indicator (MTI), Pulse Doppler, CW and FM radar
- Synthetic aperture and over-the-horizon (OTH) radar
- Air surveillance radars and weather radar
- Tracking radars: mono-pulse, sequential lobing, conical scan radars
- Track-while-scan (TWS) radar
- Airborne and multimode radars

iii. Aerodynamics and Aerospace Propulsion

- Basic aerodynamics: Lift, drag and thrust, load factor
- Airfoils, wings, and other aerodynamic shapes
- Special lift and drag control surfaces
- Elements of airplane performance
- Elements of aircraft structure
- Principles of stability and control
- Principles of helicopter flight
- Supersonic flight
- Propulsion: propeller
- Jet propulsion – The thrust equation
- Turbo jet engine, Turbo-fan engine, Ram jet engine, rocket engine
- Turbo-engine components: compressor, turbine and exhaust nozzle
- Rocket propulsion and propellants
- Nozzle design and rocket performance

iv. Flight Control Systems

- Conventional flight control systems
- Servomechanisms and automatic control fundamentals
- Sensing of attitude changes
- Synchros and instrumentation
- Conventional and radar altimeters, gyroscopes, electronic compass, accelerometer
- Command signal detection and processing
- Outer loop control
- Autopilot and flight director system
- Fly-by-wire (FBW) control systems
- Instrumental landing system (ILS), Microwave landing system (MLS)
- Ground controlled approach (GCA) radar

v. Avionics System Design

- Importance and role of avionics
- Avionics architecture
- Displays and man-machine interaction
- Air data and Air data systems
- Flight management systems (FMS)
- Multi-sensor fusion: inertial, GPS, doppler, stellar and barometer inputs
- Avionics interfaces: data buses, crew displays, power, maintenance, physical interfaces

- Avionics systems integration: data bus systems, integrated modular avionics
- Commercial off-the-shelf (COTS) avionics
- Unmanned air vehicle (UAV) avionics

Suggested Books:

- Cary R. Spitzer, "*The Avionics Handbook*", December 2000, CRC Press, ISBN: 0-8493-8348-X.
- Mike Tooley and David Wyatt, "*Aircraft Communication & Navigation Systems*", First Edition, 2007, Elsevier, ISBN: 978-0-750681377.
- R. P. G. Collinson, "*Introduction to Avionics Systems*", Second Edition, 2003, Kluwer Academic Publishers, ISBN: 1-4020-7278-3.
- Ian Moir & Allan Seabridge, "*Military Avionics Systems*", First Edition, 2006, John Wiley & Sons, Inc.,
  ISBN: 0-470-01632-9.
- Merrill I. Skolnik, "*Introduction to Radar Systems*", Third Edition, 2001, Tata McGraw-Hill,
  ISBN: 0-07-044533-8.
- John D. Anderson Jr., "*Introduction to Flight*", Fifth Edition, 2005, McGraw-Hill Higher Education,
  ISBN: 0-07-383569-3.
- E. H. J. Pallet and S. Coyle, "*Automatic Flight Control*", Fourth Edition, 2006, Blackwell Publishing,
  ISBN: 0-632-03495-5.
- P. D. Hill and C. R. Peterson, "*Mechanics & Thermodynamics of Propulsion*", Second Edition, 1991, Prentice Hall, ISBN: 978-0201028386.

4. INDUSTRIAL ELECTRONICS

i. Electrical Machines

- Magnetic circuits and calculations
- Single-phase and polyphase circuits
- Transformers (Single-Phase and Three-Phase): construction, principle of operation, equivalent circuit, phasor diagram, voltage regulation, measurement of losses and efficiency, auto transformer, phasor group (three-phase transformer), parallel operation
- DC Machines: construction, principle of operation, armature reaction, commutation, generator and motor characteristics, starting and speed control, testing, efficiency
- Induction Machine (Three-Phase): construction, principle of operation, equivalent circuit, phasor diagram output power, torque, maximum torque equation, slip-torque characteristics, starting and speed control, efficiency, testing
- Induction Generator: AC machine armature winding, three-phase windings, MMF of distributed windings, speed and direction of rotating magnetic field
- Synchronous generator
- Brushless DC motor
- Switched-reluctance motor

- Stepper motor.

ii. Power Electronics and Drives

- Solid-State Devices Used in Power Electronics**:** power diode**,** power BJT**,** power MOSFET**,** SCR, GTO, IGBT, TRIAC, DIAC
- Semi-controlled, Fully-controlled and Uncontrolled Rectifiers**:** single-phase and three-phase**,** six-Pulse**,** twelve-pulse and twenty-four pulse rectifiers
- Single-phase and three-phase inverters
- Static power supplies
- UPS
- SMPS
- Invertors

iii. Industrial Control and Electronics

- Electric Heating: principles and applications, induction and dielectric heating, high-frequency welding, spot welding control
- Industrial Control: speed control of DC, AC, and servo motors
- Process control
- Measurement of non-electrical quantities: temperature, displacement, pressure, time, frequency
- Digital industrial measuring systems
- Ultrasonic generation and applications
- Photoelectric devices
- Industrial control using PLCs
- Data acquisition
- Distributed control system in process industries.

iv. Automation & Robotics

- Industrial computer control
- Control system components
- Numerical control
- Industrial Robotics: robot anatomy and related attributes, robot control systems, sensor in robotics, industrial robot applications
- Robot programming
- Programmable Logic: discrete process control, ladder logic diagram, PLC application (conveyor systems)
- CAD/CAM, process planning
- Automated guided vehicle systems
- Automatic identification, data capture and storage systems
- Single station cells and group technology
- Flexible manufacturing systems
- Assembly and transfer lines
- Statistical process control
- Inspection principles and technologies

v. Instrumentation and Measurement Systems

- Precision Measurements Terminologies: resolution, sensitivity, accuracy, uncertainty
- Engineering units and standards
- Principles of different measurement techniques

- Instruments for Measurement of Electrical Properties: pressure, temperature, position, velocity , flow rates (mass and volume), concentration
- Systems for signal processing and signal transmission
- Modern instrumentation techniques
- Construction and Working of Different Analog and Digital Meters: oscilloscope, recording instruments
- Signal generators
- Other Electrical and Non-Electrical Instruments: types of bridges (resistance), inductance and capacitance, power and energy meters, high-voltage measurements
- Optical measurement system
- Microprocessor-based instrumentation
- Analog-to-digital and digital-to-analog converters
- PC-Based Instrumentation Systems: static and dynamic responses of instrumentation and signal conditioners, basic data manipulation skills using personal computers and graphs, data acquisition systems, principles of operation, interfacing techniques, data acquisition software and virtual instruments
- Intelligent instrumentation systems
- Transducers: strain gauges, metal resistance thermometers, thermistors and thermo-couples

vi. Control Systems

- Dynamic models
- Transfer functions of electrical, mechanical, electromechanical systems, heat and fluid flow models
- Basic properties of feedback control systems
- Time response analysis (first and second order systems)
- Performance indices and design specifications
- Concept of stability, Routh-Hurwitz stability criterion
- Frequency response analysis
- Phase margin and gain margin
- Nyquist stability criterion
- Closed-loop frequency response
- Root locus technique
- Preliminary consideration of classical design
- Classical Three-Term Controller: proportional, Proportional Integral (PI), Proportional Integral Derivative (PID) feedback control
- Derivative Feedback: control, realization of basic compensators.

Suggested Books:

- J. David Irwin"The Industrial Electronic HandBook", CRC Press.
- Theodore Wildi, "Electrical Machines, Drives and Power Systems", Prentice Hall, sixth edition 2006.
- Ned Mohan, William P. Robbins and Tore M. Undeland, "Power Electronics: Converters, Applications and Design," Media Enhanced, Third Edition, 2003, John Wiley & Sons.
- James. T. Humphries," Industrial Electronics", 4th edition, 1993, Delmar Cengage Learning.

- Groover Mikell P. ,"Automation, Production Systems, And Computer-integrated Manufacturing", Third Edition 2009, Phi Learning.
- Klaas B. Klaassen and Steve Gee, "Electronic Measurement and Instrumentation," 1996, Cambridge University Press.
- Benjamin C. Kuo, "Automatic Control Systems," Eighth Edition, 2003, John Wiley & Sons.
- John W. Web, "Programmable Logic Controllers: Principles and Applications", 5th Ed., 2002, Prentice Hall.
- Bodgen Wilamoski and J. David Irwin, "The Industrial Electronics Handbook", 2nd Ed., Five Volume Slip Case Set, 2010, CRC Press.

5. TELECOMMUNICATION ENGINEERING

i. Telecommunication Systems

- Digital subscriber line
- ISDN networks
- GSM systems and applications
- WiMAX
- Cellular networks
- Propagation models in mobile radio systems.

ii. Telecommunications Switching

- Circuit switched networks
- Packet networks
- Networking and media selection (fiber optics, cable, wireless)
- Network services and architecture
- Signaling protocols SS7
- Networks: core and access technologies, intelligent networks
- SONET and ATM networks
- Network control and operations, quality of service
- Space (terrestrial) wave propagation.

iii. Electromagnetic Theory

- Electrostatic energy, electric multi-poles, boundary conditions at surface discontinuity
- Electrostatics in the presence of matter, special methods in electrostatics
- Electric current, ampere's law, magnetic induction, integral form of ampere's law
- Vector potential, faraday's law of Induction, magnetic energy
- Magnetic multi-poles, magnetism in the presence of matter
- Maxwell's equations, scalar and vector potentials.

iv. Communication Systems

- Energy signal and power signal
- Amplitude modulation (DSB-SC,SSB ,VSB, AM)
- Frequency modulation
- PAM, PTM, PPM, PWM, PCM, DPCM
- Delta modulation, line coding
- Scrambling, regenerative repeaters, detection-error probability
- M-Ary communication
- Digital signal construction and detection

- Band-pass and complex baseband signal representation
- Inter-symbol interference channels, matched filters
- Equalization: MLSE, linear, and decision feedback, multicarrier modulation
- Channel partitioning, vector coding
- Orthogonal Frequency Division Multiplexing (OFDM), convolution coding
- Viterbi algorithm and maximum likelihood sequence detection/estimation
- Power line carrier
- TDMA, FDMA,CDMA, spread spectrum, synchronization

v. Microwave Engineering

- S-parameter
- Design of microwave transmission media
- Different impedance matching techniques
- Design, analysis and measurements of microstrip filter and coupler
- Microwave components such as isolators, couplers, circulators
- Basic diversity and fading
- Diversity in mobile radio systems
- Smith chart
- Transmission line
- Satellite transponder channels.

vi. Wireless Networks

- Basic propagation modes, free space, ground reflection and diffraction
- Ground wave propagation, sky wave propagation
- Atmospheric effects on radio wave propagation
- 802.11a/b/g/h/i/n
- Wireless networking equipment, routers and access points
- HF,VHF, and UHF networks

i. Data Communication and Computer Networks

- Architecture of internet
- LANs, WANs and internetworks
- IP addressing
- Applications: interface between networks
- Making provisions for applications and services
- Communication protocols
- Process control protocols
- OSI model
- VOIP and CODECS
- Huffman Algorithms, Hamming Codes, CRC (Cyclic Redundancy Check)

ii. Wave Propagation and Antennas

- Transmission line parameters related to antenna design and performance
- Wave-Guides and Cavities, Antenna Fundamentals: types of antennas, radiation mechanism
- Near-field, far-field regions, polarization, radiation pattern

- Antenna performance parameters (radiated power, directivity, gain, efficiency, radiation resistance and input impedance)
- Dipole and monopole antennas, loop antennas
- Broadband antennas, helical, yagi-uda, log-periodic antennas
- Overview of aperture antennas, horn and dish reflector antennas
- Microstrip antennas, rectangular, circular microstrip patch antennas
- Meteor burst communications.

Suggested Books:

- Simon Haykin, "Introduction to Analog & Digital Communications", 2nd Ed, John Wiley & Sons, 2006
- B P Lathi, "Modern Digital and Analogue Communication Systems", Third Edition, Oxford University Press.
- "Electronic Communication Systems", Fuzznel
- William H.Hayt, "Electromagnetic Theory", 5th Ed.
- William Stalling, "Wireless Communication and Networks", 2nd Edition.
- Ray Horak, "Telecommunication and Data Communication Handbook",
- John G. Proakis, "Digital Signal Processing" 4th Ed., ISBN:1420046063
- Behrouz A. Fourouzan "Data Communication & Networks", 4th Ed.

6. MECHATRONICS ENGINEERING

i. Power Electronics and Devices

- Devices Used in Power Electronics: power diode, power BJT, power MOSFET, SCR, GTO, IGBT, TRIAC, DIAC, Op-Amps, and voltage regulators
- Rectifiers and Thyristors: half-wave, full-wave, and bridge rectifiers with RL load, performance parameters of rectifiers, model of thyrist,r; turn-on and turn-off techniques
- DC-to-DC Converters: step-down operation with RL load, step-up converter with RL load, converter classifications
- PWM Inverters: principle of operation, performance parameters, single-phase bridge inverter, three-phase inverter, voltage control of three-phase inverter, advanced modulation techniques
- Static Switches: single-phase and three-phase AC switches, DC switches, solid-state relays.

Suggested Books:

- Muhammad H. Rashid, "Power Electronics", 3rd Ed., 2007.
- Floyd, "Electronic Devices", 5th Ed., 2005.
- Robert Boylestad, "Electronic Devices and Circuit theory", 6th Ed., 1996.

ii. Control Systems

- Dynamic Models: Transfer functions of electrical, mechanical, and electromechanical systems, heat and fluid flow models, basic properties of feedback control systems

- Feedback Control System Characteristics: open-loop and closed-loop systems, sensitivity to parameter variation, control of transient response, disturbance signals, steady-state errors, cost of feedback
- Performance Of Feedback Control Systems: test signals, performance of second order systems, damping ratio estimation, s-plane, steady-state errors, linear system simplification, routh-hurwitz stability criterion, stability of state variable systems, root locus method, parameter design by root locus method, PID controllers
- Frequency-Response Methods: bode plots, performance specifications, log magnitude and phase diagrams
- Stability in Frequency Domain: nyquist criterion, system bandwidth, stability of control systems with time delays, PID controllers in frequency domain
- Design of Feedback Control Systems: approaches, cascade compensation networks, phase lead design, phase lag design, system design using analytical and computer methods.

Suggested Books:

- Richard C Dorf and Robert H. Bishop, **"Modern Control System"**, 11th Ed.
- B. C. Kuo, "Automatic Control System", 8th Ed., Pearson Education, 2001, ISBN: 130432458

iii. Robotics

- Overview of Robots: robot configurations, industrial applications of robots
- Robot Kinematics and Dynamics: transformations, forward and reverse kinematics, robot dynamics, trajectory generation
- Robot Control and Sensing System: robot vision, robot programming and interfacing, gripper design and applications, mechanism design, robot configurations
- Trends in Robotics: rehabilitation robotics, behavior-based robotics, bio-mimetic design of robots
- Robot Programming Languages and Systems: three levels of robot programming, requirements of robot programming language.

Suggested Books:

- Philip McKerrow, "Introduction to Robotics", 1st Ed. Addison-Wesley Longman Publishing Co., Inc. Boston, USA ©1991, ISBN:0201182408
- Robin R. Murphy, "Introduction to AI Robotics", 2000, ISBN: 0262133830
- John J. Craig, "Introduction to Robotics", 2nd Ed., Adept Technology, Inc. ISBN: 0201543613

iv. Machine Vision

- Cameras: CCD sensors, CMOS sensors, color cameras, sensor sizes, camera performance
- Camera-Computer Interface: Analog Video Signal, Digital Video Signal, Camera Link, IEEE 1394, USB2.0

- Image and Image Geometry: sampling and quantization, perspective projection, coordinate systems
- Image Filtering: linear filters, median filter, gaussian filters, discrete gaussian filter
- Edge Detection: gradient, first derivative based edge detection operators
- Image Segmentation: segmentation by thresholding
- Feature Extraction: gray value features
- Object Measurement: size measurement, shape analysis, texture analysis
- Camera Calibration: coordinate systems, rigid body transformation, intrinsic and extrinsic parameters, simple method for camera calibration
- Object Recognition: system components, complexity of object recognition, feature detection, classification, matching.

Suggested Books:

- Bruce G. Bachelor and Paul F. Whelan, "Intelligent Vision Systems for Industry" 2002.
- Gonzalez, Woods and Eddins, "Digital Image Processing using Matlab" Pearson Ed, 2004.
- Ramesh jain, Rangachar Kasturi and Brain G. Schunck, "Machine Vision" McGraw-Hill Companies, Inc., 1995.

v. Actuation Systems

- Electrical Actuation Systems: electrical systems, mechanical switches, solid-state switches, solenoids, DC motors, AC motors, stepper motors
- Mechanical Actuation Systems: mechanical systems, types of motion, kinematics chains, cams, geartrains, ratchet and pawl, belt and chain drives, bearings, mechanical aspects of motor selection
- Pneumatic and Hydraulic Actuation Systems: pneumatic and hydraulic systems, directional control valves, pressure control valves, cylinders, process control valves, rotary actuators.

Suggested Books:

- W. Bolton, "Pneumatic and Hydraulic Systems",1997, ISBN-10: 0750638362
- G. Prede D. Scholz, "Electro-pneumatics: Basic Level", 2010.
- Robert H. Bishop, "Mechatronics Hand Book", 2nd Ed.
- W. Bolton "Mechatronics", Pearson Education, 3rd Ed.

vi. Vibration Analysis, Modeling and Simulation

- Oscillatory Motion: Vibrating system elements, harmonic motion, periodic motion and vibration terminology
- Single Degree of Freedom Systems: equation of motion, newton's method, energy method, undamped free vibration, viscously-damped free vibration, logarithmic decrement, harmonically-excited vibration, vibration isolation, vibration measuring instruments

- Two Degree of Freedom Systems: normal modes of vibration coordinate coupling, forced harmonic vibration, vibration absorber, vibration damper, orthogonality condition
- Vibration of Elastic Bodies: free and forced vibration of cables and uniform bars, free and forced lateral vibrations of simply supported thin beams, torsional vibration of circular shafts with single rotor and two rotors, critical speed of rotating shafts
- Finding Natural Frequencies: raleigh method and holzer method, electrical and mechanical analogies
- Modeling of Mechanical Systems: springs, dampers, mass, rotational and translational systems, geared systems, levered systems
- Modeling of Electrical Systems: capacitor, inductor, resistor, analog electronic devices, operational amplifiers, summers, comparators, integrators and analog computing
- Modeling of Hydraulic and Pneumatic Systems: hydraulic inertance, capacitance, introduction to discrete event systems, difference equations, z transform and sampling, introduction to s-plane and z-plane, transfer function, characteristic equation, poles, zeros, stable and unstable regions in s and z planes, modeling of event operated systems, state equation describing relation between multi input and output in digital systems
- Simulation of Modeled System: impulse, step, ramp and periodic inputs and disturbance signal in s and z planes.

Suggested Books:

- W.T.Thompson, "Mechanical Vibrations: Theory & Applications", 5th Ed., Prentice Hall.
- S. S. Rao, "Mechanical Vibrations", 3rd Ed. McGraw Hill.
- L. Meirovitch, "Elements of Vibration Analysis", McGraw Hill, 2001.
- Endrew Dimargonas, "Vibration for Engineers", Prentice Hall, 1996.
- W. Bolton, "Pneumatic and Hydraulic Systems", 2nd Ed.

vii. Mechatronics and System Design

- Introduction: mechatronics and its components, fields covered by mechatronics, applications of mechatronics, mechatronics system design approach
- Sensors: sensor criteria, sensor performance parameters, types of sensors (for example, displacement, proximity, pressure, light, force)
- Signal Conditioning: necessary condition to implement, various types of signal conditioning (for example, filters, amplifiers, ADC, DAC, noise removal)
- Actuators: pneumatic actuators, hydraulic actuators, electromechanical actuators, types of electric motors (DC, stepper, and servos)
- Motion Control: effect of vibration on a system, data acquisition and control system
- Communication: communication (LPT), serial communication (RS232, RS422)

Suggested Books:

- Robert H. Bishop, "Mechatronics Hand Book", 2nd Ed.
- W. Bolton "Mechatronics", Pearson Education, 3rd Ed.

7. BIOMEDICAL ENGINEERING

i. Clinical and Biomedical Instrumentation

a. Medical Instrumentation

- Introduction: precision, resolution, sensitivity, accuracy, uncertainty, principles and development of biomedical instrumentation, problems encountered in living systems
- Biological Systems: study of various physiological systems related biopotentials and physiological parameters
- Diagnostic Equipment: invasive and noninvasive measurement techniques and related equipments
- Cardiovascular Measurements: electrocardiography, measurement of blood pressure, blood flow, cardiac output
- Biomedical Sensors and Transducers: introduction, principles, theory, design, applications
- Patient Monitoring Equipment: patient monitors, central monitoring system, telemetry system, gas exchange and distributions, respiratory therapy equipment
- Therapic Equipment: ventilator, inhaler, defibrillator, pacemaker, heart lung machines
- Radiological Equipment: concept of ionization and nonionization radiation and related equipment, medical lasers and applications
- Safety in Medical Equipments: electrical/mechanical safety, standards of medical devices, biohazards and safety regulations
- Quality Assurance and Quality Control: calibration, maintenance, reparability of monitoring equipments.

Suggested Books:
- Cromwell, "Bio-Medical Instrumentation & Measures", 2nd P Ed.
- Walter Welhowitz, Sid Deutsch and Metin Alsey, "Biomedical Instruments: Theory & Design", Academic Press, Inc.
- R.S.Khandpur, "Handbook of Biomedical Instrumentation", Tata McGraw Hill Publishing Co
- Peter Hauptmarn, P., "Sensors:Principles and Applications", 1993, Prentice Hall.
- John G. Webster (Editor), "Bioinstrumentation", ist Ed. 2003, ISBN: 0471263273
- John G. Webster (Editor), "Medical Instrumentation: Application and Design", 3rd Ed. 1997, John Wiley & Sons, ISBN: 0471153680
- Donald L. Wise, "Bioinstrumentation and Biosensors", 1991, ISBN: 0824783379
- Donald L. Wise (Editor), "Bioinstrumentation: Research, Developments and Applications", CRC Press, ISBN: 0849354048

b. Clinical Instrumentation

- Microscopy: electron microscopy, atomic force microscopy, confocal microscopy
- Spectroscopy: UV, IR, NMR and visible absorption, flourometric methods, flame photometry, spectrographic spectroscopy, circular dichroism, mass spectrometry
- Electrochemical Methods of Analysis: electrophoresis chromatography, high performance liquid chromatography, clinical chemistry analysis, study of different blood components through automated cell-counter, centrifuging techniques, blood banking and transfusion, service automation, polymerase chain reaction.

Suggested Books:

- Nolting, Bengt, **"Methods in Modern Biophysics"**, 2nd Ed., Springer, 2005
- Cromwell, "Bio-Medical Instrumentation & Measures", 2nd P Ed.
- I.D. Campbell & Ragmod A. Dwel, "Biological Spectroscopy", The Benjamin Publications.
- Ramrit Sood, "Medical Laboratory Technology: Methods and Interpretations", 2003, Jaypee Brothers, New Delhi.
- Leslie Cromwell, Fred J. Weiball and Erich, A. Pleiffer, "Biomedical Instrumentation and Measurements", Prentice Hall , India
- Joseph, J. Carr, John, M. Brown, "Introduction to Biomedical Equipment Technology", Prentice Hall Career & Technology.
- Mary C. Haven (Editor), et al, "Laboratory Instrumentation", 4th Ed.
- James W. Dally, William, "Instrumentation for Engineering Measurements", 2nd Ed.

ii. Biomaterials and Design

a. Biomaterials

- Materials and biomedical applications
- Chemical structure of biomaterials
- Physical properties of biomaterials
- Mechanical properties of biomaterials
- Biomaterial degradation
- Biomaterials processing
- Surface properties of biomaterials
- Protein interactions with biomaterials
- Cell interactions with biomaterials
- Biomaterials implementation and acute inflammation
- Wound healing and presence of biomaterials
- Immune response of biomaterials
- Biomaterials and thrombosis
- Infection, tumor genesis and calcification of biomaterials

b. Biomaterials Design

- Body segments kinetics
- Lower-upper limb prostheses functional requirements
- Design criteria
- Alignment control

- Body powered prostheses
- Orthopedic prostheses
- Important artificial joint
- Joint pathologies
- Hard tissue pathologies
- Tissue reaction to implants
- Types and failures of implanted joints
- Body implants, heart valves
- Blood vessels
- Bones and joints
- Blood oxygenators and blood pumps
- Heart assisted devices
- Artificial heart
- Pancreas and kidney

Suggested Books:

- Johnna S. Temenoff/ Antonios G. Mikos, "The Intersection of Biology and Materials Science", International Ed., year, 2008.
- Michael N. Helmus (Editor), "Biomaterials in the Design and Reliability of Medical Devices", ISBN: 0306474425
- David Hill Hill Julia Hill, "Design Engineering of Biomaterials for Medical Devices"
- Buddy D. Ratner, et al, "Biomaterials Science: An Introduction to Materials in Medicine", 2nd Ed.
- Jos Vander Sloten (Editor), "Computer Technology in Biomaterials Science and Engineering,
- Kay C. Dee, et al, "An Introduction to Tissue-Biomaterial Interactions"
- Rolando Barbucci (Editor), "Integrated Biomaterials Science", 2002, ISBN: 0306466783
- William, D. Callister Jr., "Material Science & Engineering", 2003, John Wiley & Sons.
- Park Joon B., "Biomaterials: Principles and Applications" 2007
- IEE Publication (Section IV, Biomaterials 40 to 48 and193 Regulation of Biomaterials.

iii. Medical Imaging

- Introduction: interaction of radiation with matter scattered and absorbed radiation, spatial image formation
- Imaging Transducers: various transducers used in medical imaging systems
- Imaging development: X-Ray film, fluoroscopic imaging, digital Imaging system, X-Ray imaging, film-less radiographic imaging, CT imaging, emission tomography imaging, nuclear imaging, MR imaging, functional MRI imaging, advance imaging modalities such as PET and SPECT, emerging areas in medical imaging
- Ultrasound Imaging: ultrasonic imaging, doppler imaging, software-based estimations and measurement in ultrasonic imaging, planar and volumetric analysis techniques
- Medical Imaging Software: algorithms, techniques, imaging archival and management, molecular imaging, other advanced biomedical

imaging techniques and their image manipulation, quality assurance and control in medical imaging

- Equipment: quality assurance of medical imaging, evaluation of imaging parameters and related equipment calibration, diagnostic values, statistical performance measures.

Suggested Books

- Bushberg J.T., "The Essential Physics of Medical Imaging", 2nd ed.
- Omer Demirkaya, Musa Hakan Asyali., "Image Processing with MatLab", Boca Raton, CRC Press, 2009.
- Z.H.Cho, Joie P. Jones, Manbir Singh, "Foundations of Medical Imaging", 1993. John Wiley & Sons.
- Buxton, Richard B, "Introduction To Functional Magnetic Resonance Imaging: Principles And Techniques", Cambridge University Press, 2002.
- Andrew G. Webb, "Introduction to Biomedical Imaging (IEEE Press Series on Biomedical).
- Richard A. Robb, "Biomedical Imaging, Visualization, and Analysis", 2000, A John Wiley & Sons, Inc., Publication.
- Richard A. Robb, "Three-Dimensional Biomedical Imaging: Principles and Practice", 1994, ISBN: 978-0-471-18572-7
- Nick Van Bruggen (Editor), Timothy Roberts (Editor), "Biomedical Imaging in Experimental Neuroscience", 2002, ISBN: 9780849301223

iv. Tissue Engineering

- Introduction to the major aspects of tissue engineering
- Materials selection, scaffold fabrication
- Gene therapy using viral vectors
- Cell sources
- Cell seeding
- Bioreactor design
- Principle of designing an engineered tissue
- Properties of natural tissue replacement
- Drug delivery and tissue characterization

Suggested Book:

- Joseph D. Bronzino, "The Biomedical Engineering Handbook", 2nd Ed., CRS Press 1999, ISBN: 978-0-8493-8594-0

v. Neuroscience and Neuroengineering

a. Neuroscience

- Nervous System: sympathetic, parasympathetic and motor nervous systems and their functions
- Brain and its function
- Neurons and gila
- Structure of a neuronal cell
- Types of gila, lood brain barriers
- Signaling in brain

- Electrical excitability of neurons
- Resting membrane potentials
- Action potential, inter neuronal singling
- Synaptic events, chemical messengers
- Synaptic transmission
- Receptors: ionotropic and metabotropic receptors
- Signal transduction pathways
- G protiens
- Protein phosphorylation
- Signaling to nucleus
- Regulation of gene expression
- Neurotransmitters
- Excitatory and inhability amino acid neurotransmitters and functions in brain
- Role of excitatory neurotransmitter in learning and memory
- Disease associated with malfunctioning of neurotransmitters
- Catecholamine: functions in brain, disease associated with malfunctioning

b. Neuroengineering

- Overview of neural engineering
- Cellular mechanisms of action of therapeutic brain simulation
- Neuromodulation
- Current trends in interfering with epileptic seizures
- Responsive neurostimulation of epilepsy
- Responsive neurostimulation of epilepsy RNS^{TM}
- Deep brain stimulation for pain management
- Motor cortex stimulation for pain management
- Deep brain stimulation for obsessive compulsive disorder
- Sensory prostheses, cochlear prostheses, visual prostheses.

c. Neural Networks

- Artificial Neural Networks
- Model of Single Neuron
- Neural Network Architectures
- Feedforward Neural Networks
- Multilayer Perception
- Back Propagation Algorithm
- Radial Basis Function Networks
- Unsupervised Learning
- Hopfield Network
- Self-Organizing Map
- Other Unsupervised Networks
- Reinforcement Learning

Suggested Books:

- Roman, R. Poznanski, "Biophysical Neural Networks: Foundations of Integrative Neuroscience", 2001.
- Philip, G. Srauge, "Brain Biochemistry and Brain Disorders", Oxford Press.

- George, J. Siegal, B.W.Agranoff, S.K. fisher, M.D. Uhler, "Basic Neurochemistry: Molecular, Cellular and Medical Aspects", 6th Ed., ISBN: 0750675365
- "Neural Circuits & Networks", NATO Advanced Study Institute on Neuronal Circuits and Networks
- Christopher M. Bishop, "Neural Networks for Pattern Recognition" 2008, Oxford University Press
- Bart Kosko, "Neural Networks and Fuzzy Systems: A Dynamical Systems Approach to Machine Intelligence/Book and Disk".
- Brian D. Ripley, "Pattern Recognition and Neural Networks", 4th Ed.

vi. Biophotonics

- Nature and properties of light
- Optical fiber
- Semiconductor light sources
- Lasers and classification of lasers
- Medical applications of lasers
- Laser-tissue interaction
- Optical biosensors
- Photodynamic therapy
- Laser tweezers and laser scissors

Suggested Books:

- Paras N. Prasad "Introduction to Biophotonics", 2003, John Wiley & Sons
- Valery V. Tuchin, "Hand Book of Photonics for Biomedical Science", 3rd Ed., 2010.

vii. Economics and Health Care Management

- Basic concepts of economics, accounting, cost-benefit ratios
- Interpretation of financial statements
- Supply and demand
- Healthcare economics
- Management and motivation
- Organizational behavior and management thinking
- Strategic planning
- Performance improvement in healthcare
- Information technology
- Managing costs and revenues, managing healthcare professionals, Strategic management of human resources
- Teamwork, cultural competency and diversity, ethics and law, safety programs

Suggested Books

- Buchbinder, S.B., & Shanks, N.H., "Introduction to Health Care Management", 2007, Jones & Bartlett, Publishers

- Kaluzny, Warner,Warren,Zelman, "Management of Health Services", 2nd Ed.
- Joseph J. Carr, John M. Domach, "Introduction To Biomedical Equipment Technology", 4th Ed.

viii. Telemedicine

- Benefits of telemedicine
- Medical information storage and management for telemedicine
- Hospital information systems, security and confidentially of medical records and access control
- Cyber Laws, access to healthcare services
- Health education and self care, bio-modeling
- Medical data coding and compression
- Functions of Digital Imaging and Communications in Medicine (DICOM)
- Picture Archiving and Communication System (PACS)
- Hospital Information System (HIS) for telemedicine

Suggested Books:

- C. Norris, "Essentials of Telemedicine and Telecare", 2002.
- Yang Xiao, Hui Chen, "Mobile Telemedicine: A Computing and Networking Perspective", 2008.

8. COMPUTER ENGINEERING

i. Digital System Design

- High-level digital design methodology using verilog
- Digital design, implementation and verification in HDL/Verilog
- Floating-point to fixed-point conversion
- Architectures for basic building blocks
- Adders, compression trees and multipliers
- Transformation for high speed using pipelining, retiming and parallel processing
- Dedicated fully parallel and time shared architecture
- Hardwired and micro program state machine based design
- FPGA-based design and logic synthesis
- Digital logic testing and simulation
- Approaches to combinational and sequential circuit testing, analysis of faulted circuits and fault simulation techniques.

Suggested Books:

- Samir Palnitkar, "Verilog HDL-A guide to digital design and synthesis", Prentice Hall Publisher.
- Michael D. Ciletti, "Advanced Digital Design with Verilog HDL", Prentice Hall Publisher.

ii. Operating Systems

- Basic Concepts: early operating systems, buffering and spooling, multiprogramming, time sharing, distributed systems, real time systems, single user systems
- Computer System Architecture: interrupt based systems, I/O structure, dual-mode protection, hardware protection, general system architecture, symmetric and asymmetric processing
- Computer System Structures: system components, operating-system services, system calls, system programs, system structure, virtual machines, system design and implementation, system generation
- Processes: process concept, concurrent processes, scheduling concepts, CPU scheduling, scheduling algorithms, multiple processor scheduling, algorithm evaluation
- Threads: overview, benefits, user/kernel threads, threading models, issues
- Memory Management: swapping, single-partition allocation, multiple-partition allocation, multiple base registers, paging, segmentation, paged segmentation
- CS Problem and Resolution: introduction, problem, race condition, techniques to resolve CS problem
- Deadlocks: problem, models, characterization, RA graph, methods of handling deadlocks
- Virtual Memory and Disk Scheduling: demand paging, performance of demand paging, disk scheduling, file operations.

Suggested Books:

- Abraham Silberschatz, "Peter Baer Galvin and Greg Gagne: Operating System Concepts", 7th Edition John Wiley and Sons.
- William Stallings, "Operating Systems (Internals and Design Principles)", Prentice Hall.
- Andrew S. Tanenbaum and Albert S. Woodhull, "Operating Systems – Design and Implementation", Prentice Hall.

iii. Digital Image Processing

- Introduction to Digital Image Processing: digital image representation, acquisition, storage, processing, communication and display
- Digital Image Fundamentals: visual perception, issues in sampling and quantization of a digital image, connectivity and relations between pixels
- Image Enhancement: spatial and frequency domain methods, enhancement by point processing, histogram processing, spatial filtering techniques, enhancement in frequency domain, frequency filtering techniques
- Image Transforms: discrete fourier transform, properties of 2-D fourier transforms, Fast Fourier transform (FFT), Discrete Cosine Transform (DCT)
- Image Restoration: degradation model, spatial and frequency domain filtering, inverse filtering, and weiner filtering
- Color Image Processing: fundamentals of color image processing, color models

- Image Compression: types of redundancy, fidelity criterion, study of error free compression and lossy compression techniques, their merits and demerits, image compression standards
- Wavelets & Morphology: introduction to wavelets and their application in image compression, basic morphological algorithms.

Suggested Books:

- Rafael C. Gonzalez, Richard E. Woods, "Digital Image Processing", 2nd Ed., Addison Wesley
- Kenneth R. Castleman, "Digital Image Processing", Prentice Hall International
- Rafael C. Gonzalez and Richard E. Woods, "Digital Image Processing Using Matlab", 2004, Pearson Education, ISBN: 0130085197

iv. Digital Signal Processing

- Linear Time-Invariant (LTI) systems, convolution sum, Finite (FIR) and Infinite (IIR) Impulse Responses, difference equations, Discrete-Time Fourier Transform (DTFT) and its properties, Z-Transform (ZT) and its Properties
- Sampling of Continuous-Time Signal and Sampling Rate Conversion: sampling theorem and its variations, reconstruction formulae, application to discrete-time processing of continuous-time signals, sampling rate conversion in multirate systems, multirate signal processing, bandpass sampling
- Transform Analysis of LTI Systems: pole-zero representation for rational systems, study of various important systems including all-pass system, inverse system and minimum-phase system
- Structure for Discrete-Time Systems: signal flow graph representation, basic structures for FIR and IIR systems (direct forms, parallel, cascade), transposition theorem, effects of coefficient quantization on frequency response, round-off noise in digital filtering
- Filter Design Techniques: filter design as a numerical approximation problem, transformation techniques for the design of IIR filters, FIR filter design by windowing
- Discrete Fourier Transform (DFT): Definition and Properties of Discrete Fourier Series, Definition of DFT and its Properties, Application to Linear Convolution
- Computation of DFT: computational problem, most commonly used Fast Fourier Transform (FFT) algorithms (Radix-2, Decimation-in-Time, Decimation-in-Frequency), possible generalizations and specializations
- Programming Digital Signal Processor: basic skills in programming TMS320C67x DSP

Suggested Books:

- A.V. Oppenheim, R. W. Schafer with J. R. Buck, "Discrete-time Signal Processing", 2nd Ed., Prentice-Hall.

- E.C. Ifeachor Jervis, "Digital Signal Processing- A Practical Approach", 2nd Ed., 2002, Prentice Hall.
- James H. McClellan, Ronald W. Schafer, Mark A. Yoder, "DSP First: A multimedia approach", 2003, Prentice Hall, ISBN: 130909998
- S. K. Mitra, "Digital Signal Processing: A Computer-Based Approach", 1998, McGraw-Hill.

v. Computer Networks

- Introduction to basic networking elements
- OSI model
- TCP/IP protocol suite
- Line encoding, modulation, error detection and correction
- Flow control and error control
- Cellular networks
- Multiplexing, spread spectrum, switching
- MAC, IPv4 & IPv6, frame relay, ATM, SONET
- Unix programming environment
- Socket programming, UDP and TCP sockets, I/O
- Multiplexing including non-blocking I/O, name and address conversions

Suggested Books:

- William Stallings, "Data and computer Communications", 7th Edition, Prentice Hall
- Andrew S. Tanenbaum, "Computer Network", 4th Ed., Prentice-Hall
- Behrouz A. Forouzan, "Data communications and Networking",4th Edition, McGraw Hill.

vi. Software Engineering

- Introduction to Software Engineering
- The software process
- Project management
- Structured techniques
- Object oriented analysis and design
- Introduction to UML
- Software testing
- Software cost estimation
- Configuration management
- Case studies

Suggested Books:

- Ian Sommerville, "Software Engineering", 8th edition, Addison-Wesley, Prentice Hall
- Roger S. Pressman, "Software Engineering, A Practitioners Approach", 2005, McGraw Hill, ISBN: 0072853182

vii. Control Systems

- Open-loop and closed-loop systems
- Signal flow graphs

- System modeling, transfer function and state variable approach of physical system representation and analysis
- Stability criteria and performance
- Analysis and characteristics of linear feedback systems
- Design and compensation of feedback control systems
- Feedforward control systems
- PID controllers
- State space analysis
- Design of digital controllers and their microprocessor implementation

Suggested Books:

- Norman S. Nise, "Control Systems Engineering", 4th Ed., John Wiley and Sons.
- Katsuhiko Ogata, "Modern Control Engineering," 4th Ed., Prentice Hall.
- Stefani, Savant, Shahian & Hostetter, "Design of Feedback Control Systems", 3rd Ed., Oxford University Press.

viii. Embedded Systems Design

- Requirements for embedded design
- Basic components
- Introduction to microcontrollers
- I/O Ports, internal RAM and registers
- External memory, interrupts, timer operation, serial port
- Interfacing and driving high power AC and DC loads through relays
- Opto isolation
- Tools and techniques for software development
- Programming in assembly and C
- Software simulation and hardware emulation
- Embedded software design using foreground/background approach and using RTOSes
- Introduction to Real-Time Operating Systems (RTOS)
- Concepts of tasks and drivers
- Various scheduling algorithms and their merits and demerits
- Comparison of various scheduling methodologies.

Suggested Books:

- Arnold S. Berger, "Embedded Systems Design: An Introduction to Processes, Tools, and Techniques", CMP Books, 2002.
- Daniel Lewis, "Fundamentals of Embedded Software: where C and Assembly meet", 2002, Pearson Education.
- Jean J. Labrosse, "Micro C OS II-The Real Time Kernel", 2nd Ed., 2002, CMP Books.

ix. Computer Architecture

- Different levels of computer organization
- Data representation, arithmetic circuit
- Instruction set design
- Pipelining, instruction level parallelism

- High speed memory systems, storage systems
- Interconnection networks, multiprocessor architectures
- Large uniprocessor design, cache management.

Suggested Books:

- David A. Patterson and John L. Hennessy, "Computer Architecture: A Quantitative Approach", 3rd Edition, Morgan Kaufmann.
- Douglas V. Hal, "Microprocessors and Interfacing: Programming and Hardware", 2003, McGraw Hill.