Syllabus for M.Sc. Electronics Entrance Test

Part A (Physics)

Thermal Physics: Zeroth & First Law of Thermodynamics: functions and terminology of thermodynamics. Zeroth law and temperature. First law, internal energy, heat and work done. Work done in various thermodynamical processes. Enthalpy, relation between C P and C V . Carnot‟s engine, efficiency and Carnot‟s theorem. Efficiency of internal combustion engines (Otto and diesel). Second & Third Law of Thermodynamics: Different statements of second law, Clausius inequality, entropy and its physical significance. Entropy changes in various thermodynamical processes. Third law of thermodynamics and unattainability of absolute zero. Thermodynamical potentials, Maxwell‟s relations, conditions for feasibility of a process and equilibrium of a system. Clausius- Clapeyron equation, Joule- Thompson effect.
Kinetic Theory of Gases: Kinetic model and deduction of gas laws. Derivation of Maxwell‟s law of distribution of velocities and its experimental verification. Degrees of freedom, law of equipartition of energy (no derivation) and its application to specific heat of gases (mono, di and poly atomic).

Optics: Interference: Conditions for interference and spatial & temporal coherence. Division of Wavefront - Fresnel‟s Biprism and Lloyd‟s Mirror. Division of Amplitude - Parallel thin film, wedge shaped film and Newton‟s Ring experiment. Interferometer - Michelson and Fabry-Perot. Diffraction: Distinction between interference and diffraction. Fresnel‟s and Fraunhofer‟s class of diffraction. Fresnel‟s Half Period Zones and Zone plate. Fraunhofer diffraction at a single slit, n slits and Diffracting Grating. Resolving Power of Optical Instruments - Rayleigh‟s criterion and resolving power of telescope, microscope & grating.
Polarisation: Polarisation by dichronic crystals, birefringence, Nicol prism, retardation plates and Babinet‟s compensator. Analysis of polarized light. Optical Rotation - Fresnel‟s explanation of optical rotation and Half Shade & Biquartz polarimeters.

Modern Physics: Relativity-Experimental Background: Structure of space & time in Newtonian mechanics and inertial & non-inertial frames. Galilean transformations. Newtonian relativity. Galilean transformation and Electromagnetism. Attempts to locate the Absolute Frame: Michelson-Morley experiment and significance of the null result. Einstein‟s postulates of special theory of relativity.Relativity-Relativistic Kinematics: Structure of space & time in Relativistic mechanics and derivation of Lorentz transformation equations (4-vector formulation included). Consequences of Lorentz Transformation Equations (derivations & examples included): Transformation of Simultaneity (Relativity of simultaneity); Transformation of Length (Length contraction); Transformation of Time (Time dilation); Transformation of Velocity (Relativistic velocity addition); Transformation of Acceleration; Transformation of Mass (Variation of mass with velocity). Relation between Energy & Mass (Einstein‟s mass & energy relation) and Energy & Momentum. Inadequacies of Classical Mechanics: Particle Properties of Waves: Spectrum of Black Body radiation, Photoelectric effect, Compton effect and their explanations based on Max Planck‟s Quantum hypothesis. Wave Properties of Particles: Louis de Broglie‟s hypothesis of matter waves and their experimental verification by Davisson-Germer‟s experiment and Thomson‟s experiment. Introduction to Quantum Mechanics: Matter Waves: Mathematical representation, Wavelength, Concept of Wave group, Group (particle) velocity, Phase (wave) velocity and relation between Group & Phase velocities. Wave Function: Functional form, Normalisation of wave function, Orthogonal & Orthonormal wave functions and Probabilistic interpretation of wave function based on Born Rule.

Classical Mechanics and Statistical Mechanics: Constrained Motion: Constraints - Definition, Classification and Examples. Degrees of Freedom and Configuration space. Constrained system, Forces of constraint and Constrained motion. Generalised coordinates, Transformation equations and Generalised notations & relations. Principle of Virtual work and D‟Alembert‟s principle. Lagrangian Formalism: Lagrangian for conservative & non-conservative systems, Lagrange‟s equation of motion (no derivation), Comparison of Newtonian & Lagrangian formulations, Cyclic coordinates, and Conservation laws (with proofs and properties of kinetic energy function included). Simple examples based on Lagrangian formulation. Hamiltonian Formalism: Phase space, Hamiltonian for conservative & non-conservative systems, Physical significance of Hamiltonian, Hamilton‟s equation of motion (no derivation), Comparison of Lagrangian & Hamiltonian formulations, Cyclic coordinates, and Construction of Hamiltonian from Lagrangian. Simple examples based on Hamiltonian formulation. Macrostate & Microstate: Macrostate, Microstate, Number of accessible microstates and Postulate of equal a priori. Phase space, Phase trajectory, Volume element in phase space, Quantisation of phase space and number of accessible microstates for free particle in 1D, free particle in 3D & harmonic oscillator in 1D. Concept of Ensemble Problem with time average, concept of ensemble, postulate of ensemble average and Liouville‟s theorem (proof included). Micro Canonical, Canonical & Grand Canonical ensembles. Thermodynamic Probability, Postulate of Equilibrium and Boltzmann Entropy relation.Distribution Laws: Statistical Distribution Laws: Expressions for number of accessible microstates, probability & number of particles in ith state at equilibrium for Maxwell-Boltzmann, Bose-Einstein & Fermi- Dirac statistics. Comparison of statistical distribution laws and their physical significance. Canonical Distribution Law: Boltzmann‟s Canonical Distribution Law, Boltzmann‟s Partition Function, Proof of Equipartition Theorem (Law of Equipartition of energy) and relation between Partition function and Thermodynamic potentials.

Solid State Physics & Nuclear Physics: Crystal Structure Lattice, Basis & Crystal structure. Lattice translation vectors, Primitive & non-primitive cells. Symmetry operations, Point group & Space group. 2D & 3D Bravais lattice. Parameters of cubic lattices. Lattice planes and Miller indices. Simple crystal structures - HCP & FCC, Diamond, Cubic Zinc Sulphide, Sodium Chloride, Cesium Chloride. Crystal Diffraction: ray diffraction and Bragg‟s law. Experimental diffraction methods - Laue, Rotating crystal and Powder methods. Derivation of scattered wave amplitude. Reciprocal lattice, Reciprocal lattice vectors and relation between Direct & Reciprocal lattice. Diffraction conditions, Ewald‟s method and Brillouin zones. Reciprocal lattice to SC, BCC & FCC lattices. Crystal Bindings: Classification of Crystals on the Basis of Bonding - Ionic, Covalent, Metallic, van der Waals (Molecular) and Hydrogen bonded. Crystals of inert gases, Attractive interaction (van der Waals- London) & Repulsive interaction, Equilibrium lattice constant, Cohesive energy and Compressibility & Bulk modulus. Ionic crystals, Cohesive energy, Madelung energy and evaluation of Madelung constant. Lattice Vibrations: Lattice Vibrations: Lattice vibrations for linear mono & di atomic chains, Dispersion relations and Acoustical & Optical branches (qualitative treatment). Qualitative description of Phonons in solids. Lattice heat capacity, Dulong-Petit‟s law and Einstein‟s theory of lattice heat capacity. Free Electron Theory: Fermi energy, Density of states, Heat capacity of conduction electrons, Paramagnetic susceptibility of conduction electrons and Hall effect in metals. Band Theory: Origin of band theory, Qualitative idea of Bloch theorem, Kronig-Penney model, Effectice mass of an electron & Concept of Holes & Classification of solids on the basis of band theory. Nuclear Forces & Radioactive Decays: General Properties of Nucleus: Mass, binding energy, radii, density, angular momentum, magnetic dipole moment vector and electric quadrupole moment tensor. Nuclear Forces: General characteristic of nuclear force and Deuteron ground state properties. Radioactive Decays: Nuclear stability, basic ideas about beta minus decay, beta plus decay, alpha decay, gamma decay & electron capture, fundamental laws of radioactive disintegration and radioactive series. Nuclear Models & Nuclear Reactions: Nuclear Models: Liquid drop model and Bethe-Weizsacker mass formula. Single particle shell model (the level scheme in the context of reproduction of magic numbers included). Nuclear Reactions: Bethe‟s notation, types of nuclear reaction, Conservation laws, Cross- section of nuclear reaction, Theory of nuclear fission (qualitative), Nuclear reactors and Nuclear fusion. Accelerators & Detectors: Accelerators: Theory, working and applications of Van de Graaff accelerator, Cyclotron and Synchrotron. Detectors: Theory, working and applications of GM counter, Semiconductor detector, Scintillation counter and Wilson cloud chamber.

Part B (Electronics)

Basic Circuit Theory And Network Analysis: Kirchhoff's Current Law (KCL), Kirchhoff's Voltage Law (KVL), Node Analysis, Mesh Analysis, Source transformation, Star-Delta Conversion. DC Transient Analysis: RC Circuit- Charging and discharging with initial charge, RL Circuit with Initial Current, Time Constant, RL and RC Circuits with Sources, DC Response of Series RLC Circuits. Network Theorem: Superposition Theorem, Thevenin's Theorem, Norton's Theorem, Reciprocity Theorem, Millman's Theorem, and Maximum Power Transfer Theorem. AC circuit analysis using Network theorems.

Semiconductor Devices And Electronic Circuits: p-n junction Diode: depletion layer, barrier potential, working in forward bias and reverse bias, concept of break down, I-V characteristics, knee voltage, break down voltage, Zener and Avalanche breakdown; Working principle, Symbol, I-V Characteristics and application of Zener diode, Light emitting diode, Photo diode, Solar cell. BJT, Basic Transistor Action, Emitter Efficiency, Base Transport Factor, Current Gain, Energy Band Diagram of Transistor in Thermal Equilibrium, Quantitative Analysis of Static Characteristics (Minority Carrier Distribution and Terminal Currents), Base-Width Modulation, Modes of operation, Input and Output Characteristics of CB, CE and CC Configurations. JFET, Construction, Idea of Channel Formation, Pinch-Off and Saturation Voltage, Current-Voltage Output Characteristics. MOSFET, types of MOSFETs, Circuit symbols, Working and Characteristic curves of Depletion type MOSFET (both N channel and P Channel) and Enhancement type MOSFET (both N channel and P channel).

Analog Electronics: General principle of transistor amplifier; Load line and Q point, thermal stability, stability factors; Transistor biasing; Fixed bias, Collector to base bias, emitter bias and voltage divider bias circuits. Small Signal Transistor Amplifiers: Small signal transistor amplifier circuits in different configurations and hybrid h-parameters form and their analysis; Noise and distortion in SST amplifier. Concept of feedback, negative and positive feedback, voltage (series and shunt), current (series and shunt) feedback amplifiers, gain, input and output impedances. Multistage Amplifier: Cascading of amplifier and voltage gain; R-C, L-C and T-C coupled two stage amplifier circuits and their phase and frequency response and bandwidth. Audio Oscillators: Positive feedback and Bark-Hausen criteria of sustained oscillation; Phase shift and Wien bridge oscillator. RF Oscillator: Tuned base, Tuned collector, Hartley and Colpitts oscillator circuit and their analysis; Negative resistance oscillator; Frequency stability; Crystal controlled oscillator; Pierce and Miller circuits.

Digital Electronics : Binary Number System, Binary-to-decimal Conversion, Decimal-to-binary Conversion, Octal Numbers, Hexadecimal Numbers and their inter conversion, The Basic Gates-NOT, OR, AND, Universal Logic Gates-NOR, NAND, ANDOR-Invert Gates, Positive and Negative Logic; Digital Logic families: Fan-in, Fan out, Noise Margin, Power

Dissipation, Figure of merit, Speed power product in RTL, DTL, TTL, ECL and CMOS logic gates, Boolean Laws and Theorems, SOP and POS Method, Truth Table to Karnaugh Map, Pairs, Quads, and Octets, Karnaugh Map Simplifications, Encoders, Decoders, Multiplexer, Demultiplexer.

Microprocessor and Microcontroller: 8085 Microprocessor: Main Features, Architecture, Block Diagram, CPU, ALU, Registers, Flags, Stack Pointer, Program Counter, Data and Address Buses, Control Signals, Pin-Out Diagram and Pin Description, , Addressing Modes, Instruction Format, Instructions Set, Data Transfer, Arithmetic, Increment, Decrement, Logical, Branch and Machine Control Instructions, Assembly Language Programming Examples, Stack Operations, Subroutines and Delay Loops Call and Return Operations, Use of Counters, Timing and Control Circuitry, Timing Diagram, Instruction Cycle, Machine Cycle, T (Timing)-States, Time Delay.

Communication Electronics: Amplitude modulation – Frequency Spectrum of the AM Wave - Modulation Index – Power relations in the AM Wave – AM generation – AM Transmitter. - Forms of Amplitude Modulation – Evolution of SSB – Balanced Modulator – Methods of SSB Generation – Vestigial side band Transmission. Frequency Modulation - Frequency Spectrum of the FM Wave – Modulation Index – Effect of Noise – Adjacent & Co-Channel Interference – Wide Band & Narrow Band FM-FM Generation; Analog Pulse Modulation: Channel Capacity, Sampling Theorem, Basic Principles of PAM, PWM and PPM, Modulation and Detection Technique for PAM only, Multiplexing, TDM and FDM.

Linear Integrated Circuits: Basic Operational Amplifier: Concept of differential amplifiers (Dual input balanced and unbalanced output), constant current bias, current mirror, cascaded differential amplifier stages with concept of level translator, block diagram of an operational amplifier (IC 741)
Op-Amp Parameters: Input offset voltage, input offset current, input bias current, differential input resistance, input capacitance, offset voltage adjustment range, input voltage range, common mode rejection ratio, slew rate, supply voltage rejection ratio. Ideal and practical characteristics.