SYLLABUS OF DOMAIN KNOWLEDGE FOR THE POST OF ENGINEER A (PHOTONICS)

I. Electromagnetic Theory and Relativity

Electrostatics: Electric field, Gauss's Law in integral and differential forms, applications of Gauss's law, Scalar potential, Energy of continuous charge distribution, Poisson and Laplace equations, Boundary conditions and uniqueness theorem, Dielectrics, induces dipoles, polarization and field of a polarized object, Gauss's law for dielectric media, Displacement field, linear dielectric and dielectric constant, energy and forces in dielectric systems.

Magnetostatics: Magnetic fields & magnetic forces, Bio-Savart law, Amper's law, Applications of Amperes law, Magnetic vector potential, Magnetization, Torque and forces on magnetic dipoles, The field of a magnetized object, Ampere's law in magnetized material, Boundary conditions, Magnetic susceptibility and permeability.

Faraday's law of electromagnetic induction, energy and magnetic field, Maxwell's equations in vacuum and dielectric media, Vector and Scalar potentials, gauge transformations- Lorentz and Coulomb gauges, Solutions of Maxwell's equations in vacuum and dielectric media, Poynting's theorem, conservation of energy and momentum, Reflection and refraction of EMW at dielectric boundaries, Snell's law, TIR, Brewster's angle.

Michelson- Morley experiment, Postulates of special theory of relativity, Lorentz transformations, velocity addition, velocity dependent mass, structure of space-time and Minkowski diagram, Relativistic Mechanics- proper time, proper velocity, Relativistic momentum and energy, Compton scattering, Magnetism as a relativistic phenomenon.

II. Spectroscopy

Bohr atom model, Hydrogen spectral series, Bohr's correspondence principle, Sommerfeld's relativistic atom model, Wilson Somerfeld modification, Vector atom model, Quantum numbers, Larmor theorem, Atomic orbitals and their shapes, Spectral terms and term symbols based on electronic configuration. LS coupling, JJ coupling, Pauli's exclusion principle, Hund's rule of multiplicity, selection rules, Hyperfine structure, Zeeman effect, Stark effect, X-ray spectra.

Microwave spectra of molecules: Rotational energy levels of rigid and non-rigid diatomic molecules, Rotational term values, Pure rotational spectra of diatomic molecules, Effect of isotopic substitution on spectra.

Infrared spectroscopy: Pure vibration spectrum of diatomic molecules, simple harmonic and anharmonic oscillators, Interaction of rotation and vibration, Breakdown of Born- Oppenheimer approximation, Experimental techniques of IR spectroscopy.

Raman spectroscopy: Classical and quantum theory of Raman effect, Stokes and anti-stokes Raman lines, Pure rotational Raman spectra, Vibrational Raman Spectra, Complementary nature of IR and Raman Spectra, Structure determination from Raman and IR spectra, Experimental techniques and instrumentation.

Electronic spectroscopy: Electronic spectra of diatomic molecules, Vibrational coarse structure,

progressions and sequences, Frank-Condon principle, Intensity distribution in absorption and emission spectra, Dissociation and pre-dissociation, Evaluation of dissociation energy, Rotational fine structure of electronic spectra, P, Q, R branches, Band head formation, Experimental techniques.

III. Electronics

PN junction diode, Zener diode, light emitting diode, High frequency switching diodes (tunnel, Gunn, Schottky and varactor diodes), Rectification, Half wave, Full wave and Bridge rectifiers, ripple factor, Zener shunt regulator, Different types of filters, Voltage multipliers, clippers, clampers.

Transistor characteristics, h-parameters, transistor as an amplifier, CE, CB, CC configurations, FET, MOSFET, transistor biasing techniques, DC load line analysis, operating point, Frequency response, differential input amplifier, CMRR, Power amplifiers - Class A, class B, and Class C operations, Push-Pull configuration, positive and negative feedback, advantages of using negative feedback, voltage series feedback, current series feedback.

Oscillators, Barkhausen criteria, RC oscillators: RC phase shift oscillator, Wien bridge oscillator, LC oscillators: Hartley, Colpitts and Clapp oscillators, crystal oscillator.

Op-amps, Ideal op-amp characteristics, inverting and non-inverting amplifiers, voltage follower, current to voltage converter, adders, integrators and differentiators, comparators, Schmitt trigger, active filters, IC 555 Timer, astable and monostable multivibrators.

Cathode Ray Oscilloscope, Block diagram of Conventional CRO, dual beam and dual trace CROs, triggering modes, time base generation circuits, frequency bandwidth, risetime and sensitivity, sampling oscilloscope, digital storage oscilloscope (DSO), Lissajous figures measurement of phase difference and frequency, microcontrollers, architecture of 8051 microcontroller.

Tuned amplifiers, Chopper stabilized amplifiers, wave analyser, Spectrum analyser, lock-in amplifiers, BOXCAR averagers,

IV. Optics and Lasers

Coherent sources, spatial and temporal coherence, complex representation of light waves, Interference of two monochromatic waves, Interference by division of wave front, Young's double slit experiment, Newton’s Rings, Michelson interferometer.

Diffraction, Fresnel`s assumptions, Rectilinear propagation of light and Fresnel's theory, Fresnel's zones, theory of zone plate and its comparison with convex lens, Fresnel and Fraunhofer diffractions, plain transmission grating- oblique and normal incidence, determination of wavelength of light using grating, dispersion and resolving power, Blazed gratings.

Light polarization, Polarization by reflection and refraction, Brewster angle, Pile of plates, Malus law, Double refraction - Optic axis, Uniaxial and biaxial crystals, Quarter wave and Half wave plates, Production and detection of plane, elliptical and circular polarization of light.

Spontaneous emission, decay rate, transition probability, spectral linewidths, spectral line shapes, homogeneous and inhomogeneous broadening, Absorption and Stimulated emission, Einstein’s A and B coefficients, rate equations for three and four level systems, gain coefficient and stimulated

emission cross section for homogeneous and inhomogeneous broadening, pumping mechanisms, population inversion, saturation intensity, Development and growth of a laser beam, Laser gain saturation, Laser beam growth beyond the saturation intensity, Optimization of laser output power.

Longitudinal laser cavity modes, FP resonator, transverse laser cavity modes, Properties of laser modes, spectral and spatial hole burning, properties of Gaussian beams, Q-switching, mode-locking, generation of ultrashort optical pulses, self phase modulation, pulse compression (shortening) with gratings or prisms, femtosecond optical pulses, techniques to characterize femtosecond laser pulses.

Quantization of electromagnetic field, Fock states, coherent states, photon correlation measurements, photon counting measurements, generation and application of squeezed light, coherent interaction of light with matter, Maxwell - Bloch equations, Bell's inequalities in quantum optics, EPR argument, experimental studies, non-demolition measurements, quantum coherence, entanglement and interferometric measurements, Quantum Teleportation, Optical Stern -Gerlach experiment.

V. Optical Instrumentation

Light sources and Standardization of light sources, Incandescent lamps and Fluorescent lamps,- Tungsten and halogen lamps, High pressure and low pressure discharge lamps- Sodium, Hydrogen, Mercury, Metal Halide lamps, Electrode less discharge lamps-magnetic induction lamps, plasma lamps, sulfur lamps, Broad band LED sources, Laser Diode, Modes and threshold conditions, laser diode rate equations, external quantum efficiency, resonant frequencies, laser diode structures and radiation patterns, single mode lasers, modulation of laser diodes, temperature effects, supercontinuum sources.

Opto-electronic detectors-Thermal detectors, Photoconductive detectors - junction photodiodes, P-I-N photodetector- quantum efficiency and frequency response, Silicon photodiode performance Characteristics, APD- design issues and band width, Phototransistors, Modulated barrier photodiodes, Schottky barrier PD, Metal Semiconductor photodetectors, MSM PD, Detectors for long wavelength operation, Microcavity PD, Solar cells- I-V characteristics and spectral response, Materials and design considerations of solar cells.

Mach-Zehnder Interferometer, Sagnac Interferometer, Interferometric measurements of rotation, Detection of Gravitational waves using interferometric techniques, Recent Experimentations and Results (LIGO), Fabry Perot Interferometer and Fabry Perot etalon, resolving power and expression for finesse, Interference filters, Broad band reflectors, band pass filters, dichroic beam splitters and cold mirrors.

Optical waveguides, numerical aperture, Modes in planar waveguides, evanescent fields, cylindrical fibres, step index and graded index fibres, single mode and multimode fibres, channel waveguides, Transmission characteristics of optical fibre, attenuation, absorption and scattering losses, nonlinear losses, bend losses, wavelengths for communication, dispersion effects in optical fibres- material, waveguide dispersions, modal birefringence and polarization maintaining fibres. Nonlinear effects in optical fibres - Self phase modulation, cross phase modulation, stimulated Raman scattering, stimulated Brillouin scattering.