18-4-16

Indian Institute of Engineering Science and Technology, Shibpur

B.Tech-M.Tech Dual degree Final

(2nd Semester AE, CE,ME, MetE, MinE,) Examination, 2016

PHYSICS (PH - 1201)

Full Marks: 70 **Time: 3 hrs.**

Answer all questions

1. (a) A sinusoidal voltage $v(t) = V_0 \sin \omega t$ is applied across a parallel plate capacitor having separation d and area a. Find the displacement current in the capacitor if a dielectric medium having dielectric constant 10 is kept between the plates.

(b) Taking the fluctuating quantity of a plane wave propagating along the x-axis to be a function of $(ct \pm x)$ where c is the wave velocity, derive the differential equation of the wave.

(c) What is population inversion in lasing system? Explain why in two level system population inversion cannot be achieved.

(d) Find de-Broglie wavelength of a beta particle having kinetic energy T= 110 KeV

(e) Write down the differential and integral form of Faraday's law.

[5x2=10]

2. a) Determine the transformation/transformation matrix from cylindrical to rectangular coordinates.

b) Write down Maxwell's equations in electrodynamics in vacuum.

c) What is the limitation in Ampere's circuital law? Explain how Maxwell corrected this.

d) Obtain the wave equations corresponding to electric and magnetic fields in free space.

[5+4+1+2+3]

3. a) A mass of 10 gm is acted on by a restoring force 10 dyne per cm and a resisting force of 2 dyne sec/cm. Find

(i) Whether the motion is aperiodic or oscillatory.

(ii) The value of the resisting force which will make the motion critically damped.

(iii) The value of the mass for which the given forces will make the motion critically damped.

b) (i) Solve the differential equation of a transverse wave propagating along the length of a string by the method of separation of variables.

(ii) Apply boundary condition for a string rigidly fixed at both ends and arrive at the general solution of the wave equation.

(iii) Find the average kinetic energy of a vibrating string.

[(2+1.5+1.5) + (3+4+3)]

(PTO for question 4 and 5)

4. a) (i) Find the angular width of the central bright fringe in the Fraunhofer diffraction pattern of a single slit of width 0.24 mm. The wavelength of light used is 500 nm.

(ii) What is the maximum resolving power of grating having grating element 12.5 x 10^{-5} cm and total number of lines is 33000? The Wavelength of light used is 500nm.

b) (i) What is optical resonator? Discuss its role in laser system.

(ii) Explain the working principle of He-Ne laser with energy level diagram.

(iii) Find the ratio of population of two states in thermal equilibrium at room temperature 27°C. The wavelength corresponding to the energy difference between the two states is 550nm.

(iv) Find the ratio of Einstein's coefficient of spontaneous to stimulated emission of a two level system having ground state energy E_1 and excited state energy E_2. Assume the wavelength of radiation is 600 nm. Which one is greater spontaneous or stimulated emission? [(2+3) +(2+3+2+3)]

5. a) (i) Define proper length.

(ii) Muons have an average life time of 2 microseconds in their own frame of reference. In a beam of cosmic ray muons has a speed of 0.98c relative to earth. Find the average life time of these muons with respect to an observer on earth surface. Also find and the distance travelled by the beam during the life interval.

(b) (i) Find the maximum possible Compton shifts of wavelength for X-rays of wavelengths 1.5 Å. (Given rest mass energy of electron = 0.511 MeV, c = 3×10^{8} m/s, h = 6.62×10^{-34} J-s, 1 eV = 1.6×10^{-19} J)

(ii) Find the group velocity of an electron having energy 1 MeV.

(iii) A quantum mechanical particle is free to move in a one dimensional rigid box of length L. Write down the Schrodinger equation and solve it to obtain the normalized wave function and energy eigenvalues. Plot schematically the probability density corresponding to the ground and first excited states within the box.

[(1+(2+2)) + (2+2+1+3+2)]