2pm 27/4/17

Indian Institute of Engineering Science and Technology, Shibpur

B.Tech-M.Tech Dual degree Semester

(2nd Semester) Examination, 2017

PHYSICS (PH - 1201)

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

Answer all questions

Different parts of each question should be answered sequentially

1. a) Show that electric field of a static point charge is a conservative force field.

b) Find $\vec{\nabla}\emptyset$ at point (2,3,4), where $\emptyset = r^4$.

c) If a wave group consist of two harmonic waves of frequencies ω and $\omega + d\omega$ and propagation constant k and $k+dk$ respectively, show that the group velocity is given by $\frac{d\omega}{dk}$

d) Determine the minimum number of lines in a grating that are able to resolve the sodium lines of wavelengths 589 nm and 589.6nm in the first order.

e) Write the postulates of special theory of relativity. [2+2+2+2+2]

2. a) State Stoke's theorem. Find $\iint \vec{\nabla} \times \vec{A} . \hat{n}\, dS$ over the curve surface area of a cone of height h and base radius r, placed vertically on the xy-plane, whose axis coincides with z-axis, and $\vec{A} = (x^2 + y^2 + z)\hat{\phi}$.

b) (i) A voltage $V(t) = V_0 \cos(\omega t)$ is applied across a parallel capacitor of thickness d and area A, find the maximum displacement current inside the capacitor. Plot the displacement current with time for the time interval $0 \leq t \leq \frac{4\pi}{\omega}$.

(ii) Write down Maxwell equations in free space. Derive wave equation for electric field in free space.

(iii) Find the Poynting vector for the light with $\vec{E}(z,t) = 4cos(kz - \omega t)\hat{\imath} - 2sin(kz - \omega t)\hat{\jmath}$ and $\vec{B}(z,t) = sin(kz - \omega t)\hat{\imath} + 2cos(kz - \omega t)\hat{\jmath}$. [2+3]+[(2+2)+(2+2)+2]

3. a) What do you mean by sharpness of resonance? Show that the quality factor for resonance is given by $Q = \frac{\omega_0 \pi}{R_m}$ (Symbols have their usual meaning).

b) Assuming the differential equation for harmonic wave along a perfectly flexible stretched string to be of the form $c^2 \frac{\partial^2 y}{\partial x^2} = \frac{\partial^2 y}{\partial t^2}$; where the symbol have usual meaning, solve the equation by the method of separation of variables and applying the boundary conditions for a stretched string rigidly fixed at both ends, show that the string can vibrate only with some characteristic frequencies. 5+10

Please tern over

4. a) Obtain an expression for the intensity of light diffracted from a double slit. Hence find the condition of missing order.

b) (i) Find the relation between Einstein's A, B coefficients in a two level LASER system. Hence find the relation between the rate of spontaneous to stimulated emission.

(ii) Calculate the relative population of Na atoms in a sodium lamp in the 1st excited state and in the ground state at temperature 300°C. Assume the wavelength of light 590 nm.

(iii) Define optical resonator in LASER. Calculate the number of modes when LASER beam of 600 nm is emitted from an optical resonator with the distance between two mirrors kept at 25 cm. [3+2] + [(3+2)+2+(1+2)]

5. a) (i) What is the underlying principle that makes Lorentz transformation a linear one?

(ii) The average lifetime of a π-meson in its own frame of reference is 2.6×10^{-8} s. If the meson moves with a speed of 0.95c, what is the average distance it travels before decaying, as measured by an observer on Earth?

b) (i) Calculate the fractional change in the wavelength of an X-ray of wave length 0.4 Å that undergoes a 90° Compton scattering from an electron.

(ii) Write down the uncertainty relation for the position-momentum and time-energy.

(iii) Find the de Broglie wavelength of a 0.01 kg pellet having a velocity of 10 m/s.

(iv) Find out the expectation value of $\langle x^2 \rangle$ for wave function $\psi(x) = \left(\frac{1}{\sigma\sqrt{\pi}}\right) \exp\left(-\frac{x^2}{2\sigma^2}\right)$

(v) The wave function for a particle inside a rigid wall in its ground state is given by $\psi_0(x) = A \sin\left(\frac{\pi x}{L}\right)$ (Symbols have their usual meaning). Find the position at which the probability of obtaining the particle is maximum. [2+3] + [2+2+2+2+2]