Indian Institute of Engineering Science and Technology, Shibpur

B.Tech 1st semester End Sem Examination, 2021

Physics (PH 1101)

Full Marks: 50 **Time: 1 hr 30 min**

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Answer all the questions

(Use separate papers for Group I & II and upload them separately.)

Group-I

1. a) If $\vec{A} = 2x^2\hat{\imath} - 3yz\hat{\jmath} + xy^2\hat{k}$ and $\varphi = 2z - x^3y$, find $\vec{A}.\vec{\nabla}\varphi$ at the point (1, -2, 3).

Show that the unit vectors $\hat{\rho}, \hat{\varphi}\ and\ \hat{z}$ are perpendicular to each other in cylindrical coordinate system. [2+2]

b) Draw a neat diagram of an electromagnetic plane wave.

Show that the plane electromagnetic waves in free space travel with the velocity of speed of light. [1+3]

2. a) Write down the time dependent Scrodinger equation. State the physical significance of the wave function. Using the method of separation of variables find the time independent schrodinger equation.

b) Find the expectation value of position $< x >$ and momentum $< p_x >$ of a particle in a one dimensional box with respect to the ground state.

c) Find the wavelength of the scattering X-ray scattered at an angle of 45^o in Compton effect. The wavelength of the incident ray is $1\dot{A}$. [(1+1+2)+3+1.5]

3. a) Write down Lorentz transformations equations?

b) At time t = 0.6 ms, the position coordinates of a particle are x = 1000 m, y = 150 m, z = 300 m in S-frame. Find the position of the particle in the S' frame, moving with constant velocity v = 0.01c (c is the speed of light in free space) with respect to the S-frame along the common x-x' axis.

c) Two particles move in opposite directions, each with a speed of 0.7c. What is the speed of one particle as seen by the other? [2+3.5+3]

Group-II

1. a) Two oscillators are connected through a spring of spring constant 1000 dyne/cm. The mass and spring constant of the first oscillator is 20g and 3000 dyne/cm. 30g and 8000 dyne/cm is the mass and spring constant for the second oscillator. Calculate the normal frequencies (ω_+ and ω_-) of this coupled system.
What would be the direction of motion of these two oscillators at $\omega = \omega_+$? [3+1]

b) Calculate the kinetic energy of a vibrating string.
What would be the maximum energy of this vibrating string? [3+1]

2. a) Obtain the intensity distribution for a double slit Fraunhofer diffraction with suitable diagram. Obtain the conditions for interference maxima and diffraction minima. Deduce the missing orders for a double slit Fraunhofer diffraction pattern, if the slit width is 0.16mm and they are 0.8mm apart.
b) What are the factors that control the resolving power of a grating? Explain.
c) Write down the basic differences between an ordinary and an extraordinary ray of light. [(2.5+2+1)+1+2]

3. a) What is stimulated emission?
b) What is the role of population inversion in Lasing action?
c) Show that, at thermal equilibrium

$$A_{21} = B_{21}\frac{8\pi h\nu^3}{c^3}$$

where A_{21} is the Einstein coefficient of spontaneous emission, B_{21} is the Einstein coefficient of stimulated emission, h is the plank constant, ν is the frequency and c is the velocity of light in the medium.
d) Draw the energy level diagram with all relevant transitions of He-Ne Laser (Explanation not required). [1+2+3+2.5]