FEBRUARY 2023 EXAMINATION **1213**

I YEAR B.E./B.TECH EXAMINATION

PH-10016: PHYSICS

TIME: 3 Hrs. **Max. Marks: 70**

Note: Total questions are 5. Parts (a), (b) and (c) are compulsory. Attempt any one question from (d) or (e) section.

S.No	Questions	Marks	CO	BL	PI
Q.1.					
(a)	A progressive sinusoidal wave is represented by Y (x, t) = A sin [(0.2 m^{-1}) x – (0.4 s^{-1}) t + $\pi/6$], where x and t are in meter and second respectively. Determine the speed of propagation of the wave.	**(2)**	1,4	2,3	1.6
(b)	Explain the physical significance of Gauss and Stoke's theorems.	**(2)**	2,4	1,2	1.5
(c)	A particle with a proper lifetime of 1 μs moves through the laboratory at 2.7 x 10^8 ms^{-1}. (i) What is its lifetime, as measured by observers in the laboratory? (ii) What will be the distance traversed by it before disintegrating?	**(3)**	1,4	3,5	1.2
(d)	What are Maxwell's equations? State and Derive Maxwell's equations in differential form.	**(7)**	2,4	1,3	2.3
	OR				
(e)	Define Poynting vector. Derive an expression for it and explain its physical significance for electromagnetic wave in free space.	**(7)**	2,4	2,4	2.2
Q.2					
(a)	In a Newton's rings experiment the diameter of 10^{th} ring changes from 1.40 to 1.27 cm when a drop of liquid is introduced between the lens and the glass plate. Calculate the refractive index of the liquid.	**(2)**	2,4	2,5	1.6
(b)	A monochromatic light of wavelength 650 nm falls normally on a grating. The first order spectrum is observed at 15° from the mean position. Calculate the grating element.	**(2)**	3,4	3,5	1.2
(c)	Define resolving power of an optical instrument? Explain Rayleigh's criterion for limit of resolution.	**(3)**	1,3	1,2	1.4
(d)	Describe and explain the formation of Newton's rings in reflected light. Prove that in reflected light the diameter of the dark rings is proportional to the square roots of natural numbers.	**(7)**	2,3	2,3	1.5
	OR				
(e)	Discuss the phenomenon of Fraunhofer's diffraction at a single slit and determine the conditions for maximum and minimum.	**(7)**	2,3	3,4	1.2
Q .3					
(a)	The lifetime of an excited state of an atom is about 10^{-8} sec. calculate the minimum uncertainty in the determination of the energy of the excited state.	**(2)**	1,4	2,4	1.6
(b)	What are matter waves? Write any four properties of matter waves.	**(2)**	1,2	2,3	2.2
(c)	Calculate the de Broglie wavelength associated with (i) A 46-gm golf ball with velocity 36 m/s (ii) An electron with a velocity 10^7 m/s Which of these two, show wave character and why?	**(3)**	2,4	2,4	1.2

(d)	Discuss & derive Planck's radiation formula. Explain Wien's law & Rayleigh-Jeans law as special cases of it.	**(5+3)**	2,3	3,4	1.4
	OR				
(e)	Establish the Time Independent & Time-dependent Schrodinger's wave equation. Explain why the integral of $\|\psi^2\|$ overall space must equal to unity.	**(3+3+ 1)**	1,2	3,4	1.4
Q.4					
(a)	Calculate the number of photons emitted by ruby laser of output power 1W. The lasing frequency of the Ruby laser is 694.3 nm.	**(2)**	2,4	3,2	1.6
(b)	The ratio of population inversion of two energy levels at 300 K is 10^{-30}. Find the wavelength of the radiation emitted.	**(2)**	1,4	2,1	1.3
(c)	What is a resonant cavity? Highlight its importance in the production of laser radiation.	**(3)**	1,2	2,3	1.1
(d)	Explain with neat a diagram the principle, construction and working of He-Ne laser. What are its merits and demerits?	**(5+2)**	2,3	2,3	1.5
	OR				
(e)	State the necessary condition for stimulated emission. Explain the Einstein's A and B coefficients and establish relation between them.	**(2+5)**	1,3	2,4	1.4
Q.5					
(a)	An optical fiber had a diameter of 60 μm, a core index of 1.48 and a cladding index of 1.41. the wavelength of the light source is 0.8 μm. Determine the number of modes propagating in the fiber.	**(2)**	2,4	3,4	1.4
(b)	The refractive index of core is 1.5 and the fractional refractive index between the core and the cladding is 1.8 %. Estimate (a)Numerical aperture (b) Critical angle at the core-cladding interface.	**(2)**	3,4	2,3	1.5
(c)	What do you understand by terms acceptance angle? Explain the expression of acceptance angle in terms of refractive indices of core and cladding.	**(3)**	1,3	2,3	2.2
(d)	Explain what is step-index, graded index, monomode and multimode fibre. Draw relevant sketches.	**(7)**	1,2	2,4	1.5
	OR				
(e)	Give the block diagram of an optical fibre communication system, explaining the functions of different blocks. Compare its merits over conventional communication system.	**(4+3)**	2,3	3,4	1.5
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Note: Total questions are 5. Parts (a), (b) and (c) are compulsory. Attempt any one question from (d) or (e) section.

S.No	Questions	Marks	CO	BL	PI
Q.1.					
(a)	A progressive sinusoidal wave is represented by $Y(x, t) = A \sin [(0.2\ m^{-1})\ x - (0.4\ s^{-1})\ t + \pi/6]$, where x and t are in meter and second respectively. Determine the speed of propagation of the wave.	**(2)**	1,4	2,3	1.6
Soln	$Y = A\sin(\omega t - kx + \phi)$ $\omega = 0.4\ s^{-1}$, $k = 0.2\ m^{-1}$ & $\phi = \pi/6$ Speed of Propagation $v = \frac{\omega}{k}$ $\therefore v = \frac{0.4}{0.2}$ Ans = 2 m/s				
(b)	Explain the physical significance of Gauss and Stoke's theorems.	**(2)**	2,4	1,2	1.5
(c)	A particle with a proper lifetime of 1 μs moves through the laboratory at 2.7 x 10^8 ms^{-1}. (i) What is its lifetime, as measured by observers in the laboratory? (ii) What will be the distance traversed by it before disintegrating?	**(3)**	1,4	3,5	1.2
Sol	(i) $t_0 = 1\mu s = 10^{-6}\ s$, $v = 2.7 \times 10^8\ m\ s^{-1}$; $t = ?$ $t = \frac{t_0}{\sqrt{1 - \frac{v^2}{c^2}}} = \frac{10^{-6}}{\sqrt{1 - \frac{(2.7\times10^8)^2}{(3\times10^8)^2}}} = 2.3 \times 10^{-6}\ s$ (ii) $(2.7\times10^8) \times (2.3\times10^{-6}) = 620\ m$				
(d)	What are Maxwell's equations? State and Derive Maxwell's equations in differential form.	**(7)**	2,4	1,3	2.3
	OR				
(e)	Define Poynting vector. Derive an expression for it and explain its physical significance for electromagnetic wave in free space.	**(7)**	2,4	2,4	2.2
Q.2					
(a)	In a Newton's rings experiment the diameter of 10th ring changes from 1.40 to 1.27 cm when a drop of liquid is introduced between the lens and the glass plate. Calculate the refractive index of the liquid.	**(2)**	2,4	2,5	1.6
Sol	$\mu = \frac{(D_m^2)_{air}}{(D_m^2)_{liq}} = \frac{(1.40\ cm)^2}{(1.27\ cm)^2}$ Ans = 1.215				

(b)	A monochromatic light of wavelength 650 nm falls normally on a grating. The first order spectrum is observed at 15° from the mean position. Calculate the grating element. Sol $e\sin\theta = n\lambda$, $e = \frac{n\lambda}{\sin\theta} = \frac{1\times 6.5\times10^{-7}}{\sin 15^\circ}$ $= \frac{6.5\times10^{-7}}{0.2588} \Rightarrow 2.512\times10^{-6}\,m$	**(2)**	3,4	3,5	1.2
(c)	Define resolving power of an optical instrument? Explain Rayleigh's criterion for limit of resolution.	**(3)**	1,3	1,2	1.4
(d)	Describe and explain the formation of Newton's rings in reflected light. Prove that in reflected light the diameter of the dark rings is proportional to the square roots of natural numbers.	**(7)**	2,3	2,3	1.5
	OR				
(e)	Discuss the phenomenon of Fraunhofer's diffraction at a single slit and determine the conditions for maximum and minimum.	**(7)**	2,3	3,4	1.2
Q .3					
(a)	The lifetime of an excited state of an atom is about 10^{-8} sec. calculate the minimum uncertainty in the determination of the energy of the excited state. Sol $\Delta E \geq \hbar/2\Delta t = \frac{1.054\times10^{-34}}{2(10^{-8})}$ $\Delta E \geq 0.527\times10^{-26}\,J = 3.29\times10^{-8}\,eV$ $\Delta\nu = \frac{\Delta E}{h} = \frac{0.527\times10^{-26}}{6.63\times10^{-34}}$ $\Delta\nu = 8\times10^{6}\,Hz$	**(2)**	1,4	2,4	1.6
(b)	What are matter waves? Write any four properties of matter waves.	**(2)**	1,2	2,3	2.2
(c)	Calculate the de Broglie wavelength associated with (i) A 46-gm golf ball with velocity 36 m/s (ii) An electron with a velocity 10^7 m/s Which of these two, show wave character and why? Sol (i) $v \ll c$ $\therefore \lambda = \frac{h}{mv} = \frac{6.63\times10^{-34}\,Js}{(0.046\,kg)(36\,m/s)}$ $\lambda = 4.0\times10^{-34}\,m$ (ii) $v \ll c$ $m \to m_0 = 9.1\times10^{-31}\,kg$ $\lambda = \frac{h}{mv} = \frac{6.63\times10^{-34}}{(9.1\times10^{-31})\times10^{7}} = 7.3\times10^{-11}\,m$	**(3)**	2,4	2,4	1.2
(d)	Discuss & derive Planck's radiation formula. Explain Wien's law & Rayleigh-Jeans law as special cases of it.	**(5+3)**	2,3	3,4	1.4
	OR				
(e)	Establish the Time Independent & Time-dependent Schrodinger's wave equation. Explain why the integral of $\lvert\psi^2\rvert$ overall space must equal to unity.	**(3+3+1)**	1,2	3,4	1.4

Q.4					
(a)	Calculate the number of photons emitted by ruby laser of output power 1W. The lasing frequency of the Ruby laser is 694.3 nm.	**(2)**	2,4	3,2	1.6
Sol	Let n be no. of photons emitted per sec $nh\nu = P \Rightarrow \frac{P}{h\nu} = \frac{P\lambda}{hc} = \frac{1 \times 694.3 \times 10^{-9}}{6.63 \times 10^{-34} \times 3 \times 10^{8}}$ Ans = 3.49×10^{18}				
(b)	The ratio of population inversion of two energy levels at 300 K is 10^{-30}. Find the wavelength of the radiation emitted.	**(2)**	1,4	2,1	1.3
Sol	$\frac{N_2}{N_1} = \exp\left(\frac{-hc}{\lambda k_B T}\right) \Rightarrow 10^{-30} = \exp\left(\frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{\lambda \times 1.38 \times 10^{-23} \times 300}\right)$ $\therefore \lambda = \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{1.38 \times 10^{-23} \times 300} = 48.6$ μm				
(c)	What is a resonant cavity? Highlight its importance in the production of laser radiation.	**(3)**	1,2	2,3	1.1
(d)	Explain with neat a diagram the principle, construction and working of He-Ne laser. What are its merits and demerits?	**(5+2)**	2,3	2,3	1.5
	OR				
(e)	State the necessary condition for stimulated emission. Explain the Einstein's A and B coefficients and establish relation between them.	**(2+5)**	1,3	2,4	1.4
Q.5					
(a)	An optical fiber had a diameter of 60 μm, a core index of 1.48 and a cladding index of 1.41. the wavelength of the light source is 0.8 μm. Determine the number of modes propagating in the fiber.	**(2)**	2,4	3,4	1.4
Sol	$NA = \sqrt{n_1^2 - n_2^2} = \sqrt{1.48^2 - 1.41^2} = 0.450$ $V = \frac{\pi d NA}{\lambda_0} = \frac{\pi \times 60 \times 0.450}{0.8} = 106.08$ No. of modes $= \frac{V^2}{2} = \frac{106.8^2}{2} = 4.55 \times 10^3$ 4550				
(b)	The refractive index of core is 1.5 and the fractional refractive index between the core and the cladding is 1.8 %. Estimate (a)Numerical aperture (b) Critical angle at the core-cladding interface.	**(2)**	3,4	2,3	1.5
	$NA = n_1 (2\Delta)^{1/2} = 1.52 (2 \times 1.8 \times 10^{-2})^{1/2} = 0.285$ $i_a = \sin^{-1} NA = \sin^{-1} 0.285 = 16.6^0$ $\Delta = \frac{n_1 - n_2}{n_1} = 0.018 \therefore n_1 - n_2 = 0.018 n_1, \frac{n_2}{n_1} = 0.982$ $i_c = \sin^{-1}\left(\frac{n_2}{n_1}\right) = \sin^{-1} 0.982 = 79.8^0$				
(c)	What do you understand by terms acceptance angle? Explain the expression of acceptance angle in terms of refractive indices of core and cladding.	**(3)**	1,3	2,3	2.2
(d)	Explain what is step-index, graded index, monomode and multimode fibre. Draw relevant sketches.	**(7)**	1,2	2,4	1.5
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(e)	Give the block diagram of an optical fibre communication system, explaining the functions of different blocks. Compare its merits over conventional communication system.	**(4+3)**	2,3	3,4	1.5
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