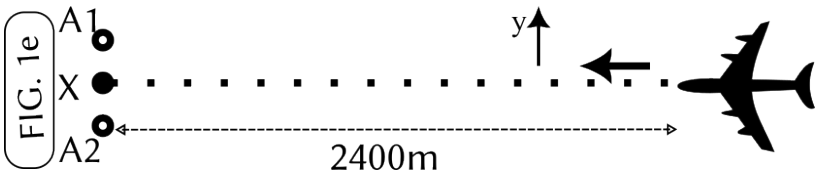
APRIL 2024 EXAMINATION
I Yr. B.TECH. (ALL BRANCHES)
PH10017: PHYSICS

Time : 3 hours Max Marks : 70

TOTAL NUMBER OF SECTIONS IN THIS PAPER - 05.

Q.	No.	: Question and Answer	
1	(a)	What is Rayleigh criterion to resolve two objects?	2
		Defined or explained	1 mark
		Used graphical explanation of resolved/well/just	1 mark
	(b)	A glass plate shatters when excited by waves of frequency ω and a minimum intensity of $\mathbf{3}\boldsymbol{I_0}$. Suggest a method to shatter this glass when two coherent sources, each of intensity $\boldsymbol{I_0}$ and frequency $\boldsymbol{\omega}$ is available.	2
		Superposition is mentioned	1 mark
		$(\sqrt{I_1}+\sqrt{I_2})^2=(2\sqrt{I_0})^2=4I_0$ or anything similar	1 mark
	(c)	In Newton's rings experiment setup air is replaced with a liquid. If the refractive indices of liquid and lens are equal ($\boldsymbol{n_{liquid}=n_{lens}}$), explain the nature of interference with appropriate formula?	3
		If $\boldsymbol{n_{liquid}=n_{lens}}$, no/very weak reflected ray from air-liquid interface or $1/f=1/R=0$	2 marks
		a complete bright / dark / unclear image/pattern may occur. Explained mathematically ($r\to 0$) or two plane surfaces, etc.	1 mark
		If $D^2=(...)/n_{liquid}$ and explained	1 mark.
	(d)	(i) Obtain an expression of intensity at an arbitrary point $\boldsymbol{P}$ from an $\boldsymbol{N}$-slit Fraunhofer diffraction grating. (ii) Discuss the position of maxima and minima as functions of grating element and number of slits ($\boldsymbol{N}$).	3+4
		Derivation done correctly with figure	2+1 marks
		Diffraction pattern explained graphically	1 mark
		derivation/conditions of max and minima	2 marks
		primary and secondary maxima discussed	1 mark
	(e)	(i) With a neat sketch explain division of wavefront. (ii) As shown in Fig. 1e, two antennas, A1 & A2 separated by a distance of 50m emit signals at 33MHz. Generally an aircraft is guided to the point X, by locking to the central maxima of the superposing signals from the antennas. By mistake, if the pilot locks to the first maxima, how much error in horizontal position is made along the y-direction?	2+5
			
		Using slits and wavefront explained	2 marks
		Understanding the problem through math/graph representation	1 marks
		Pilot locks to central maxima $\Rightarrow d\sin\theta=m\lambda,\ \theta=0$	1 mark
		First maxima $\theta=\sin^{-1}(1\times\lambda/d)=32.91^\circ\approx 32^\circ$	2 marks
		y-shift, $y=L\tan\theta=443$m	1mark

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2	(a)	With a neat sketch discuss components of a laser.	2
		Sketch showing all three parts with names	1 mark
		Small discussion on each component	1 mark
	(b)	How a three level laser is more efficient than a two level laser?	2
		Any good and valid discussion with life time and or efficiency of population inversion.	2 marks
	(c)	If 15% of the power fed at the input end of a 500m optical fiber is lost during propagation, find the attenuation in dB/km.	3
		Expression, attenuation $\alpha = \frac{10}{L}\log_{10}\left(\frac{Pi}{Po}\right)$	1 mark
		parameters converted for km	1 mark
		calculation $\alpha = -16.48$dB/km	1mark
	(d)	(i) With suitable diagram, describe various absorption and emission processes. (ii) Find the ratio of Einstein's A and B coefficients at thermal equilibrium.	3+4
		diagram for all three processes	1½ mark
		Explanation of all three processes	1½ mark
		Explained the process with appropriate expressions	1 mark
		Obtained the ratio of A and B correctly and explained	2 marks
		Discussed A/B ratio too small to have Stimulated process	1 mark
	(e)	(i) With energy diagram explain the working of a Ruby laser. (ii) Discuss in details at least two fiber optic sensors.	3+4
		Energy digram given correctly	1 mark
		Components of Ruby laser given correctly	1 mark
		Working of Ruby laser explained	1 mark
		Digram, prupose and working principle explained in each case	2×2=4 marks

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3 (a)	What do you understand by "inertial frame of reference"?	2
	Explain frame of reference	1 mark
	Mentioned no or zero acceleration in inertial FOR	1 mark
(b)	A sun radiates electromagnetic energy of $\mathbf{3.92 \times 10^{26}}$J/s. How much mass does the sun lose in a year?	2
	$\delta m = E/c^2$	½mark
	$E = 3.92 \times 10^{26} \times 365 \times 24 \times 60 \times 60 = 1.236 \times 10^{34}$ J	½mark
	mass lost by sun every year = $\delta m = 1.374 \times 10^7$kg	1 mark
(c)	Show that objects with finite mass ($\boldsymbol{m_0 \neq 0}$), cannot reach the speed of light.	3
	$m(v) = m_0/\sqrt{1-(v/c)^2}$	1 mark
	when $v \to c$, $m(c) \to \infty$, , this implies that particle with non-zero mass can not acheive $v = c$.	1 mark
	if $m_0 = 0$, $m(c) = m_0 = 0$, hence particle with zero initial mass can achieve $v = c$	1 mark
(d)	(i) What are the postulates of special theory of relativity? (ii) Obtain relativistic relation between mass and energy.	2+5
	Postulates given or explained, correctly.	2 mark
	Started with integral form of Newton's second law	2 mark
	derived expression for relativistic KE	2 mark
	for $v \ll c$, obtained KE=$\frac{1}{2}mv^2$	1 mark
(e)	(i) A particle travels at $\mathbf{0.65}\boldsymbol{c}$ and lives for **20**ns with respect to an observer at rest. How long does the particle live as viewed in its moving frame of reference? (ii) Modify and obtain an expression for Newton's second law using relativistic mass.	3+4
	$t' = t_0/(1-v^2/c^2)$, $v = 0.65 \times 3 \times 10^8$m/s and $t_0 = 20 \times 10^{-9}$s	2 mark
	1.32 x 20 = 26.4ns	1 mark
	Defined differential form of Newton's second law with $m(v)$	2 mark
	obtained expression $F = \frac{m_0 a}{(1-v^2/c^2)^{3/2}}$ or in terms of a	2 mark

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4 (a)	Find the probability in the region $\frac{a}{2} \leq x \leq a$ for a particle defined by a wave-function $\phi(x) = \sqrt{\frac{3}{2a}}\,(1 - \frac{x}{a})$, . 2
	Defined probability = $\int \lvert\phi(x)\rvert^2 dx$ ½ mark
	$\int_a /2^a \frac{3}{2a}(1 - x/a)^2 dx$ ½ mark
	Probability = $1/16$ 1 mark
(b)	A photon has the same momentum as that of an electron moving with a speed of $\mathbf{3 \times 10^5}$m/s. Find the wavelength of the photon. 2
	defined $p_{electron} = mv$, $\lambda = h/p_{photon}$ and $p_{photon} = p_{electron}$ 1 mark
	$\lambda = 2.424$nm 1 mark
(c)	What is a well behaved wavefunction? Analyze, which of the following are well behaved wavefunctions? 3 $\psi_1(x) = A_1 \tan(n\pi x/L)$, $\psi_2(x) = A_2 \cos(n\pi x/L)$, $\psi_3(x) = A_3 \exp(-\pi x/L)$.
	Defined all three conditions of well behaved wavefunction. 2 mark
	Only $\psi_2(x)$ is well behaved as it is continuous and normalizable, while others are not. 1 mark
(d)	(i) How Planck's radiation formula resolves Ultraviolet Catastrophe? (ii) Obtain energy eigen-values and normalised wavefunction of a particle in a 1-dimensional box. 3+4
	Explained UV catastrophe with graph. 2 mark
	Discussed Plank's formula and explained the spectra in UV region 1 mark
	Definition of 1D potential well and obtained Eigen values E_n 2 marks
	Obtained normalised Eigen functions 2 marks
(e)	(i) Describe Compton effect and its significance in quantum mechanics. (ii) A 5.5MeV gamma ray is scattered at 60° from an electron. Find the energy of the scattered photon in MeV. 2+5
	Explained Compton effect 1 mark
	Confirmation of light as particle as significance mentioned 1 mark
	Energy to wavelength $\lambda = hc/E = 2.26 \times 10^{-13}$m 1 mark
	Compton wavelength shift $\lambda' - \lambda = h/(m_0 c)(1 - \cos 60) = 1.2 \times 10^{-12}$m 2 mark
	$\lambda' = 1.438 \times 10^{-12}$m 1 mark
	Energy of scattered photon = $E = hc/\lambda' = 0.864$MeV 1 mark

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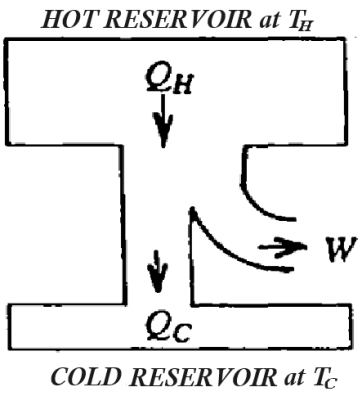
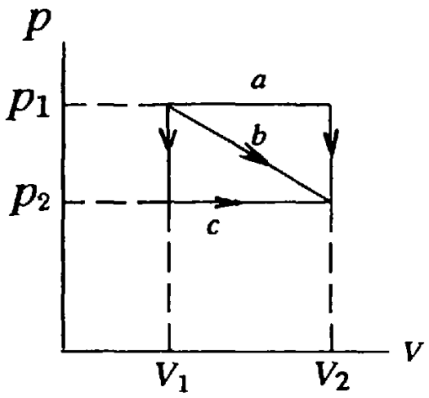
5 (a)	State or define first law of thermodynamics.	2
	Explained or defined first law in terms of Q ans W	1 mark
	Given $\Delta U = Q - W$	1 mark
(b)	Explain the process as depicted in the Fig. 5b where $\boldsymbol{T_H > T_C}$.	2
	Represent a Heat Engine, mentioned	1 mark
	Mentioned II law of thd and explained process	1 mark
(c)	Find the amount of work done by a gas (see Fig. 5c) in going from $(\boldsymbol{p_1, V_1})$ to $(\boldsymbol{p_2, V_2})$ in each paths $\boldsymbol{a, b}$ and $\boldsymbol{c}$.	3
	 FIG. 5b  FIG. 5c	
	$W_a = P\Delta V = p_1(V_2 - V_1)$, $W_b = \frac{1}{2}h(b_1 + b_2) = \frac{1}{2}(p_1 + p_2)(V_2 - V_1)$ and $W_c = p_2(V_1 - V_2)$	1 mark each
(d)	What is absolute zero temperature? At absolute zero, what happens to entropy, volume and mass.	2+5
	0 Kelvin or -273.15°C and explain	2 marks
	Discussed Zeroth law of Thermodynamics. $S = k \ln W$ or S is a measure of disorder, hence S will be zero	3 marks
	Volume of all gasses $\rightarrow$ 0	1 mark
	since volume zero, density will be infinity,	1 mark
(e)	Discuss Second law of thermodynamics for a heat engine, a reversed heat engine and a reversible heat engine.	7
	Discussed second law with a sketch and PV diagram	3 marks
	Diagram given and discussed whats is reversed	2 marks
	Diagram given and discussed whats is reversible	2 marks