MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
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II SEMESTER B. TECH (PHYSICS)
IN SEMESTER EXAMINATION – II, JUNE 2020 (Re Test 2)
SUBJECT: ENGINEERING PHYSICS (PHY 1051)
REVISED CREDIT SYSTEM

Time: 90 Minutes **MAX. MARKS: 15**

Note: Answer ALL the questions.

1.	Explain photoelectric effect. Does it prove the wave nature or particle nature of light? Which are the features of photoelectric effect-experiment explained by Einstein's photoelectric equation?	**03**
2.	Consider a photon scattering off a proton which is initially at rest. Derive the expression for the maximum kinetic energy of the recoiling proton in terms of the incident photon frequency. (The derived expression should be independent of the scattered photon frequency)	**03**
3.	For a free relativistic quantum particle moving with speed u, prove that the group speed of the wave is the same as the speed of the particle.	**02**
4.	Electrons are incident on a pair of narrow slits **0.060** μm apart. The 'bright bands' in the interference pattern are separated by **0.40** mm on a 'screen' **20.0** cm from the slits. Determine the potential difference through which the electrons were accelerated to give this pattern. Speed of light in vacuum c = 3.00×10^{8} m/s Electron charge = 1.60×10^{-19} C Electron mass = 9.11×10^{-31} kg Avogadro number = 6.023×10^{23} /mol Boltzmann constant = 1.38×10^{-23} J/ K Planck's constant = 6.63×10^{-34} J.s	**03**
5.	Tunneling is a process of finding a particle on farther side of the barrier. Consider a scenario in which electrons with energies of 1.0 eV and 2.0 eV are incident on a tunnel barrier of height 10.0 eV. (a) Calculate their respective transmission and reflection probabilities. Take the width of the barrier as 0.5 nm. Speed of light in vacuum c = 3.00×10^{8} m/s Electron charge = 1.60×10^{-19} C Electron mass = 9.11×10^{-31} kg Avogadro number = 6.023×10^{23} /mol	**02**

	Boltzmann constant = 1.38×10^{-23} J/ K Planck's constant = 6.63×10^{-34} J.s	
6.	A ruby laser emits 694.3 nm light. Assume light of this wavelength is due to a transition of an electron in a box from its $n = 2$ state to its $n = 1$ state. Find the length of the box. Speed of light in vacuum c = 3.00×10^{8} m/s Electron charge = 1.60×10^{-19} C Electron mass = 9.11×10^{-31} kg Avogadro number = 6.023×10^{23} /mol Boltzmann constant = 1.38×10^{-23} J/ K Planck's constant = 6.63×10^{-34} J.s	**02**

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HAND BOOK FOR STUDENTS

Wien's Displacement Law	$\lambda_m T = 2.898 \times 10^{-3}$ m.K	λ_m: wavelength corresponding to peak intensity. T : equilibrium temperature of the blackbody.
Stefan's Law	$P = \sigma A e T^4$	P : power radiated from the surface area A of the object. T : equilibrium surface temperature. σ : Stefan-Boltzmann constant. e : emissivity of the surface
Planck's law	$I(\lambda, T) = \frac{2\pi h c^2}{\lambda^5} \frac{1}{e^{\frac{hc}{\lambda k_B T}} - 1}$	$I(\lambda,T)\,d\lambda$: intensity or power per unit area emitted in the wavelength interval $d\lambda$ from a blackbody at the equilibrium temperature T h : Planck's constant. k_B : Boltzmann's constant c : speed of light in vacuum
Einstein's photoelectric equation	$K_{max} = hf - \phi$	f : frequency of incident photon. K_{max} : kinetic energy of the most energetic photoelectron. ϕ : work function of the photocathode material.
Relativistic momentum of a particle	$p = \gamma m v$ $\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$	p : momentum of the particle m : mass of the particle v : speed of the particle c : speed of light in vacuum
Relativistic kinetic energy of a particle	$K = (\gamma - 1) m c^2$	

Total energy (relativistic) of the particle	$E = \gamma m c^2$ $E^2 = p^2 c^2 + m^2 c^4$	
Compton shift equation	$\lambda' - \lambda_o = \frac{h}{mc}(1 - \cos\theta)$	λ_o : wavelength of the incident photon. λ' : wavelength of the scattered photon, θ : angle of scattering
de Broglie wavelength, λ	$\lambda = \frac{h}{p} = \frac{h}{mv}$ $p = m v = \sqrt{2 m q \Delta V}$	h : Planck's constant p : momentum of the quantum particle. m : mass of the particle v : speed of the particle q : charge of the particle ΔV : accelerating voltage
Relation between group speed and phase speed	$v_g = v_P - \lambda\left(\frac{dv_P}{d\lambda}\right)$	v_g : group speed v_P : phase speed
Heisenberg uncertainty relations.	$(\Delta x)(\Delta p_x) \geq h/4\pi$ $(\Delta E)(\Delta t) \geq h/4\pi$	Δx : uncertainty in the measurement of position x of the particle. Δp_x : uncertainty in the measurement of momentum p_x of the particle. ΔE : uncertainty in the measurement of energy *E* Δt : time interval in the measurement of *E*.
One dimensional time independent Schrödinger equation	$-\frac{\hbar^2}{2m}\frac{d^2\psi}{dx^2} + U\psi = E\psi$	$\hbar$: Reduced Planck's constant m : mass of the particle ψ : *wave function* $U(x)$: potential energy function E : total energy of the system h : Planck's constant L : length of the "box". n : integers T : tunneling probability
Expectation value of x	$\langle x \rangle \equiv \int_{-\infty}^{+\infty} \psi^* x \psi \, dx$	
Particle in a "box" E_n - quantized energy values of the particle.	$E_n = \left(\frac{h^2}{8 m L^2}\right) n^2$	
Transmission coefficient	$T \approx e^{-2CL}$ $C = \frac{\sqrt{2m(U-E)}}{\hbar}$	