Roll No.:.....

National Institute of Technology, Delhi

Name of the Examination: B.Tech. (End-Sem)

Branch	: EEE+ECE	Semester	: I
Title of the Course	: Electromagnetics and Quantum Physics	Course Code	: PHL100

Time: 3 Hours | Maximum Marks: 50

Note : This question paper divided into three sections A, B and C and each section must be solved with rules given as follows:
Section A: Contains Ten (10) questions of 01 mark each and all questions are compulsory.
Section B: Contains Five (05) questions of 5 marks each and any four (04) are to be attempted.
Section C: Contains Three (03) questions of ten (10) marks each and any two (02) are to be attempted.
Assume suitable data, if found missing.
Used symbols have their usual meaning.

Section A

Q1: Write down the solenoidal condition for a vector field.

Q2: Write down the integral form of the electrostatic potential.

Q3: Why is the wave nature of matter less apparent in our daily observations?

Q4: What is the physical significance of the numerical aperture in optical fiber?

Q5: Quantum mechanical operator of kinetic energy is.....

Q6: The best suited rays for the study of Compton effect is .....

Q7: Calculate the coherence length for a light source whose line 1/1000 of its wavelength.

Q8: What is difference between phenomena of interference and diffraction of light wave?

Q9: What is the value of ground state energy of a quantum particle in an infinite potential well?

Q10: The uncertainty in the location of a particle is equal to its de Broglie wavelength. The uncertainty in its velocity is .....

Section B

Q1: Given the total electromagnetic energy $W = \frac{1}{2}\int(\boldsymbol{E}.\boldsymbol{D} + \boldsymbol{H}.\boldsymbol{B})dv$ show from Maxwell's equations that $\frac{\partial W}{\partial t} = -\oint(\boldsymbol{E}\times\boldsymbol{H})\boldsymbol{ds} - \int \boldsymbol{E}.\boldsymbol{J}\, dv$. **(5)**

Q2:[a]: Distinguish between temporal coherence and spatial coherence. Discuss why two independent sources of light of the same wavelength cannot produce interference fringes. **(2)**

[b]: An optical fiber is 1.5 m long and has a diameter of 20 μm. If a ray of light is incident on one end of fiber at an angle 30^0, how many reflections does it undergo before emerging from the other end? Refractive index of the fiber is 1.3. **(3)**

Q:3-Given a vector field $\boldsymbol{D} = r\sin\varphi\, \boldsymbol{a}_r - \frac{1}{r}\sin\theta\cos\varphi\, \boldsymbol{a}_\theta + r^2\, \boldsymbol{a}_\varphi$. Determine, (i)-$\boldsymbol{D}$ *at point* $P\ (10, 150^0, 330^0)$, (ii)-The component of $\boldsymbol{D}$ tangential to the spherical surface $r = 10$ at P and (iii)- A unit vector at P perpendicular to $\boldsymbol{D}$ and tangential to the cone, $\theta = 150^0$ **(5)**

Q:4. Derive the expression for Compton shift. Why is it not observable in the visible region of electromagnetic radiation? **(5)**

Q:5. [a] White light is incident on a soap film at an angle $\sin^{-1}(4/5)$ and the reflected light on examination by a spectroscope shows dark ands. Two consecutive dark bands correspond to wavelength 6.1×10^{-5} cm and 6×10^{-5} cm. If refractive index of the film be 4/3, calculate its thickness. **(3)**

[b] What do you understand by quarter wave plate and half wave plate. **(2)**

Section C

Q1: [a]: Write down the Schrodinger's time dependent and independent wave equations of matter wave. Explain, why: (i) the wave function Ψ must be single valued and continuous function of position. (ii) the integral of $|\Psi|^2$ overall space must be equal to unity. **(5)**

[b]: Calculate the wavelength of incident x-ray photon which produces recoil electron of energy *4.0 KeV* in Compton effect. The electron recoils in the direction of incident photon and photon is scattered at an angle of 180^0. **(3)**

[c]: Find the maximum energy of the photoelectron, the work function and threshold frequency, if the potassium surface is illuminated by a light of wavelength 5893 A^0. The stopping potential for the emitted electron is 0.36 V. **(2)**

Q2: [a]: What are the characteristics of de-Broglie wave? Show that group velocity of the de-Broglie wave associated with a microscopic particle is equal to the particle velocity itself. **(5)**

[b]: Explain 'absorption', 'spontaneous', and 'stimulated' emission of radiation. Obtain relation between transition probabilities of spontaneous and stimulated emission. **(3)**

[c]: What are the characteristics of laser beam. **(2)**

Q3: [a]: Consider a particle whose normalized wave function is: **(5)**

$\psi(x) = 2\alpha\sqrt{\alpha}\, x\, e^{-\alpha x}$; $x > 0$

$= 0$; $x < 0$

(i) For what value of x does probability take peak?

(ii) What is the probability that the particle is found between $x = 0$ *and* $x = 1/\alpha$?

(iii) Calculate the wave function in momentum space.

[b]: Show that double slit Fraunhoffer diffraction provides the intensity four times of the one obtained by single slit. **(3)**

[c]: In a grating spectrum, which spectral line in 4^{th} order will overlap with 3^{rd} order line of 5491 A^0 ? **(2)**

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