PHYSICS – II (AEIE)
(PHY2102)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) For a function $f(z) = e^{\frac{1}{z}} \quad z = 0$ is
(a) a removable singularity (b) an essential singularity
(c) a branch point (d) a pole

(ii) Parseval identity is given by
(a) $\int_{-\infty}^{\infty} f(x)\overline{g(x)}dx = \int_{-\infty}^{\infty} e^{x-k}F(k)\overline{G(k)}dk$
(b) $\int_{-\infty}^{\infty} f(x)\overline{g(x)}dx = \int_{-\infty}^{\infty} e^{ikx}F(k)\overline{G(k)}dk$
(c) $\int_{-\infty}^{\infty} e^{ikx}f(x)\overline{g(x)}dx = \int_{-\infty}^{\infty} F(k)\overline{G(k)}dk$
(d) $\int_{-\infty}^{\infty} f(x)\overline{g(x)}dx = \int_{-\infty}^{\infty} F(k)\overline{G(k)}dk$

(iii) Free electron in metal are
(a) K-shell electrons (b) valence electron
(c) L-shell electrons (d) none of these

(iv) The solution of Schrodinger equation for an electron moving in a periodic potential is of the form
(a) $\psi_k(\vec{r}) = e^{i\vec{k}.\vec{r}}$ (b) $\psi_k(\vec{r}) = u_k(\vec{r})$
(c) $\psi_k(\vec{r}) = u_k(\vec{r})e^{i\vec{k}.\vec{r}}$ (d) $\psi_k(\vec{r}) = u_k(\vec{r}) + Ae^{i\vec{k}.\vec{r}}$

(v) Resistivity of a metal of the semiconductor is given by
(a) $\rho = \frac{m}{ne^2\tau}$ (b) $\rho = \frac{ne^2\tau}{m}$ (c) $\rho = \frac{n}{me^2\tau}$ (d) $\rho = \frac{me^2\tau}{n}$

(vi) For an electromagnetic wave the relation between the electric field $\vec{E}$ and a unit vector in the direction of propagation $\hat{n}$ follow the relation
(a) $\vec{E} \times \hat{n} = 0$ (b) $\vec{E}.\hat{n} = 0$ (c) $\vec{E}.\hat{n} = 1$ (d) $\vec{E}.\hat{n} \neq 0$

(vii) The Lorentz force acting on a unit charge moving with a velocity $5\hat{\imath} + 6\hat{\jmath}$ in a magnetic field $\vec{B} = 2\hat{\imath} + 5\hat{k}$ is

(a) $30\hat{\imath} - 12\hat{k}$ (b) $30\hat{\imath} - 25\hat{\jmath} - 25\hat{k}$

(c) $25\hat{\imath} - 12\hat{\jmath}$ (d) $30\hat{\imath} - 25\hat{\jmath} - 12\hat{k}$

(viii) Grain size of nanocrystals are in the range

(a) 1 to 100 nm (b) 100 to 1000 nm

(c) 1000 to 100000 nm (d) 10000 to 10000 nm

(ix) The dimension of polarizability in SI unit is

(a) Fm^2 (b) Fm (c) Fm^{-1} (d) Fm^{-2}

(x) The density of charge carrier in a pure semiconductor is proportional to

(a) $e^{-\frac{E_g}{KT}}$ (b) $e^{-\frac{2E_g}{KT}}$ (c) $e^{-\frac{E_g}{KT^2}}$ (d) $e^{-\frac{E_g}{2KT}}$

Fill in the blanks with the correct word

(xi) The first excited state of an electron moving freely inside a cubical ___ is fold degenerate.

(xii) For an electromagnetic field in conductor the imaginary parts of the wave vector cause_____.

(xiii) Fourier transform of $f(x-a)$ is equal to Fourier Transform of $f(x)$ multiplied by _____.

(xiv) An analytic function satisfies _____ condition.

(xv) An electrostatic field has curl equals _____.

Group - B

2. (a) Evaluate the integral $\int_0^{\pi} \frac{d\theta}{1+sin^2\theta}$ *[(CO3)(Analyse/HOCQ)]*

(b) The equation of motion of a weakly damped oscillator is given by $\frac{d^2x}{dt^2} + 3\frac{dx}{dt} + 25x = 0$. Construct a general solution of the equation with the method of residues. *[(CO4)(Apply/IOCQ)]*

(c) Examine that $f(z) = z^2 + 2z$. is an analytic function. *[(CO2)(Analyse/IOCQ)]*

4 + 5 + 3 = 12

3. (a) Using convolution theorem for Laplace transform find the convolution $\cos u * e^{2t}$ *[(CO3)(Remember/LOCQ)]*

(b) Using convolution theorem show $\beta(m,n) = \frac{\Gamma(m)\Gamma(n)}{\Gamma(m+n)}$ where $\beta(m,n) = \int_0^1 x^{m-1}(1-x)^{n-1}dx\,,\ m,n>0$ and $\Gamma(m) = (m-1)!$ *[(CO4)(Understand/LOCQ)]*

(c) Using Fourier Transform construct the general solution of of the equation $\frac{d^2x}{dt^2} + \lambda^2 x = f(t)$. *[(CO2)(Create/HOCQ)]*

4 + 4 + 4 = 12

Group - C

4. (a) Using Schrodinger equation, determine the energy eigen value and corresponding eigen states of a free electron moving inside and one-dimensional box of length l. *[(CO2)(Evaluate/LOCQ)]*

   (b) Estimate the expectation value of position for a particle in a box of length l. *[(CO2)(Apply/IOCQ)]*

   (c) What do you mean by degeneracy in the context of a particle confined in a 3D box *[(CO2)(Understand/IOCQ)]*

(3 + 3) + 3 + 3 = 12

5. (a) State Bloch theorem. What is the outcome of this theory? *[(CO2)(Remember/LOCQ)]*

   (b) Discuss the concept of valence band, conduction band and forbidden gap of solids *[(CO2)(Understand/LOCQ)]*

   (c) An insulator has an optical absorption which occurs for all wavelengths shorter than 1800 Å. Find the width of the forbidden energy band for this insulator. *[(CO2)(Apply/IOCQ)]*

(2 + 2) + 5 + 3 = 12

Group - D

6. (a) Explain briefly the phenomenon of total internal reflection. *[(CO3)(Understand/LOCQ)]*

   (b) Assuming the expression of plane wave representing the electric field $\vec{E}(\vec{r},t) = \vec{A}e^{i(\vec{k}.\vec{r}-\omega t)}$ and applying Maxwell equation in free space show that electric field, magnetic field and the direction of propagation are mutually perpendicular. *[(CO4)(Analyse/IOCQ)]*

   (c) Prove that angle of incidence is equal to angle of reflection. *[(CO2)(Evaluate/HOCQ)]*

4 + 4 + 4 = 12

7. (a) From the Maxwell equation in free space show that $\vec{E} = -\vec{\nabla}\varphi - \frac{\partial \vec{A}}{\partial t}$ where φ and $\vec{A}$ are scalar and vector potential respectively *[(CO3)(Remember/LOCQ)]*

   (b) The electric and magnetic field of an electro-magnetic wave are given by $\vec{E} = Acos(kz - \omega t)\hat{\imath}$ and $\vec{B} = Bsin(kz - \omega t)\hat{\jmath}$. Evaluate the direction and magnitude of the Poynting vector *[(CO4)(Evaluate/HOCQ)]*

   (c) Briefly explain the Poynting Theorem in general *[(CO2)(Remember/LOCQ)]*

4 + 4 + 4 = 12

Group - E

8. (a) Write down the expression of density of states of holes in valence band of an intrinsic semiconductor. Deduce the expression of hole concentration of intrinsic semiconductor in the valence band. *[(CO4)(Analyse/IOCQ)]*

   (b) From the expression of effective density of states of electrons at conduction band edge and that of holes in the valence band edge show that Fermi level is located half way between the valence and conduction band. *[(CO4)(Apply/IOCQ)]*

(2 + 6) + 4 = 12

9. (a) What are Nanomaterials and how they are classified? *[(CO4)(Remember/LOCQ)]*

(b) What are the different methods of preparing Nanomaterials. *[(CO4)(Remember/LOCQ)]*

(c) Discuss the unique properties of Nanomaterials and mention their application in real life *[(CO4)(Remember/LOCQ)]*

(1 + 3) + 3 + (2 + 3) = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	43.7	39.6	16.7