

CITY COLLEGE
Internal Examination 2020
Physics (Hons.) [1+1+1 System] Part 2
Paper: 4A, 4B
Time: 2 Hours 30 Minutes; Full Marks: 50

Group A

Answer any five questions [5 × 5 = 25]

1. (a) Show that the momentum operator $\hat{p}_x = -i\hbar \frac{d}{dx}$ is Hermitian in nature. (b) Show that $\exp[ikx]$ is an eigenfunction of the momentum operator in one dimension. Find out the corresponding eigenvalue. [3 + 2 = 5]
2. (a) What do you mean by a linear operator? Examine whether the operator \hat{L} is linear or not when $\hat{L}f(x) = f(-x)$ and $\hat{L}f(x) = f^*(x)$. (b) If the operators \hat{A} and \hat{B} are Hermitian, then is the operator $[\hat{A}, \hat{B}]$ Hermitian or not? [3 + 2 = 5]
3. (a) State and prove the uncertainty principle. (b) Can the solution of Schrödinger equation be real? [4 + 1 = 5]
4. (a) The normalized wave-function of a particle can be written as

$$\Psi(x) = N \sum_{n=0}^{\infty} \left(\frac{1}{\sqrt{7}} \right)^n \phi_n(x),$$

where $\phi_n(x)$ are the normalized energy eigenfunctions of a given Hamiltonian. What is the value of N ? (b) The relation between the angular frequency ω and the wave number k for a given type of wave is $\omega^2 = \alpha k + \beta k^3$. What is the wave number k_0 for which the phase velocity equals the group velocity? [3 + 2 = 5]

5. (a) (b) State Kelvin-Planck and Clausius versions of the second law of thermodynamics and establish their equivalence. [5]
6. (a) The internal energy $E(T)$ of a system at a fixed volume is found to depend on the temperature T as $E(T) = aT^2 + bT^4$. Obtain the entropy $S(T)$ as a function of temperature. (b) Prove that $\left(\frac{\partial T}{\partial V} \right)_S = - \left(\frac{\partial P}{\partial S} \right)_V$, where symbols have their usual meanings. [3 + 2 = 5]

Group B

Answer any five questions [5 × 5 = 25]

7. (a) What do you mean by a semiconductor. Give an example. (b) Sketch clearly the two signals: $V_1(t) = \cos \omega t$ and $V_2(t) = \cos(\omega t + \phi)$, where $0 < \phi < \frac{\pi}{2}$ against t on the same graph. [3 + 2 = 5]
8. (a) What do you mean by an optically active substance. Give an example of such a substance.

- (b) What is the difference between interference and diffraction? [3 + 2 = 5]
9. (a) Briefly explain the working principle of a Wheatstone bridge with relevant circuit diagram.
(b) In a LCR circuit, the current peaks at a frequency $\omega_0 = 5$ kHz. Draw a current-vs-frequency curve in the frequency range 0 Hz to 10 Hz. [3 + 2 = 5]
10. (a) What should be the resistance of an ideal ammeter and an ideal voltmeter? (b) Define the coefficients of mutual inductance and self inductance. What is the unit of magnetic flux? [3 + 2 = 5]
11. (a) How does a FET differ from a BJT? (b) State Thevenin and Norton's theorem. [2 + 3 = 5]
12. (a) State the condition of resonance in a series LCR circuit. What is meant by power factor of a circuit? What is its value at resonance? (b) In a LCR circuit, the RMS value of the voltage across the resistor is V_R , the inductor is V_L and the capacitor is V_C , while the signal has RMS value V_0 . It is found by measuring that $V_0 < V_R + V_L + V_C$. Does this indicate violation of conservation of energy? Explain. [3 + 2 = 5]

Answer scripts must be emailed to part2hcityphysics@gmail.com within 15 minutes of the end of the examination.