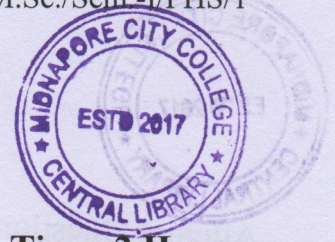


PG (NEW) CBCS
M.Sc. Semester-I Examination, 2018
PHYSICS
PAPER: PHS-102

**Full Marks: 40****Time: 2 Hours**

Write the answer for each unit in separate sheet

The figures in the right-hand margin indicate full marks.
 Candidates are required to give their answers in their own words as far as practicable.

PHS 102.1: QUANTUM MECHANICS - I

Marks: 20

Attempt Question number 1, 2 and any one from the rest.

1. Attempt any two of the following (2 × 2 = 4)
- The relation between angular frequency ω and wave number k for a given type of waves is $\omega = \alpha k + \beta k^2$.
Find out the wave number k_0 for which the phase velocity (v_p) equalise the group velocity (v_g).
 - Find the value of $[\hat{x}, e^{2\pi i p a/h}]$
 - For the ground state of the hydrogen atom, evaluate the expectation value of the radius vector r of the electron where $\psi_0 = \frac{1}{\sqrt{\pi a_0^2}} e^{-r/a_0}$
 - In a stationary state of rigid rotator, show that the probability density is independent of the angle φ .

2. Attempt any two of the following (4 × 2 = 8)
- The solution of the Schrodinger equation for a free particle of mass m in one dimension is $\psi(x, t)$ at $t=0$,
 $\psi(x, 0) = A \exp[-\frac{x^2}{a^2}]$
 Find the probability amplitude in momentum space at $t = 0$ and time t .
 - Evaluate $e^{\frac{2\pi i p a}{h}} \hat{x} e^{-\frac{2\pi i p a}{h}}$
 - i) The operator e^A is defined by

$$e^A = 1 + A + \frac{A^2}{2!} + \frac{A^3}{3!} + \dots$$

Show that $e^D = T_1$, where $D = (\frac{d}{dx})$ and T_1 is defined by $T_1 f(x) = f(x+1)$.

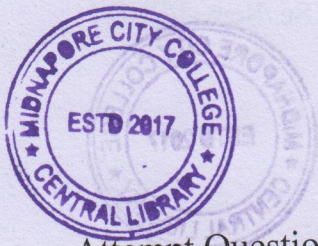
- Check whether the operator $-i\frac{h}{2\pi}x(\frac{d}{dx})$ is Hermitian.
- Consider a particle of mass m in the one-dimensional short range potential

$$V(x) = -V_0 \delta(x), \quad V_0 > 0$$

Where $\delta(x)$ is the dirac delta function. Find the energy of the system.

3. Answer any one of the following (1 × 8 = 8)
- Find the Hamiltonian operator of a charged particle in an electromagnetic field described by the vector potential A and scalar potential φ . (3)
 - Prove that $\Delta x \Delta p_n = (n+1/2)h$ for a one dimensional harmonic oscillator using operator method. (5)
4. a) Show that the zero point energy of $(1/2) h\omega/2\pi$ of a linear harmonic oscillator is a manifestation of the uncertainty principle. (3)
- b) If $\hat{H} = \frac{p^2}{2m} + \frac{1}{2} m \omega^2 x^2$
 Evaluate $[\hat{x}(t), \hat{x}(0)]$ using Heisenberg equation of motion. (5)

(Turn Over)



PHS 101.2: SOLID STATE - I

Marks: 20

Attempt Question number 1, 2 and any one from the rest.

1. Answer any two bits (2 × 2 = 4)
 - a) Explain what is meant by single crystal and polycrystalline material and how can they be identified experimentally.
 - b) Show the stereogram and matrix representation of e/m.
 - c) The velocity of sound in metal $\sim 3 \times 10^3 \text{ ms}^{-1}$. Interatomic distance is 3 Angstrom. Estimate the order of magnitude of cut-off frequency assuming a linear lattice.
 - d) A hypothetical semi-conductor crystal has a conduction band that can be described by $E_{cl} = E_1 - E_2 \cos(ka)$. What is the effective mass of the electron at the bottom of the conduction band?
 - e) What is meant by Brillion zone? How can you construct it?
2. Answer any two bits. (2 × 4 = 8)
 - a) Find an experiment of density of states for a linear chain of atom. What is Van Hove Singularity? (3+1)
 - b) Prove that 'optical branch' does not arise in case of a monoatomic lattice.
 - c) Prove that effective number of free electron in a solid is maximum when the outer most band is half-filled. What us meant by negative effective mass?
3. Derive the Laue equation assuming X-ray falling on a crystal. (8)
4. Describe in detail Debye Waller effect and hence find Debye Waller factor. Derive the vibrational modes of a diatomic linear chain of atom. (4+4)
