Physics 101

Sheet 1 — PH181101

Homework problems - Total Marks: 30

1 Part 1: Wave properties of particles, 10

- 1. Write briefly about the following instrument and experiment. Word limit is 300 words for each topic.
 - (a) Electron microscope.
 - (b) Davisson-Germer experiment.

2 Part 2: Particle in a box, $5 \times 4 = 20$

Students are advised to check "Lecture 7" notes before attempting this part.

1. Solve the Schrodinger's equation for a particle trapped inside a box

$$\frac{d^2\psi}{dx^2} + \frac{2m}{\hbar}E\psi = 0, \qquad (1)$$

to find the solution

$$\psi = A \sin\left(\frac{\sqrt{2mE}}{\hbar}x\right) + B \cos\left(\frac{\sqrt{2mE}}{\hbar}x\right).$$
(2)

2. Verify that the energy eigenfunctions of a particle trapped in a box meet all requirements to be a well-behaved wavefunction, i.e. for each quantum number n, ψ_n is finite, single valued function of x, and ψ_n and $\partial \psi_n / \partial x$ are continuous (except at the boundaries of the box). Here

$$\psi_n = \sqrt{\frac{2}{L}} \sin\left(\frac{n\pi x}{L}\right), \quad n = 1, 2, 3, \dots$$
(3)

- 3. Find the expectation value $\langle x \rangle$ of the position of a particle trapped in a box of width L.
- 4. Prove that the energy eigenfunctions ψ_n are not eigenfunctions of momentum
- 5. **Bonus question:** An important property of the eigenfunctions of a system is that they are orthogonal to one another, which means that

$$\int_{-\infty}^{\infty} \psi_n \psi_m dV = 0, \qquad n \neq m.$$
(4)

Verify this relationship for the eigenfunctions of a particle in a one-dimensional box given by Eq. (3).