

Modern Physics Problem Set 9

Due: Nov 25, 2025

Problem 1

Show that $\Psi(x, t) = Ae^{i(kx - \omega t)}$ satisfies both the time-dependent Schrödinger equation for free particle ($V(x, t) = 0$) and the classical wave equation.

Problem 2

A particle is in an infinite square well of size L . Calculate the ground state energy if

- a) the particle is a proton and $L = 0.1$ nm, a typical size for a molecule; and
- b) the particle is a proton and $L = 1$ fm, a typical size for a nucleus.

Problem 3

A particle is in a ground state of an infinite square well potential given by

$$V(x) = \begin{cases} 0 & \text{if } 0 < x < L \\ \infty & \text{if } x < 0 \text{ or } x > L \end{cases} \quad (1)$$

Find the probability of finding the particle in the interval $\Delta x = 0.002L$ at

- a) $x = L/2$
- b) $x = 2L/3$
- c) $x = L$.

Since Δx is very small, you do not need any integration.

Problem 4 (extra credit)

A particle with mass m and total energy zero is in a particular region of space where its wave function is $\psi(x) = Ce^{-x^2/L^2}$.

- a) Find the potential energy $V(x)$ versus x and
- b) make a sketch of $V(x)$ versus x .