25PY101: Engineering Physics

Module 1 – Unit 2

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Assignment 2: Schrödinger wave equation

Wave function

Temperature $\leftrightarrow$ wave function

1. Determine the wave number, wavelength, angular frequency and period of a wave function that describes a thermal electron at room temperature. If it is traveling along +ve x direction, write the expression for the wave function.
2. The sketches below in Figure. 1 represent a thermal electron moving along x direction. Determine the temperature of the thermal electron.

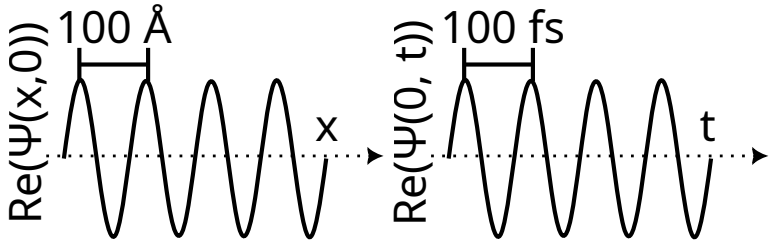

Figure 1: Spatial part of wave function of a thermal electron.

Spatial part of wave function

Two unknown particles have spatial part of their wave functions $\psi_1(x, 0)$ and $\psi_2(x, 0)$ as shown below in Figure. 2 that are plotted at time $t = 0$. The wavelength, wave vector, momentum, frequency, angular frequency, kinetic energy, potential energy, and total energy are denoted respectively by $\lambda, k, \nu, \omega, T, V, E$. Fill the blank with either $<, >, =$ or ?. ? means "needs more information"

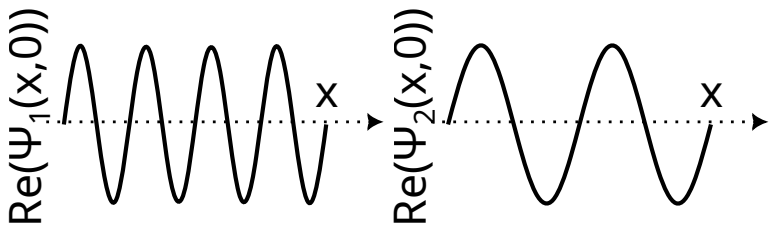

Figure 2: Spatial part of wave functions of two particles.

1. λ_1 __ λ_2
2. k_1 __ k_2
3. p_1 __ p_2
4. ν_1 __ ν_2
5. ω_1 __ ω_2
6. T_1 __ T_2
7. V_1 __ V_2
8. E_1 __ E_2

Temporal part of wave function

Two unknown particles have temporal part of their wave functions $\psi_1(0,t)$ and $\psi_2(0,t)$ as shown below in Figure. 3 that are plotted at a position $x = 0$.

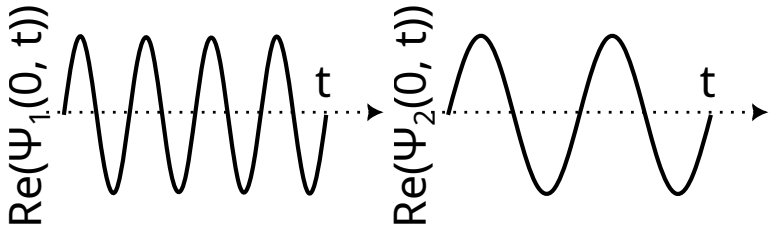

Figure 3: Temporal part of wave functions of two particles.

1. λ_1 __ λ_2
2. k_1 __ k_2
3. p_1 __ p_2
4. ν_1 __ ν_2

5. ω_1 __ ω_2
6. T_1 __ T_2
7. V_1 __ V_2
8. E_1 __ E_2

$V(x)$: free space

A proton and electron are traveling in free space with equal kinetic energies.

1. λ_p __ λ_e
2. k_p __ k_e
3. p_p __ p_e
4. ν_p __ ν_e
5. ω_p __ ω_e
6. T_p __ T_e
7. V_p __ V_e
8. E_p __ E_e

$V(x)$: infinite potential well

A proton and an electron are in two separate potential wells of same width. Both are in ground state energy level.

1. λ_p __ λ_e
2. k_p __ k_e
3. p_p __ p_e
4. ν_p __ ν_e
5. ω_p __ ω_e
6. T_p __ T_e
7. V_p __ V_e
8. E_p __ E_e

$V(x)$: step function

An electron is incident from $x = -\infty$ towards a step potential energy function. List the possible wave functions from below in Figure. 4. Give reasons for choosing or rejecting them.

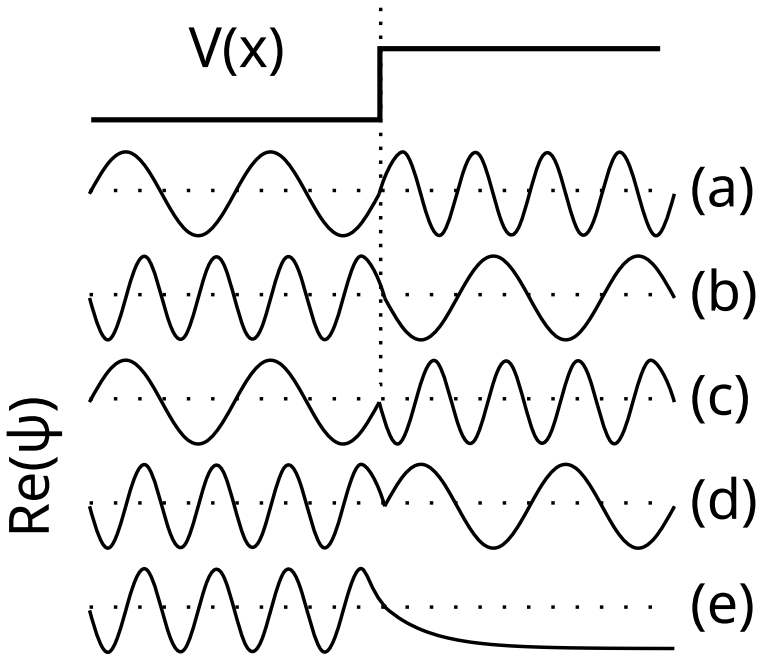

Figure 4: Spatial part of wave functions of particle incident on step potential.

$V(x)$: finite potential well

An electron is inside a finite potential energy function. List the possible wave functions from below in Figure. 5. Give reasons for choosing or rejecting them.

$V(x)$: finite potential barrier

An electron is incident from $x = -\infty$ towards a finite potential energy barrier. List the possible wave functions from below in Figure. 6. Give reasons for choosing or rejecting them.

Wave packet

Sketch the wave packet

$$\psi(x) = \exp(-x^2)\sin(10\pi x).$$

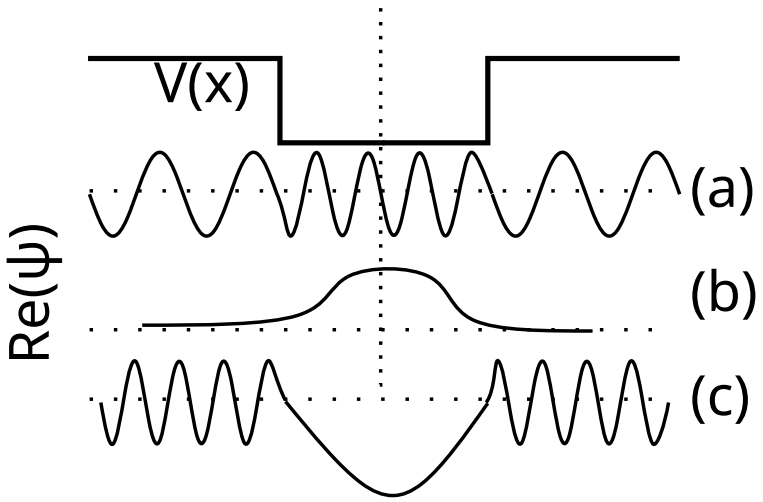

Figure 5: Spatial part of wave functions of particle inside potential well.

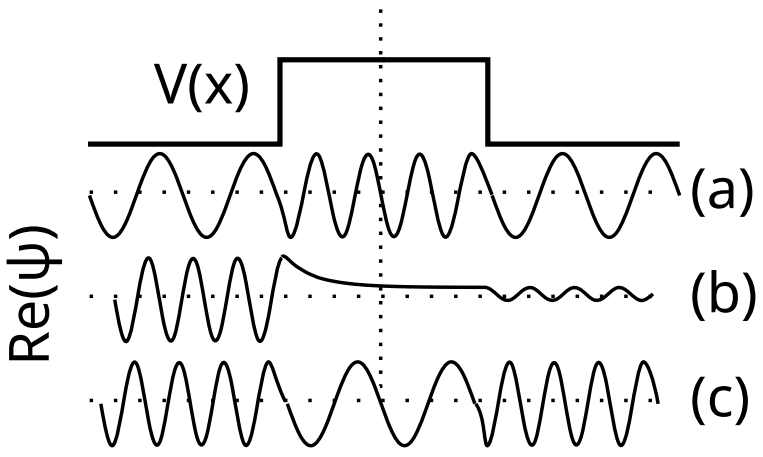

Figure 6: Spatial part of wave functions of particle incident on finite barrier potential.