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RESEARCH ARTICLE

VERIFY THE ENERGY OF PARTICLES TRANSFER THROUGH THE FINITE SQUARE POTENTIAL WELL

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ABSTRACT

In this work we study the the energy of particles transfer through the finite the square well potential. Derive the wave function particles from finite the square well potential. Employing the approximation of linear variation method,I calculate the energy of particles transfer through the finite the square well potential.

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INTRODUCTION

The finite potential well is a concept of quantum mechanics. It is an extension of the infinite potential well, in which a particle is confined to a box, but one which has finite potential walls. Unlike the infinite potential well, there is a probability associated with the particle being found outside the box. The quantum mechanics interpretation is unlike the classical interpretation, where if the total energy of the particle is less than the potential energy barrier of the walls it cannot be found outside the box. In the quantum interpretation, there is a non-zero probability of the particle being outside the box when the energy of the particle is less than the potential energy barrier of the walls. Quantum mechanics phenomenon passing through a barrier is known as tunneling. The wave function is different inside and outside. Therefore there exists a finite probability of reflection at the well walls, called quantum mechanical reection at the well walls. It is used in Tunnel diodes and operation of many other solid-state devices. One of the usage of this phenomenon for high frequency device is called Resonant Tunneling Diode, which would be used as an oscillator and even as an amplifier.

Finite square well potential: A single particle of mass m confined to within a region 0 < x < L and x < 0 or x > L with potential energy V (x) = 0 and V (x) = V0 respectively.

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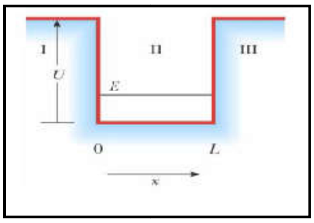

Potential of the particle is

$$V(x) = \begin{cases} 0, if\ 0 < x < L \\ V_0, if\ x > L\ or x < 0 \end{cases} \qquad \text{.................(1)}$$

In region: I

The time independent Schrödinger equation is:

$$\left(\frac{-\hbar^2}{2m}\nabla^2 + V(x)\right)\Psi_{1=E}\Psi_1 \qquad \text{...............(2)}$$

Then becomes $\frac{d^2}{dx^2}\Psi_1 - k^2\Psi_1 = 0$ ....(3)

Where $k^2 = \frac{2m(v-E)}{\hbar^2}$ ....(4)

The general solution tion is

$$\Psi_1 = Be^{-kx} \qquad \text{.................(5)}$$

Equation (5) can be written as

$$\Psi_1 Acos(kx - \omega t) - Bsin(kx - \omega t) \qquad \text{................(6)}$$

Since the particle travel to the left side

$\Psi_1 = Ae^{kx}$ ……………(7)

Similarly equation (7) can be written as before

$\Psi_1 = Ccos(kx - \omega t) + Dsin(kx - \omega t)$ ……………(8)

Since the particle travel to the left sides

Linear Variation Method

The variation method allows us to obtain an approximation to the ground state energy of the system without solving the Schrodinger equation. The principle of the variation is say that the expectation value energy will be greater than the true value of energy (E0) with the trial function.

$\Psi = \alpha_{1\Phi_1} + \alpha_{2\Phi_2} + \ldots + \alpha_n \Phi_n$ …………..(9)

Where Φ_1 and Φ_2 are basic function.

α_1 and α_2 mixing coefficient and the expectation energy is

$$E = \frac{\int \psi H dr}{\int \psi\psi dr}$$

$$E = \frac{\int(\alpha_{1\Phi_1} + \alpha_{2\Phi_2})H(\alpha_{1\Phi_1} + \alpha_{2\Phi_2})dr}{\int(\alpha_{1\Phi_1} + \alpha_{2\Phi_2})(\alpha_{1\Phi_1} + \alpha_{2\Phi_2})dr}$$

$$E = \frac{\alpha_1{}^2 \int \Phi_1 H\Phi_1 dr + \alpha_2{}^2 \int \Phi_2 H\Phi_2 dr + 2\alpha_1\alpha_2 \int \Phi_1 H \Phi_{2dr}}{\int \alpha_1{}^2\Phi_1{}^2 dr + \int \alpha_2{}^2\Phi_2{}^2 dr + 2\alpha_1\alpha_2 \int \Phi_1 H \Phi_{2dr}}$$

$$\frac{\alpha_1{}^2 H_{11+\alpha_2{}^2 H_{11}+\alpha_1\alpha_{2H_{12}}}}{\alpha_1{}^2 k_{11+\alpha_2{}^2 k_{11}+\alpha_1\alpha_{2k_{12}}}}$$

Where $H_{11} = \int \Phi_1 \; H\Phi_1 dr, H_{22} = \int \Phi_2 \; H\Phi_2 dr, H_{12} = \int \Phi_1 H \; \Phi_{2dr}, K_{11} = \int \Phi_1 \, \Phi_1 dr, K_{22} = \int \Phi_2 \, \Phi_2 dr$ and $K_{12} = \int \Phi_1 \, \Phi_2 dr = \int \Phi_2 \, \Phi_1 dr.$

For minimization of expectation value of energy

$\frac{\partial E}{\partial \alpha_1} = \frac{\partial E}{\partial \alpha_2} = 0$ ………………..(10)

$\frac{\partial E}{\partial \alpha_1} = \frac{\partial}{\partial \alpha_1}\left(\frac{\alpha_1{}^2 H_{11+\alpha_2{}^2 H_{11}+\alpha_1\alpha_2 H_{12}}}{\alpha_1{}^2 k_{11+\alpha_2{}^2 k_{11}+\alpha_1\alpha_2 k_{12}}}\right) = 0$ ………………...(11)

This gives

$\alpha_1 H_{11+}\alpha_2 H_{12-}\bar{E}(\alpha_1 K_{11+}\alpha_2 K_{12)} = 0$ ………………...(12)

$\alpha_1(H_{11-}\bar{E}K_{11)+(}\alpha_1 H_{12-}\bar{E}K_{12)} = 0$ ………………...(13)

Similarly for α_2

$\frac{\partial E}{\partial \alpha_2} = \frac{\partial}{\partial \alpha_2}\left(\frac{\alpha_1{}^2 H_{11+\alpha_2{}^2 H_{11}+\alpha_1\alpha_2 H_{12}}}{\alpha_1{}^2 k_{11+\alpha_2{}^2 k_{11}+\alpha_1\alpha_2 k_{12}}}\right) = 0$ ..………………(14)

Gives

$\alpha_2 H_{22+}\alpha_1 H_{21-}\bar{E}(\alpha_2 K_{22+}\alpha_1 K_{21)} = 0$ ………………(15)

$\alpha_2(H_{22-}\bar{E}K_{22)+}\alpha_{1(}H_{21-}\bar{E}K_{21)} = 0$ ………………..(16)

In matrix form the above equations (13) and (16) are written as

$\begin{pmatrix} H_{11-}\bar{E}K_{11} & H_{12-}\bar{E}K_{12} \\ H_{21-}\bar{E}K_{21} & H_{22-}\bar{E}K_{22} \end{pmatrix}\begin{pmatrix} \alpha_1 \\ \alpha_2 \end{pmatrix} = 0$ …………………(17)

Equation (17) becomes

$\begin{pmatrix} H_{11-}\bar{E}K_{11} & H_{12-}\bar{E}K_{12} \\ H_{21-}\bar{E}K_{21} & H_{22-}\bar{E}K_{22} \end{pmatrix}$ ………………....(18)

Through normalizations $K_{11} = K_{22} = 1$

$\begin{pmatrix} \frac{\hbar^2 k^2}{4m} + \frac{V_0}{2} - \bar{E} & 0 \\ 0 & \frac{\hbar^2 k^2}{4m} + \frac{V_0}{2} - \bar{E} \end{pmatrix} = 0$ ………………..(19)

From the determinant of equation (19), average energy becomes

$\bar{E} = \frac{1}{8m}(\hbar^2 k^2 + 2mV_0) \pm \sqrt{\frac{(\hbar^2 k^2 + 2mV_0)(-3\hbar^2 k^2 + 2mV_0)}{4m(4m)}}$ ..(20)

Where, $A^2 = \frac{(\hbar^2 k^2 + 2mV_0)}{4m}$, $B^2 = \sqrt{\frac{(-3\hbar^2 k^2 + 2mV_0)}{4m}}$

Then the average energy becomes

$\bar{E} = \frac{A^2}{2} \pm AB$ ………(21)

Therefore

$\bar{E}_+ = \frac{A^2}{2} + AB$ and $\bar{E}_- = \frac{A^2}{2} - AB$ ………(22)

Conclusion

In this research study the energy of the particle transfer through finite square well potential and obtain the wave function of the particle in region one and region three. Employing linear variation method and the function of particle of finite square well potential, calculate energy of the particle $\bar{E}_+ = \frac{A^2}{2} + AB$ and $\bar{E}_- = \frac{A^2}{2} - AB$.This result indicate that the attractive and repulsive energy of the particle.

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