ENGINEERING PHYSICS

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ENGINEERING PHYSICS

Unit III : Application of Quantum Mechanics to Electrical transport in Solids

- ***Suggested Reading***

  1. *Solid State Physics, S.O Pillai, Chapter 6*
  2. *Concepts of Modern Physics, Arthur Beiser, Chapters 9 &10*
  3. *Learning material prepared by the department-Unit III*

- ***Reference Videos***

  1. *Physics Of Materials-IIT-Madras/lecture-26.html*

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Unit III : Application of Quantum Mechanics to Electrical transport in Solids

Class #30

Motion of electron in periodic potential (one dimensional treatment), Bloch theorem

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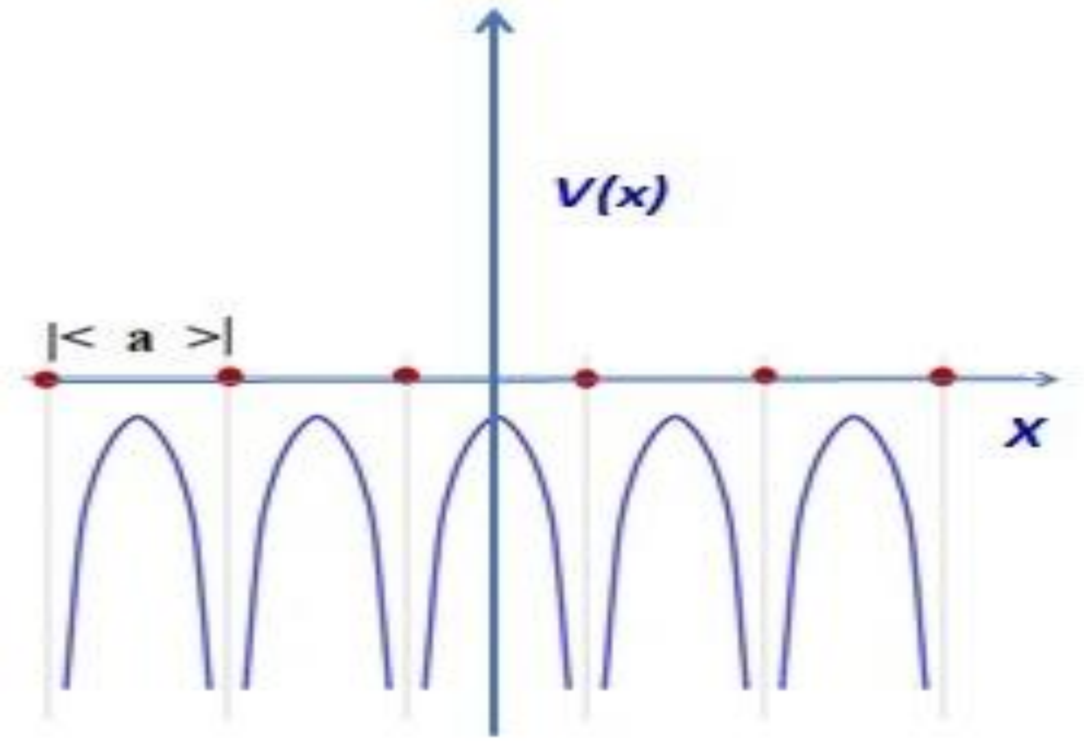
One-Dimensional Periodic Potential



If V(x) is the potential at x then we can express mathematically this property as V(x) = V (x+a)

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Motion of electron in 1D-periodic lattice

Let us consider wave function associated with free electron

$$\psi(x) = e^{ikx}$$

If electrons move through a periodic lattice then

$$\psi(x + a) = e^{ik(x+a)}$$

$$= e^{ikx} * e^{ika}$$

We know that $k = \dfrac{n\pi}{a}$

$$= e^{ikx} * e^{in\pi}$$

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Motion of electron in 1D-periodic potential

When the electrons moves through the periodic potential

$$V(x) = V(x+a) = V(x+2a)\cdots$$

According Bloch the free electron wave function is modulated

by the term $V_k\,(x)$ *which has the periodicity of the lattice*

So the wave function is $\psi_k(x) = V_k(x)e^{ikx}$

This is known as Bloch Theorem

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Motion of electron in 1D-periodic potential

In a periodic potential $V_k(x) = V_k(x+a)$

$$\psi_k(x+a) = V_k(x+a)\, e^{ik(x+a)}$$

$$= V_k(x)e^{ikx}e^{ika}$$

$$\psi_k(x+a) = \psi_k(x)e^{ika}$$

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Motion of electron in 1D-periodic potential

Suppose if we investigate the probability density of the electron wave

$$\psi^*(x+a)\,\psi(x+a) = \psi^*(x)\,\psi(x)$$

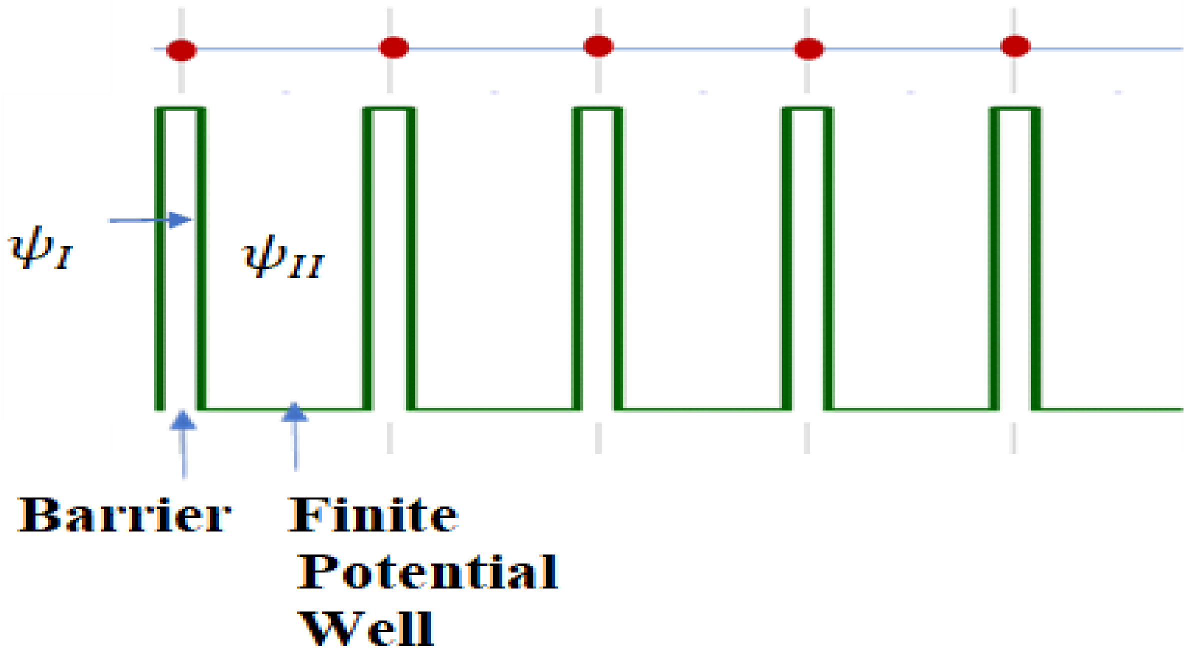
$$|\psi(x+a)|^2 = |\psi(x)|^2$$

when electron moves through a distance a, 2a, 3a …….

probability density remains invariant

Motion of electron in 1D-periodic potential

Potentials in real crystals - approximated as series rectangular potentials wells and barriers



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The concepts which are correct are….

1. *Electrons move in a periodic potential due to the regular arrangement of ionic cores.*
2. *The potential of the electron at the positive ionic site is maximum and zero between the site .*
3. *The wave function of the electrons is not affected by the periodic potential*
4. *The potential in the real crystal is approximated by rectangular potentials.*

THANK YOU

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