AAST-Cairo
EC210
Solid State Electronics
Fall 2016

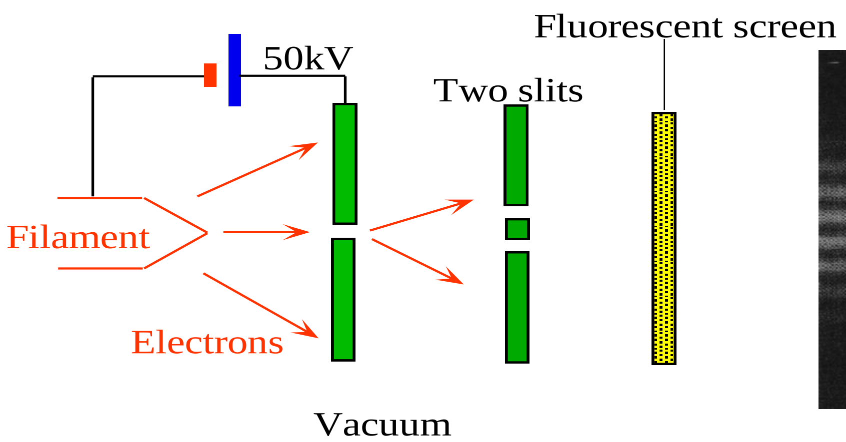
Lecture 4
Introduction to Wavefunction, Schrodinger Eqn.

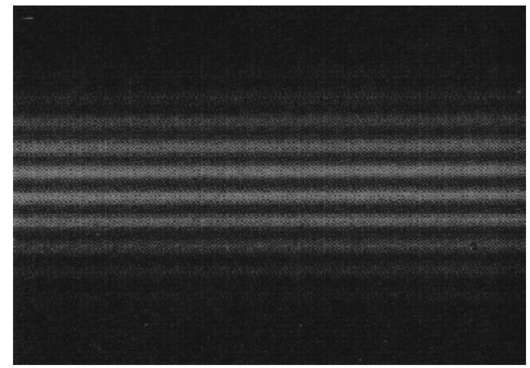
Original Lecture Notes Prepared by:
Dr. Amr Bayoumi, Dr. Nadia Rafat

Kasap:

- Page 199-201
- Page 205-212

Young’s Experiment





Electron diffraction fringes on the screen

Fig 3.12: Young's double slit experiment with electrons involves an electron gun and two slits in a cathode ray tune (CRT) (hence in vacuum). Electrons from the filament are accelerated by a 50 kV anode voltage to produce a beam which is made to pass through the slits. The electrons then produce a visible pattern when they strike a fluoresecent screen (e.g. a TV screen) and the resulting visual pattern is photographed (pattern from C. Jönsson, D. Brandt, S. Hirschi, Am. J. Physics, **42**, Fig. 8, p. 9, 1974.

http://www.youtube.com/watch?v=DfPeprQ7oGc

Schrödinger equation: Wavefunction

- **The Schrödinger equation plays the role of Newton's laws in classical mechanics**

- **Explains the wave-like nature of electrons using photon-like concepts**

Assuming:

$$\psi(x,t) = \psi(x)\,\phi(t) = \psi(x)\,e^{-i\omega t} = \psi(x)\,e^{-i\frac{E}{\hbar}t}$$

$$e^{i\theta} = \cos\theta + i\,sin\,\theta$$

1-D Time-independent Schrödinger Equation

$$-\frac{\hbar^2}{2m}\frac{d^2\psi(x)}{dx^2}+U(x)\psi(x)=E\psi(x)$$

- **U(x): Potential Energy**
- **E: Total energy**

- **Equivalent of energy conservation equation in classical mechanics.**
- **Predicts the shape of the wave function.**
- **System is defined by potential energy, boundary conditions**

Boundary Conditions

(1) **Wavefunction Magnitude is Continuous:**

$$\psi\,(x^-) = \psi\,(x^+)$$

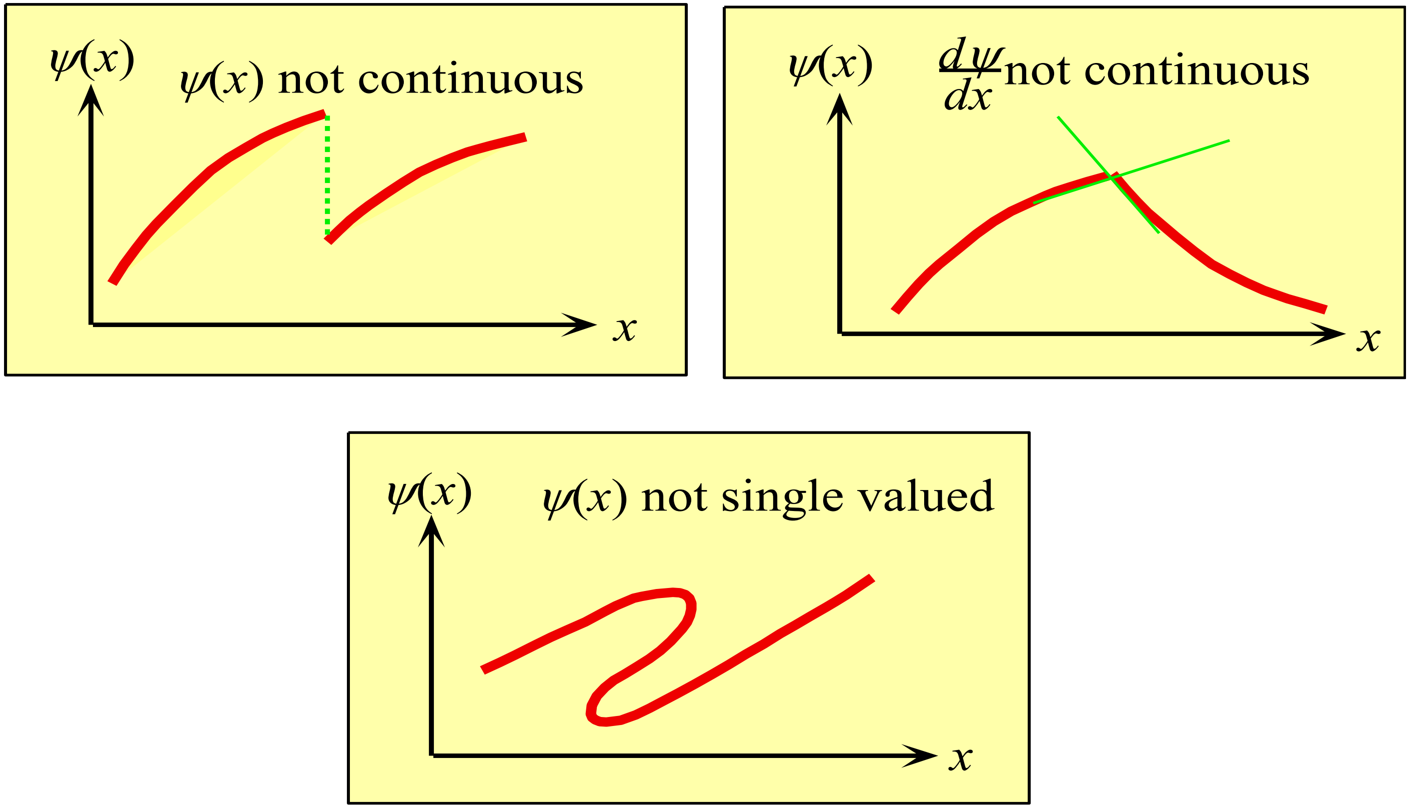
(2) **Wavefunction Slope is Continuous:**

$$\frac{d\Psi(x^-)}{dx} = \frac{d\Psi(x^+)}{dx}$$

(3) **Normalization Condition:**

$$\int_{-\infty}^{\infty} |\psi(x)|^2\, dx = 1$$

Unacceptable Forms of Wavefunctions



Unacceptable forms of $\psi(x)$

Fig 3.14

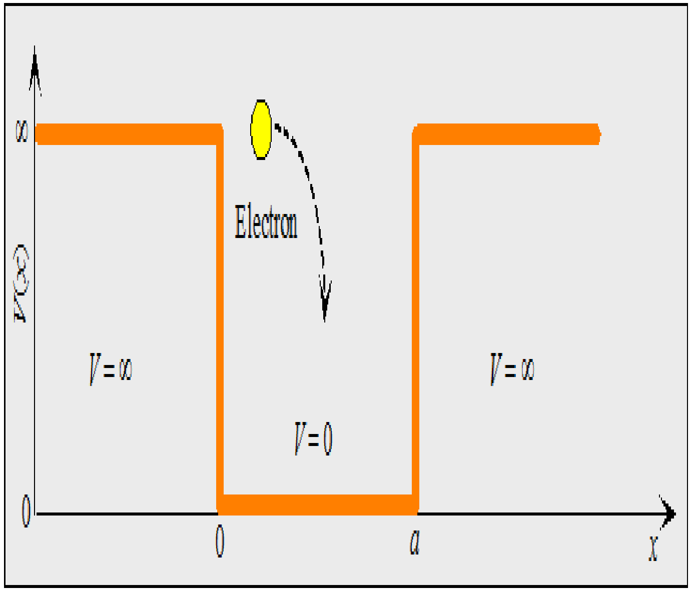
From *Principles of Electronic Materials and Devices, Third Edition*, S.O. Kasap (© McGraw-Hill, 2005)

Applications

(1) Particle in an Infinite Potential Well:

Particle in a Box (1-D):

A particle of mass m is completely trapped in a region and is moving freely between x=0 and x=L

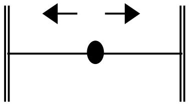


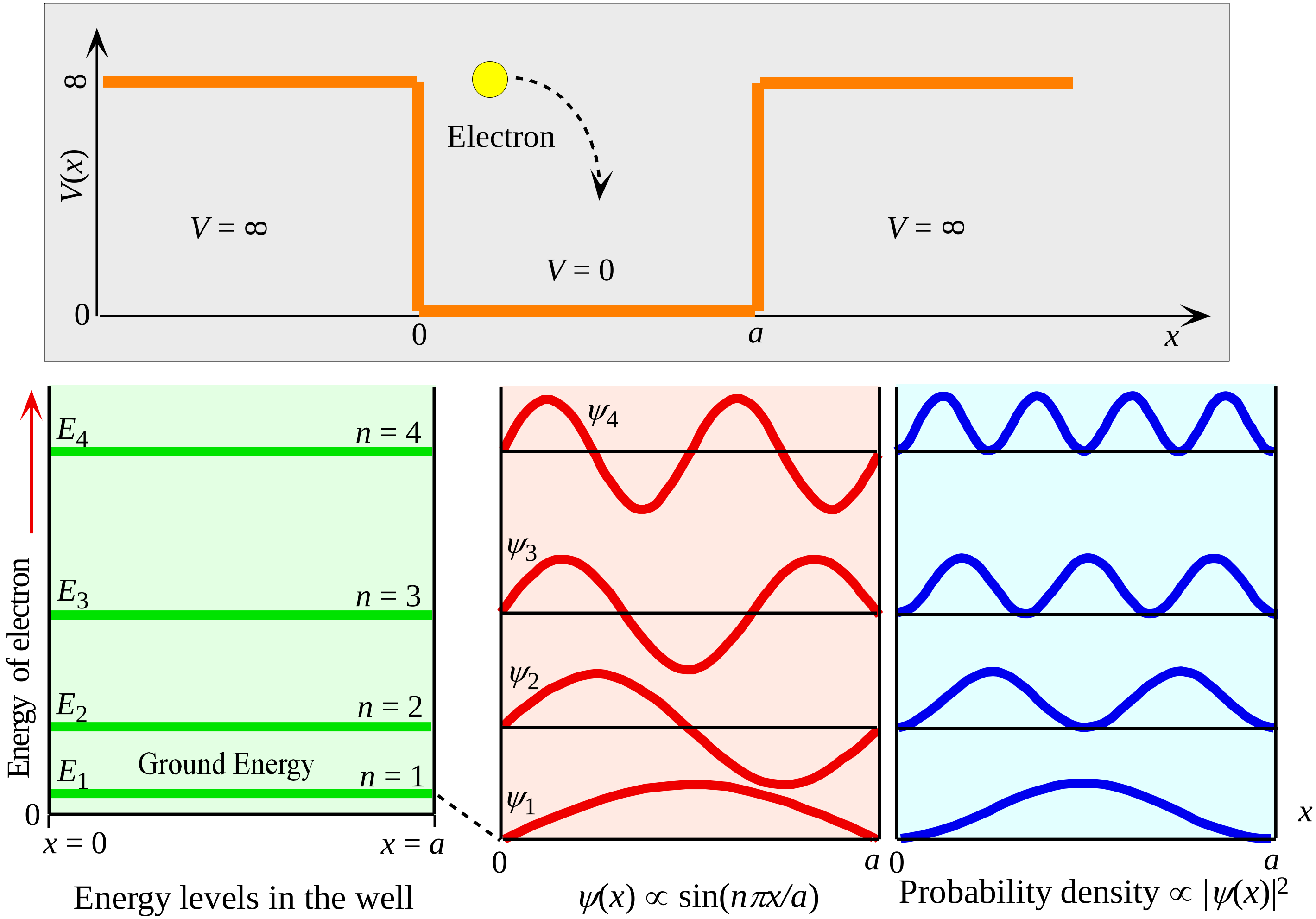
U(x)=0,   if 0 ≤ x ≤ a

- ***U(x)=∞, if x<0 or x>a***
- ***Boundary conditions on ψ:***

Ψ must be continuous across any boundary

Ψ(0)=0=Ψ(a)





Electron in a one-dimensional infinite PE well. The energy of the electron is quantized. Possible wavefunctions and the probability distributions for the electron are shown.

Fig 3.15