# Section 4 - Elements of Quantum Mechanics

## 4.3 Why do we need quantum mechanics?

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PURDUE UNIVERSITY

School of Electrical and Computer Engineering

# Section 4
# Elements of Quantum Mechanics

One Video Segment

One Video Segment

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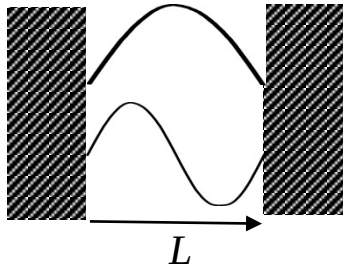
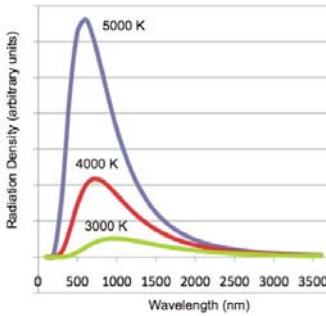
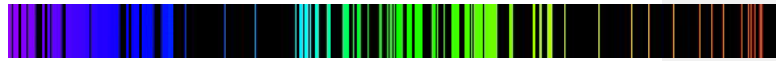
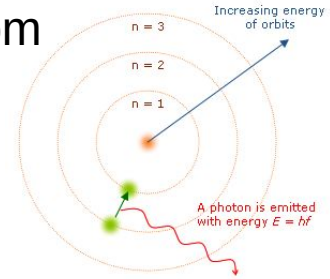
- 4.1 Classical Systems
  - » Particles
  - » Propagating Waves
  - » Standing Waves
  - » Chromatography






- 4.2 Strange Experimental Results => The Advent of Quantum Mechanics
  - » Black Body Radiation => light emission is quantized
  - » Discrete Optical Spectra => light emission/absorption quantized – Bohr Atom
  - » Photoelectric Effect => light is described by particles
  - » Particle-Wave Duality






$$p = hf/c$$
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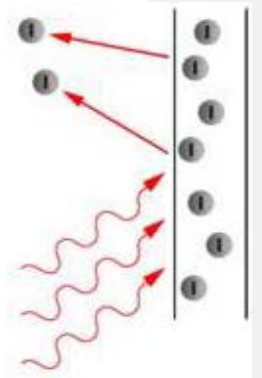
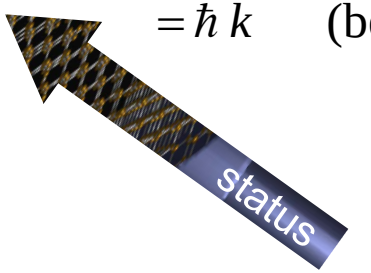
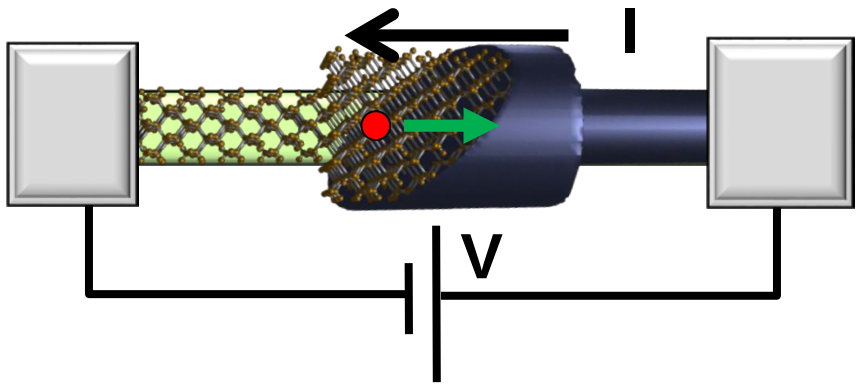
- 4.3 Why do we need quantum mechanics?



- 4.4 Formulation of Schrödinger's Eq.



## Why do we need Quantum Mechanics?




$$I = G \times V$$
$$= q \times n \times v \times A$$

charge density  velocity  area

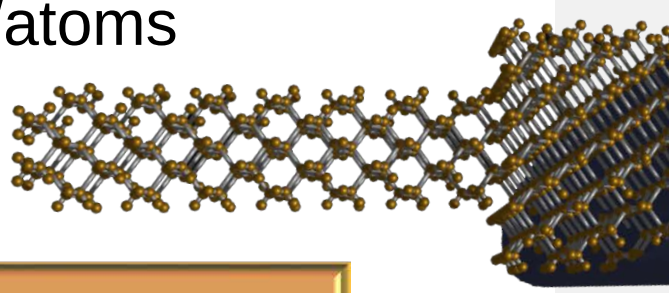
| II | III | IV | V | VI |
|---|---|---|---|---|
| 4 Be | 5 B | 6 C | 7 N | 8 O |
| 12 Mg | 13 **Al** | 14 **Si** | 15 **P** | 16 S |
| 30 **Zn** | 31 **Ga** | 32 Ge | 33 **As** | 34 **Se** |
| 48 Cd | 49 In | 50 Sn | 51 Sb | 52 Te |
| 80 Hg | 81 Tl | 82 Pb | 83 Bi | 84 Po |

$$n \neq \rho \times N$$

Number of electrons available for conduction

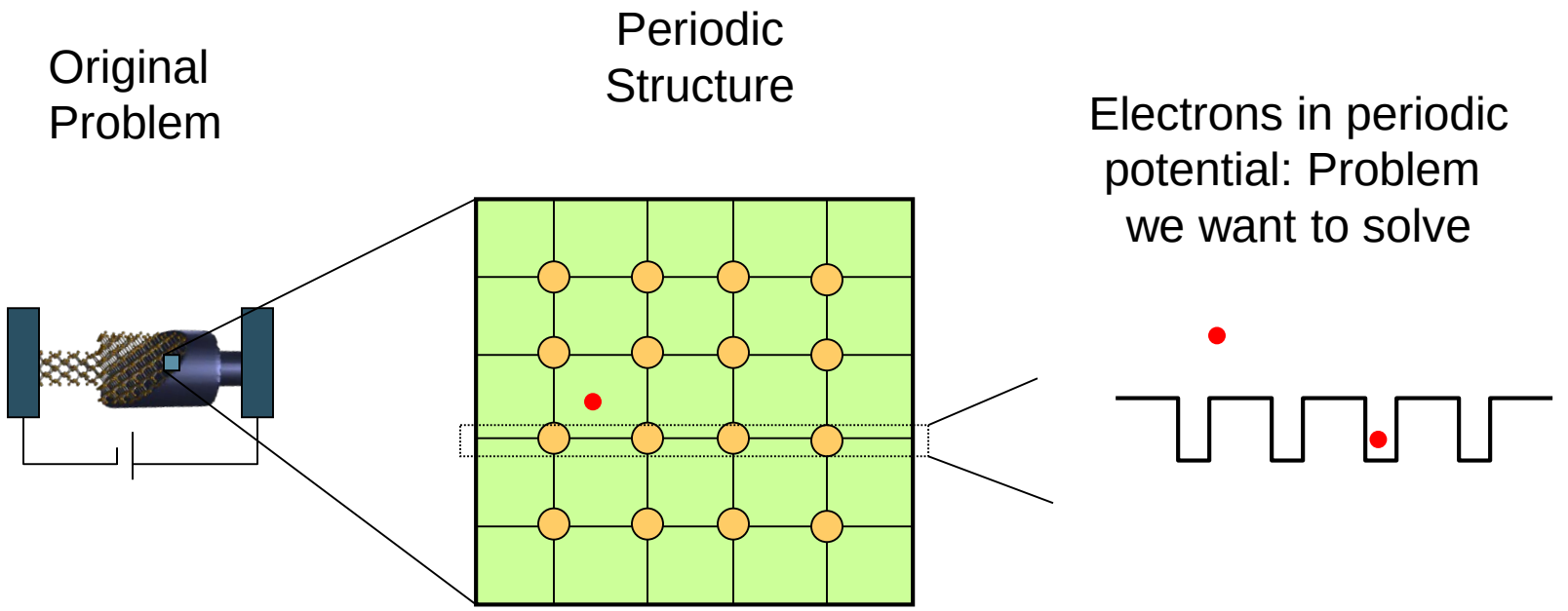
Number of atoms/volume from crystal structure

Number of electrons/atoms



- All electrons may be created equally, but they appear do not behave identically!

# Do I really need Quantum Mechanics ?




If it were large objects, like a skier skiing past a set of obstacles, Newton's mechanics would work fine, but in a micro-world ……

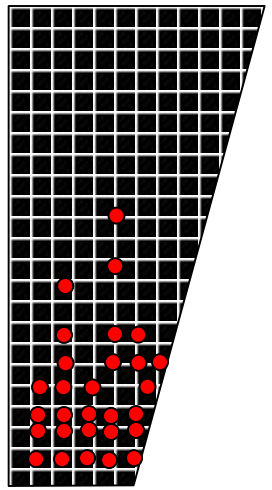
- Some electrons are closely bound to the atomic cores
- Some electrons are loosely bound
  => they can move through the structure freely
- Even free electrons need empty states to flow into
  => not only the states, but their filling is important!

# Carrier Density

Carrier number = Number of states x filling factor

Chapters 2-3 Chapter 4

Total number of occupants
= Number of apartments
X The fraction occupied



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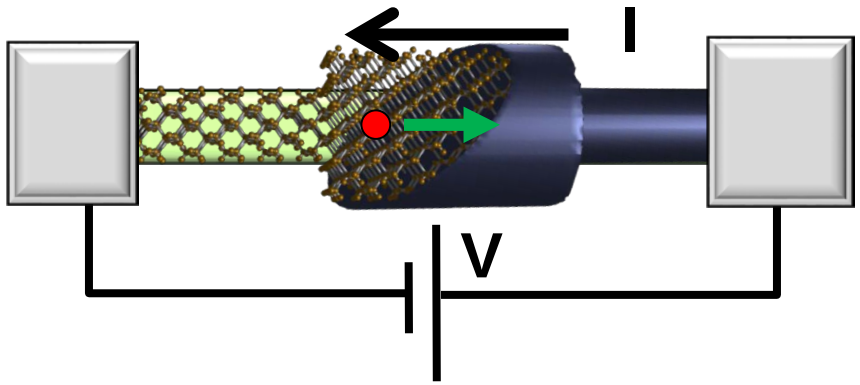


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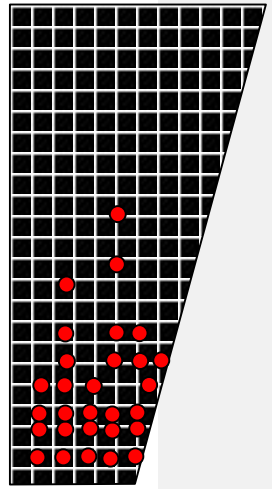
- Given chemical composition and atomic arrangements, we can compute electron density by using quantum mechanics.
- We discussed the origin of quantum mechanics – experiments were inconsistent with the classical theory.
- We saw how Schrödinger equation can arise as a consequence of quantization and relativity, but this is not a derivation.



- We will solve some toy problems in the next section to get a feeling of how to use quantum mechanics.

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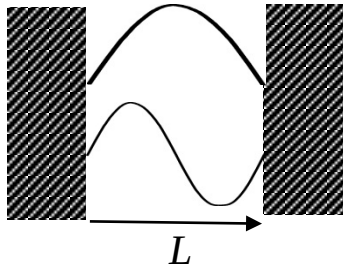

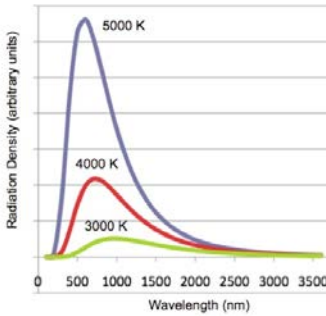


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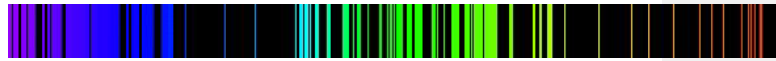

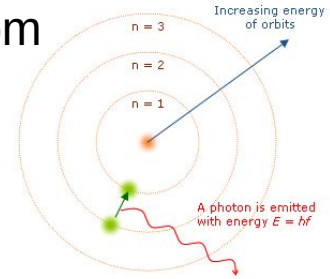


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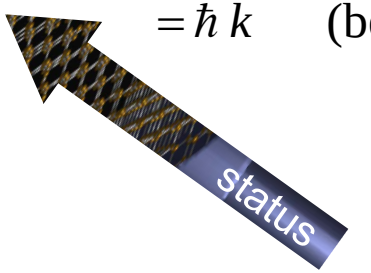


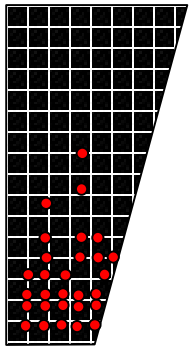

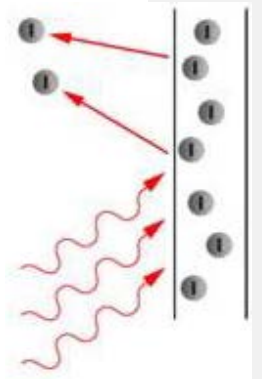

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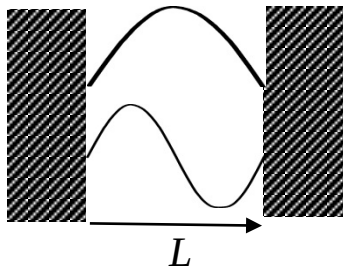

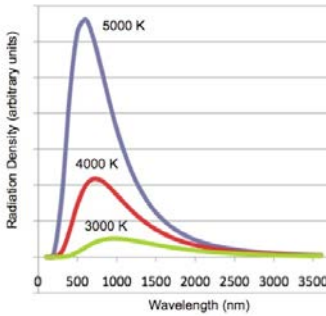


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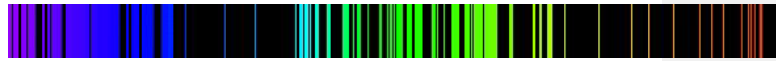

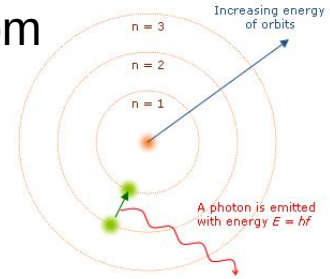


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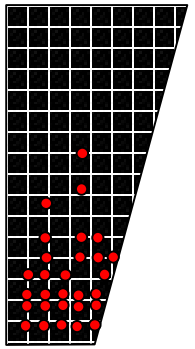

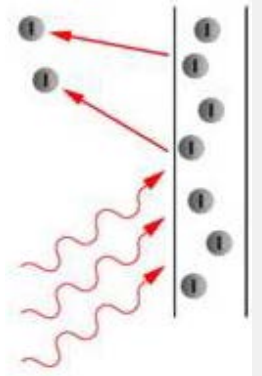

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