

Big Idea: Quantum Mechanics

Important Concepts: Tunneling and Quantum Confinement

Science Content Needed:

- Scale and scientific notation
- Waves: standing, traveling, amplitude, phase
- Classical Mechanics
- Electrostatics. Charge and field
- Differential equations and integrals

Difficulties and Misconceptions:

- Waves
- Energy carried by waves
- Traveling versus standing waves
- Phase
- Energy not medium moves
- Momentum

Key Ideas:

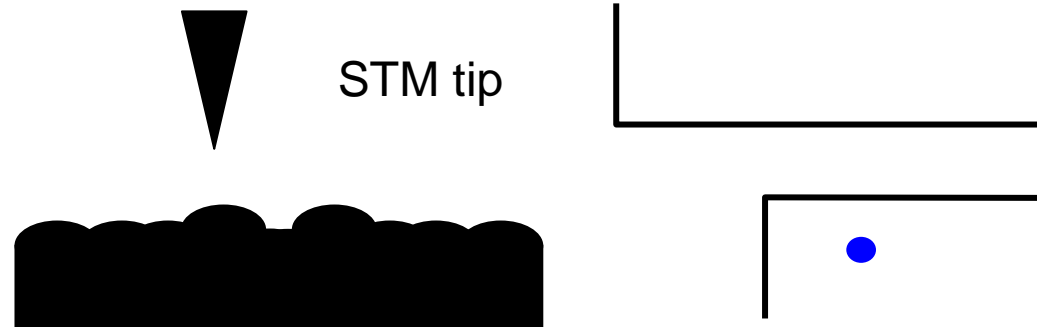
- Wave-particle duality
- Probability amplitude
- Decay of wave function in a barrier
- Wave propagation
- Confinement produces standing waves
- Quantization of energy
- Frequency \sim energy

Student “Be Able To’s”

BAT # 1 [Learning Outcome]

Construct an energy “schematic representation” from an application of tunneling. Use this representation to illustrate how the current depends on the barrier:

- Height
- Thickness
- Potential Energy on each side



Task & Evidence:

Exam or homework problem that contains a schematic representation of an application that involves a tunneling barrier. Drawings that show how to increase (decrease) the tunneling current by changing the:

- Thickness of the barrier
- Potential energy of the barrier
- Potential energy in either side of the barrier

How To Teach:

- Give a short, interactive lecture
- Students pair up and experiment with computer simulation
- Students complete an assignment in which they explain results from simulation in writing and state what they did not understand.

Student “Be Able To’s”

3

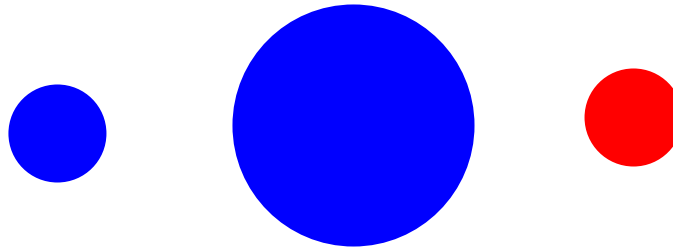
BAT # 2 [Learning Outcome]

Calculate and illustrate the energy levels in a structure exhibiting quantum confinement as a function of the size and material changes

Task & Evidence:

Exam or homework problem in which students calculate and comparatively illustrate the lowest three energy levels in three quantum dots:

- Material A, size r_0
- Material A size $3r_0$
- Material B, size r_0



How to Teach:

Ask question in class then use think-pair-square-share

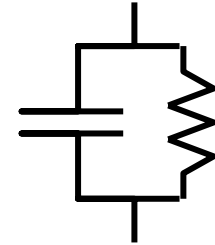
Student “Be Able To’s”

5

BAT # 3 [Learning Outcome]

Optimize (analyze and evaluate) an electronic device as a function of the gate oxide...

- Thickness
- Material
- Thickness tolerance



Task & Evidence:

A project written report recommending a particular device that presents evidence in the form of graphs with written explanations

How to Teach:

- Assign readings before class
- Give small group projects in class that illustrate parts of the project
- Three to five students in a group. Give a short “organizing” lecture at the end of each class.

