

Introduction to Quantum Wells and Tunneling

A Lesson Plan Suitable for K-12 Students

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Quantum Wells and Tunneling

- **Class:** Valparaiso, Indiana, Community Schools
Gifted and Talented Program
Introduction to Nanotechnology

- **Standards:**

Science 4.3

Students continue to investigate changes of the Earth and sky and begin to understand the composition and size of the universe. They explore, describe, and classify materials, motion, and energy.



Objectives and Materials

Objectives:

- The students will be able to understand the basic functions and concepts of quantum wells and tunneling.
- Students will be able to relate the concepts of memory and logic gates to an electron in a quantum well.

Materials:

- Desks
- Chalk and chalkboard



Opening

- Recall previous knowledge of memory.
- Draw several circles on the board, not overlapping but close to represent atoms. These circles shall create an overall shape that has a large space in the middle, the well.
- In the well, draw a single dot to represent an electron. Explain that this electron is always in linear motion. Eventually, the electron will hit an atom and bounce off, only to hit another atom in the diagram. The atoms trap the electron.
- Explain that if a quantum well contains at least one electron (or more), the quantum well can represent a logical true.
- The students should recall this logical true from logic gates. If the well does not contain an electron, then the quantum well represents a logical false.



Activity

- Arrange the desks in a long, rectangular pattern such that two desks on both ends act as caps.
- Pick a student to go into the “quantum well” as an “electron”.
- Ask the student to get out of the well without pushing the desks apart or climbing over or under the desks. The student will soon see that he/she cannot escape.
- The current situation represents a logical true. Like memory, unless an outside force acts upon the well, the well will always be a logical true.



Activity, continued

- Move the desks and have the student get out.
- Now explain that atoms are not always touching, but rather rapidly bounce back and forth against each other. It is possible for the electron in the well to line up exactly between the space between two atoms and escape the well. This is called tunneling.
- Now return to the desks and move them apart, enough so one person can fit between them. Have another student be an “electron” and bounce between the desks until he/she lines up exactly with a space between the desks and escapes.



Closing

- Reinforce previous statements relating quantum wells and memory.
- Though tunneling is extremely rare, there is a small probability of occurrence.
- The use of quantum wells can be an analogy of how memory devices, such as thumb drives operate.



Assessment

- The students were given a worksheet containing statements that the students used to determine the true or false nature of outputs.
- This assessed their understanding and ability to evaluate the outputs of logic gates.
- Students were assessed concerning the application of this knowledge through class discussion and group examples.



Reflections

- The students enjoyed acting like an electron inside the quantum well.
- As students partake in the activity, their understanding of memory and quantum wells was satisfactorily established.