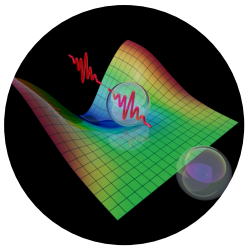

Quantum Mechanics Lesson 3: It is a Platypus, not a Duck or a Beaver

Quantum Mechanics

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Grade Level	11th – 12th Grade	**Time Frame**	215 minutes
Subject	Science	**Duration**	4-5 periods
Course	Physics		

Essential Question

Is light a wave or a particle?

Summary

In this lesson, students learn about the surprising results of the double slit experiment showing that particles have wavelike behavior through watching a Dr. Quantum video and through the PhET Quantum Wave Interference simulation. Students are split into groups to watch curated videos and create slideshow presentations to present either Wave-Particle Duality, De Broglie Wavelength, Heisenberg Uncertainty Principle, or Fourier Transformation. Students take notes that summarize the concepts presented that they could use while answering reflection questions at the end of the lesson.

Snapshot

Engage

Students make observations and form questions over the Double Slit Experiment by viewing a video about it.

Explore

Students complete a simulation about quantum wave interference.

Explain

Students work in pairs to create a presentation about quantum phenomenon and then present their findings to the class. As students present, the other students take notes over the key concepts.

Extend

Students complete a simulation to reinforce how the Fourier Transformation helps explain the Heisenberg Uncertainty Principle. To shrink the range of positions of a wave packet, the uncertainty in momentum of the packet must increase.

Evaluate

Students respond to reflection questions about the lesson content while using the notes they have taken

previously.

Standards

Next Generation Science Standards (Grades 9, 10, 11, 12)

HS-PS4-1: Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.
HS-PS4-3: Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.

Attachments

- Exit Ticket Teacher Guide - It is a Platypus, not a Duck or a Beaver.docx
- Exit Ticket Teacher Guide - It is a Platypus, not a Duck or a Beaver.pdf
- Fourier Making Waves PhET Simulation Teacher Guide - It is a Platypus, not a Duck or a Beaver.docx
- Fourier Making Waves PhET Simulation Teacher Guide - It is a Platypus, not a Duck or a Beaver.pdf
- Fourier Making Waves Simulation—It is a Platypus, not a Duck or a Beaver - Spanish.docx
- Fourier Making Waves Simulation—It is a Platypus, not a Duck or a Beaver - Spanish.pdf
- Fourier Making Waves Simulation—It is a Platypus, not a Duck or a Beaver.docx
- Fourier Making Waves Simulation—It is a Platypus, not a Duck or a Beaver.pdf
- Is Light a Wave or a Particle Teacher Guide - It is a Platypus, not a Duck or a Beaver.docx
- Is Light a Wave or a Particle Teacher Guide - It is a Platypus, not a Duck or a Beaver.pdf
- Lesson Slides - It Is A Platypus, not A Duck Or A Beaver.pptx
- Presentation Note Catcher—It is a Platypus, not a Duck or a Beaver - Spanish.docx
- Presentation Note Catcher—It is a Platypus, not a Duck or a Beaver - Spanish.pdf
- Presentation Note Catcher—It is a Platypus, not a Duck or a Beaver.docx
- Presentation Note Catcher—It is a Platypus, not a Duck or a Beaver.pdf
- Presentation Summary Teacher Guide - It is a Platypus, not a Duck or a Beaver.docx
- Presentation Summary Teacher Guide - It is a Platypus, not a Duck or a Beaver.pdf
- Quantum Wave Interference Simulation Teacher Guide - It is a Platypus, not a Duck or a Beaver.docx
- Quantum Wave Interference Simulation Teacher Guide - It is a Platypus, not a Duck or a Beaver.pdf
- Quantum Wave Interference Simulation—It is a Platypus, not a Duck or a Beaver - Spanish.docx
- Quantum Wave Interference Simulation—It is a Platypus, not a Duck or a Beaver - Spanish.pdf
- Quantum Wave Interference Simulation—It is a Platypus, not a Duck or a Beaver.docx
- Quantum Wave Interference Simulation—It is a Platypus, not a Duck or a Beaver.pdf

Materials

- Lesson Slides (attached)
- Is it a Wave or a Particle Teacher Guide (attached)
- Quantum Wave Interference Simulation handout (attached, 1 per group of 2 students)
- Quantum Wave Interference Simulation Teacher Guide (attached)
- Presentation Note Catcher (attached, 1 per student)
- Presentation Summary Teacher Guide (attached)
- Fourier Making Waves Simulation handout (attached, 1 per group of 2 students)
- Fourier Making Waves Simulation Teacher Guide (attached)
- Exit Ticket Teacher Guide (attached)
- Student devices with internet access (1 per group of 2 students)
- Notebook paper
- Pencil

30 minutes

Engage

Use the attached **Lesson Slides** to guide the lesson. Display **slides 3 and 4** to review the essential questions and learning objectives with students. Have students take out a piece of notebook paper. Move to **slide 5** and Introduce the I Notice, I Wonder strategy to students. Move to **slide 6** and watch the Dr. Quantum - Double Slit Experiment video. Give students 3-4 minutes to individually write down two things they noticed and two things they wonder about from the video.

Move to **slide 7** and go over the three questions with the students. Go back and watch the video on **slide 6** a second time. After the video is over, go back to **slide 7** and have the students use their notes individually from the I Notice/I Wonder table for 3-4 minutes to answer the questions.

Have a class discussion to share answers to the questions. See the attached **Is it a Wave or a Particle Teacher Guide** for a list with timestamps of the ideas covered in the video. If any of the parts are not brought up by the students, cue the video to that section because students will reproduce the results in the next section. Students do not need to have any explanations at this point. They need to understand the experiments and what unpredicted results were observed from each one.

30 minutes

Explore

Have students break into groups of 2 with a laptop and pass out the attached **Quantum Wave Interference Simulation** handout to each pair of students. Have students access the activity at https://phet.colorado.edu/en/simulation/quantum-wave-interference. The website is also on the handout for students. Display **slides 8-10** to help guide them to the simulation, and have each group fill out their handout as the group spends 20 minutes working through the simulation.

Teacher's Note: Simulation Guidance

The **Quantum Wave Interference Simulation Teacher Guide** is also attached which has explanations for the simulation.

Display **slide 11** and use the What Did I Learn Today? strategy to have the students spend 5 minutes individually doing a free-write over what they learned and answer the question to show where they are at this point in the lesson.

100 minutes

Explain

Display **slide 12** and have the students access the Wakelet. Display **slides 13-14** to go over the presentation requirements with the students. Have students pair up into groups of two to view their assigned videos and take notes, then create a slideshow presentation. Approximately one class period is needed for students to view the videos and create their slideshow presentation.

Teacher's Note: Wakelet Video Distribution

In the Wakelet, three groups emphasize Wave-Particle Duality. One group emphasizes De Broglie Wavelength; two groups emphasize Heisenberg Uncertainty; and two groups emphasize Fourier Transformation. To work out the group numbers better, more than one group of two can have the same number and can work on the presentation together or some of the groups covering the same topic can be removed. Each video group has different videos that may cover additional points and hearing multiple presentations should reinforce the concept, but the main points should be covered in each set of videos.

The next time class meets, pass out the attached **Presentation Note Catcher** to each student. Have each group present their slideshow while the rest of students take notes. Tell students that at the end of the lesson, the note catcher can be used to answer reflection questions about the lesson content.

See the attached **Presentation Summary Teacher Guide** for the presentation directions as well as explanations of the content that is included in each of the videos students will present. This information is helpful when assessing the student created presentations.

30 minutes

Extend

Have students break into groups of two with a laptop and pass out the attached **Fourier Making Waves Simulation** handout to each pair of students. Have students access the activity at https://phet.colorado.edu/en/simulations/fourier-making-waves/about. The website is also on the handout. Display **slides 15-16** to help guide students to set up the simulation and explore how the simulation works. Display **slides 17-18**, and have the students spend about 10 minutes playing the wave game. Display **slide 19** to guide students back to the first part of the simulation, and have them work through the rest of the handout.

The **Fourier Making Waves Simulation Teacher Guide** is attached with explanations for the simulation.

Display **slide 20** and have the students use the Point of Most Significance strategy to reflect on what was learned from the simulation.

25 minutes

Evaluate

Display **slides 21-25**, and have students use the Bell Ringers and Exit Ticket instructional strategy to evaluate student understanding for the unit by having them answer the questions on the slides by using notebook paper. Encourage students to use their notes from the Presentation Note Catcher.

Refer to the attached **Exit Ticket Teacher Guide** for possible responses to the questions.

Resources

Angel Art. (2020, December 27). Dr. Quantum - Double slit experiment. Video. YouTube. https://www.youtube.com/watch?v=Q1YqgPAtzho

K20 Center. (n.d.). Bell ringers and exit Ttckets. Strategies. https://learn.k20center.ou.edu/strategy/125

K20 Center. (n.d.). I notice, I wonder. Strategies. https://learn.k20center.ou.edu/strategy/180

K20 Center. (n.d.). Point of most significance. Strategies. https://learn.k20center.ou.edu/strategy/101

K20 Center. (n.d.). What did I learn today? Strategies. https://learn.k20center.ou.edu/strategy/169

University of Colorado-Boulder. (n.d.). Fourier: Making waves? - Phet interactive simulations. https://phet.colorado.edu/en/simulations/fourier-making-waves

University of Colorado-Boulder. (n.d.). Quantum wave interference. PHET interactive simulations. https://phet.colorado.edu/en/simulations/quantum-wave-interference

University of Colorado at Boulder. (n.d.). Quantum wave interference simulation. PHET Interactive Simulations. https://phet.colorado.edu/sims/cheerpj/quantum-wave-interference/latest/quantum-wave-interference.html?simulation=quantum-wave-interference