3D Science Performance Assessment Tasks

HIGH SCHOOL

SOLAR ENERGY TECHNOLOGY AND WAVE-PARTICLE DUALITY

These materials were developed under a grant awarded by the Michigan Department of Education

Task Title	Solar Energy Technology and Wave-Particle Duality

Standards Bundle Information
Performance Expectations • 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 the wave model or a particle model, and that for some situations one model is more useful than the other.
Science and Engineering Practices ● Students will correlate data related to wave speed, frequency, and energy to wave travel and the photoelectric effect. ● Students will evaluate the contributions of Newton and Huygens regarding properties of light and apply it to the success of solar energy technology. ● Students will use their knowledge of wave-particle duality to write an argumentative essay debating whether the wave or particle model is most significant in the recent success of solar energy technology.
Cross-Cutting Concepts • Empirical evidence is used to make claims about a specific cause and its related effect. • Mathematical representations are needed to identify some patterns that support claims within the performance task.
Disciplinary Core Ideas • Electromagnetic radiation has a dual wave-particle nature • Travels as an electromagnetic wave • Photons interact with mediums • Wave speed and behavior changes according to the medium
CCSS ELA • RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g. ,quantitative data,video,multimedia) in order to address a question or solve a problem. • RST.11-12.1 Write an argument to support a claim in an analysis of a topic using valid reasoning, and relevant and sufficient evidence.
CCSS Mathematics: • L1.2.1 Use mathematical symbols to represent quantitative relationships and situations. • L1.2.4 Organize and summarize a data set in a table, plot, chart, or spreadsheet; find patterns in a display of data; understand and critique data displays in the media.

Overview / Introduction of the Assessment Task

Solar power in the United States is more affordable and accessible than ever before. Today's structures have the ability to power 5.7 million homes. With the continued trend of "going green," the use of solar panel technology will continue to grow as well as the profits that companies such as Super Solar, SunCity, and Wavegevity are making.

Student Task: Your great-great-great grandfather is either Christiaan Huygens or Isaac Newton (determined by your teacher). You deserve some of these profits since pure genius runs through your veins! The only thing standing in the way between you and your fortune is the misinformed descendent of (Huygens or Newton) who thinks that their relative's unique discovery of light is the reason solar panels are so awesome. Write an argumentative document to convince a panel from the International Council of Scientists that you are correct and you will begin to live a life of leisure.

If your ancestor is Newton: You deserve a kickback from the recent explosion of solar panel installations! He proposed that light travels as particles and in your opinion this is the most significant reason that solar panels are so effective. Courtesy of the photoelectric effect you have a chance to be a millionaire.

If your ancestor is Huygens: You deserve a kickback from the recent explosion of solar panel installations! He proposed that light travels as a wave and in your opinion this is the most significant reason that solar panels are so effective. Courtesy of this mode of wave travel, you have a chance to be a millionaire.

Teacher Background

This could be used as a summative assessment for a light unit (with a focus on the electromagnetic spectrum) that would also allow students to practice writing an argumentative essay using science content. The investigation will also give students practice reading informational texts which is essential in preparing students to become career and college ready.

Information for Classroom Use

Connections to Instruction:

The task is written as a summative assessment of: HS-PS4-1, HS-PS4-3

You will present your class with prior instruction of the electromagnetic spectrum and light's dual nature. Your students will take this information and do an in depth investigation to be able to create an argumentative essay defending their position that the recent success of solar energy is due to the discovery of their ancestor (Newton or Huygens) regarding either the wave or particle nature of light.

Approximate Duration for the Summative Task: (all components)

2-3 class periods (approximately 140 minutes)

Assumptions:

The 3DSPA was designed to assess students' ability to perform the task by applying previous knowledge learned to the new phenomena in the performance assessment without having been exposed to this specific phenomena in advance.

Content within HS-PS4-1 and HS-PS4-3 should have already been taught.

Materials Needed:

Access to computer, and the internet for research

Black poster board or construction paper and glow in the dark stars

Rubric for student assessment- argumentative paper

Optional peer edit form

Student instruction handout

https://docs.google.com/document/d/10cBMqGZs8laN9pO8VOr6MeorcfdwyxTZUk3wZWNyQcc/edit?usp=sharing

Supplementary Resources:

For teacher: http://hyperphysics.phy-astr.gsu.edu/hbase/mod1.html

ELA- writing argumentative essay rubric http://sbac.portal.airast.org/wp-content/uploads/2013/09/PerformanceTaskWritingRubric_Argumentative.pdf

Citation form

https://docs.google.com/document/d/1kUaoaj2V3ogvzu0AmD_vgJYAoHVCzUZDoRD0zIrJI8w/edit

Learning Performances

- Students will create an argument that states why the particle model of light is most useful in explaining the mechanism that results in the photoelectric effect.
- Students will create an argument that states why the wave model of light is most useful in explaining the mechanism sunlight uses to travel to Earth through the vacuum of space.

Performance Assessments

<table>
<tr><th colspan="3">Student Performances</th></tr>
<tr><td rowspan="4">Formative Assessment Task 1

Student will use evidence from doing the lab and by completing measurements and diagrams with drawings that evaluates the dual nature of light</td><td>Learning Performance:

Students will use evidence based on observations from the single slit experiment to evaluate the claim that light travels as photons.</td><td rowspan="4">Expected Duration:

20 minutes</td></tr>
<tr><td>Description

This is a quick way for students to shine a laser through a single slit to observe the particle model of light.</td></tr>
<tr><td>Directions

*The pre reading portion of this document is optional. If setting up an inquiry experience, the teacher may want to delete it prior to making student copies.

https://docs.google.com/document/d/19eh6JqF56bs2Losw5HKG08P_DWKBfy4k97YHn-nWNus/edit?usp=sharing</td></tr>
<tr><td>Scoring / Teacher Look-For’s:

Single slit experiment: Measurements and drawings that indicate the phenomenon</td></tr>
<tr><td rowspan="4">Formative Assessment Task 2

Student will use evidence from doing the lab and by completing measurements and diagrams with drawings that evaluates the dual nature of light</td><td>Learning Performance:

Students will use evidence based on observations from the double slit experiment to evaluate the claim that light travels as a wave.</td><td rowspan="4">Expected Duration:

20 minutes</td></tr>
<tr><td>Description

This is a quick way for students to shine a laser through 2 slits to observe the wave model of light.</td></tr>
<tr><td>Directions

https://docs.google.com/document/d/19eh6JqF56bs2Losw5HKG08P_DWKBfy4k97YHn-nWNus/edit?usp=sharing</td></tr>
<tr><td>Scoring / Teacher Look-For’s:

Double slit experiment: Measurements and drawings that demonstrate the phenomenon</td></tr>
</table>

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<tr>
<td rowspan="4">Formative Assessment Task 3

Students will determine claims,evidence,and reasoning behind the idea that electromagnetic radiation can be described either by the wave model or a particle model, and that for solar cells situations one model is more useful , and so they should be compensated as a descendant of the discoverer of the model.</td>
<td>Learning Performance:

Student will engage in peer argument with their collected evidence regarding their claim that either the wave or particle model is most important in the effectiveness of solar technology.</td>
<td>Expected Duration:

30-45 minutes</td>
</tr>
<tr>
<td>Description (Phenomena, Scenario, Task)

After student has researched their claim and gathered evidence in support of it, they will gather with peers who have the same claims . This will allow them to strengthen and critique each other’s evidence in support of their claim.</td>
<td></td>
</tr>
<tr>
<td>Directions

Split students into peer groups of 3-5. They should be grouped with people who share their common claim. Students should take turns summarizing their evidence and allowing feedback. This will allow students to refine and strengthen their claims prior to writing their argumentative essay.</td>
<td></td>
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<tr>
<td>Scoring / Teacher Look-For’s:

Have each student evaluate the strength of their peers’ collection of evidence. They could rate them and possibly offer areas where evidence is lacking or weak.

Here is a sample template that could be used:

https://docs.google.com/document/d/1x1dplAJwLJicaJpFCT2OM8mBU341UQ4LMWNnuQj7_v4/edit?usp=sharing</td>
<td></td>
</tr>
<tr>
<td rowspan="2">Final Task:</td>
<td>Learning Performance: Students will create an argument that states why the particle model of light is most useful in explaining the mechanism that results in the photoelectric effect.

Students will create an argument that states why the wave model of light is most useful in explaining the mechanism sunlight uses to travel to Earth through the vacuum of space.

Students will use evidence based on observations from the double slit experiment to evaluate the claim that light travels as photons.</td>
<td>Expected Duration:

140 minutes</td>
</tr>
<tr>
<td>Phenomena: The teacher should obtain some type of glow in the dark toy such as stars and planets and glue onto black poster paper. These should be secretly exposed to light prior to the students entering the room. As class begins, turn off the lights.</td>
<td></td>
</tr>
</table>

	Pose the question to students: Does the wave or particle model of light best explain what you are observing?		
	Goal: Prove that their ancestor's contribution to wave-particle duality is most important in the recent success of solar panel technology	Role: Descendent of a famous scientist hoping to get rich quick	
	Audience International Council of Scientists	Situation A descendent of Huygens and Newton are looking to profit from the success of solar panels due to their great-great-great grandfather's contribution to the world of physics.	
	Product / Performance a 6 paragraph argumentative essay defending their position.		
	Directions Student will use a variety of valid resources, including charts, diagrams and data. They will complete a resource site form for all (see template) for all online articles. https://docs.google.com/document/d/1kUaoaj2V3ogvzu0AmD_vgJYAoHVCzUZDoRD0zIrJI8w/edit They will fill out a pre- write peer edit form- based on the facts pro (3) and con (1) they gather. (Collaborative activity) Students will have one peer edit their information, and fact check. Student will write final draft from peer edit and information and data gathering after doing the experiments. Final draft will be turned in to be judged based on the rubric presented to the student. Good Luck!! May the best descendent win!		

CheckBric

Student Name _____

Teacher Name _____

Learning Performance: Students will create an argument that states why the particle model of light is most useful in explaining the mechanism that results in the photoelectric effect.					**Comments**
Evidence Statements below:					
Student models photons causing electrons to be ejected from a metal via the photoelectric effect ● *Isaac Newton proposed the particle model of light* ● *Emphasis placed on the incident light wave having a minimum energy to achieve the effect* ● *Energy of ejected electrons is directly proportional to energy of incident light*	**1**	**2**	**3**	**4**	
Student argues that the wave model is not a viable model to explain the photoelectric effect ● *Light intensity alone has no impact on the photoelectric effect* ● *The energy of the incident light is transferred to the ejected electron*	**1**	**2**	**3**	**4**	
Student connects the photoelectric effect to the functionality of solar cells. ● *The energy from the ejected electrons is captured to transform solar energy into electrical energy*	**1**	**2**	**3**	**4**	
LP Total:					
Learning Performance: Students will create an argument that states why the wave model of light is most useful in explaining the mechanism sunlight uses to travel to Earth through the vacuum of space.					**Comments**
Evidence Statements here:					
Student provides evidence that the regeneration of the electric and magnetic fields of a light wave that enables its propagation through space ● *Evidence could include but not limited to data from the single and double slit experiments* ● *Christiaan Huygens proposed the wave model of light* ● *It's the vibration of electric charge that propagates the wave*	**1**	**2**	**3**	**4**	
Student connects the wavelike nature of light to the functionality of solar cells. ● *Sunlight would never reach the solar panel if it did not have a wavelike nature*	**1**	**2**	**3**	**4**	
LP Total:					
Checkbric Total					

4 Exemplary	Work at this level is of exceptional quality. It is both thorough and accurate. It exceeds the standard. It shows a sophisticated application of knowledge and skills.
3 Proficient	Work at this level meets the standard. It is acceptable work that demonstrates application of essential knowledge and skills. Minor errors or omissions do not detract from the overall quality.
2 Developing	Work at this level does not meet the standard. It shows basic, but inconsistent application of knowledge and skills. Minor errors or omissions detract from the overall quality. Your work needs further development.
1 Emerging	Work at this level shows a partial application of knowledge and skills. It is superficial (lacks depth), fragmented or incomplete and needs considerable development. Your work contains errors or omissions.

Item Production Information

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http://hyperphysics.phy-astr.gsu.edu/hbase/mod1.html

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