Bell Ringer: Light Intensity vs. Distance – ID: 13672

Time required
15 minutes

Topic: Light

- *Describe the relationship between light intensity and distance from the light source.*

Activity Overview

In this activity, students will derive the equation relating the intensity of light at a given point to the distance of that point from the light source.

Materials

To complete this activity, each student will require the following:

- *TI-Nspire™ technology*
- *pen or pencil*
- *blank sheet of paper*

TI-Nspire Applications

Graphs & Geometry, Notes

Teacher Preparation

Before carrying out this activity, review with students the units for power and the difference between power and energy.

- *The screenshots on pages 2–5 demonstrate expected student results. Refer to the screenshots on pages 6 and 7 for a preview of the student TI-Nspire document (.tns file). The solution .tns file contains sample responses to the questions posed in the student .tns file.*
- ***To download the student .tns file and solution .tns file, go to education.ti.com/exchange and enter "13672" in the search box.***
- *This activity is related to activity 12336: Light Intensity. If you wish, you may extend this bell-ringer activity with the longer activity. You can download the files for activity 12336 at education.ti.com/exchange.*

Classroom Management

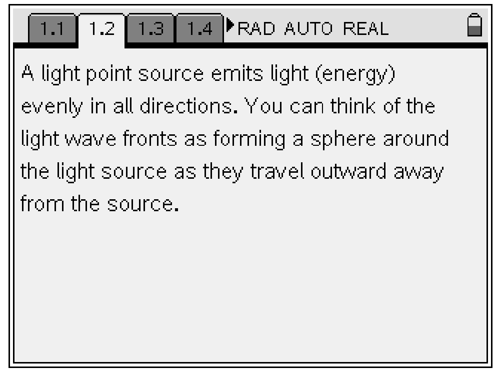
- *This activity is designed to be **teacher-led**, with students following along on their handhelds. You may use the following pages to present the material to the class and encourage discussion. Note that the majority of the ideas and concepts are presented only in **this** document, so you should make sure to cover all the material necessary for students to comprehend the concepts.*
- *If you wish, you may modify this document for use as a student instruction sheet. You may also wish to use an overhead projector and TI-Nspire computer software to demonstrate the use of the TI-Nspire to students.*
- *If students do not have sufficient time to complete the main questions, they may also be completed as homework.*
- *In some cases, these instructions are specific to those students using TI-Nspire handheld devices, but the activity can easily be done using TI-Nspire computer software.*

The following question will guide student exploration during this activity:

- What is the relationship between light intensity and the distance from a light point source?

Students will derive the equation relating light intensity to power and distance from the light source. They will use this equation to make inferences about the effects of changing distance and power on the intensity of the light.

Step 1: Students should open the file **PhysBR_week243_light_intensity.tns** and read the first two pages. They should then answer questions 1–3.



Q1. Light intensity values typically have units of power per unit area. Use this information to explain why light intensity decreases as the distance from the source increases.

A. *The power output of the light source is constant. That constant power is divided by increasing areas as one moves out from the source. As the area increases, the intensity decreases. You may wish to discuss dimensional analysis with students to help them understand how to answer this question.*

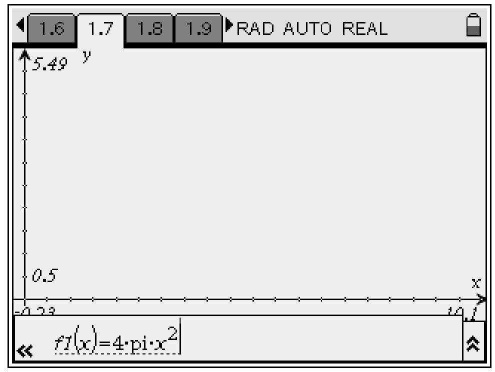
Q2. What is the equation for the surface area of a sphere? Identify the meaning of each variable in the equation.

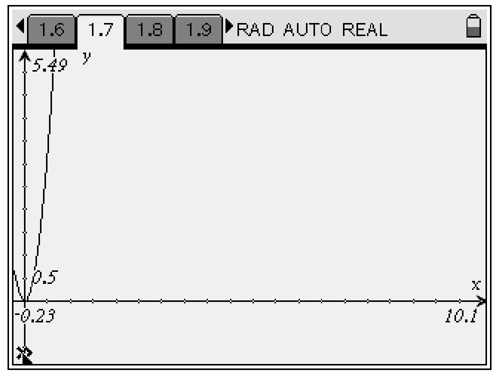
A. *The formula is $SA = 4\pi r^2$, where* SA *is surface area and* r *is radius.*

Q3. What is the equation for light intensity as a function of power and distance from the light source? Identify the meaning of each variable in the equation.

A. *The equation is* $I = \frac{P}{SA} = \frac{P}{4\pi r^2}$*, where* I *is intensity,* P *is power, and* r *is radius.*

Step 2: Next, students should read page 1.6 and then move to page 1.7, which contains an empty *Graphs & Geometry* application. Students should enter the equations they wrote for questions 2 and 3 into the function entry line on page 1.7. To show the function entry line, they should click once (press) on the double arrowhead (**>>**) at the bottom of the screen. You may need to remind students that, in this case, *x* is the variable representing distance from the source. Students must insert a multiplication sign between each term in each equation. They can simply type "pi" to insert π into an equation. They can press x^2 to insert an x^2 term. When they have finished entering an equation, they can press enter to graph the function.

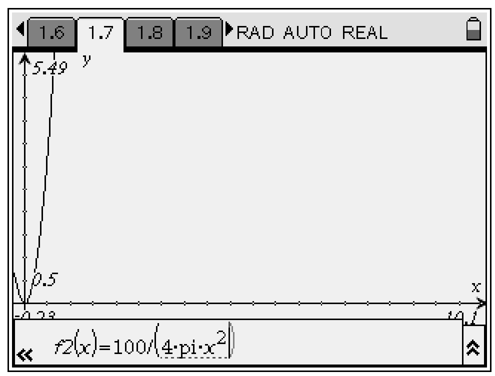


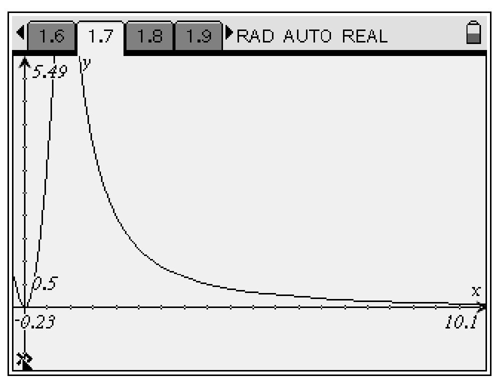


Step 3: Once students have plotted both functions, they should study the graphs. Then, they should answer questions 4–6.

Q4. Describe the shape of each curve.

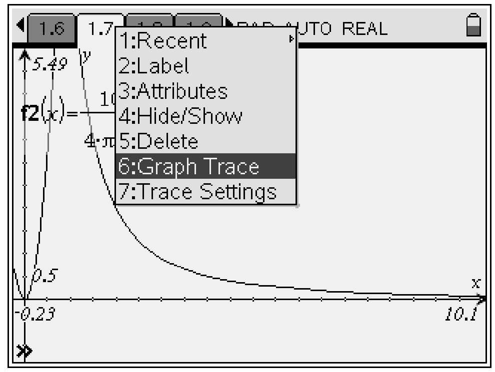
A. *The surface area curve is a parabola. The intensity curve is a hyperbola. Remind students that the* y*-coordinates of the two graphs are different. Encourage discussion of the implications of this. If you wish, you may have students insert a second* Graphs & Geometry *application by pressing* ctrl I*, and have them plot one function on each application. Alternatively, students can hide the surface area graph before plotting the volume curve. To hid a curve, students should choose the* ***Hide/Show*** *tool (**Menu > Actions > Hide/Show**). Once the tool is selected, they can click on one of the graphs to hide it.*

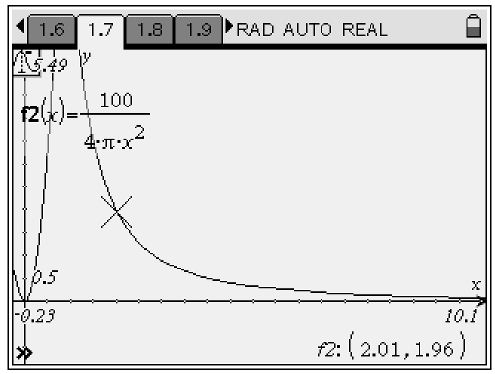


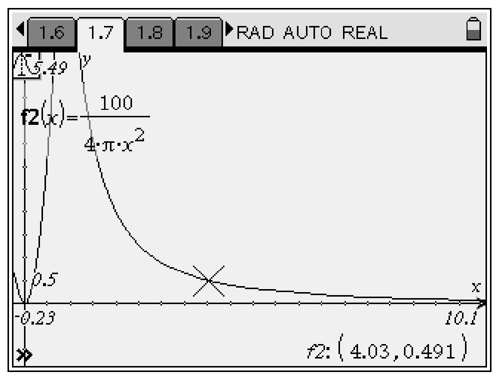


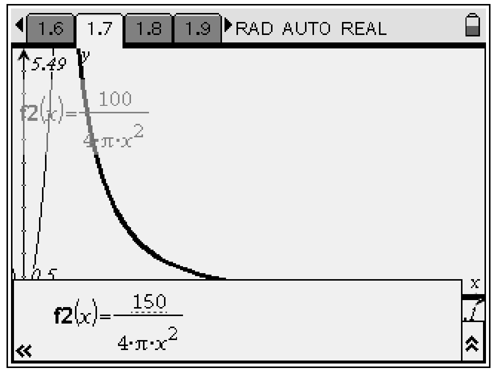
Q5. If the distance to a light source doubles, how does the light intensity change?

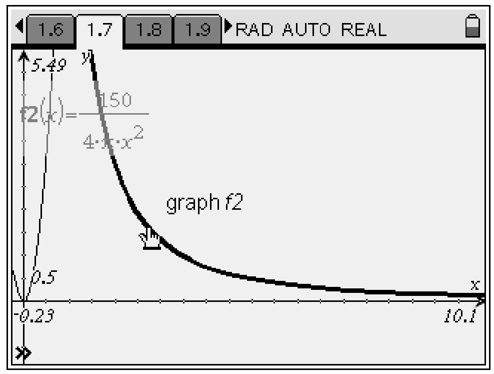
A. *When the distance to the light source doubles, the intensity decreases to one-quarter of its original value. Students can answer this question in two different ways: by studying the equation or by tracing the graph. Students can use the equation they identified in question 3 to calculate the change in power when radius doubles. They could also trace the graph of the intensity function to identify the intensity at different radius values. To trace the function, students should click once on it, and then press* ctrl menu *to show the context-sensitive menu. From that menu, they should select* ***Graph Trace****. They can then use the NavPad left and right arrow keys to move along the curve. The coordinates at each point will be displayed on the screen. Note that the increment by which the trace point moves may not allow students to choose two points that are related by an exact factor of two. If this is the case, students should account for that inaccuracy in their discussion of the answer.*











Q6. How does the shape of the light intensity curve change if the power of the light source changes? Describe how these changes would affect the perception of the light at various distances from the source.

A. *As the power of the light source increases, the hyperbola moves away from the origin. This change alters the distance at which the light would no longer be detectable (i.e., where the curve is indistinguishable from zero). As power increases, the light is detectable at larger and larger distances from the source. To answer this question, students should change the intensity equation by inputting a new power value, and then observe how the graph changes.*

Step 4: Next, students should read page 1.11, study the graph on page 1.12, and then answer questions 7 and 8.

Q7. Calculate the ratio of the light intensity at 1 m to that at 3 m, and the ratio of the light intensity at 3 m to that at 9 m. Compare the two ratios.

A. *Both ratios are approximately 1:9, as would be expected from the equation relating light intensity to distance. Students should use the* ***Graph Trace*** *function to identify the intensity values at 1 m, 3 m, and 9 m. They may not be able to hit those values exactly; they should account for that in their calculations.*

Q8. What is the power of the light source?

A. *Students should use the* ***Graph Trace*** *function to find the* x- *(distance) and* y- *(intensity) values for a specific point, and then solve the equation for power. The power of this light source is 50 W.*

Suggestions for Extension Activities: If you wish, you may have students do research to learn the approximate intensity of solar radiation at Earth's equator. They can use this information, along with data on the distance between Earth and the sun, to infer the sun's total power output. They could also calculate the intensity of solar radiation on other planets or celestial objects.

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(Student)TI-Nspire File: *PhysBR_week24_light_intensity.tns*

1.1

LIGHT INTENSITY VS. DISTANCE

Physics

Light

1.2

A light point source emits light (energy) evenly in all directions. You can think of the light wave fronts as forming a sphere around the light source as they travel outward away from the source.

1.3

1. Light intensity values typically have units of power per unit area. Use this information to explain why light intensity decreases as the distance from the source increases.

1.4

2. What is the equatino for the surface area of a sphere? Identify the meaning of each variable in the equation.

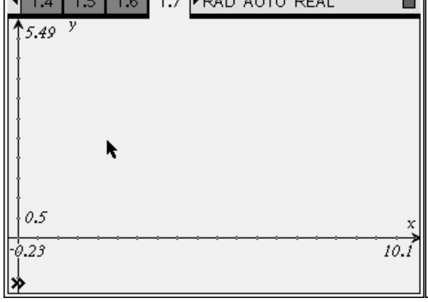
1.5

3. What is the equation for light intensity as a function of power and distance from the light source? Identify the meaning of each variable in the equation.

1.6

On the next page, make a graph of surface area vs. radius for a sphere. Then, make a graph of light intensity vs. distance from a 100-W light point source.

1.7



1.8

4. Describe the shape of each curve.

1.9

5. If the distance to a light source doubles, how does the light intensity change?

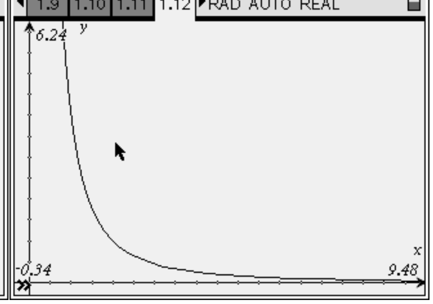
1.10

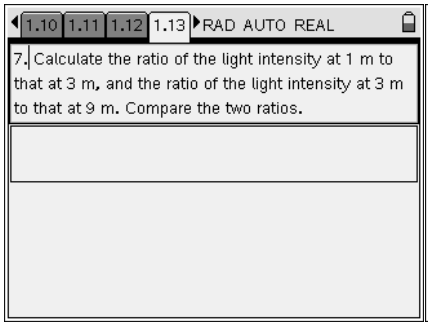
6. How does the shape of the light intensity curve change if the power of the light source changes? Describe how these changes would affect the perception of the light at various distances from the source.

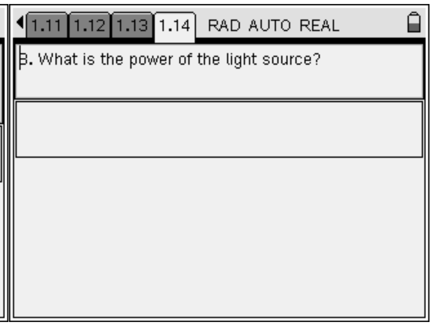
1.11

The next page shows a graph of light intensity vs. distance from a light source. Use the graph to answer questions 7 and 8.

1.12




1.10 1.11 1.12 1.13 RAD AUTO REAL
7. Calculate the ratio of the light intensity at 1 m to that at 3 m, and the ratio of the light intensity at 3 m to that at 9 m. Compare the two ratios.


1.11 1.12 1.13 1.14 RAD AUTO REAL
8. What is the power of the light source?

