Laser Interferometer Gravitational-Wave Observatory
Supported by the National Science Foundation
Operated by Caltech and MIT

LIGHT DOTS

Grade(s): Middle School

Topic: **Physical Science**

Standards:
MS-PS4-2

Objective:
Students will be able to demonstrate and explain that light travels in a straight line equally in all directions with an incandescent light, but an LED is considered a point source light.

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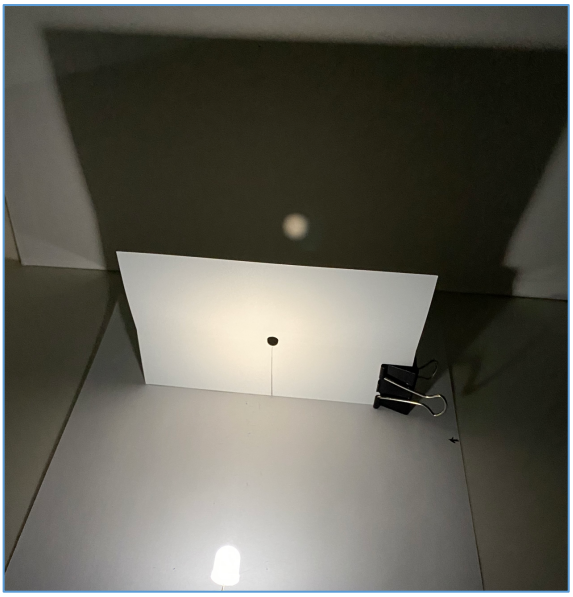
Materials:
3 - Index cards (1-hole, 2-hole, 3-hole)
Screen (white poster paper or wall)
3 - small plastic cups
3 - LED's white
1 – LED yellow
3 – 3 Volt button cells
straw
1 - binder clip
tape (masking tape works best)
hole punch

Advanced Preparation:
Punch holes in the index cards ahead of time.
Locate or create a dark room

When thinking about light, how would you describe light?

When thinking about shadows, how would you describe shadows?



Quick discussion on LED's and connecting to 3 V cells.
We will take 10 minutes for each group to organize and set up their experiment.

Activity

Part 1

Draw a picture of what you think is going on in the photo? Label as many parts of the experiment as possible.

Part 2

Use the materials provided in your packet to explore ways in which to prove these facts:

- Light travels in straight lines away from an LED light source.
- Shadows are created by an object(s) blocking light.

Breakout to explore with other teachers. 10 minutes

Have one person as the spokesperson to report findings.

Use the table to record your experiments. Use only white LED's.

Experiment and materials used. Ex: #of light sources or #of holes in the index card.	**Prediction**	**Results**	**What surprised you?**

1. What questions do you have?

2. What new things did you discover?

3. What is the maximum number of light dots?

Part 3

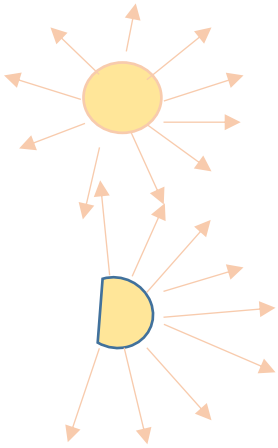
Use the yellow LED with the white LED's to support your results.

Write a statement about your results.

Underlying Science:
There are 3 parts to creating the light dots: a light source, an index card with a hole punched and a screen or background.
Light dots are created when the index card acts as an object to block most of the light from the LED. The index card reflects light except where the hole punch allows light to pass through. Some light is absorbed by the index card and some light is traveling all around the room either being reflected or absorbed by the objects in the room.
Light travels in straight lines from the light equally. In this case only the light that is traveling in a straight line towards the hole and passes through the hole creates the light dot on the screen. The location of each piece (screen, index card and/or light source) determines how large or sharp the light dot is on the screen? For example: If the index card is close to the screen the light dots will be about the same size as the hole punch and have sharp edges. Moving the index card farther away from the screen will increase the size of the light dots and these dots will be less sharp. There are other ways to increase or decrease the size of the light dots. Explore to find out those ways.

Recall experimenting with a variety of light sources and number of holes in the index card. Did you notice that more light sources and holes used created more light dots?
Was it difficult to determine which light dots come from which light sources?
Drawing ray diagrams is a great way to model how light travels. (figure-1 below)

Figure 1



Model of incandescent light rays, light travels equally in all directions.

Model of LED light rays, light travels equally in all directions except for the back side of the LED. No light is emitted from the back.

In figure 2, the ray diagrams are modeling how only some of the light can pass through the punched hole. The light source on the right will pass through to make the light dot on the left. The light source in the middle creates the brightest light dot in the middle. The light source on the left creates the light dot on the right. There are other ways to model the properties of light. Notice that in the figure all the light converges at the punched hole.
The straw can be placed near the light source and then moved so that the one end would pass through the hole.
My favorite way to model is by using a different color of LED. Photo 1

Figure 2
Index card with one hole

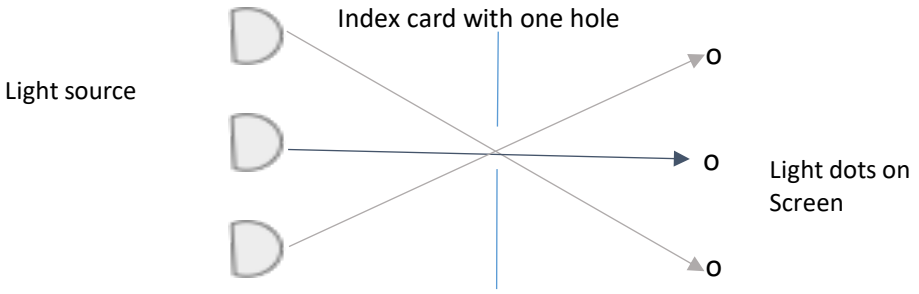


Photo 1

In this photo, the yellowish LED is on the right and an orange-red light dot is on the left. The orange –red color has to do with the mixing of light.
This is explained in Colored shadows activity found on our website.

LIGO Connection:
LIGO uses an infrared (invisible laser) and a green laser to align the mirrors in each of the beam tubes. Scientist must understand the properties of light when improving detections. Laser light will reflect, transmit, scatter and can be absorbed. Here are some examples: baffles are used to keep laser light from scattering (photo 2), reflected light is recycled back into the detector, some laser light is absorbed by the mirrors which increases thermal noise, some laser light is transmitted through the mirror.

Photo 2
LIGO team member Alena Ananyeva is seen at LIGO Livingston Observatory installing new baffles on part of the LIGO instrument that controls stray light.

Credit Matt Heintze/Caltech/MIT/LIGO Lab

Resources:

Andreou, C. and Raftopoulos, A. (2011). Lessons from the history of the concept of the ray for teaching geometric optics. *Science and Education,* 20**,** 1007-1037.

Dedes, C. and Kanstantinos, R. (2007). Teaching image formation by extended light sources: the use of a model derived from the history of science. *Research in Science Education,* 39**,** 57-73.

Safety Considerations:

Stacked cells can create heat. LED light is very bright, keep from looking directly into the light.

Sources:

Light Emitting Diode, Led Diode Assortment Kit, Diffused 2pin Round Color White/Red/Yellow/Green/Blue Kit Box (5 Colors x 100pcs)
Sold by: CESFONJER-US

LiCB CR2032 3V Lithium Battery(10-Pack)
Sold by: LiCB

4 of Gikfun 10mm LED Emitting Diodes Light Lamp Diffused F10 Round Led for Arduino (Pack of 20pcs) AE1258
Gikfun_Official_Store

Small plastic cups from Dollar Tree or Walmart

Activity developed by Kathy Holt 2020 for MISE and GNO STEM
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