



Applied STEM Challenges Activity Plan

Activity Title: It's the Mirrors

Theme: Applied Science; Reflection & Frequency

Target Audience: Grades 3 – 12

Authors: Engineers & Educators of
Ten80 Education and Texas Instruments



www.ten80education.com
www.fasttrackrc.com



www.dlp.com



Applied STEM Challenges Activity Plan

Title: It's the Mirrors

Theme / Topic: Applied Science; Reflection & Frequency

Recommended Level: 3-12

Time: Approximately 50 minutes

Assessed National Standards:

Will add once activity approved

Assessed State Standards and Additional Learning Outcomes:

Will add once activity approved

Materials:

- 6 x mirrors (approx 6 inches square)
- Stopwatches
- Light Source; Overhead Projector
- Cylinder approximately 12 inches long and 4 inches in diameter
- Thin membrane like a rubber or neoprene glove
- Mylar surface; a reflective surface approximately 4 inches on each side
- Tape and/or glue

Vocabulary

Semiconductor: A material that is typically crystalline which allows current to flow only under certain circumstances. Common semiconductors are silicon, germanium, and gallium arsenide. Semiconductors are used to make electronic components like transistors.

Reflection: Reflection occurs when light changes direction as a result of "bouncing off" a surface like a mirror.

Frequency: The rate at which a repeating event occurs, such as the full cycle of a wave. Frequencies are usually measured in hertz which is equal to one cycle per second.

Activity Introduction & Connections

As the story goes...In 213 AD, the Greek scientist Ioannis Sakas organized sixty soldiers to defend their homeland. Each held a large mirror and aimed it so that reflected sunlight hit the invading boats 50 meters away. Within three minutes, the boats were in flames.

One of the enduring stories of antiquity is that Archimedes constructed a "burning mirror" to defend the city of Syracuse from Roman naval invasion. If such a device ever existed it was most likely a large collection of mirrors that reflected sunlight.

There are several reprints circulating on the internet about this attempt at demonstrating that Archimedes could have built such a device.

The mirrors would likely have been the polished metal shields of hundreds if not thousands of soldiers. Literally an army of soldiers would have learned to reflect the sun off their shields onto a moving target; their movements coordinated precisely in time. It is theoretically plausible that Archimedes created his burning mirror but the logistics of making it work are rather daunting.

On the other hand, with modern electronics (semiconductors) the theory becomes entirely practical. Hundreds of microscopic mirrors can fit in the dot of an "i" (as in the word 'idea'). Combined with electronic switches, you can turn those mirrors thousands of times in one second.

Now you can ask the question, "Why would you want to do that?" Well, just like Archimedes' army, controlling the movement of light can come in handy. In fact, these turning, microscopic mirrors are the core of a technology that many of you use every day! The images from high quality televisions and projectors made with a DLP[®] chip use millions of tiny mirrors to either reflect through the lens (to the screen) or absorb various colors of light. It the mirrors.

Activity Procedure, Part 1: Reflections

Illustrate the reflection technology with a light source and an array of mirrors. Use an overhead projector as your light source. Use six mirrors that are each approximately 6 inches on each side. In place of complicated electronic switches, students will become manual controls.

1. Break into teams of nine students each.
2. One team at a time, students stand in front of the overhead projector in a 3x3 pattern. That is three rows of three students each. Each student should hold a mirror.
3. Challenge each team of students to reflect the light that hits each mirror onto the same object; that will be nine points of light hitting a single object.
4. Next, challenge each team of students to reflect the light that hits each mirror onto a wall so that together, the reflections form a letter or number.
5. Next, challenge teams to make another letter or number then switch back to their first letter/number. Test skills and team coordination with a competition. Choose a sequence of numbers or a word; each team will create the same images. Challenge teams to spell out the numbers or word as fast and as accurately as possible.
 - a. Measure the time each team takes using stopwatches.
 - b. Judge the quality of their images with a number 1-5 (1 is best and 5 is worst).
 - c. The final score is the teams' time in seconds multiplied by their quality score

$$\text{Team Score} = (\text{Time in seconds})(\text{Quality Score})$$

Make a table on the board to log the times, quality ratings and scores for each team.

	Total Time (Seconds)	Quality Score (1 to 5)	Team Score (Quality x Total Time)
Team 1			
Team 2			

Complete this part of the activity by discussing the enormous advantage of electronic switching, coordinated by a single computer with micro-second input-out rates. Compare this electronic controls to that of students.

Activity Procedure, Part 2: Frequency

Demonstrate the frequency of mirror vibration.

1. Make a laser reflector.
 - a. Stretch a rubber glove over the end of a cylinder that is 4 inches in diameter (4 inches across its widest part) and about 12 inches long. You can use a pipe, paper towel roll or any other open ended cylinder.
 - b. Glue a small piece of Mylar reflective film (approximately 1" square) to the top of the stretched glove.
 - c. Point a laser pointer at the Mylar film; keep it at a low incident angle (that is, the beam is almost parallel to the drum head). Move your device around so that the reflected laser beam hits a wall, some distance from the device. Secure the device with tape so that the movement you see is from vibrations, not from shaky hands.
2. Make a moving image (albeit a pretty simple one). Use a pad of paper or something like it to clap the open end of the pipe. Though you aren't hitting them directly, the beating will vibrate the glove on the other end of your cylinder, the Mylar film and therefore the reflected beam.
3. Talk about frequency (how often the laser moves in one complete cycle; there and back). Show that one cycle is completed when the reflected laser moves from one extreme to the other and back. One cycle per second is called a hertz.

Your reflected laser probably moves between 5 and 30 times in every one second; that is between 5 and 30 hertz. If the movement from one letter or number to another is one cycle, what was the frequency of your student projectors from the previous activity?

Grade3: How many seconds did it take to cycle on your team? Was it always the same?

Grades 4 – 7: What was the frequency of your team images? Was it always the same? What was your average frequency?

[1] Frequency = (1 cycle) ÷ (the number of seconds it took to cycle)

[2] Average Frequency = (sum of the frequencies from each trial) ÷ (the number of trials)

Grades 8 – 12: What was the frequency of your team images? Was it always the same? What was your average frequency?

[3] Frequency in hertz = $\frac{1 \text{ cycle}}{x \text{ seconds}}$;

where x = the number of seconds it took to cycle from one image to another.

Without a lot of practice, the frequencies will be less than one hertz for student projectors (cycles per second). Think of how slow the image was to change; this low number reflects that.

Imagine on the other hand how fast projectors with a DLP[®] chip cycle to give you the clear and detailed images you see. They can cycle the image from one to the next image thousands of times in one second; that's 1000 times faster than typical LCD (Liquid Crystal Display) screens. Your student projector was less than one hertz while the DLP[®] driven projectors are thousands of hertz. That is so fast that the human eye can't see them moving. This ultra-fast movement of the mirrors ensures the image they create is extremely sharp, crisp.