

LIGHT BENDING 101

**STEM²D Topic:
SCIENCE**

**Target Population:
Students, ages 11-14**

Light Bending 101 is part
of the **STEM²D Student Activities Series**.

Developed by FHI 360 and JA Worldwide
as part of Johnson & Johnson's WiSTEM²D
initiative (**W**inning in **S**cience, **T**echnology,
Engineering, **M**athematics, **M**anufacturing,
and **D**esign). The series features interactive
and fun, hands-on activities for youth, ages
12–18, globally.



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ACTIVITY DESCRIPTION

In this Ignite STEM²D activity, students will apply their science knowledge and use critical thinking and problem-solving skills to explore how light behaves moving through different mediums.

ESTIMATED TIME



This activity is intended to be done at a career fair, science fair, exhibit, or other type of “booth” event. It typically takes **5-10 minutes** to complete.

STUDENT DISCOVERIES

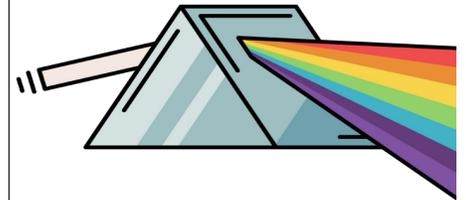
Students will:

- Apply their knowledge of science and physics to solve a problem.
- Build important STEM²D skills, such as communication and critical thinking.
- Have fun experiencing STEM²D.
- Be inspired to participate in other types of STEM²D experiences.

GETTING READY

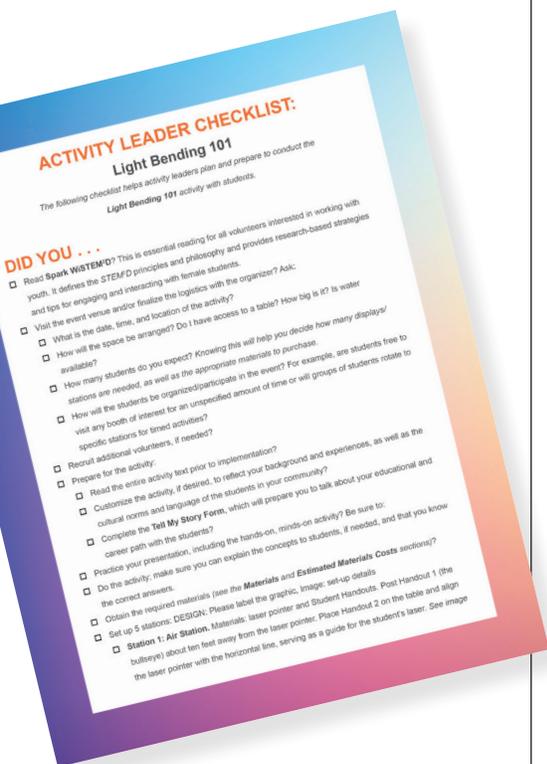
Materials

- Activity Leader Checklist
- Tell My Story Form, *optional*
- Student Handout, *5 copies*
- 4 (minimum) transparent objects at least 1/4” thick, such as:
 - Glass
 - Plexiglass
 - Plastic
 - Gelatin



STEM²D Skills

- Communication
- Creative Thinking
- Critical Thinking
- Drawing Conclusions
- Problem Solving



- Glass or clear plastic dish filled with water
- 5 laser pointers
- 5 protractors
- STEM²D brochures, flyers, or other informational materials, *optional*

Estimated Materials Cost:

Activity leaders can expect to incur less than \$70 in materials costs when conducting this activity with large groups of students. This cost includes 5 laser pointers; cost goes down sharply if these can be sourced from the local operating company or volunteers.

Activity Leader Preparation

- Read **Spark WiSTEM²D**. This is essential reading for all volunteers interested in working with youth. It defines the STEM²D principles and philosophy and provides research-based strategies and tips for engaging and interacting with students. Download at www.STEM2D.org.
- See the **STEM²D Student Activities Overview** for additional information.
- Review the **Light Bending 101 Activity Leader Checklist** (at the end of this document) for details and specific steps for planning, preparing, and implementing this activity.
- Set up the “Light Bending 101” display. See the Activity Leader Checklist for more information.

STEP-BY-STEP INSTRUCTIONS: Light Bending 101

1. Welcome & Introductions (1 minute)

- Welcome the students as they arrive at the table/booth.
- Introduce yourself by saying your name, title, and your organization/company.

2. Learning Activity: Refracting Light (3-4 minutes)

- Indicate that there are five stations.
- Tell students that the goal at each station is to hit the bullseye with the laser pointer. In Stations 2-5, the laser must travel through a transparent object to hit the bullseye.
- After the students have moved through the stations, initiate a

discussion and brainstorming activity about the behavior of the lasers.

- Ask:
 - Why do you think one laser moves in a straight line, but the others don't?
 - Why do you think some laser stations are less accurate than the others?
- Gauge the students' knowledge by having the students talk about what they already know. If time allows, try asking:
 - Have you ever heard the word refraction (i.e. light is deflected when passing through an object of varying density)?
 - Have you ever looked at items underwater? How does this exercise remind you of that?
 - What do you know about how fast light travels? Have you heard about the speed of light?
- Explain: the speed of light varies as the light (in this case the laser) moves through the different objects. This means that, as the light enters the object at an angle (the **angle of incidence**), the light slows down, creating a bending effect. The larger the bending effect, the slower light is travelling through the medium. The angle at which the light is bent as it hits the medium is the **angle of refraction**.
- Depending on time/level of students, you can tell them about **Snell's Law**, a formula for figuring out the new speed of light.

Snell's Law is:

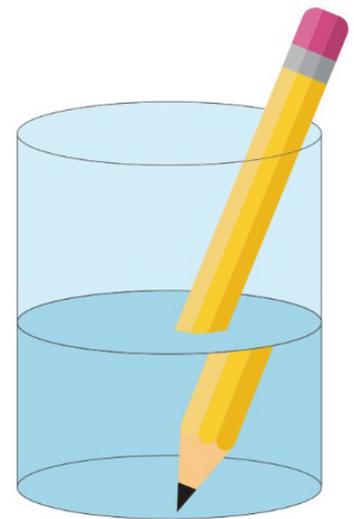
$$\frac{\sin\theta_1}{\sin\theta_2} = \frac{v_1}{v_2}$$

Where $\sin\theta_1$ is the angle of incidence (in this case, 45 degrees since you turned the medium 45 degrees) and $\sin\theta_2$ is the angle of refraction. You will need to calculate the angle of refraction. Speed of light in air (v_1) is about 299,792 kilometers per second. Students should use the protractors you brought to measure the angle of refraction; simply have them fire the laser along the line on the piece of paper, and measure the angle with the protractor. So, the equation should look like this:

$$\sin(45)/\sin(\text{measured angle}) = 299,792/x$$

KEY WORD

- STEM²D
- Refraction
- Speed of light
- Angle of Incidence
- Angle of Refraction
- Snell's Law



The way we see a pencil in a glass of water is an example of refraction.



Pickles are usually sold in circular glass jars filled with vinegar. As a result, the pickles in the jar appear bigger than they really are.

3. Student Reflection (1-2 Minutes)

- Ask students to reflect on the activity. Have them spend a few minutes thinking about the following questions: Give students some examples of refraction in everyday life, and remind them that this is due to light physically slowing down as it enters different mediums. Examples include:
 - Pickles are usually sold in circular glass jars filled with vinegar. As a result, the pickles in the jar appear bigger than they really are.
 - In scuba diving classes, instructors warn their students that the objects they see underwater seem 25% larger than actual size.
 - At sunset, just when the sun has almost disappeared from view, it is actually below the horizon. It appears to be higher in the sky than it really is.
 - Your glasses and contact lenses alter the path of light to compensate for defects in your vision.
 - Stars twinkle because their light is refracted in the Earth's atmosphere; they twinkle as the gasses that comprise our atmosphere shift in the light's path. Refraction is often used in astrophysics to calculate where things are.
- Tell students that the study of light and lasers is part of Physics; encourage them to continue studying science if they're interested in this display.
- Thank students for joining you today and encourage them to continue exploring STEM²D.

Key Words

Refraction: The fact of phenomenon of light, radio waves, etc., being deflected in passing obliquely through the interface between one medium and another or through a medium of varying density.

Speed of light: Constant, finite speed at which light moves; the speed varies based on the medium through which the light travels.

Angle of incidence: The angle at which light enters a medium.

Angle of refraction: The angle at which light is "bent" by a medium.

Snell's Law: A mathematical formula with which you can calculate the speed of light, based on the angles of incidence and refraction.

STEM²D: The acronym used for the disciplines of science, technology, engineering, mathematics, manufacturing, and design.

Activity Leader Reflection

After the activity, take a few moments to reflect on the following:

- What went well and what could be improved? What would you do differently next time?
- How comfortable did you feel talking about the broader applications of this exercise on refraction?
- Do you have a better understanding of STEM²D concepts?
- How useful was the information presented in Spark WiSTEM²D to implementing this activity?
- Will you volunteer for this type of experience again?

Resources and References

Activity concepts and real-life connections adapted from:

“Science Project: How Fast Does Light Travel in Water vs. Air?

Refraction Experiment,” Education.com. Accessed 6 November 2017.

<https://www.education.com/science-fair/article/refraction-fast-lighttravel-air/>

Deborah Byrd. “Why stars twinkle, but planets don’t,” EarthSky.

Accessed 6 November 2017. <http://earthsky.org/space/why-dontplanets-twinkle-as-stars-do>

“Examples of Refraction in Our Everyday Life,” ScienceNews.

Accessed 6 November 2017. <http://taylorsciencegeeks.weebly.com/blog/examples-of-refraction-in-our-everyday-life>

In scuba diving classes, instructors warn their students that the objects they see underwater seem 25% larger than actual size.



ACTIVITY LEADER CHECKLIST:

Light Bending 101

The following checklist helps activity leaders plan and prepare to conduct the

Light Bending 101 activity with students.

DID YOU . . .

- Read **Spark WiSTEM²D**? *This is essential reading for all volunteers interested in working with youth. It defines the STEM²D principles and philosophy and provides research-based strategies and tips for engaging and interacting with students. Download at www.STEM2D.org.*
- Visit the event venue and/or finalize the logistics with the organizer? Ask:
 - What is the date, time, and location of the event?
 - How will the room be arranged? Do I have access to a table? How big is it?
 - How many students do you expect? How will the students be organized/participate in the event? For example, are students free to visit any booth of interest for an unspecified amount of time or will groups of students rotate to specific stations for timed activities? *Knowing this will help you decide how many demonstrations to run, as well as the appropriate materials to purchase.*
- Recruit additional volunteers, if needed?
- Prepare for the activity? Did you:
 - Read the entire activity text prior to implementation?
 - Customize the activity, if desired, to reflect your background and experiences, as well as the cultural norms and language of the students in your community?
 - Complete the **Tell My Story Form**, which will prepare you to talk about your educational and career path with the students?
- Obtain the required materials? (See the Materials and Estimated Materials Costs sections.)
- Practice your presentation? Did you:
 - Do the activity? *Make sure you can explain the concepts to students, if needed, and that you know the correct answers. See the Step-by-Step Instructions for more information.*
- Set up the site appropriately for the activity? Did you:
 - Line table(s) with the tablecloth to contain spills and ease cleanup?
 - Make sure the table(s) and materials are arranged to quickly accommodate each new demonstration?
- Bring a camera, if desired, to take photographs?
- Obtain and collect permission slips and photo release forms for conducting the activity if applicable?
- Have fun!**

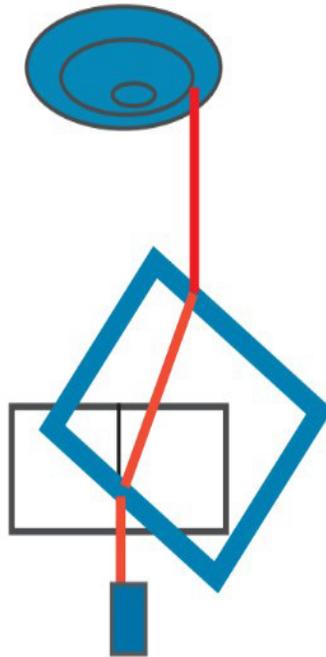
ACTIVITY LEADER CHECKLIST CONTINUED:

Light Bending 101

SET-UP DETAILS:

- Set up five stations:
 - Station 1: Air Station. Materials: laser pointer and Student Handouts. Post Handout 1 (the bullseye) about ten feet away from the laser pointer. Place Handout 2 on the table and align the laser pointer with the horizontal line, serving as a guide for the student's laser. *Note: the goal is to hit the bullseye with the laser pointer; in this station, there is nothing between the laser pointer and the bullseye.*
 - Stations 2-5: Materials for each station: 1 laser pointer, 1 copy of the Student Handouts, and 1 transparent object. Post Handout 1 (the bullseye) about ten feet away from the laser pointer. Place Handout 2 on the table and align the laser pointer with the horizontal line, serving as a guide for the student's laser. Place the transparent object at a 45-degree angle from the line on Handout 2. See image for set-up details. *Note: the goal is to hit the bullseye with the laser pointer. In these stations, the laser must travel through the transparent object to hit the bullseye; encourage students to notice the refraction is different for each station. The straight line under the angled medium should act as a reference for the bend of the laser.*

Set-up Details for
Stations 2-5



Tell My Story Form

This form will help activity leaders and other volunteers prepare to talk about their STEM²D interests, education, and career path.

ABOUT YOU

Name: _____

Job Title: _____

Company: _____

When/Why did you become interested in STEM²D? _____

What do you hope young people will get out of this activity? _____

FUN FACT:

Share a little about your background. Ideas:

- Share a memory from childhood when you first had your “spark” or “interest” in STEM.
- Detail your journey, highlighting what you have tried, what you learned, steps to success, etc.
- Failures or set backs are also great to talk about—difficulties, and/or challenges, and how you overcame them.

EDUCATION AND CAREER PATH

What classes/courses did you take in secondary school and in college that helped or interested you most? _____

How did you know you wanted to pursue a STEM²D career? _____

What was your postsecondary path, including the institution you attended and your degree? *If you switched disciplines, make sure you explain why.* _____

What your current position entails. *Be sure to include how you use STEM²D during a typical work day.* _____

Light Bending 101

Student Handouts

Handout 1



Light Bending 101

Student Handouts

Handout 2



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