WS2
WOMEN SUPPORTING
WOMEN IN THE SCIENCES

Training for Educators
Light & Color

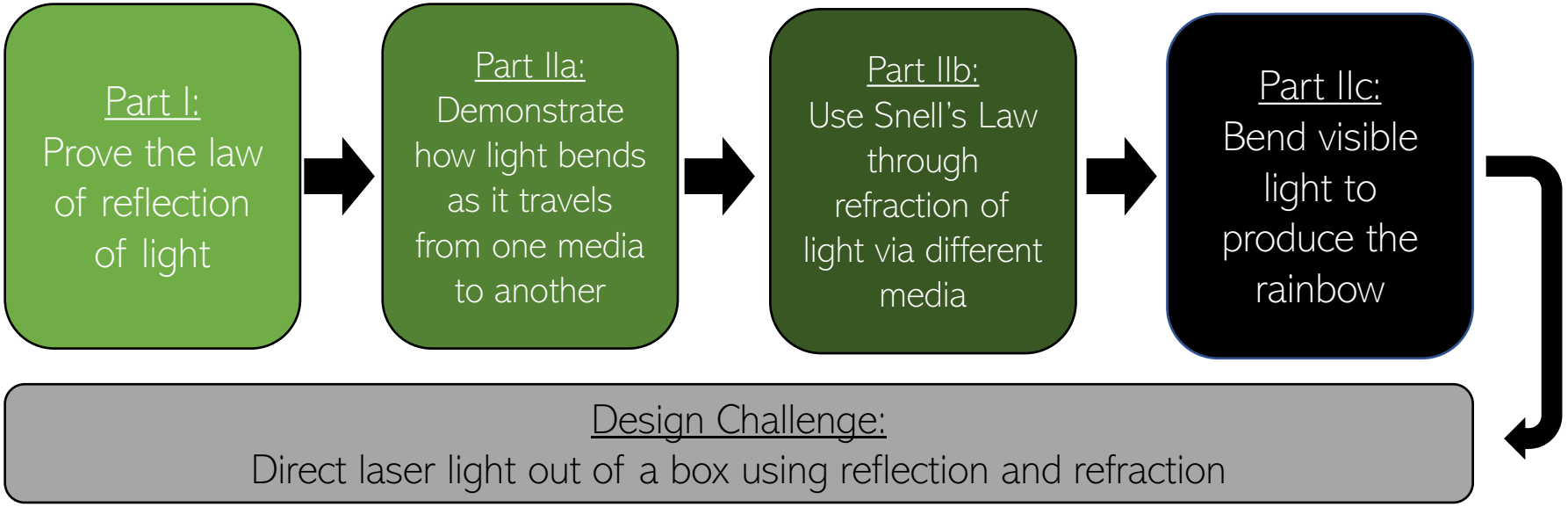
Secondary Level

Ages 12-18

Mission of the lab

- This laboratory describes how light behaves when it encounters matter, specifically how light bounces off the matter (reflection) and how light bends after passing through matter (refraction).
- The main takeaways are:
  - Reflection is when a ray of light bounces off of a surface, and refraction is when a ray of light is bent as it changes speed and moves from one medium through another medium.
  - The law of reflection states that the angle of the reflected light ray is equal to the angle of the incident light ray.
  - Snell's law relates the refractive indices of two materials and incident angles of light hitting the interface between these two materials.
  - White light contains the colors of the rainbow, and using a prism and the principles of refraction, these colors can be viewed.

Summary of experiments



There are 4 experiments in total.

Supplies list

- Clear drinking glasses/glass jars
- Square glass/plastic container
- Cardboard
- Laser pointer (Class 2 or lower)
- Light source (e.g., sunlight, lamp)
- Paper (lined or unlined)
- Pencils
- Plane mirror with stand (could be heavy book or board)
- Protractor
- Water
- Sugar (alternative: canola or other oil)
- Scissors
- Tape
- Prism (optional)

Safety considerations

Before the students begin the laboratory, please take into consideration the following safety concerns:

- Students should never look directly at the Sun. This can permanently damage their eyes. If you are using the Sun as a light source, have the students look at a sunny spot on the ground or at the horizon away from the direction of the Sun.
- Students should never look directly at a laser point, as this can also permanently damage their eyes due to the laser intensity and emission as a tight beam.

Setting up your space

- Gather your supplies and separate by experiment(s) on your table.
- These are our recommendations:
  - Each student should have a pencil or pen.

<u>Groups of 2-4 students can be given the following supplies:</u>

- Laser pointer (if needed, the class can share these supplies)
- Plane mirror with stand/book (if needed, the class can share these supplies)
- Protractor
- Paper (approximately 3-4 pieces)
- Empty glass (round)
- Square plastic or glass container (reduced curvature)
- Cardboard (approximately 0.5x0.5 m)
- Pencil

<u>The class can share the following supplies:</u>

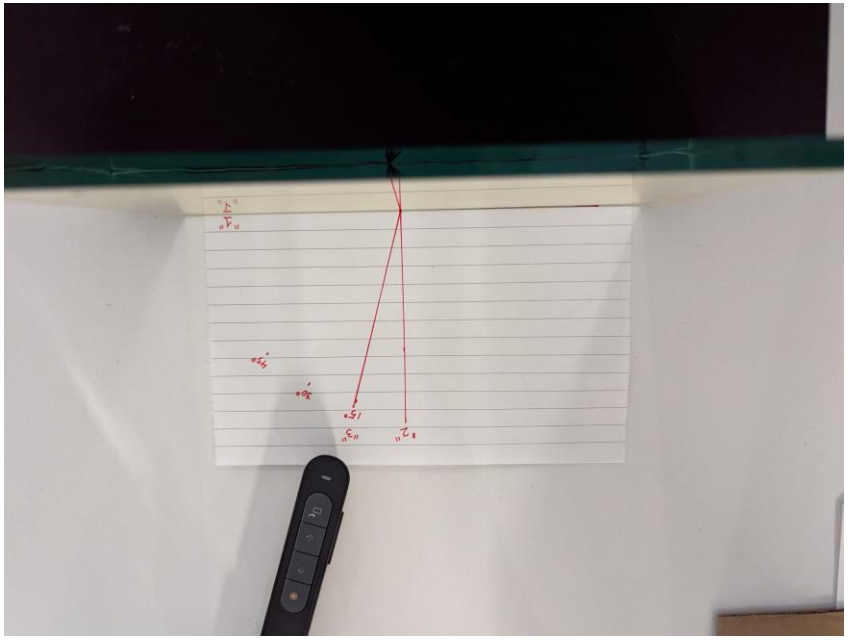
- Water (needed for Parts IIa, IIb, IIc) – does not need to be potable, but should be clear
- Sugar (approximately 50-100 g (1/4-1/2 c) per group)
- Scissors
- Tape

Part I. Light and Reflection

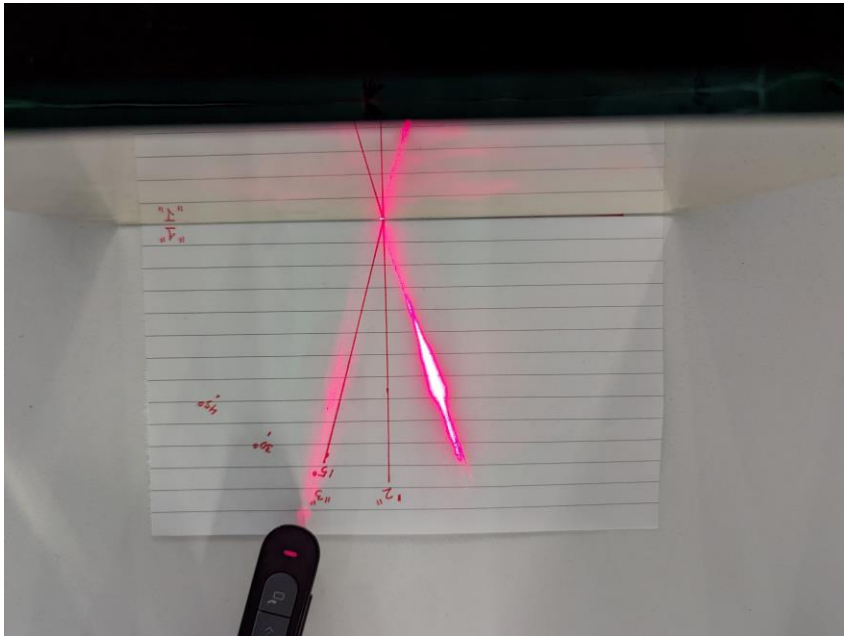
- Set-up:
  - Each group (2-4 students) will need a laser pointer, plane mirror with stand/book, protractor, and paper.
- Procedure:
  - Students will shine an incident ray on a plane mirror and measure the angle of reflection.
- Results:
  - Students should see that the angle of incidence and reflection are the same, which is the law of reflection.

The takeaway is that the angle of incidence of a light ray is equal to the angle of reflection if the incident surface is smooth and shiny like a mirror.

Part I. Light and Reflection Set-Up and Results



Set-up of experiment



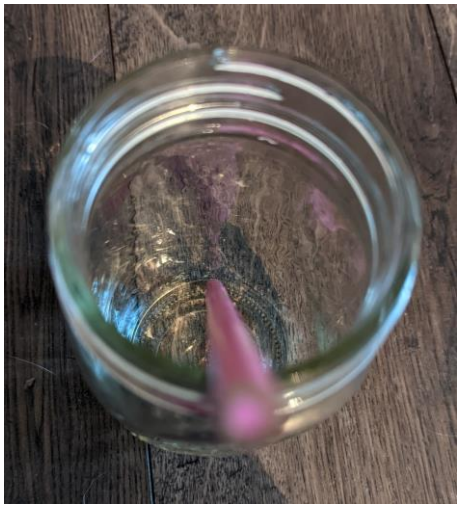
Reflection off of plane mirror

Part IIa. Light and Refraction

- Set-up:
  - Each group (2-4 students) will need an empty glass, pencil, and water.
- Procedure:
  - Students will observe a pencil in a glass before adding water to the glass and observing the pencil again.
- Results:
  - Students should see that the pencil in the water appears bent and perhaps broken, as opposed to the pencil in the empty glass which appears unchanged.

The takeaway is that students should understand that the bending of light as it passes between media makes the pencil appear bent or broken to their eye.

Part IIa. Light and Refraction –Results



No water in glass

Water in glass

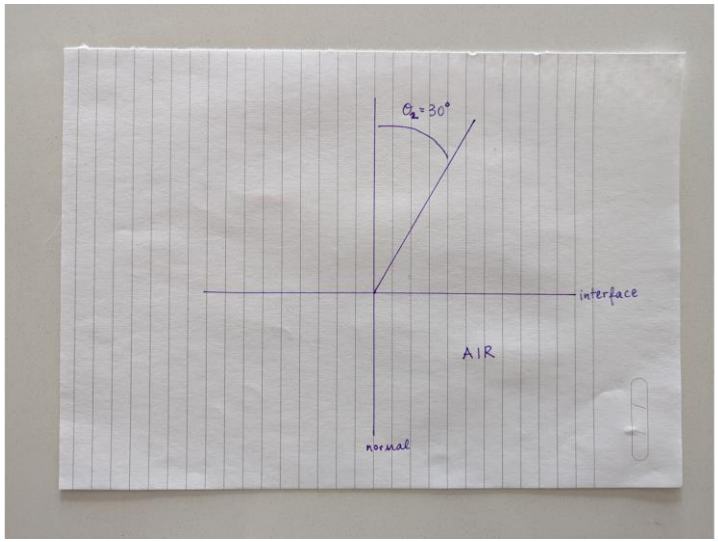
Part IIb: Snell's Law

- Set-up:
  - Each group (2-4 students) will need a laser pointer, laser mount (cardboard pieces/thin book), tape, protractor, paper, square plastic/glass container, water, and sugar.
- Procedure:
  - Students will measure the angle of incidence with a fixed angle of refraction through glass/air and glass/sugar-water (you can alternatively use canola or anther oil).
- Results
  - Students should note that the addition of sugar-water to the container causes the angle of incidence to change due to refraction of the laser. Students can then calculate the refractive index of the sugar-water using Snell's Law (~1.3-1.4)

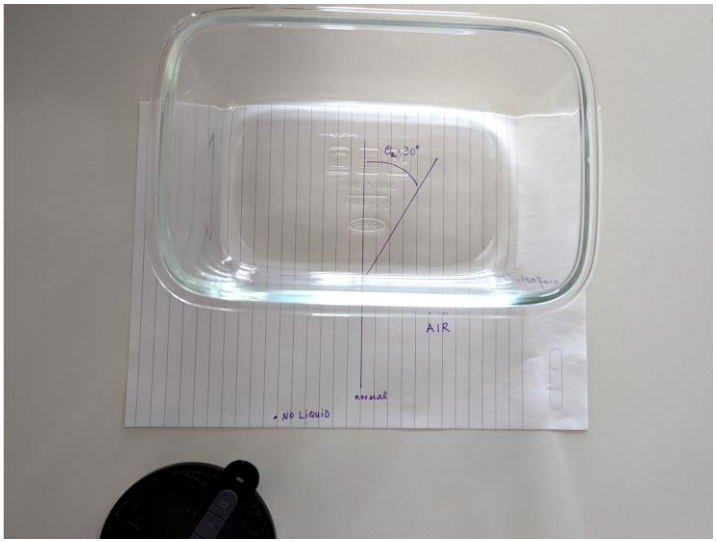
The takeaway is that the relationship between incident and refracted angles yields information about the refractive indices of the two media. The larger the refractive index of a material, the slower the light travels in that medium.

Part IIb: Snell's Law – Set-Up

Supplies

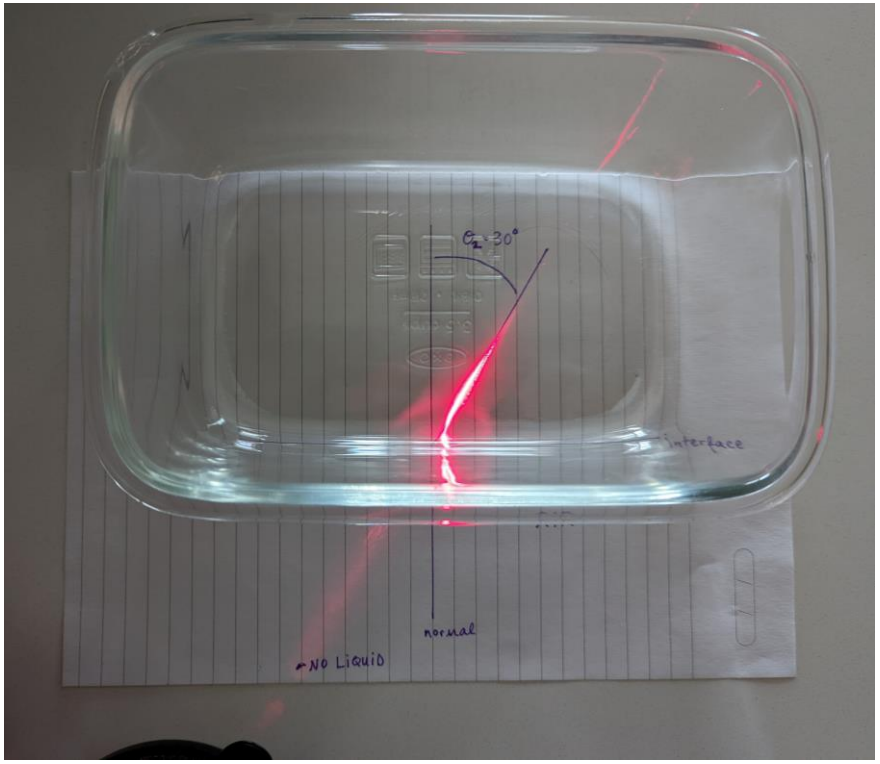


Prepared paper with angles

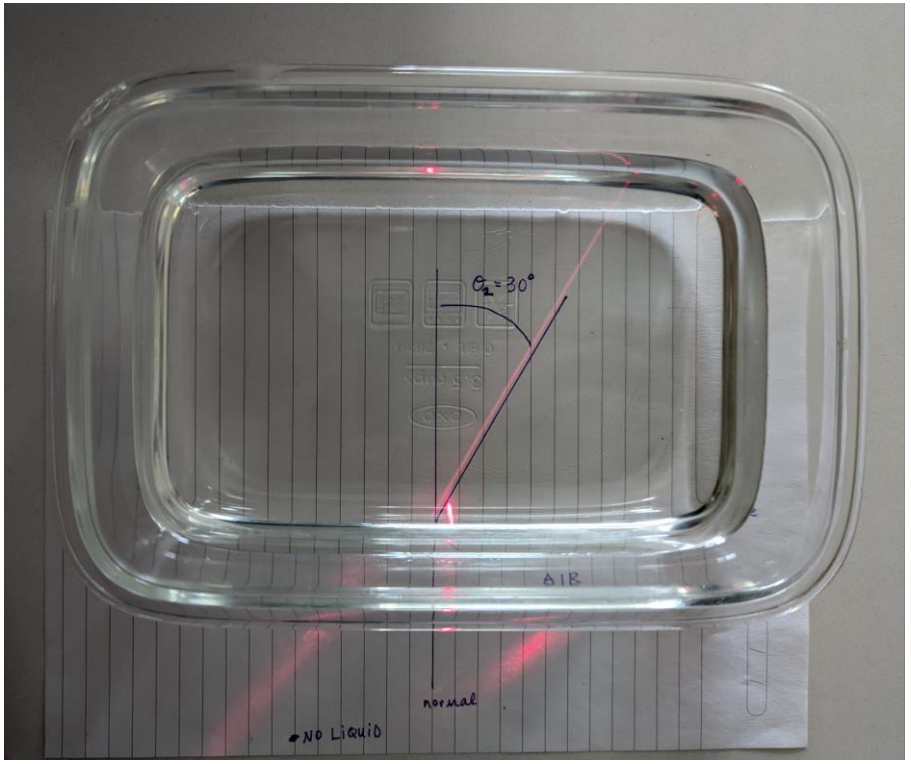


Set-up with container

Part IIb: Snell's Law – Results



No liquid in container



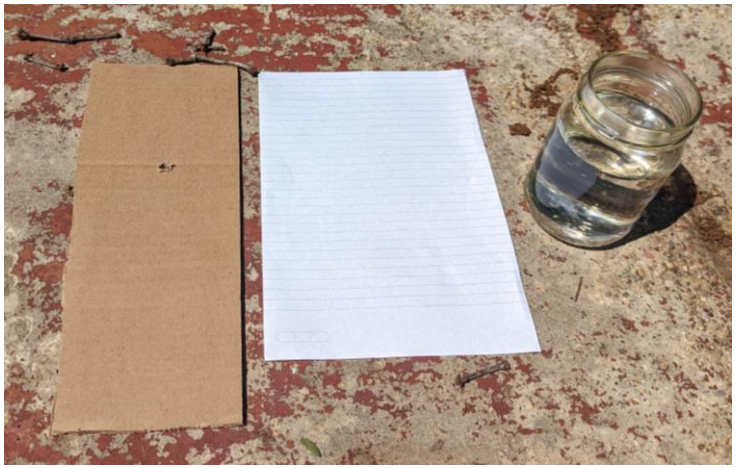
Sugar-water in container

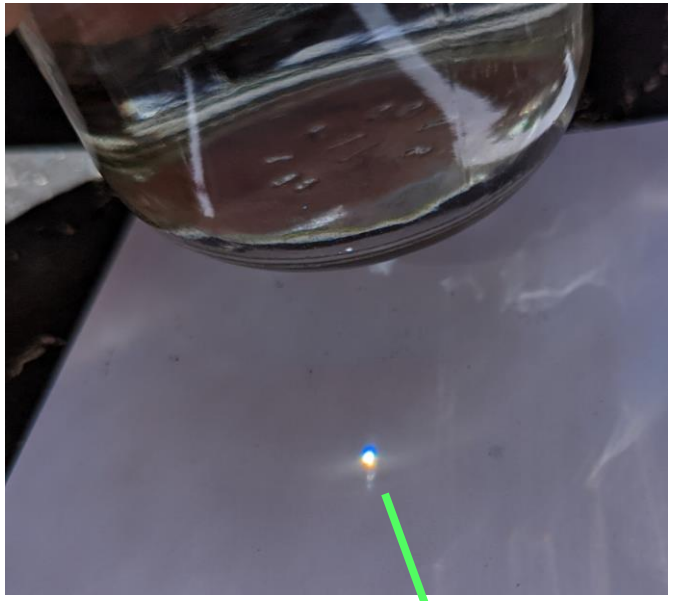
Part IIc: Light and the Rainbow

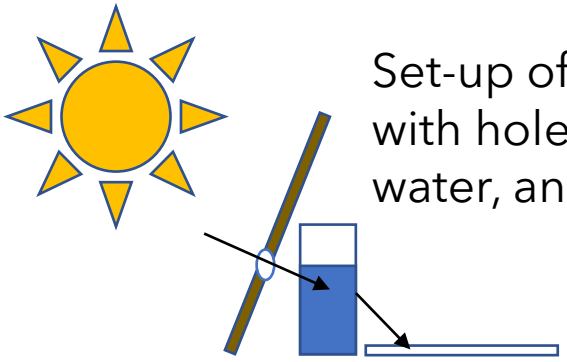
- Set-up:
  - Each group (2-4 students) will need 1 piece of cardboard, scissors, 1 clear glass-half filled with water, and paper.
- Procedure:
  - Students will use the glass with water as a prism (placing it behind the cardboard with a small hole for sunlight to pass through) to disperse sunlight into the colors of the rainbow.
- Results
  - Students should see that the glass with water acts as a prism and refracts the sunlight which allows us to see the colors of the rainbow.

The takeaway is sunlight or white light is composed of the colors of the rainbow and refraction of the sunlight through a prism or glass of water allows us to see this.

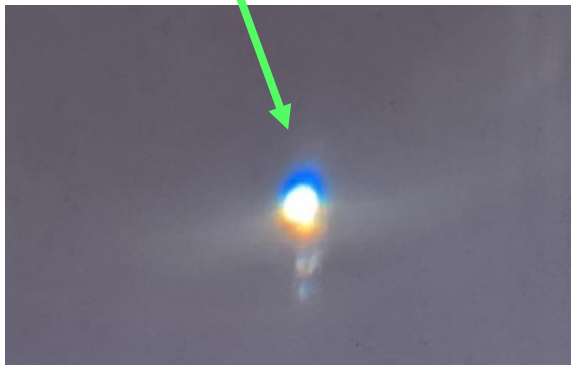
Part IIc: Light and the Rainbow – Set-Up and Results







Set-up of cardboard with hole, glass with water, and paper



Design challenge

Students are asked to imagine they are given a box with two holes in it. A laser is pointed through one hole and students will need to design two scenarios that move the light out of the other hole in the box. In the first scenario, students are asked to use only mirrors to direct the light, and in the second scenario, students are asked to use both mirrors and prisms.

- Questions to ask the students
  - What concepts of reflection and refraction did you use in your designs?
  - Did you try several methods to complete these challenges? Which had the most success and why?
  - What was challenging about completing these designs?

Troubleshooting – Laser Pointers

- If you do not have access to a laser pointer for Part I and IIb, you can use a torch or cell phone light, but likely you will need to collimate it with a piece of cardboard and a small hole (i.e., place the cardboard with small hole between the light source and the mirror to create a parallel beam of light).
- If you do not have enough laser pointers for each group, consider sharing the laser pointers and have other groups not using laser pointers work on other parts of the lab kit.

Troubleshooting – Experiments

- In Part I, be sure the plane mirror is flipped so that the mirror side is facing the light, not the glass side. Try to keep the mirror as upright as possible.
- In Part IIb, stabilizing the laser pointer on a base will help. Students may need to view the entry of the laser pointer into the container from above to make sure it appears aligned. As you move from the empty container to the filled container, not moving any part of the set-up will reduce errors.
- In Part IIc, choose a sunny day when the Sun is mostly overhead. Students may have to look very closely for the rainbow of colors refracted from the sunlight.