WS2
WOMEN SUPPORTING
WOMEN IN THE SCIENCES

Training for Educators
Light & Photons

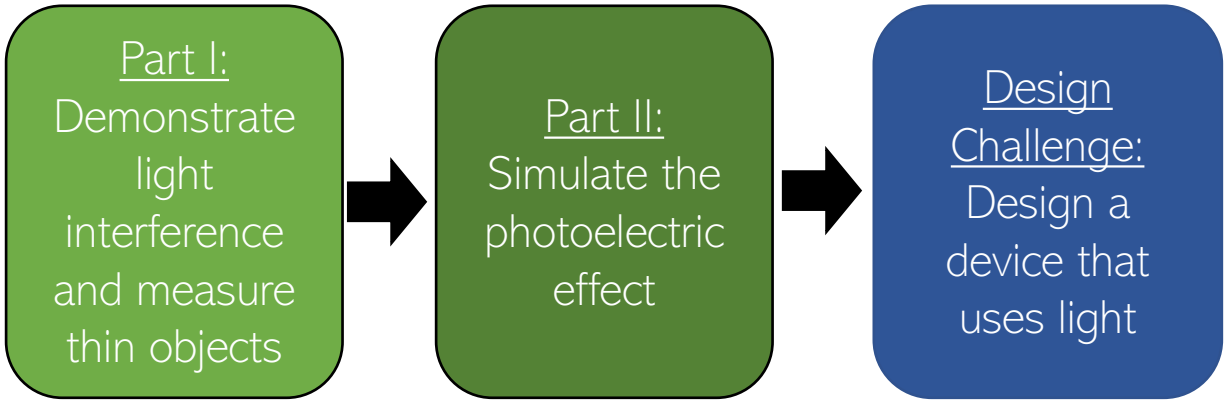
Secondary Level

Ages 12-18

Purpose of the lab

- The purpose of this lab kit is to enable students to conceptualize the basics of light through theory, demonstration, and experiments. The manual introduces the students to the properties of light as a wave through wave properties including diffraction and interference. It will also introduce students to the quantization of light using the photoelectric effect.
- <u>The main takeaways are:</u>
  - Light is both a wave and particle, exhibiting so-called wave-particle duality.
  - The wave-like properties light displays are interference and diffraction.
  - Light behaves like a particle as seen in the photoelectric effect.

Summary of experiments



There are 2 experiments/activities and one design challenge.

Supplies list

- Laser pointer (red or green)
- Thin objects (hair, fishing line)
- Large index card
- Paper
- Binder clip(s)
- Ruler or measuring tape
- Cardstock (heavy paper)
- Straws (or wooden dowels or sticks)
- Colored markers (or colored pencils or crayons)
- Marbles
- Tape
- Scissors

Safety considerations

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

- 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>
    - 2-3 thin objects (hair from humans or animals, fishing line, etc)
    - 1 large index card
    - 1 piece of regular paper
    - 1 piece of cardstock (heavier) paper
    - 2 wooden dowels or straws
    - 2 marbles
    - 2 binder clips

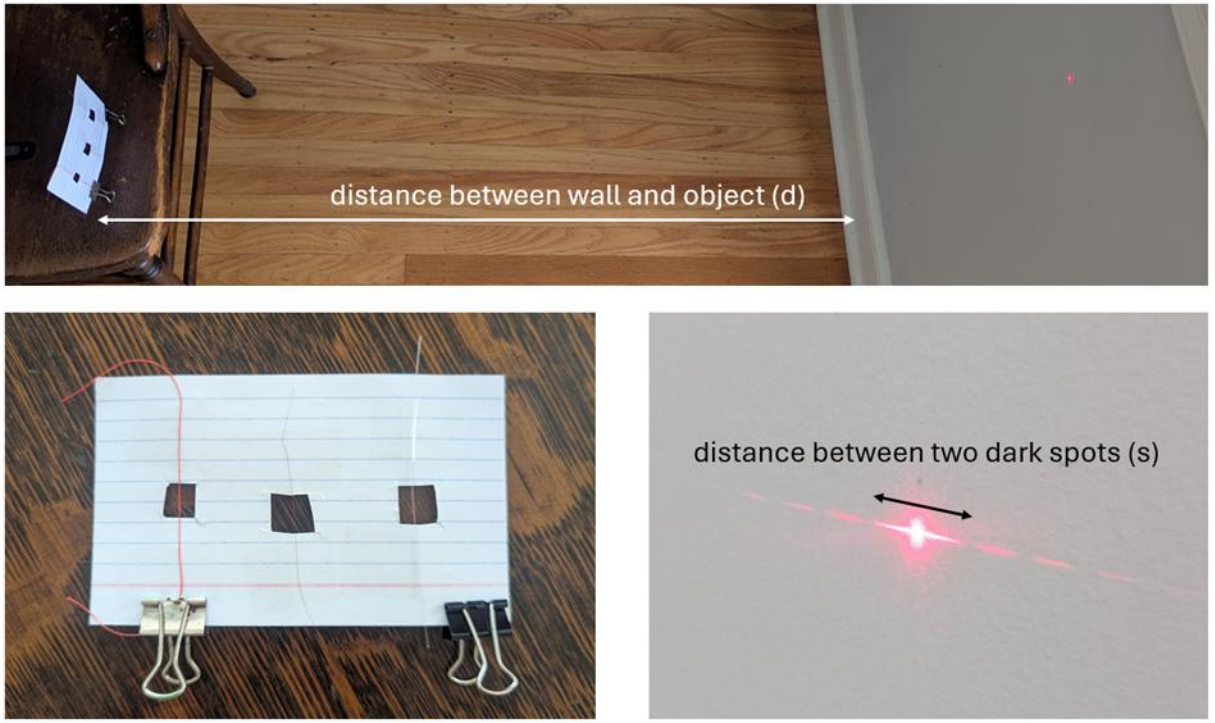
  <u>The class can share the following supplies:</u>
    - Laser pointers
    - Tape
    - Scissors
    - Rulers
    - Colored markers
- If doing the optional supplemental activity, groups should have access to computers with internet access.

Part I. Measuring Thin Objects

- Set-up:
  - Each group of 2-4 students gets 2-3 thin objects, large index card, paper, and binder clips.
- Procedure:
  - Students should prepare their index card (cut small holes and tape thin objects across the holes) and shine laser light at the object, noting the interference pattern that appears.
- Results:
  - Students will calculate the width of their thin objects by measuring the distance between two dark spots on the interference pattern and distance between index card and interference pattern and using the single slit equation.

The takeaway is that light exhibits wave-like properties such as interference, and this phenomenon can be used to measure very thin objects.

Part I. Measuring Thin Objects



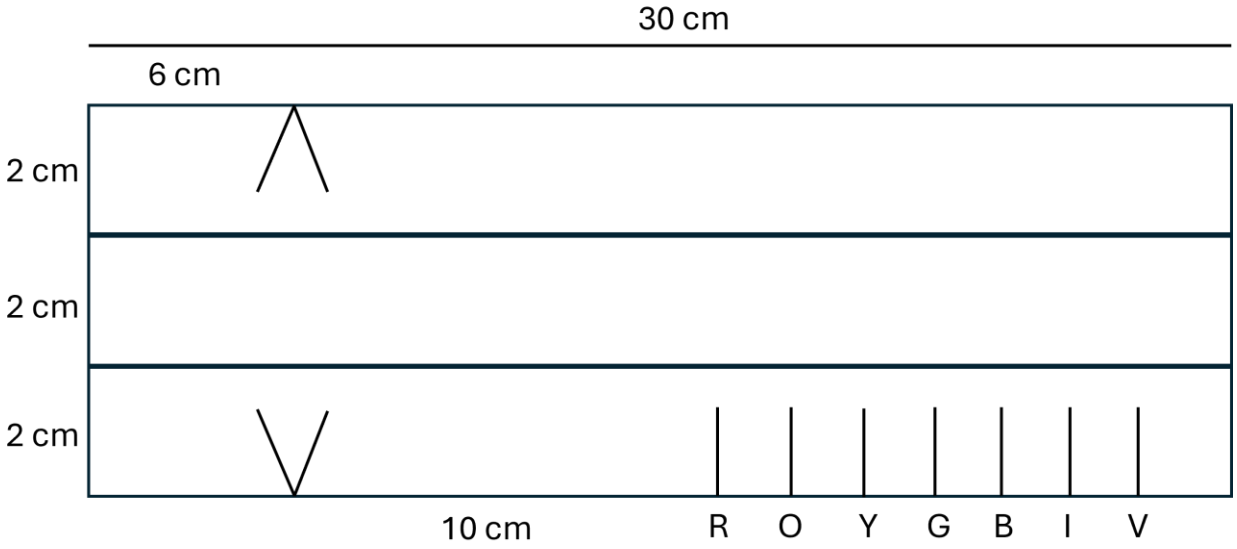
(Top) Example experimental set-up for Part 1. The index card should be placed on a flat surface, with the laser light shining toward the wall with paper taped to it. The distance between the wall and object is indicated (L). (Bottom left) Example of index card with three thin objects. (Bottom right) Example interference pattern with distance between two dark spots (across the brightest middle spot) indicated (x).

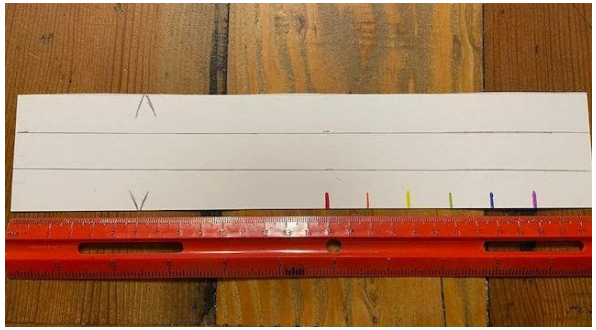
Part II. Modelling the Photoelectric Effect

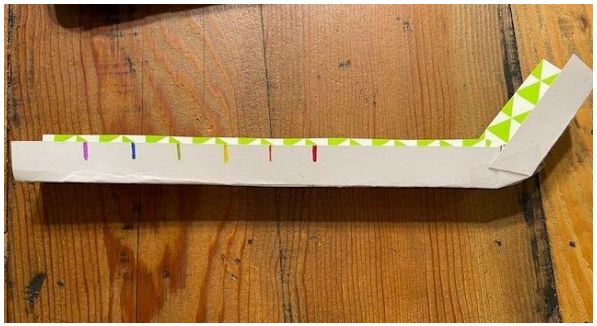
- Set-up:
  - Each group (2-4 students) will need cardstock paper, straws (or wooden dowels), and marbles.
- Procedure:
  - Students will prepare a ramp and release marbles from different heights on the ramp (marked by colors) toward a marble at the bottom of the ramp.
- Results
  - Students should see that certain heights ("energies") will cause the bottom marble to launch off of the ramp. This is analogous to the photoelectric effect.

The takeaway is that light exhibits particle-like properties through the photoelectric effect.

Part II. Modelling the Photoelectric Effect







Dimensions of ramp to be constructed. Note that this is not drawn to scale and should not be directly printed and used. (Bottom left) Ramp construction prior to cutting and taping. (Bottom right) Complete ramp construction.

(optional) Part III. Simulating the Photoelectric Effect

- Set-up:
  - Students will need access to a computer with internet access.
- Procedure:
  - Students will use the PhET simulation and follow the procedure in the manual.
- Results
  - Students should see varied impacts of light frequency and intensity on current output.

The takeaway is that light exhibits particle-like properties through the photoelectric effect.

(optional) Part III. Simulating the Photoelectric Effect

- Source:
  - https://phet.colorado.edu/sims/cheerpj/photoelectric/latest/photoelectric.html?simulation=photoelectric

Design challenge

Students are asked to design a device that uses light to do something useful. They have seen in previous experiments that light can be described as a wave and as a particle and there are many ways to produce light.

- Questions to ask the students (encourage creativity)
  - Think about the needs of your community and in your life. What kinds of devices are or could be useful to you?
  - How could the properties of light be useful in a device? Consider the various phenomena that were discussed today including diffraction, interference, and the photoelectric effect. Think broadly about many types of devices and machines.
  - How will light be utilized in the device you are designing?
  - How can light energy be transformed into other types of energy (mechanical, electrical, etc.)? How could this be utilized in your device?