# Photon Phun

**Grades:** Grades 4-5
**Team Size:** 2-3 competitors
**Duration:** 35 minutes
**Supervisors:** Katsuyo Thornton, Ashwin Shahani, Elizabeth Bernhardt, Maya Thornton

## Summary Description

This event will test the students' understanding of light and its behavior. All participants will compete in a reflection relay in which the team of students will enter an unlit room with one light source (a flashlight affixed on a stand) and a total of 6 targets. Using 3 mirrors, the students must reflect the light from the source, passing through all 3 mirrors, to illuminate each target. Participants will conduct hands-on experiments and answer a few questions about their observations, complete a written quiz about light, and also complete one reflection diagram. Teams will receive points for each illuminated target and each question answered correctly. (**Note: A team of 3 is STRONGLY recommended. The reflection relay is significantly more challenging for a team of 2 and adjustments will <u>not</u> be made to the event or the scoring.)**

## Concepts Covered:

- Colors of the rainbow and how a rainbow is produced.
- The RGB and CMYK color models.
- Concept of items (materials) being transparent, translucent, or opaque.
- Reflection of light – angle of incidence and angle of reflection
- Colors of light – how white light is made, how colored light is made, why objects appear to be certain colors, how objects may look to be different colors in different lights.
- Wave nature of light, including their energy. Be able to identify a wavelength or frequency period on a wave drawing.
- Know values of wavelengths of colored (visible) lights, infrared (IR), ultraviolet (UV), and the order of magnitude of wavelengths across the spectrum from the radio wave through gamma rays, including X-rays.

- Know the relationship between wavelength and frequency.
- Understand primary and complementary colors of light and how they differ from pigments (i.e., additive versus subtractive color mixing).
- Understand how a lens works.
- Understand why a prism splits white light into different colors

## Rules/Competition Format

Each team will be given an individual station with the question sheet and supplies for hands-on activities. Students must not bring any items into the competition area, including pencils, paper, calculator, phone, etc. All required materials are provided at the station. During the session, teams will be randomly called to enter the reflection relay room, located adjacent to the room with team stations. Unless the team is the first one, they will be given one minute warning before they are asked to move toward the relay room.

Reflection Relay Room:

1) Teams will enter the reflection relay room one team at a time. The reflection relay room will be unlit but not completely dark.
2) Teams will be given a maximum of **3 minutes** in the reflection room.
    a. Each team will receive three 4"x4" acrylic mirrors and brief instructions from the event supervisor (script ) . They then have **up to 1 minute** to survey the room and strategize. After a maximum of one minute, or sooner if the team announces they are ready to start, the team will begin their reflection relay.
    b. The relay will begin when the supervisor says "GO", at which point the timer will start.
    c. Each team will have up to **2 minutes** to illuminate as many of the 6 targets as they can.
    d. Using less strategy time (2a) will not increase the time for the reflection relay (2c).
    e. The reflection relay will end after 2 minutes. A countdown clock will be located in the room. A timekeeper will note the time when the event supervisor says "NEXT" after a target has been hit.
    f. At the end of 2 minutes, the timer will sound an alert and the event supervisor will say "STOP".
3) There will be one light source in the room provided by the event supervisor.

   a. The light source will remain in the same fixed position in the room for the entire grade's reflection relay. It will be placed at approximately chest height parallel to the ground.
   b. The light source may be placed by the event supervisor anywhere in the room.
   c. The light source used will be an adjustable-focus, high intensity LED flashlight, identical to that provided to schools in 2025.
   d. Students will not be permitted to touch or adjust the light source. The students and their mirrors must keep at least **2 feet** away from the light source. This distance will be marked by tape on the floor. Teams crossing this line will be instructed to move, will not receive any additional time for their reflection relay, and will not receive points for any targets hit while the line is crossed.

4) There will be 6 targets in the room.
   a. Targets are numbered 1 through 6.
   b. Targets are approximately 8.5" x 11" sheets of paper (may be laminated) taped into position.
   c. The *recommended* ordering will be 1, 2, 3, 4, 5, 6. Difficulty will increase with target number.
   d. Teams are NOT required to illuminate the targets in numerical order.
   e. Targets may be positioned anywhere in the room (on the walls, the ceiling, on the floor, under a table, in a cupboard, etc.).
5) Teams must reflect light from the source, sequentially through all 3 mirrors, to each target. When the target has been illuminated by light reflected from the 3rd mirror, the event supervisor will count "1, 2, 3, NEXT" at which point the target and hit time will be recorded by the timekeeper and the team may move on to the next target.
6) Every member of the team must hold at least one mirror.
   a. If a team has only 2 members, one member must hold two mirrors.
   b. Teams may not bring in their own mirrors and may not bend, distort, or alter the mirrors in any way.
   c. Mirrors used will be approximately 10 x 10 cm square. The mirrors will be acrylic, not glass.
   d. Mirrors must be held at least 1 foot apart.
   e. The light must be reflected sequentially through all three mirrors.
7) Teams will get 10 points for each target hit. The more difficult targets will **not** be worth more points.
8) A lux meter will be used by event supervisors on the day of competition to monitor the intensity of the light source as well as the light/dark conditions of the room. Readings will be recorded throughout the event to ensure consistent conditions for all participants.

Hands-On Experiment Room for Experiments and Quiz:

1) The participants will take a written test, worth 60 points, in teams. The test will include a written quiz, a reflection diagram, and hands-on experiments with multiple questions.
2) The test may ask questions about any of the topics listed above.
3) Hands-on experiments that may include topics from any listed above. Participants will be asked to complete the experiments and record their observations.

4) The reflection diagram will have a Light Source (labeled "S" or "Source"), a target (labeled "Target"), mirrors, and potentially non-reflective obstacles (labeled "O" or "Obstacle"). A light beam is shown to be emerging from a source along a particular direction. There will be one unique solution to each reflection sheet. Students will not be told how many reflections are necessary to solve the sheet. An example reflection diagram is attached.
5) For the reflection diagram, the teams will be asked to predict which mirrors the beam of light will hit along its reflection path from the light source to a target. There will be mirrors on the reflection sheet that will not be hit by the light beam. The answer to the reflection sheet is the identifying letter of the mirrors that the light beam hits, in order, on its way from the source to the target. The answer must be completely correct – no partial credit will be given. The number of reflections on each diagram required to reach the target from the source will be the child's grade level plus or minus 1. That is, a 4$^{th}$-grade reflection diagram could contain from 3– 5 reflections, while a 5th grade diagram could require from 4 – 6 reflections.
6) Pencils, along with straight edges and protractors like those provided to participating schools in the coaches' kit, will be provided in the test room for the students to use. Teams are not allowed to bring any implements to the competition.
7) Calculators will not be allowed.

## Scoring

The teams will be scored as follows:

a. 60 points for the Reflection Relay (10 points per target hit).
b. 60 points for the written portion (quiz, reflection diagram, and hands-on experiment responses).
c. The highest score out of 120 possible points wins.

## Tie Break Criteria

a. A tie score will be broken first using the highest number of targets hit.
b. If a second tie breaker is required, the fastest finishing time for the last target hit in the reflection room will be used.

## Materials Distributed by WESO

Follow the link below for the list of the Photon Phun event equipment provided by WESO.
Equipment supplied by WESO

The flashlight and/or laser should be handled by the coaches only. The brightness of the flashlight is adjustable, and the lowest setting visible under the lighting condition should be used. Students should be trained to reflect the light towards the lower part of the body so as to avoid faces. Students should also be trained to look toward their own body to find the reflected light, rather than looking directly at the mirror that is sending the light to them.

## Additional Materials Useful for Practices

The script used in the reflection room can be found on the WESO website (script).

## Materials to Be Brought to the Event

Students should bring nothing to this event. All equipment will be provided.

## Event Questions

Please go to https://wesoscience.org/events/ for information on how to submit questions about this event.

## Additional Resources/References

Some references (some of these may be available at Ann Arbor District Library):

- Rogers, Kirsteen, et al., *The Usborne Internet - Linked Library of Science Light, Sound & Electricity,* 2001, Usborne Publishing Limited.
  https://a.co/d/9iTVA2Z
  This book has a website linked to it. While it covers more than light and covers some light-related topics we do not cover, there are some contents that have helpful explanations and activities.

- Gardner, Robert, *Easy Genius Science Projects with Light,* Enslow Publishers, NJ, 2009.
  https://a.co/d/8bhOV6r
  This book has a chapter with interesting experiments about reflection and another one on color.

- *Bill Nye the Science Guy: Light optics, Light and Color* (DVD)
  https://a.co/d/d3Y7UTN

- The Ann Arbor Hands-On Museum has Light and Optics exhibits- including color, mirrors, lenses, optical illusions, just to name a few.
  https://discoverscienceandnature.org

- Slides and worksheets from previous training sessions https://thorntongroup.engin.umich.edu/outreach/

More advanced materials that contain helpful information

Hewitt, Paul G., *Conceptual Physics*. (Used ones are reasonably priced)

https://www.physicsclassroom.com

Reflection Relay Strategies:

- Practice as a team.
  - Know your role (designate one person to always be closest to the light, one to be closest to the target, and one floater perhaps).
  - Know how to communicate effectively and quickly (under the two-minute time limit).
  - It is critical to work together to succeed in the relay.
- Hold the mirror by the edges only to allow the greatest possible surface area for reflections.
- Hold the mirror in front of your chest and brace it against your body. This will help to keep it still and it will also block any stray light.
- Look only at where you are aiming your beam of light and trust other team mates to do the same. If a student looks in one direction they tend to move their mirror in that direction.
- WESO and the Event Supervisors make every effort to not have problems during the event, but just in case… Practice for unexpected conditions such as brighter than usual room, dimmer than usual flashlight, someone walked through the beam. It is important to not get flustered and waste time when something unexpected happens.
- If the team has only 2 students, then the person holding 2 mirrors should practice holding one mirror still (braced against your body) and moving only one mirror. Mirrors must be at least 1 foot apart.
- A common error in the reflection room is the light not hitting all 3 mirrors. Help the students practice identifying where their mirror is reflecting and making the light reflect through all mirrors before hitting the target.

**It is critical to practice the Reflection Relay in advance in order to be successful in this event. Students should practice hitting targets in**

**varying locations and they should enter the Reflection Relay Room with a clear plan and with assigned team member roles. Planning and practicing are critical to all teams, but especially for teams with only two members.**

General Feedback on Teams' performance at the the 2025 Photon Phun workshop are here Workshop Feedback

## Example Questions

Quiz questions

Examples for multiple choice questions:

1. Which of these electromagnetic waves have the lowest frequency?

A. visible light

B. infrared

C. ultraviolet

D. gamma ray

2. Blue jeans appear blue because the jeans have been dyed. This dye

A. generates blue light by color synthesis.

B. absorbs light of all colors except blue and reflects blue light.

C. absorbs only blue light and so gives the jeans a blue color.

D. reflects all colors except blue light.

3. When you look down into a fishbowl, the fish you see looks

A. larger than it would appear if there were no water

B. smaller than it would appear if there were no water

C. the same size as it would appear if there were no water

D. reversed

Additional questions require writing out answers in sentences and/or involve hands-on activities.

Reflection Diagram:

See event page https://wesoscience.org/photon-phun/ for examples of reflection diagrams.