

1. **DESCRIPTION:** Teams participate in an activity involving positioning mirrors to direct a laser beam towards a target and are tested on their knowledge of geometric and physical optics.

**A TEAM OF UP TO:** 2    **EYE PROTECTION:** None Required    **APPROX. TIME:** 50 Minutes

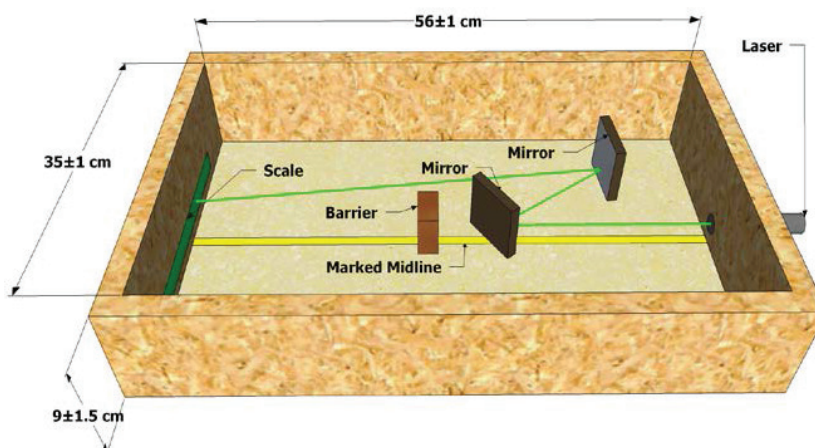
2. **EVENT PARAMETERS:**

- a. Each team may bring one three-ring binder of any size containing information in any form and from any source attached using the available rings; which may be removed during the event.
- b. Participants may bring any measuring tools, premade templates, writing utensils and two calculators of any type **dedicated to computation** for use during any part of the competition.
- c. Participants must not bring lasers or mirrors.

3. **LASER SHOOT SETUP:**

- a. Example setups are available on the event page at [www.soinc.org](http://www.soinc.org).
- b. The event supervisor will provide the Laser Shoot Setup (LSS), including laser, mirrors and barriers.
- c. The LSS has a horizontal flat surface  $56 \pm 1.0$  cm by  $35 \pm 1.0$  cm enclosed by a  $2 \pm 0.5$  cm thick wall. The bottom surface may be a table top. **A black surface with a ferrous metal component to which magnets will adhere is recommended. Directions and resources on how to retrofit an existing LSS can be found at [www.soinc.org](http://www.soinc.org).** The height of the wall above the surface is  $9 \pm 1.5$  cm.

- d. Five moveable flat mirrors with a width of 5.0 – 8.0 cm must be placed in the LSS and must be **front-surface mirrors or back-surface mirrors 1/16 of an inch or less thick**. Each mirror must be mounted so that it stands vertically ( $\sim 90$  degree angle to the bottom surface), does not have excess mounting material on its sides, has its approximate center at the level of the laser beam and can be easily relocated anywhere in the LSS by the participants. **In order to facilitate measurements by competitors, no part of the mirror support may extend in front of the reflective surface.** The mirror faces must initially be covered with a cardboard sleeve or other easily removable non-reflecting, opaque material. **The mirrors may have magnets affixed to them to secure them in place on a ferrous metal bottom surface of the LSS.**



- e. A laser is mounted through the approximate center of one of the 35 cm walls at a height of 1.5 - 6.0 cm above the bottom surface. The laser must be securely mounted such that it cannot be moved and the beam is perpendicular to the wall through which it is mounted. The laser must remain fixed throughout the entire event. The Laser Policy on [www.soinc.org](http://www.soinc.org) must be followed.
- f. A midline is drawn on the LSS from a point directly below the emitting tip of the laser to a point directly below the center of the laser beam where it strikes the opposite wall.
- g. A metric scale with a resolution of at least 1 mm must be attached horizontally to the other 35 cm wall at the level at which the laser strikes. One of the marks on the scale is the Target Point. A sheet of paper must be also fastened to the wall, with a mark on the paper indicating the Target Point location.
- h. The barrier(s) must have a width of 2.0 - 8.0 cm and be tall enough to block the laser beam. They must be fixed in the same position and orientation in the LSS for all teams. The barrier(s) must have a mirror similar to the others attached to one side and covered similarly.
- i. **For Division B only**, a barrier must be placed somewhere along the midline to block the laser beam (non-perpendicular angles permitted).
- j. **For Division C only, three barriers must be placed in the LSS. One will be somewhere along the midline to block the laser beam (non-perpendicular angles permitted). The other two will be placed elsewhere in the LSS.**

4. **THE COMPETITION:**

**Part I: Written Test**

- a. Teams will be given a minimum of 20 minutes to complete a written test consisting of multiple choice, true-false, completion, or calculation questions/problems.
- b. The competition will consist of at least two questions from each of the following areas. *Topics in italics are for Division C only and will be exclusively assessed at State and National Tournaments.*

- i. Law of reflection: specular, diffuse
- ii. Refraction: index of refraction
- iii. Prism: deviation, dispersion
- iv. Convex, concave, and **plane** mirrors: ray tracing, focal length, real object, images (real/virtual, erect/inverted, magnification)
- v. Convex and concave lenses: ray tracing, focal length, real object, images (real/virtual, erect/inverted, magnification)
- vi. Operating principles of optical equipment: microscopes, telescopes, cameras, glasses
- vii. Visible spectrum: primary/secondary colors, additive/subtractive, absorption/reflection
- viii. Structure and function of the parts of the human eye **that produce images and color perception**
- ix. Polarization of light using polarizing films or by scattering
- x. Optical absorption spectra: films, chemicals, dyes
- xi. *Ray tracing off two perpendicular or parallel plane mirrors: corner reflector, periscope*
- xii. *Ray tracing or measurement to find the focal length of a lens system: real and virtual objects and images (erect/inverted, magnification)*
- xiii. *Lasers: theory of operation, difference between coherent and non-coherent light*

c. Unless otherwise requested, answers must be in metric units with appropriate significant figures

## Part II: Laser Shoot

- d. The objective is to reflect a laser beam with mirrors around barriers towards the Target Point.
  - e. **The event supervisor will select a Target Point location and home position for the mirror(s) that is the same for all teams. Teams will be informed of the Target Point when it is their turn to compete in Part II.**
  - f. All mirrors **will** be placed in the **designated** home position before each team is permitted to see the LSS.
  - g. **The supervisor will demonstrate the beam's alignment before each team begins their laser shoot.**
  - h. When a team is ready to begin, the event supervisor **will** give a countdown of "3, 2, 1 start" and **then** start a timer. Event Supervisors **will** give teams a warning when 3 minutes have elapsed.
  - i. Participants must make all measurements, calculations, and mirror placements/alignments within a 4-minute time period. Participants may choose to use between 1 and 5 moveable mirrors.
  - j. Timing stops when 4 minutes have elapsed or the **participants intentionally** remove the material covering the face of one mirror. Participants must not make any additional adjustments to the mirrors other than to remove the other mirror and **barrier** coverings. The supervisor must not remove coverings.
  - k. Participants must not mark on or modify the LSS **nor adjust/move the barrier(s) position.**
  - l. Participants must not touch the laser or change its orientation and/or position.
  - m. The laser must not be turned on until timing stops. Once turned on, the event supervisor must mark on the paper mounted above the metric scale where the laser strikes it to record the results. **Only the intended, normally reflected, path of the laser will be counted (e.g. secondary beams due to beam splitting or halos must be ignored).** Participant tools/templates may remain on the LSS during this process.
  - n. Multiple LSS's may be used to facilitate all teams being able to compete in a timely manner.
  - o. The supervisor will review with the team the data recorded for Part II on their scoresheet.
5. **SCORING:**
- a. A scoring rubric is available on the event page on [www.soinc.org](http://www.soinc.org).
  - b. Final Score (FS) = TS + MS + AS + BS. The maximum possible FS is 100 points. High score wins.
  - c. Test Score (TS) = (Part I score / Highest Part I score of all teams) x **60 points**
  - d. Mirrors Score (MS) = # moveable mirrors the laser reflects off of x **2 points**. The max possible MS is **10**.
  - e. Accuracy Score (AS) = (**15** - (accuracy (in mm)/10)) points. The smallest possible AS is 0.
  - f. **Accuracy** is the horizontal distance from the Target Point to the center of where the laser strikes on the **35 cm Target Wall**. If the laser strikes another wall, accuracy is the sum of the straight-line measurements from the Target Point to the corner along one wall and along the other wall from the corner to the laser dot. **If the laser does not strike a wall, AS is 0, but the MS and BS are calculated.**
  - g. **Division B - Barrier Score (BS) = 15 points** if the laser reflects off the barrier mirror
  - h. **Division C - Barrier Score (BS) = # of barrier mirrors the laser reflects off of x 5 pts; max pts. possible is 15.**
  - i. Teams disqualified for unsafe operation receive an AS, MS and BS of 0, **but still compete in Part I.**
  - j. **Violations of rules in the COMPETITION section result in the AS, MS, and BS being multiplied by 0.9 when calculating the Final Score.**
  - k. **Ties are broken using test question(s) designated by the supervisor at the start of the competition.**

**Recommended Resources:** The Science Olympiad Store ([store.soinc.org](http://store.soinc.org)) carries the Optics Video and Chem/Phy Science CD; other resources are on the event page at [soinc.org](http://soinc.org).

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