

# Optics B/C

## National SO Resources:

<https://www.soinc.org/optics-c>

<https://www.soinc.org/optics-b>

**Event Objective:** 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

## Equipment Needs:

- At least one Laser Shoot System (LSS) - preferably one for every ten teams in a time block
  - LSS has a horizontal flat surface 55.0 - 57.0 cm by 34.0 - 36.0 cm with walls 1.5 - 2.5 cm thick and 7.5 - 10.5 cm high
  - LSS should have a ferrous metal component on its surface to allow magnets to be attached to magnets and barriers to allow easier adjustment and alignment by students
  - A guide for building a LSS can be found on [www.soinc.org](http://www.soinc.org)
  - Ensure you have a Class II or Class III laser (follow the laser policy on [www.soinc.org](http://www.soinc.org)) that will follow the laser shoot line to the target area
    - Always have a backup laser for each box
    - Always have backup batteries for each box
    - Do not store the lasers with the batteries inserted to avoid leakage problems
    - Ensure that turning the laser on does not move the laser, this can often be done with a clamp or closepin
- **Division C** - Three barriers with mirrors (front surface or mirror-like reflective material) on the back of them that are high enough to block the mirror and at between 5.0 and 8.0 cm wide
- **Division B** - One barrier with a mirror (front surface or mirror-like reflective material) on the back of it that is high enough to block the mirror and at between 5.0 and 8.0 cm wide
- Five mirrors (front-surface or mirror-like reflective material) that are high enough to reflect the mirror and are between 5.0 and 8.0 cm wide

## Number of Volunteers Needed:

- For the number of teams you may need the following volunteer support
  - Division C teams normally take longer than Division B teams for laser shoots and often take up to 5-6 min per laser shoot including reset time
  - 1-10 teams per session, 1-2 persons for the test/grading and 1-2 persons for each laser shoot box (1 should be sufficient)
  - 11-20 teams per session, 1-2 persons for the test/grading and 1-2 persons for each laser shoot box (2 should be sufficient, for a total of 2-4 people for the laser shoot)
  - 20+ teams per session, 1-2 persons for the test/grading and 1-2 persons for each laser shoot box (need one laser shoot surface box per ten teams, for a total of 1-2 people PER BOX needed)
- For the state tournament you will be provided names and contact info for your volunteers

and YESS team. It is required that you contact them prior to the tournament to relay any event-specific information.

### Prior to the Event:

- Test each laser shoot surface box with the laser to ensure that it follows the target line and hits the target and can be easily turned on and off
- Test all mirrors (including those on the back of a barrier) reflect the laser for that box at a normal angle. This can be tested by putting the mirror or barrier (with the mirror side facing the laser) on the target end of the box and test the laser reflecting off the mirror to the laser incident wall. If it is a normal angle, the laser will be at the same height as the laser.
- Test the maximum number of mirrors and mirrored barrier surfaces to ensure that the combination of the reflections do not cause the laser main beam to rise out of the box or hit the floor surface
- Keep the same lasers, mirrors, and barriers together with the same laser shoot surface box to ensure they have all been tested together
- Develop a plan for the barriers that will be used
  - **Division B** - One barrier with a mirror back
  - **Division C** - Three barriers with mirror backs
  - All mirrored surfaces must be covered with some sort of cover at the beginning of the laser shoot
  - At least one barrier with a non-reflective surface must stop the incident laser beam from striking the target wall
  - You will also need a stopwatch per box to time the setup time (does not have to be accurate to less than a second)
  - You will also need a ruler per box to measure the distance of the impact to a mm accuracy
  - Once the plan is developed, create a easy to use template for quick assembly of the barriers
    - The template can be out of paper, foam poster board, cardboard, etc
    - The template should be marked such that you easily align it to the center fire line of the laser
    - The template will be used to ensure that the setup can be recreated if a student accidentally moves any of the barriers
  - Ensure the plan creates a possible solution (i.e. don't make it impossible to hit the target) and matches the difficulty of the event
    - For first invitational tournaments and lower level regionals, it usually works best to have all of the barriers parallel to each other and normal to the direction of the laser
    - For larger invitational and harder regional and state tournaments, create simple and difficult solutions to the laser shoot solution where getting the maximum points is difficult, but simple 2 and 4 mirror solutions are achievable
- Create copies of Optics checklists (if you have the team numbers go ahead and put them on

the individual sheets). The Optics checklist is available at [www.soinc.org](http://www.soinc.org)

- Create a checklist for all items including the laser, batteries, activation pin/mechanism, laser shoot ox, mirrors, barriers, barrier set up template, equipment required, colored pens/pencils, calculator, tablet/laptop, flash drive, stapler/staples, etc. as needed.

### The Written Test:

- Finalize writing the test well before the competition (if possible) and check it over well. Consider having another person evaluate the test. It should have a mix of easy, medium, and hard questions and tiebreaker questions to separate teams.
  - Be sure to follow the topics in the rules for the test
  - Have a variety in the difficulty of questions within each topic throughout the test
- Aim for the following goals for the written test:
  - There should be no perfect scores or very few perfect scores
  - There should be no zero scores
  - High score in the target range of 75% to 95%
  - Low score is in the target range of 10% - 30%
  - Less than 5% of teams score above 90%
  - Less than 5% of teams score less than 15%
  - Less than 10% of teams are involved in ties
- A good mix of easy, medium, difficult, and extremely challenging problems will often obtain the above results. Also, make sure the test is long enough to separate the “contenders” from the “pretenders”...remember, kids can bring in a binder!

### Scoring of Individual Teams:

- There is a score sheet available on [www.soinc.org](http://www.soinc.org)
- **Division B** - Test worth 60 points, each mirror that laser hits worth 2 points (max of 10 points), each barrier mirror that laser hits worth 5 points (max of 15 points), 15 points for accuracy
- **Division C** - Test worth 60 points, each mirror that laser hits worth 2 points (max of 10 points), barrier mirror that laser hits worth 15 points, 15 points for accuracy
- High score wins
- Test score is each individual team's test score divided by the highest test score multiplied by 60. So the team that scores the best gets the 60 points and everything is based off of that. The test does NOT need to be out of 60 points.

### Day of the Competition:

- Show up at your room as early as you can (even the day before if possible)
- Set up the room and laser shoot surface box as early as you can (even the day before if possible)
  - Usually best to put the laser shoot surface box in the back of a classroom so that when you call students up to do their tests they won't be watched by the rest of the competitors
- Lay out tests, answer sheets, scrap paper, equipment, and ensure you have planned out walkways and lab space
- Provide general instructions on a white/chalk board or overhead if available
- Cover the plan with all volunteers, including all of their assignments

### Competition:

- Meet all teams outside the room for final instructions including
  - Turning all cell phones off and clearly explain what happens if a cell phone should go off (the Event Supervisor may ask them to raise their hand and not touch the cell phone at all)
  - Explain any other policies and if you have assigned seating or what they can do (i.e. can they look at the test)
- Let teams in one at a time
  - Check that they have wristbands if used at your tournament
  - Check that their binders do not have loose material by gently shaking them by the spine to see if anything falls out...if any papers fall out they are not allowed to be used in the exam (especially for state tournament).
  - They are allowed to keep their laser shoot tools separate from their binders
  - Allow single team members to enter if they are waiting for their partner
    - Generally a person can show up late to an event, but after the event has started you may not leave and reenter (so if the teammates have to leave, they cannot return)
- Go over the specifics on the test and on how the laser shoot will work, answering questions
- Begin the examination period and start whatever timer you will use
  - Always have the exam be five minutes or more less than the allotted session time and be consistent among all sections (i.e. if they are 50 minute sessions, you have a 45 min exam)
- Call up teams one at a time for each box used to start
  - Teams are allowed to send only one person up to do the laser shoot to allow the other team member to continue to work on the test or they may both do the laser shoot.
  - Ensure that the laser will hit the target if not blocked before each measurement
  - Ensure the team fills out the gray area of the checklist (available from [www.soinc.org](http://www.soinc.org))
  - Start the timer for their setup
    - They may use templates, protractors, rulers, t-squares, etc. to set up the mirrors
    - They may put the mirrors (but not the barriers) on top of their templates if

- they are thin (such as paper or thin plastic)
  - Templates must not impede the laser shoot or else it will count as not hitting a wall
  - They may want to remove unused mirrors from the laser shoot surface box, which is fine
- o Give teams a 30 second warning when they are about to run out of time for doing the laser shoot
- o Once they believe they have the mirrors in the proper position, they should tell you so you can stop the setup clock
- o The teams can then remove the blocking barriers sleeves for each mirror they are going to use. They can also readjust those mirrors should they accidentally move them, but not reuse their templates if they are no longer in the box.
- o Once all the surfaces have been removed, let them know you are about to make the measurement and turn on the laser
- o Using a piece of paper or other surface follow the laser path to count all the mirrors hit and the final hit point of the laser
- o The final hit point of the laser is the mid-point of the main beam of the laser (not the hollow). Please note that the main beam may be elliptical after all the reflections.
  - If the laser beam is somehow split follow the following rules
    - Always follow the intended reflection route of the mirror
    - If the laser misses the mirror, follow the direct main beam of the laser not blocked by the laser
    - Ignore all diffuse reflection and diffraction effects
    - If the final hit point is the side or rear of the box, measure the distance from the target along the wall (not diagonal)
    - If the final hit point does not hit the target, side, or rear of the box, count it as not hitting the wall and do not put down any distance score
- o Enter the data on the checklist
- o Have the students sign and agree to the numbers on the checklist
- o If there is a disagreement or something unusual, make as many measurements as possible and take pictures if possible to mark what is unusual. Also put all the additional measurements and notes on the back of the form.
  - The students should still sign it, even if they plan on filing an arbitration, but with the additional information on the form you can easily assign whatever points the arbitration committee determines (it is tough to reshoot)
- Reset the laser shoot box by checking the laser hitting the target if unblocked, putting the barriers back into their standard position, and putting barrier covers on all mirrors
- Call up the next team

### Scoring at End of Day:

- Calculate a team's score by adding up the Test Score, Mirrors Score, Accuracy Score, and Barrier Score. The maximum score possible is 100 points.
- Write all team scores on the provided scorecard and take all tests, team score checklists, and scorecards to scoring at the end of the day