

Optics

Division B/C

Georgia Tech Event Workshop Series
2024-25



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02

03

04

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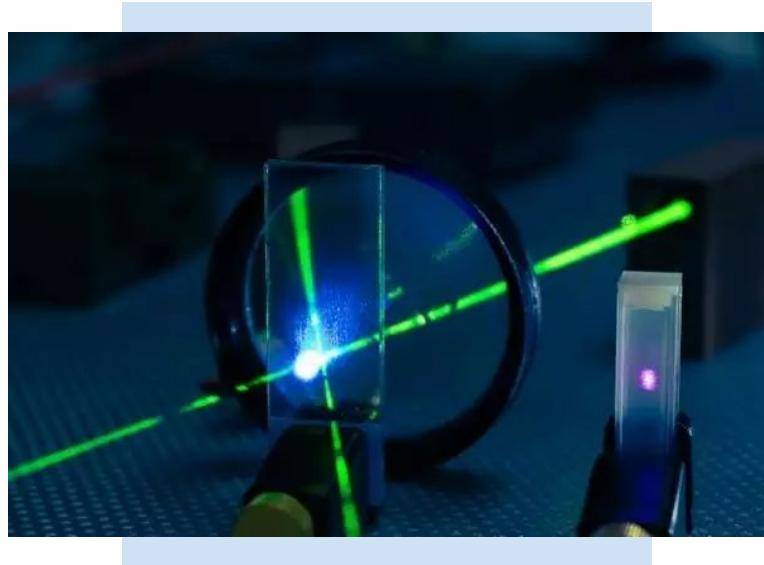
RULES SHEET

DIFFICULT TOPICS

COMMON QUESTIONS

TIPS FROM A VETERAN

OTHER FREE RESOURCES



The Rules Sheet

- Written Test
 - Important to know every topic at least on the surface level!
 - All supplement material can be in the binder
 - E.g., formulas and refractive indices
- Laser Shoot
 - Practice with your partner!
 - You need to have  synergy 
 - Think first, act last!! Even if you work slow
 - Make sure to stop on time
 - Move with care

OPTICS B
See General Rules, Eye Protection & other Policies on www.scholastic.org as they apply to every event.

DESCRIPTION: Teams will participate in an activity involving positioning mirrors to direct a laser beam toward a target and a written test on the principles of geometry and physical optics.

A TEAM OF UP TO: 2

CALCULATOR: Class III

APPROXIMATE TIME: 50 minutes

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. Sheet protectors, lamination, tabs and labels are permitted. Participants may remove information from their binder for use during any part of the competition.
- b. Each team may also bring tools, protractors, compasses, squares, and two calculators (Class III).
- c. Teams must not bring lasers, mirrors, other optical devices (aside from personal eyeglasses or contacts), or electronics (other than calculators).

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.
- b. Unless otherwise requested, answers must be in metric units with appropriate significant figures.
- c. The event supervisor must select a Target Point location that is the same for all teams.

Part II: Laser Shoot

- a. The objective is to reflect a laser beam with mirrors around barriers towards the Target Point located on the floor.
- b. The event supervisor must select a Target Point location that is the same for all teams. Teams must not move the target point during the competition.
- c. The Event Supervisor must test the team's alignment before each team is permitted to see the LSS.
- d. All mirrors must be placed in a home position designated by the event supervisor before each team is permitted to see the LSS.
- e. When a team is ready to begin, the event supervisor must give a countdown of "3, 2, 1, start" and start a timer. Event Supervisors give teams a warning when 5 minutes have elapsed.

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OPTICS C
See General Rules, Eye Protection & other Policies on www.scholastic.org as they apply to every event.

DESCRIPTION: Teams will participate in an activity involving positioning mirrors to direct a laser beam toward a target and complete a written test on the principles of geometry and physical optics.

A TEAM OF UP TO: 2

CALCULATOR: Class III

APPROXIMATE TIME: 50 minutes

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. Sheet protectors, lamination, tabs and labels are permitted. Participants may remove information from their binder for use during any part of the competition.
- b. Each team may also bring tools, protractors, compasses, squares, and two calculators (Class III).
- c. Teams must not bring lasers, mirrors, other optical devices (aside from personal eyeglasses or contacts), or electronics (other than calculators).

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. Unless otherwise requested, answers must be in metric units with appropriate significant figures.
- c. The event supervisor must select a Target Point location that is the same for all teams.

Part II: Laser Shoot

- a. The objective is to reflect a laser beam with mirrors around barriers towards the Target Point located on the floor.
- b. The event supervisor must select a Target Point location that is the same for all teams. Teams must not move the target point during the competition.
- c. The Event Supervisor must test the team's alignment before each team is permitted to see the LSS.
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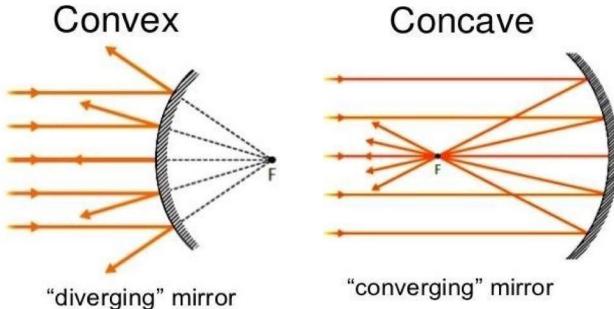
DIFFICULT TOPICS

Topic 1: Reflection & Refraction

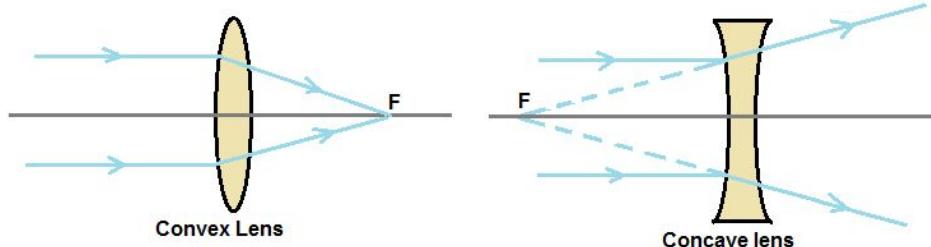
- Law of Reflection
 - Angle of incidence = angle of reflection
- Snell's Law
 - $n_1 \sin(\theta_1) = n_2 \sin(\theta_2)$
- Critical Angle
 - Angle of incidence where the angle of refraction is 90° (direct reflection)
 - $\theta = \arcsin(n_r/n_i)$
- Index of Refraction
 - $n = c/v$
 - Understand what happens to v when light enters a different medium

Topic 2: Mirrors & Lenses

- Mirrors
 - Convex: curves “out”
 - Concave: like an entrance to a cave, caves “in”

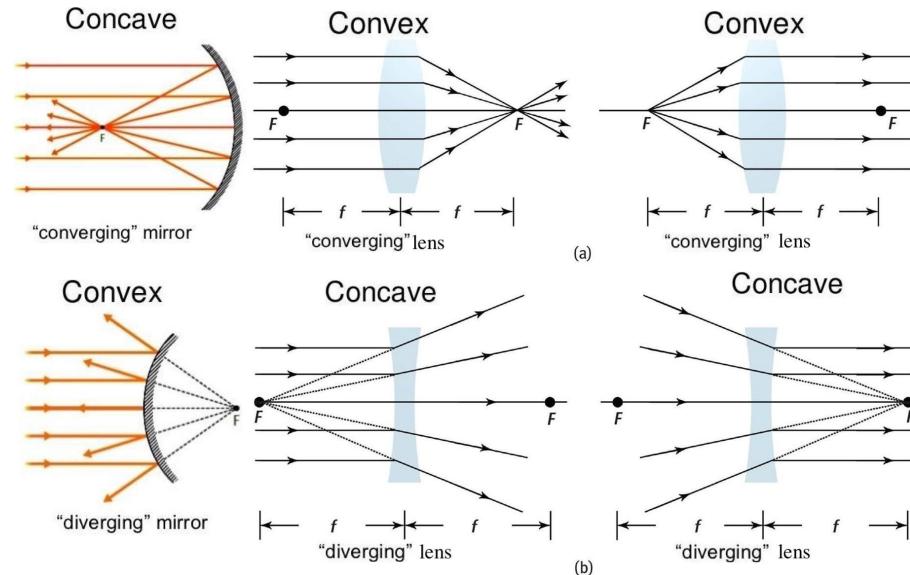


- Lenses
 - Convex: middle thicker than edges
 - Concave: middle thinner than edges



Topic 2: Mirrors & Lenses

- Watch out for naming!
- Mirrors:
 - Concave: converging
 - Convex: diverging
- Lenses:
 - Concave: diverging
 - Convex: converging
- This is simply a reflection of how they interact with light



Topic 2: Mirrors & Lenses

- Focal Length
 - $1/f = 1/u + 1/v$
 - u = object to lens
 - v = lens to image
- Magnification
 - $m = h_i/h_o = -d_i/d_o$
 - i = image
 - o = object
 - All distances are measured from the mirror/lens
- Often used in the context of vision correction
- Important to measure all distances/heights correctly!

Topic 3: Color Theory

- Additive Color Theory
 - RGB (human vision)
 - More light added = brighter & lighter resulting color
- Subtractive Color Theory
 - CMY (pigments)
 - More color added = closer to black
- Primary and Secondary Colors
 - RGB/CMY vs. colors resulting from their mixing
- Absorption and Reflection
 - Which colors are absorbed/reflected when struck with, e.g., white light?

COMMON QUESTIONS

All of the following questions have been pulled from past YJI exams (which can be found on our website) or the Text Exchange on SciOly Wiki

Question 1

- If a concave mirror forms a real image 45 cm from the mirror when the object is 30 cm from the mirror, what is the focal length of the mirror, in cm?

Solution:

$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$$

$$\frac{1}{f} = \frac{1}{45} - \frac{1}{30} = \frac{2 - 3}{90}$$

$$\frac{1}{f} = \frac{-1}{90}$$

$$f = -90 \text{ cm}$$

Question 2

- Light enters a diamond at an angle of 30° and bends to an angle of 22° . Calculate the index of refraction of the diamond, to the nearest thousandth.

Solution:

$$n_1 \sin(\theta_1) = n_2 \sin(\theta_2)$$

$$1 \cdot \sin(30^\circ) = n_2 \cdot \sin(22^\circ)$$

$$n_2 = \frac{\sin(30^\circ)}{\sin(22^\circ)}$$

$$n_2 = 1.335$$

Question 3

- A ray of light passes through a glass prism ($n = 1.5$) with an apex angle of 60° . Calculate the angle of minimum deviation, to the nearest hundredth of a degree.

Solution:

$$n = \frac{\sin\left(\frac{A+D_{\min}}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

$$\sin\left(\frac{A+D_{\min}}{2}\right) = n \cdot \sin\left(\frac{A}{2}\right)$$

$$\frac{A+D_{\min}}{2} = \arcsin\left(n \cdot \sin\left(\frac{A}{2}\right)\right)$$

$$D_{\min} = 2 \cdot \arcsin\left(n \cdot \sin\left(\frac{A}{2}\right)\right) - A$$

$$D_{\min} = 2 \cdot \arcsin\left(1.5 \cdot \sin\left(\frac{60^\circ}{2}\right)\right) - 60^\circ$$

$$D_{\min} = 37.18^\circ$$

Tips from a Veteran

- Teamwork is key
 - Specialize in separate topics, especially those that you enjoy more
 - A good split is anatomy/color/basics & mirrors/lenses
- Organization of your binder is essential
 - Sort your binder in a logical manner
 - Sort it in a way you will *remember* on competition day
- Less is more
 - A lot of people move mirrors in the perfect position before moving it away for their final run :(
 - Limit your overthinking
- PRACTICE (nothing else to say)

Additional Resources

Example tests

- Tournament websites
- SciOly test exchange

[physicsclassroom.com](https://www.physicsclassroom.com)

hyperphysics.phy-astr.gsu.edu !

phys.libretexts.org !

THANKS!

