Purdue Science Olympiad Invitational 2025

Optics: Division B

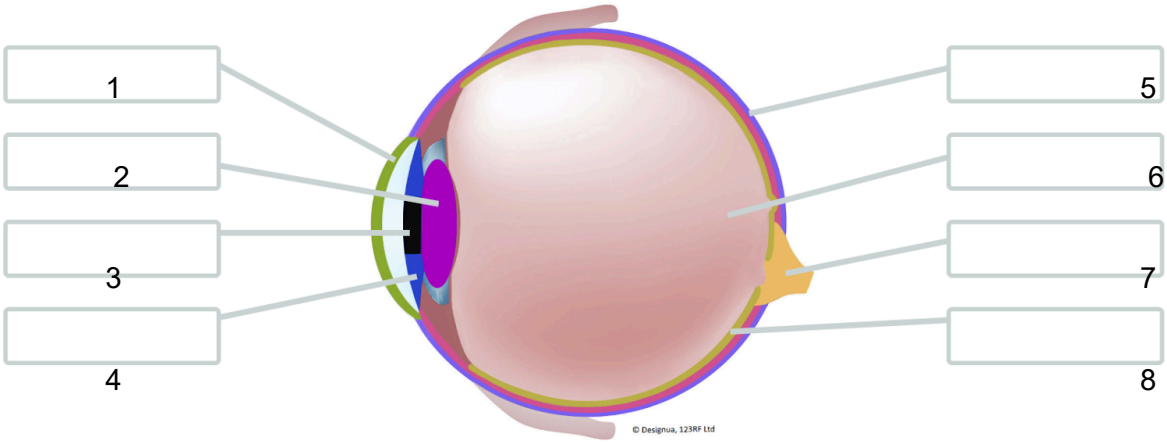
Team Name: _____

Team Members: _____

Team Number: _____

Human Eye (2 points each)

Fill in the blank with the corresponding eye structure.



1. _Cornea__

2. __Lens___

3. ___Pupil___

4. __Iris___

5. _Schlera_

6. Vitreous Humour

7. __Optic Nerve__

8. __Retina___

Reflection and Refraction (18 points)

1) In around one sentence, describe the main difference between specular and diffuse reflection. (2 points)

Specular reflection is reflection where the reflected rays are all parallel to each other, whereas diffuse reflection is reflection where the reflected rays all travel in random directions.

2) When a beam of light travels from a medium of higher index of refraction to a medium of lower index of refraction, does the angle of refraction increase or decrease? Briefly use mathematics to show how/why this is the case. (4 points)

Increases

Snell's law: $n_1 * \sin\theta_1 = n_2 * \sin\theta_2$, simple rearranging or explanation of how ratios of indices of refraction on either side of the equation compare

3) If a beam of light is moving from a medium of higher index of refraction to a medium of lower index of refraction, at what minimum angle, in degrees, will the beam of light need to hit the surface between the two mediums in order to remain trapped inside the first medium? You may leave your answer as an expression. (2 points)

θ = inverse sin n_2/n_1

4) Perform a simple mathematical derivation for the equation used to solve the previous question. (4 points)

Applying Snell's Law to calculate the critical angle:

$n_1 * \sin\theta_1 = n_2 * \sin 90$
$n_1 * \sin\theta_1 = n_2 * 1$
$\sin\theta_1 = n_2/n_1$
$\sin\theta_1 = \sin(\text{critical angle})$
θ_1 = inverse sin n_2/n_1
Where $n_1 > n_2$

5) At what angle, in degrees, will a beam of light propagating through ice (n = 1.31) need to strike a plate of plexiglass (n = 1.49) in order to achieve maximum polarization? (2 points)

a) 41.25
b) 48.68
c) 52.43
d) 56.09

b

$$\theta_B = tan^{-1}(n_2/n_1)$$

Brewster's angle:

Mirrors and Lenses (19 points)

1) For a flat mirror, by what factor does the distance between an object and its image change if the object is moved from 10 cm away from the mirror to 5 cm away from the mirror? (1 point)

    a) 1
    b) 2
    c) ½
    d) ¼

    c

2) Calculate the lateral magnification of an object of height 3 inches placed 12 inches in front of a 7 inch tall flat mirror. (2 points)

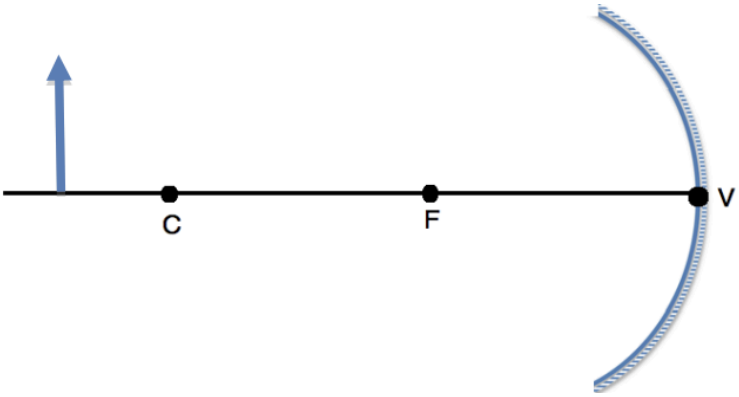
    1, always 1 for a flat mirror

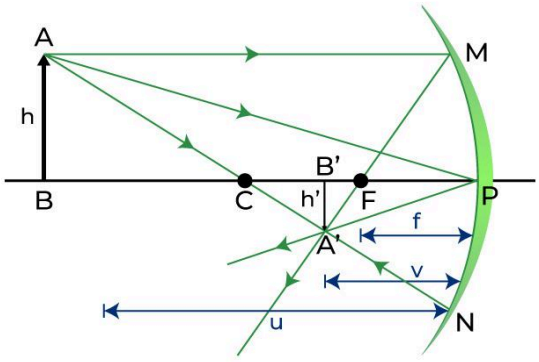
3) Which of the following best describes the images formed by a concave mirror when the object is located between the focal point and the mirror? (1 point)

    a) Real, inverted, and diminished
    b) Virtual, upright, and magnified
    c) Real, upright, and magnified
    d) Virtual, inverted, and diminished

    b

4) Complete the following ray diagram for a concave mirror using at least 3 distinct rays. Draw the image at its approximate image point with the right orientation and state whether it is real or virtual. (4 points)





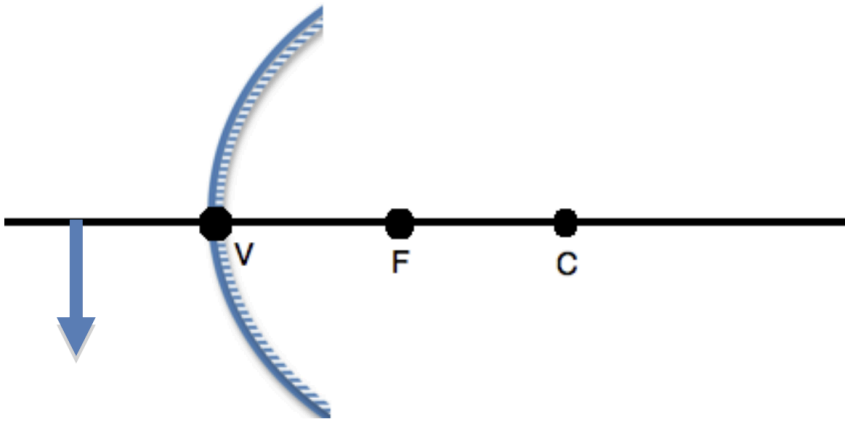
Something like this, no need to label u

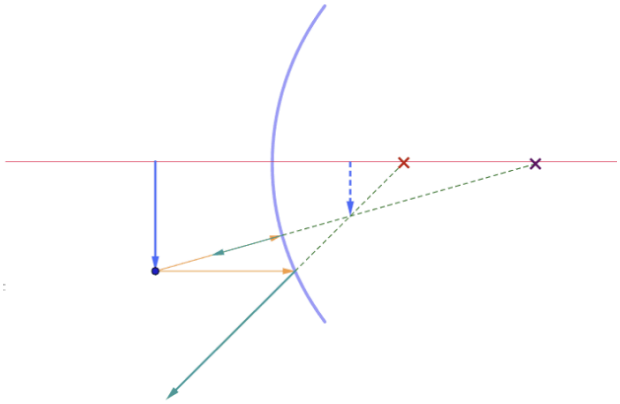
- **Real, inverted, diminished image**

5) Calculate the image distance and magnification given that the focal length of the mirror is 5 cm and the object distance is 12 cm. (2 points)

Image distance = 8.57 cm, magnification = -0.71 (full credit only if sign is correct)

6) Repeat the process in questions 4 and 5 for the following diagram of a convex mirror. (6 points)





Something like this, if it is done with 2 rays instead of 3 that is honestly fine, give full credit

- **Virtual, upright, diminished image**
- **Magnification will be positive sign here**

7) Classify each of the following lenses as either converging or diverging. (3 points)

a) Bi-convex
b) Plano-convex
c) Convex meniscus
d) Bi-concave
e) Plano-concave
f) Concave-meniscus

Converging, converging, converging, diverging, diverging, diverging

Color theory (10 points)

1) When light is absorbed by a material, what happens to the electrons in the atoms of that material? (2 points)

    a) They lose energy and move closer to the nucleus
    b) They gain energy, become excited, and move to a higher energy level
    c) They emit photons without changing their energy level
    d) They are released from the atom entirely

    b

2) Which phenomenon causes the colors we see in objects? (2 points)

    a) Selective absorption and reflection of certain wavelengths
    b) Complete absorption of all wavelengths
    c) Equal transmission of all wavelengths
    d) Reflection of only one wavelength

    a

3) Sheets of which of the following fundamental colors of the subtractive model can overlay to produce blue light when placed in front of a white light? (2 points)

    a) Blue only
    b) Blue, green and magenta
    c) Cyan and magenta
    d) Red and green

    c

4) Which of the following correctly describes how a green filter affects light? (2 points)

    a) It allows only green light to pass through and absorbs other colors
    b) It reflects green light and allows all other colors to pass through
    c) It converts green light into red light
    d) It blocks green light completely

    a

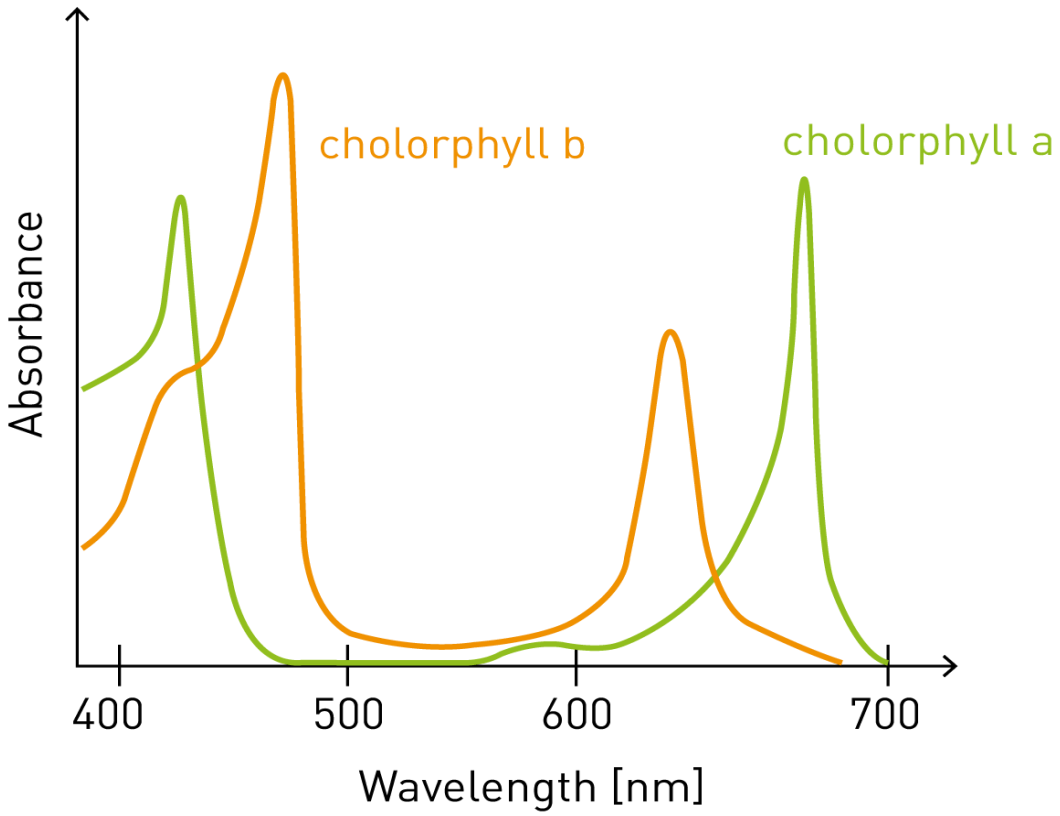
5) What color of light is absorbed when white light passes through a cyan filter? (2 points)

a) Blue
b) Green
c) Red
d) Yellow

c

Absorption (6 points)

1) What are the respective wavelengths (in nm) a spectrometer should be set to to measure absorbance most accurately? (4 points)



Chlorophyll A: **650-700** Chlorophyll B: **450-500**

Tiebreaker: What are the colors of the wavelengths for Chlorophyll A and B?

Chlorophyll A - Blue Chlorophyll B - Red

2) What is the relationship between absorbance and concentration of a solution (i.e. what happens to the amount of light absorbed by a solution as the particles dissolved in the solution increases)? (2 points)

a) Absorbance increases exponentially as concentration increases
b) Absorbance decreases exponentially as concentration increases
c) Absorbance increases linearly as concentration increases
d) Absorbance decreases linearly as concentration increases