

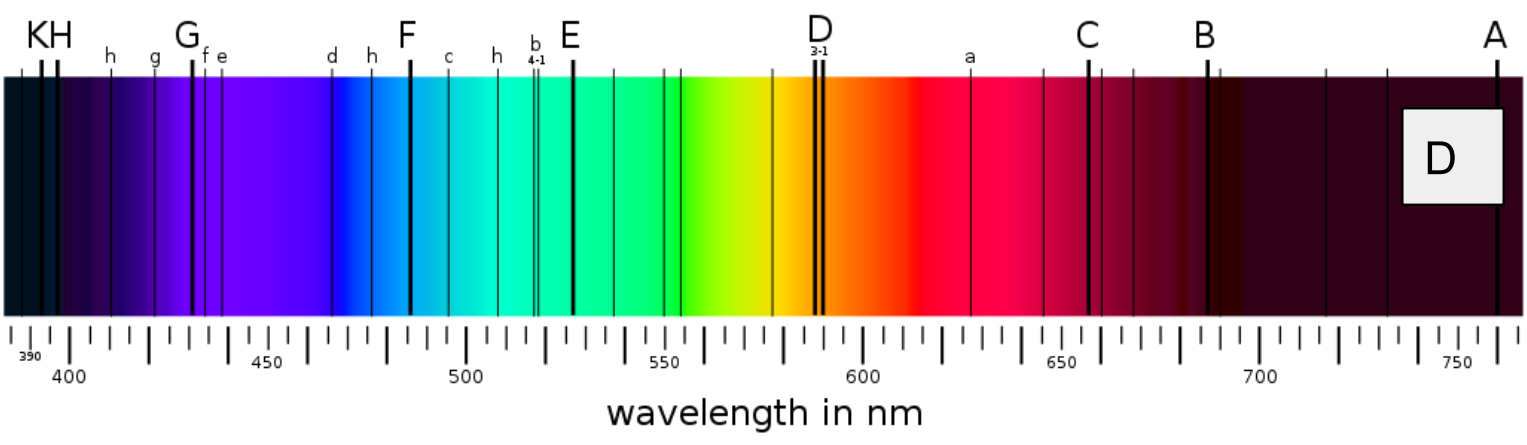
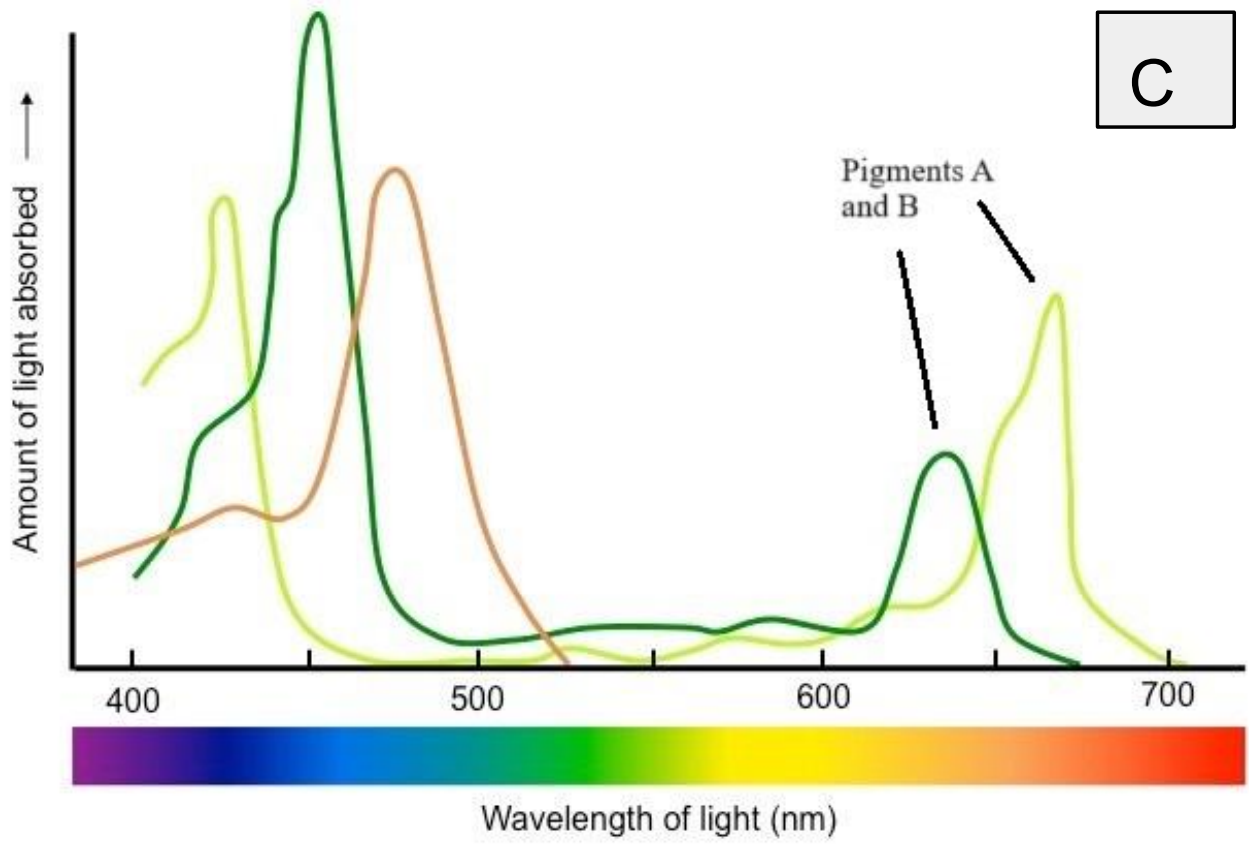
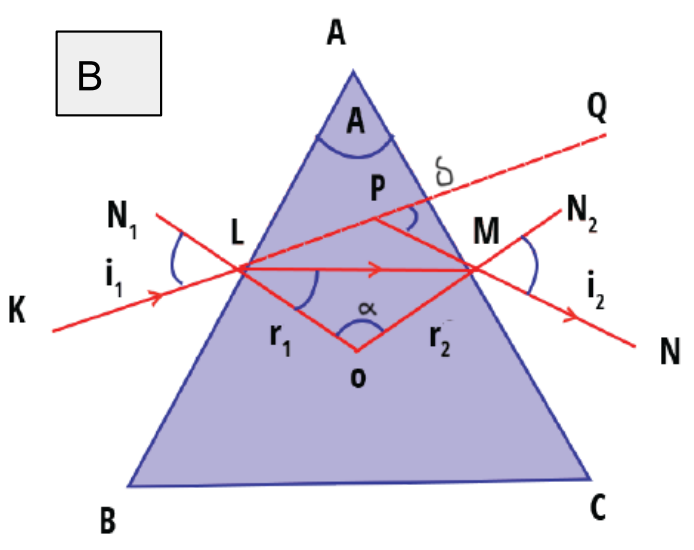
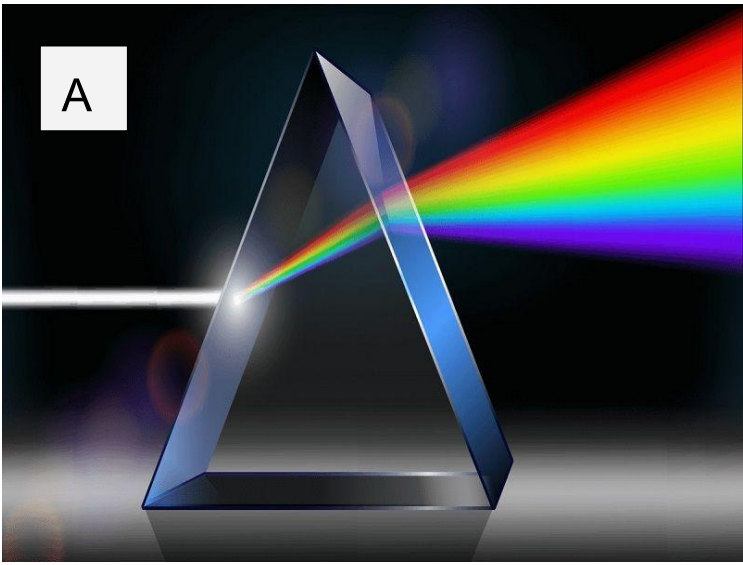
Optics

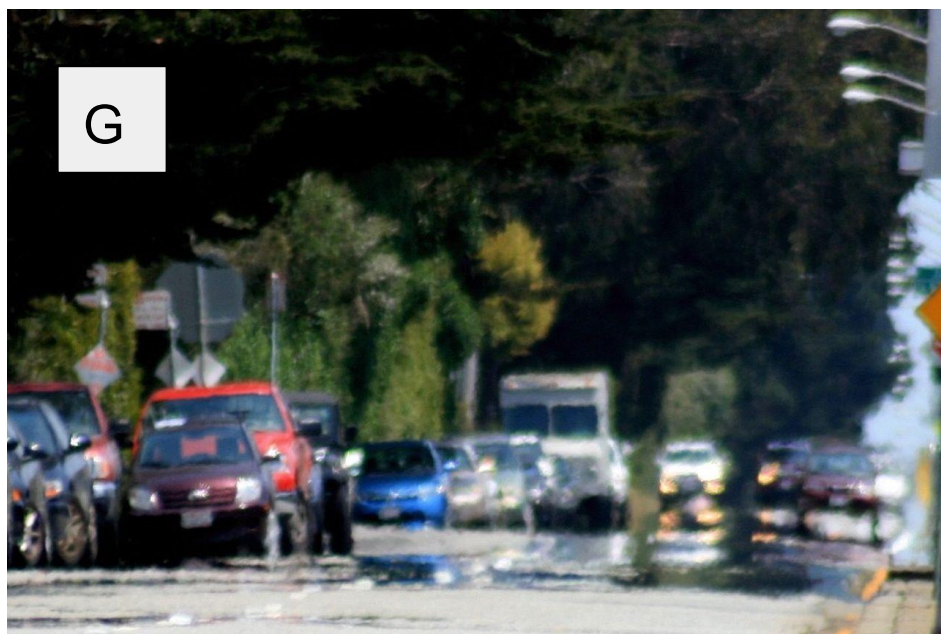
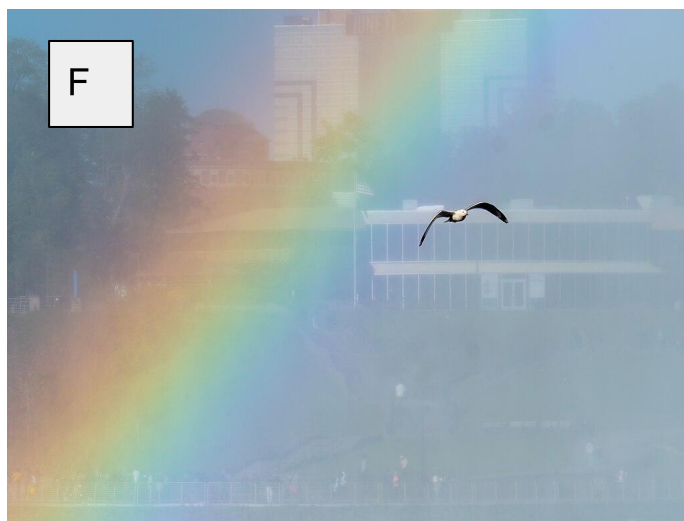
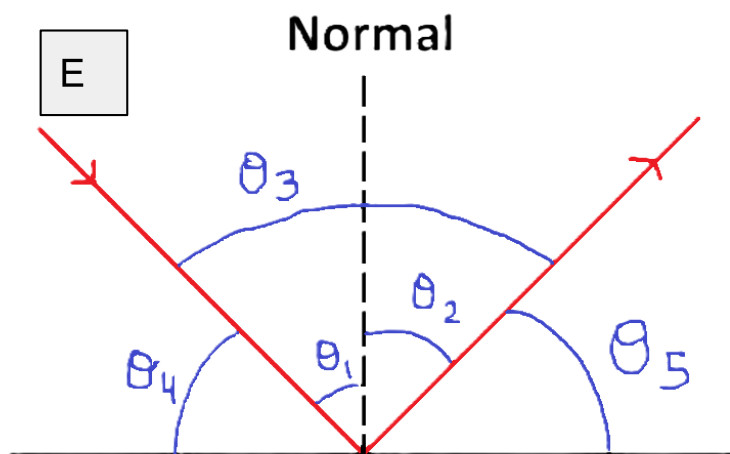
Brown Science Olympiad Div B Invitational
December 2, 2023



Instructions:

1. You may use one 8.5" x 11" sheet of paper with information on one/both sides.
2. You may use stand-alone calculators.
3. You do not have to show your work unless you are explicitly asked to do so. Partial credit may be awarded if correct work is shown in these cases.
4. Round all calculations to the tenths place, if necessary.
5. Tiebreaker Questions: #51, #24, #30, #19, #15
6. All questions are worth 1 point unless marked otherwise.
7. Put your team name and team number at the top of all answer sheets.
8. Write all answers on the answer sheets provided; answers written on the question/image sheets will not be graded.
9. Refer to the image sheet in this packet for a question when stated, eg. **Image A**.
10. Good luck!





1. Which of the following is true regarding the index of refraction?
 - (a) A ratio that describes how much light will “slow down” in a medium
 - (b) The index of refraction is another name for wavelength
 - (c) Most solids have an index of refraction less than 1.00
 - (d) Water’s high index of refraction is responsible for glare
2. What are the units of the index of refraction for a medium?
 - (a) Meters / second
 - (b) 1 / Seconds
 - (c) Meters
 - (d) Unitless

Questions 3-4 refer to Image A in the image sheet of this test packet.

3. What is the phenomenon shown in **Image A** known as?
 - (a) Diffraction
 - (b) Reflection
 - (c) Dispersion
 - (d) Polarization
4. Which of the following are true regarding why violet light is towards the bottom of the rainbow produced by the prism in **Image A**?
 - (a) Violet has the greatest index of refraction
 - (b) Index of refraction is a function of the frequency of light
 - (c) A prism exhibits normal dispersion
 - (d) All of the above
5. **Image B** is a cross section of a triangular prism. For a light ray entering the prism from point K, which of the following 3 points describes the angle of deviation?
 - (a) N₁, O, N₂
 - (b) Q, P, N
 - (c) K, P, N
 - (d) P, L, M

For questions 6 through 10, match the following terms to the appropriate description: microscope, telescope, camera, retroreflector, and periscope.

6. This device has an eyepiece lens much smaller than the objective lens, and generally uses 2 mirrors.
7. The light-sensitive surface of this device is protected by a shutter until the user wants to allow light into it.
8. “Cat’s eye” is a common type of this device, which looks similar to a cat’s eye catching a beam of light.
9. This device has an eyepiece lens much smaller than the objective lens, and usually uses only 1 mirror.
10. Advanced versions of these use beams of electrons to capture images rather than light.

Questions 11-12 refer to Image C in the image sheet.

11. What color(s) would pigments A and B most likely appear as if they were mixed together?
12. These pigments are typically found in plants. What are they called?
13. Which of the following is false regarding dyes and pigments?
 - (a) Pigments are insoluble in water
 - (b) Dyes are often organic compounds
 - (c) Pigments are often inorganic compounds
 - (d) Some examples of dyes are charcoal and lapis lazuli
14. Why are green screens typically used in producing movies and television shows?
 - (a) Green is the highest energy of light in the visible spectrum
 - (b) It is the furthest color from human skin tone
 - (c) Green has the lowest luminance in the RGB color channels
 - (d) It comes from historically used silver halide crystals in film (i.e. it is arbitrary)
15. **Image D** shows an absorption spectrum of “white” light from the Sun. Why does it have several missing wavelengths of light? These are known as Fraunhofer lines and they are unique to our Sun. (TB #5)
 - (a) Those wavelengths of light are absorbed by the Sun’s atmosphere
 - (b) The electromagnetic radiation emitted from the Sun does not contain those wavelengths
 - (c) Those wavelengths are “forbidden” according to quantum mechanics
 - (d) It is an artifact of diffraction caused by our measuring instruments
16. Two plane mirrors meet at a 120° angle. If light rays strike one mirror at 45° , at what angle do they leave the second mirror?
17. The magnification of a convex mirror is $+0.5$ for objects 3.0 m from the mirror. What is the focal length of the mirror?
18. A small candle is 40 cm to the left of a concave mirror having a radius of curvature of 25 cm. [3 points]
 - (a) What is the focal length of the mirror?
 - (b) Where will the image of the candle be located? Specify a distance and whether it is to the left or right of the mirror. Round to the nearest whole number.
 - (c) Will the image be upright or inverted?
19. An object 5.0 mm high is placed 20 cm from a convex mirror of radius of curvature 15 cm. (TB #4) [3 points]
 - (a) Is the resulting image real or virtual? Use a ray tracing diagram to demonstrate.
 - (b) Calculate the image distance if the focal length is 7.5 cm.
 - (c) Compute the image size.
20.
 - (a) Where should an object be placed in front of a concave mirror so that it produces an image at the same location as the object?
 - (b) Is the image real or virtual? [0.5 points]
 - (c) Is the image inverted or upright? [0.5 points]
 - (d) What is the lateral magnification of the image?

21. When walking toward a concave mirror you notice that your image flips at a distance of 0.80 m from the mirror. What is the radius of curvature of the mirror?
22. How far from a converging lens with a focal length of 25 cm should an object be placed to produce a real image which is the same size as the object?
23. How far apart are an object and an image formed by a 80 cm focal-length converging lens if the image is 3 times larger than the object and is real?
24. A certain lens focuses an object 2.15 m away as an image 48.3 cm on the other side of the lens. (TB #2) [2 points]
 - (a) What type of lens is it and what is its focal length?
 - (b) Is the image real or virtual?
25. Two 28.0-cm-focal-length converging lenses are placed 16.5 cm apart. An object is placed 35.0 cm in front of one lens. [2 points]
 - (a) Where will the final image formed by the second lens be located?
 - (b) What is the total magnification?
26. The axons from _____ in the retina make up the optic nerve.
 - (a) amacrine cells
 - (b) photoreceptors
 - (c) bipolar cells
 - (d) retinal ganglion cells
27. What is the fovea?
 - (a) location on the retina without any photoreceptors
 - (b) area of the eye right behind the iris
 - (c) location on the retina where visual acuity is highest
 - (d) connective tissue that binds the optic nerve to the retina
28. What is the primary function of the aqueous humor?
 - (a) Refracting light onto the retina
 - (b) Maintaining the shape of the eyeball
 - (c) Absorbing excess light energy
 - (d) Transmitting visual signals to the brain
29. Which part of the eye is responsible for producing tears to keep the eye moist?
 - (a) Lacrimal gland
 - (b) Conjunctiva
 - (c) Sclera
 - (d) Optic nerve
30. What role do bipolar cells play in the visual signal processing within the retina? (TB #3)
 - (a) Transmit signals directly to the optic nerve
 - (b) Amplify visual signals before reaching the ganglion cells
 - (c) Connect photoreceptor cells to the optic nerve
 - (d) Inhibit the activity of ganglion cells

31. Which type of photoreceptors are more sensitive to low light conditions and contribute to night vision?
 - (a) Rod cells
 - (b) Cone cells
 - (c) Bipolar cells
 - (d) Ganglion cells
32. Which part of the eye is responsible for the initial bending of light as it enters the eye?
 - (a) Retina
 - (b) Cornea
 - (c) Vitreous humor
 - (d) Lens
33. Which structure is responsible for adjusting the curvature of the lens for near and far vision?
 - (a) Cornea
 - (b) Ciliary body
 - (c) Retina
 - (d) Choroid
34. Which part of the eye contains the highest density of rod cells, contributing to low-light vision?
 - (a) Macula
 - (b) Fovea
 - (c) Peripheral retina
 - (d) Optic disc
35. The angle of incidence equals the angle of reflection in...
 - (a) diffuse reflection
 - (b) specular reflection
 - (c) mirror reflection
 - (d) more than one of the above
 - (e) none of the above
36. What type of reflection is occurring when you see a red hoodie?
 - (a) diffuse reflection
 - (b) specular reflection
 - (c) mirror reflection
 - (d) more than one of the above
 - (e) none of the above
37. The Law of Reflection holds true for which areas of the electromagnetic spectrum?
 - (a) radio waves
 - (b) visible light
 - (c) gamma rays
 - (d) all of the above
 - (e) none of the above

Questions 37-38 are based on Image E on the image sheet.

38. Which angle represents the angle of incidence?
- (a) θ_1
 - (b) θ_2
 - (c) θ_3
 - (d) θ_4
 - (e) θ_5
39. Which equation defines the Law of Reflection?
- (a) $\theta_3 = \theta_1 + \theta_2$
 - (b) $\theta_4 = \theta_5$
 - (c) $\theta_1 = \theta_2$
 - (d) $\theta_1 + \theta_4 = \theta_2 + \theta_5$
 - (e) $\theta_1 = \theta_5$
40. In an additive color system, the more colors you add, the closer you get to...
- (a) white
 - (b) black
 - (c) rainbow
 - (d) brown
 - (e) invisibility
41. The additive primary colors are...
- (a) cyan, magenta, yellow
 - (b) red, blue, yellow
 - (c) red, blue, green
 - (d) magenta, blue, yellow
 - (e) red, cyan, green
42. Mixing printing inks is an example of...
- (a) complex colors
 - (b) psychological color
 - (c) additive color
 - (d) subtractive color
 - (e) equality color
43. If an object absorbs green light, it will appear...
- (a) red
 - (b) green
 - (c) blue
 - (d) orange
 - (e) magenta

-
44. Mixing green and blue light will result in which color?
- (a) yellow
 - (b) cyan
 - (c) magenta
 - (d) black
 - (e) violet
45. A white light is passed through a filter that blocks out blue light. What is the color of the resulting light?
- (a) orange
 - (b) cyan
 - (c) blue
 - (d) yellow
 - (e) magenta
46. Mixing which two colored lights will result in a subtractive secondary color?
- (a) magenta and yellow
 - (b) red and blue
 - (c) green and red
 - (d) blue and green
 - (e) yellow and blue
47. If an object only reflects magenta light, it will appear...
- (a) blue
 - (b) red
 - (c) cyan
 - (d) magenta
 - (e) yellow
48. White light passes through a cyan, magenta, and yellow filter. What is the color of the resulting light?
- (a) white
 - (b) red
 - (c) blue
 - (d) green
 - (e) black
49. What color results from mixing cyan and magenta ink?
- (a) yellow
 - (b) white
 - (c) blue
 - (d) black
 - (e) Red

50. Which of the following principles does **not** work to produce the optical phenomenon shown in **Image F**?
- (a) Refraction
 - (b) Aberration
 - (c) Internal reflection
 - (d) Dispersion
51. Which of the following explanations correctly describe why a mirage occurs in **Image G**? (TB #1)
- (a) There must be an inversion in the air column due to smog and other pollutants
 - (b) The presence of fast moving cars and thus fast moving air particles diffracts the light
 - (c) The hot asphalt causes air close to the ground to have a different index of refraction than the air above it.
 - (d) The “mirage” is just an artifact caused by a faulty camera

ANSWER SHEET

Team Name: _____

Team Number: _____

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____
16. _____
17. _____
18. (a) _____

(b) Answer below:

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(c) _____

Team Name: _____

Team Number: _____

19. (a) _____

(b) _____

(c) _____

20. (a) _____

(b) _____

(c) _____

(d) _____

21. _____

22. _____

23. _____

24. (a) _____

(b) _____

(c) _____

25. (a) _____

(b) _____

(c) _____

26. _____

27. _____

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50. _____

51. _____