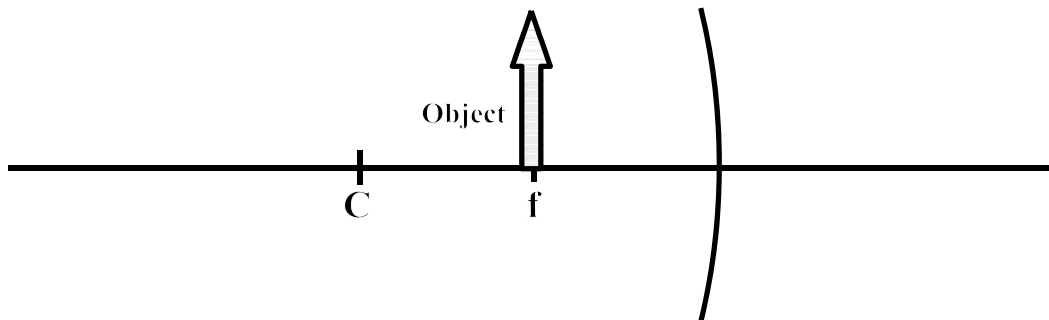


REFLECTION AND REFRACTION OF LIGHT

For each of the following complete the ray diagrams, indicate the direction of each ray, draw in the appropriate image and indicate whether the image is real or virtual. Neatness does count! All rays must be drawn precisely! Real rays should be drawn as solid lines while virtual rays should be drawn as dotted lines.

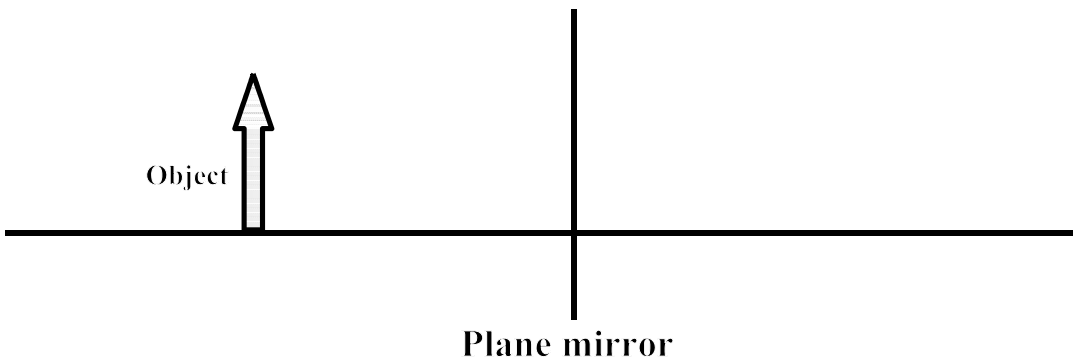
1. [4 PTS]

Real or Virtual?



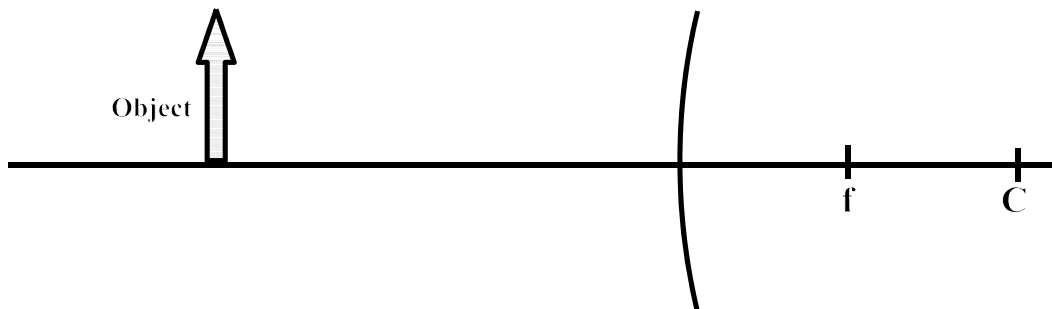
2. [4 PTS]

Real or Virtual?



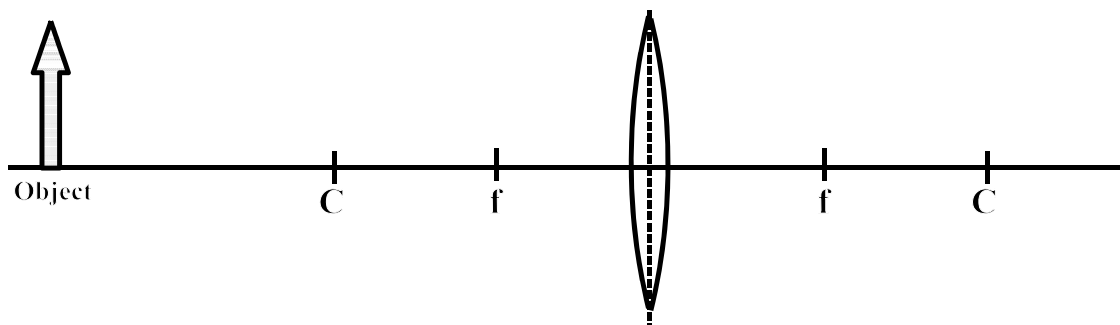
3. [4 PTS]

Real or Virtual?



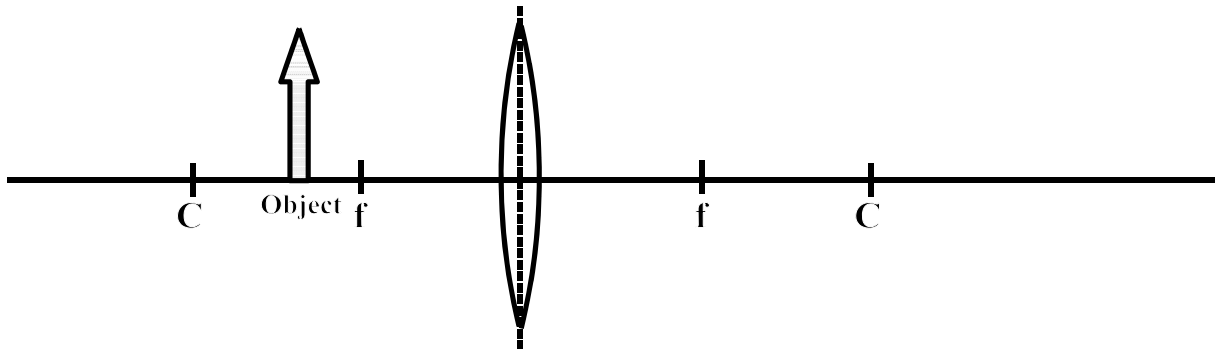
4. [4 PTS]

Real or Virtual?



REFLECTION AND REFRACTION OF LIGHT

5. [4 PTS]

Real or
Virtual?

[Each of the following is worth 3 pts each!]

A concave, spherical mirror is made from a glass sphere which has a radius of 38 centimeters. The mirror itself has a diameter of 4.0 cm. An object, which has a height of 4.5 cm, is placed a distance of 13.0 cm in front of the mirror.

6. What is the focal length of this mirror?

- A. 38.0 cm B. 19.0 cm C. 31.0 cm D. -38.0 cm E. -12.0 cm

7. What is the aperture of this mirror?

- A. $f/5.6$ B. $f/11.3$ C. $f/0.5$ D. $f/4.75$ E. $f/22.5$

8. What will be the final position of the resulting image?

- A. -12.0 cm B. 12.0 cm C. -41.0 cm D. -67.0 cm E. 99.6 cm

9. What will be the height of the final image?

- A. 14.2 cm B. 4.44 cm C. 11.3 cm D. 19.2 cm E. 2.20 cm

10. Where could you place this object if you wanted to produce a real image with this mirror?

- A. Place the object on the focus. B. Place the object on the vertex.
C. Place the object outside the focus. D. Place the object inside the focus.
E. A real image cannot be produced with this mirror.

A double concave lens is made of glass which has an index of 1.50. This lens is then, in turn, immersed in a liquid which has an index of refraction of 1.85. One surface of the lens has a radius of curvature of 15.0 cm, the second face has a radius of curvature of 30.0 cm and the lens has a diameter of 5.0 cm. An object, which has a height of 6.0 cm, is placed 50 cm from the lens.

11. What is the focal length of this lens?

- A. -40.0 cm B. 28.6 cm C. -57.2 cm D. 60.0 cm E. 20.0 cm

12. What will be the position of the final image produced by this lens?

- A. 18.2 cm B. 33.3 cm C. -62.8 cm D. 66.8 cm E. 41.0 cm

REFLECTION AND REFRACTION OF LIGHT

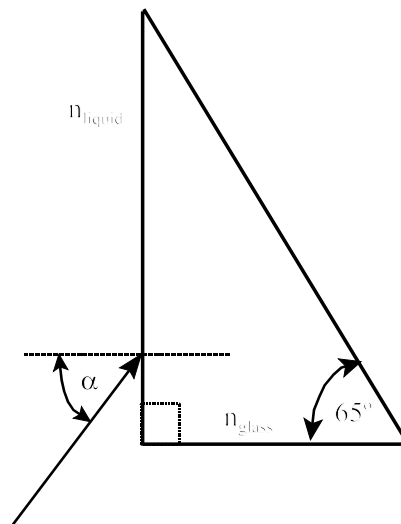
13. What will be the focal length of this lens if it is removed from the liquid into air?
 A. 150 cm B. 82.0 cm C. -20.0 cm D. -52.0 cm E. infinity

A concave, parabolic mirror, which has a focal length of 1.20 meters and a diameter of 15.0 cm, is to be used to construct a reflecting telescope for observing the moon. The moon has a diameter of 3480 km and is, on average, 380000 km from the Earth.

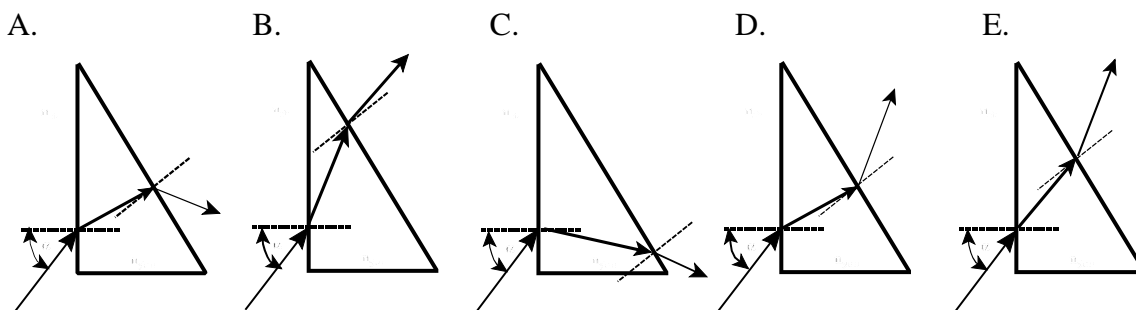
14. How far from the mirror should the viewing screen be placed ?
 A. 25.0 cm B. 4.0 cm C. 1.00 cm D. 1.2 m E. 1.50 cm
15. What will be the diameter of the resulting image on the viewing screen?
 A. 3.35 cm B. 0.335 cm C. 82.2 cm D. 0.042 m E. 1.1 cm

A light ray is incident upon a right prism as shown to the right. The prism is made of crown glass having an index of refraction of $n_{\text{prism}} = 1.53$. This prism is sitting in a liquid which has an index of $n_{\text{liquid}} = 1.22$. The angle α between the incident light ray and the normal to the first interface is 63.0° .

16. What will be the angle of the light ray after it enters the prism?
 A. 45.3° B. 34.2° C. 47.4° D. 88.5° E. 30.6°
17. What will be the critical angle between the glass of the prism and the liquid?
 A. 56.7° B. 34.8° C. 18.8° D. 41.3° E. 52.9°



18. Which of the following diagrams most closely describes the path of the light beam through the prism?

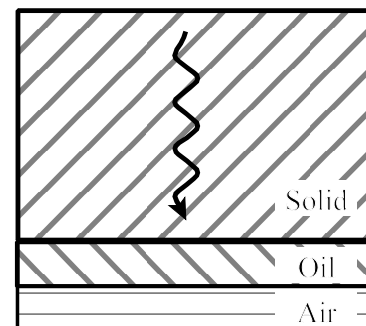


19. At what angle will the light beam emerge from the prism?
 A. 2.1° B. 4.5° C. 13.0° D. 19.3° E. 26.0°
20. An object is placed on the focus of a concave mirror. The resulting image will be found;
 A. there will be no image formed.
 B. inside the focus of the mirror.
 C. behind the mirror.
 D. directly on the focus.
 E. between the vertex and the focus.

REFLECTION AND REFRACTION OF LIGHT

21. A virtual image is formed by a convex lens. Which of the following statements is true?
- This image can be projected on a screen.
 - This image will be found on the opposite side of the lens from the object.
 - This image will be upside-down.
 - This image will always have a magnification greater than one.
 - This image will be formed at infinity.

Monochromatic light, which has a wavelength of 3500 \AA within the solid ($n_{\text{solid}} = 1.42$) through which it is moving, is normally incident upon a thin layer of oil ($n_{\text{oil}} = 1.22$) as shown to the right. The space immediately below the oil film is filled with air ($n_{\text{air}} = 1.0$).



22. What will be the wavelength of this light in air?
- 8890 \AA
 - 4500 \AA
 - 3400 \AA
 - 5500 \AA
 - 4970 \AA
23. How will the phase of the light reflected from the solid-oil interface compare with the phase of the light reflected from the oil-air interface?
- They will differ by 450°
 - They will differ by 270°
 - They will differ by 180°
 - They will be the same
 - They will differ by 90° .
24. Which of the following is a characteristic of a real image?
- Light rays only appear to converge.
 - It is always erect.
 - It can be projected
 - Its position can be determined using parallax.
 - It can be made by either mirrors or lenses.
25. Which of the following are the primary pigments?
- red, green, blue
 - magenta, cyan, yellow
 - cyan, red, green
 - red, blue, yellow
 - orange, red, blue
26. Which of the following colors is the complement of red?
- cyan
 - blue
 - green
 - magenta
 - yellow
27. Which of the following colors are the primary colors?
- red, green, blue
 - red, blue, yellow
 - cyan, red, green
 - magenta, cyan, yellow
 - orange, red, blue
28. You are looking into a so called "beauty mirror" and you see a virtual image of yourself with a magnification of $3.0 \times$. Given that the focal length of this mirror is 45.0 cm , how far from the mirror must your face be located?
- 12.0 cm
 - 30.0 cm
 - 22.0 cm
 - 27.0 cm
 - 45.0 cm
29. What will be the speed of light within a piece of diamond which has an index of refraction of 2.40 ?
- $2.25 \times 10^8 \text{ m/sec}$
 - $1.25 \times 10^8 \text{ m/sec}$
 - $3.0 \times 10^8 \text{ m/sec}$
 - $4.89 \times 10^8 \text{ m/sec}$
 - $1.84 \times 10^8 \text{ m/sec}$

REFLECTION AND REFRACTION OF LIGHT

30. Suppose that a beam of white light enters a very thick sheet of glass. Which of the following colors would emerge from the glass first?
A. red B. orange C. yellow D. blue E. all colors will emerge at the same time.
31. A ray of light passes from air into water, striking the surface of the water with an angle of incidence of 45° . Which of the following four quantities do **NOT** change as the light enters the water:
(1) wavelength (2) frequency (3) period (4) direction of propagation.
A. 1 and 2 only B. 2, 3 and 4 only C. 1, 3 and 4 only D. 2 and 3 only E. 1, 2, 3, and 4
32. The spherical distortion of the image produced by a mirror can be reduced by:
A. making the mirror smaller. B. reducing the aperture of the mirror. C. immersing the mirror in a liquid.
D. reversing the curvature of the mirror. E. decreasing the radii of curvature of the mirror.
33. The chromatic aberration in the image produced by a thin lens can be reduced by:
A. making the lens smaller.
B. immersing the lens in a liquid whose index is greater than the lens.
C. immersing the lens in a liquid whose index is less than the lens.
D. reversing the orientation of the lens.
E. using an achromatic lens set.
34. Chromatic aberration in a lens occurs because:
A. thin lenses are made of glass rather than plastic.
B. the edges of thin lenses are shaped very much like a prism.
C. thin lenses have indices that are generally too high.
D. the surfaces of most lenses are diffuse rather than specular.
E. light passing through the center of the lens undergoes dispersion.

USEFUL INFORMATION

$$10^{10} \text{ \AA} = 1 \text{ m} \quad 10^7 \text{ \AA} = 1 \text{ mm} \quad 10^8 \text{ \AA} = 1 \text{ cm} \quad c = 3.0 \times 10^8 \text{ m/sec}$$

REFLECTION AND REFRACTION OF LIGHT

6. B	11. B	16. A	21. D	26. A	31. D
7. D	12. D	17. E	22. E	27. A	32. B
8. C	13. C	18. E	23. D	28. B	33. E
9. A	14. D	19. E	24. E	29. B	34. B
10. C	15. E	20. A	25. B	30. A	