

Physics: Principle and Applications, 7e (Giancoli)
Chapter 23 Light: Geometric Optics

23.1 Conceptual Questions

1) A light beam has speed c in vacuum and speed v in a certain plastic. The index of refraction n of this plastic is

- A) $n = cv$.
- B) $n = (v/c)^2$.
- C) $n = v/c$.
- D) $n = c/v$.
- E) $n = (c/v)^2$.

Answer: D

Var: 1

2) If the index of refraction of a material is 2, this means that light travels

- A) 2 times as fast in air as it does in vacuum.
- B) 2 times as fast in the material as it does in air.
- C) 2 times as fast in vacuum as it does in the material.
- D) 2 times as fast in the material than it does in vacuum.
- E) 1/2 as fast in air as it does in the material.

Answer: C

Var: 1

3) Light enters air from water. The angle of refraction will be

- A) greater than the angle of incidence.
- B) equal to the angle of incidence.
- C) less than the angle of incidence.

Answer: A

Var: 1

4) Light enters glass from air. The angle of refraction will be

- A) greater than the angle of incidence.
- B) equal to the angle of incidence.
- C) less than the angle of incidence.

Answer: C

Var: 1

5) The index of refraction of a type of glass is 1.50, and the index of refraction of water is 1.33. If light enters water from this glass, the angle of refraction will be

- A) greater than the angle of incidence.
- B) equal to the angle of incidence.
- C) less than the angle of incidence.

Answer: A

Var: 1

6) Light goes from material having a refractive index of n_1 into a material with refractive index n_2 . If the refracted light is bent away from the normal, what can you conclude about the indices of refraction?

A) $n_1 > n_2$

B) $n_1 \geq n_2$

C) $n_1 < n_2$

D) $n_1 \leq n_2$

E) $n_1 = n_2$

Answer: A

Var: 1

7) A beam of light traveling in air strikes a glass slab at an angle of incidence less than 90° . After entering the glass slab, what does the beam of light do? (There could be more than one correct choice.)

A) It follows the same path as before it struck the glass.

B) It follows the normal to the glass slab.

C) It bends away from the normal at the point of contact.

D) It bends closer to the normal at the point of contact.

E) It slows down.

Answer: D, E

Var: 1

8) The critical angle for a beam of light passing from water into air is 48.8° . This means that all light rays with an angle of incidence in the water that is greater than 48.8° will be

A) totally absorbed by the water.

B) totally reflected.

C) partially reflected and partially transmitted.

D) totally transmitted.

Answer: B

Var: 1

9) Which one of the following sets of characteristics describes the image formed by a plane mirror?

A) real and inverted

B) real and upright

C) virtual and upright

D) virtual and inverted

E) virtual and larger than the object

Answer: C

Var: 1

10) The image formed in a plane mirror is

- A) at the same distance in front of the mirror as the object is in front of the mirror.
- B) a real image behind the mirror.
- C) at the same distance behind the mirror as the object is in front of the mirror.
- D) at a shorter distance behind the mirror than the distance the object is in front of the mirror.
- E) at a larger distance behind the mirror than the distance the object is in front of the mirror.

Answer: C

Var: 1

11) You may have seen ambulances on the street with the letters of the word AMBULANCE written on the front of them, in such a way as to appear correctly when viewed in your car's rear-view mirror. (See the figure.) How do the letters appear when you look directly at the ambulance (not through the mirror)?

a) ECNALUBMA b) AMBULANCE

c) ECNALUBMA d) AMBULANCE

e) AMBULANCE

A) a

B) b

C) c

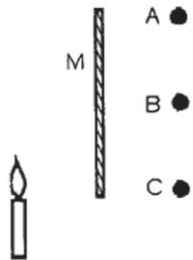
D) d

E) e

Answer: E

Var: 1

12) A lighted candle is placed a short distance from a plane mirror, as shown in the figure. At which location will the image of the flame appear to be located?



A) at A

B) at B

C) at C

D) at M (at the mirror)

Answer: C

Var: 1

13) Which one of the following numbers is the correct magnification produced by a plane mirror?

- A) $1/2$
- B) $1/4$
- C) 2
- D) 1
- E) $3/2$

Answer: D

Var: 1

14) As you walk away from a plane mirror on a wall, the height of your image

- A) gets smaller.
- B) may or may not get smaller, depending on where the observer is positioned.
- C) is always a real image, no matter how far you are from the mirror.
- D) changes from being a virtual image to a real image as you pass the focal point.
- E) is always the same size.

Answer: E

Var: 1

15) Suppose you place an object in front of a concave mirror. Which of the following statements *must* be true? (There could be more than one correct choice.)

- A) The image of the object will always be smaller than the object.
- B) No matter where you place the object, a real image of the object will be formed.
- C) The image of the object will always be inverted.
- D) If you position the object between the mirror and the focal point of the mirror, its image must be upright and virtual.
- E) No matter where you place the object, the image of the object will always be virtual and upright.

Answer: D

Var: 1

16) Which statements about images are correct? (There could be more than one correct choice.)

- A) A virtual image cannot be formed on a screen.
- B) A virtual image cannot be viewed by the unaided eye.
- C) A virtual image cannot be photographed.
- D) A real image must be erect.
- E) Mirrors always produce real images because they reflect light.

Answer: A

Var: 1

- 17) A negative magnification for a mirror means that
- A) the image is inverted, and the mirror could be either concave or convex.
 - B) the image is upright, and the mirror is convex.
 - C) the image is inverted, and the mirror is convex.
 - D) the image is inverted, and the mirror is concave.
 - E) the image is upright, and the mirror could be either concave or convex.

Answer: D

Var: 1

- 18) The focal length of a concave mirror has a magnitude of 20 cm. What is its radius of curvature?

- A) 10 cm
- B) 40 cm
- C) -40 cm
- D) 20 cm
- E) -20 cm

Answer: B

Var: 1

- 19) The focal length of a convex mirror is has a magnitude of 20 cm. What is its radius of curvature?

- A) -10 cm
- B) 40 cm
- C) -40 cm
- D) -20 cm
- E) 20 cm

Answer: C

Var: 1

- 20) If a spherical concave mirror has a radius of curvature R , its focal length is

- A) $R/4$.
- B) $R/2$.
- C) R .
- D) $2R$.
- E) $4R$.

Answer: B

Var: 1

- 21) If a spherical convex mirror has a radius of curvature R , the magnitude of its focal length is

- A) $R/2$.
- B) $R/4$.
- C) R .
- D) $2R$.
- E) $4R$.

Answer: A

Var: 1

22) Which of the following statements about spherical mirrors is correct? (There could be more than one correct choice.)

- A) A concave mirror always produces a real image.
- B) A convex mirror always produces a virtual image.
- C) A concave mirror always produces a virtual image.
- D) A convex mirror always produces a real image.
- E) A convex mirror always produces an upright image.

Answer: B, E

Var: 1

23) An object is placed to the left of a spherical mirror in front of the mirror. If the image of the object is formed on the right side of the mirror, which of the following statements *must* be true? (There could be more than one correct choice.)

- A) The image is upright and the mirror must be convex.
- B) The image is inverted and real, and the mirror must be convex.
- C) The image is upright and the mirror must be concave.
- D) The image is upright and virtual.
- E) The mirror could be either concave or convex.

Answer: D, E

Var: 1

24) An object is placed in front of a convex mirror at a distance larger than twice the magnitude of the focal length of the mirror. The image will appear

- A) in front of the mirror.
- B) inverted and reduced.
- C) inverted and enlarged.
- D) upright and reduced.
- E) upright and enlarged.

Answer: D

Var: 1

25) A convex mirror has a focal length of magnitude f . An object is placed in front of this mirror at a point $\frac{2}{3}f$ from the face of the mirror. The image will appear

- A) behind the mirror.
- B) upright and reduced.
- C) upright and enlarged.
- D) inverted and reduced.
- E) inverted and enlarged.

Answer: B

Var: 1

26) If an object is placed at the center of curvature of concave mirror, the image formed by the mirror is located

- A) out beyond the center of curvature.
- B) at the center of curvature.
- C) between the center of curvature and the focal point.
- D) at the focal point.
- E) at infinity.

Answer: B

Var: 1

27) If you stand in front of a convex mirror, at the same distance from it as its radius of curvature,

- A) you won't see your image because there is none.
- B) you won't see your image because it is focused at infinity.
- C) you will see your image and you will appear smaller than you.
- D) you will see your image and you will appear larger than you.
- E) you will see your image and it will be the same size as you except upside down.

Answer: C

Var: 1

28) If you stand in front of a convex mirror, at the same distance from it as its focal length,

- A) you won't see your image because there is none.
- B) you won't see your image because it is focused at infinity.
- C) you will see your image and you will appear smaller than you.
- D) you will see your image and you will appear larger than you.
- E) you will see your image and it will be the same size as you except upside down.

Answer: C

Var: 1

29) Sometimes when you look into a curved mirror you see a magnified image (a great big you) and sometimes you see a diminished image (a little you). If you look at the bottom (convex) side of a shiny spoon, what will you see?

- A) You won't see an image of yourself because no image will be formed.
- B) You will see a little you, upside down.
- C) You will see a little you, right side up.
- D) You will see a little you, but whether you are right side up or upside down depends on how near you are to the spoon.
- E) You will either see a little you or a great big you, depending on how near you are to the spoon.

Answer: C

Var: 1

30) Single concave spherical mirrors produce images that

- A) are always smaller than the actual object.
- B) are always larger than the actual object.
- C) are always the same size as the actual object.
- D) could be smaller than, larger than, or the same size as the actual object, depending on the placement of the object.
- E) are always real.

Answer: D

Var: 1

31) Single convex spherical mirrors produce images that

- A) are always smaller than the actual object.
- B) are always larger than the actual object.
- C) are always the same size as the actual object.
- D) could be larger than, smaller than, or the same size as the actual object, depending on the placement of the object.
- E) are sometimes real.

Answer: A

Var: 1

32) A beam of light that is parallel to the principal axis strikes a concave mirror. What happens to the reflected beam of light?

- A) It also is parallel to the principal axis.
- B) It is perpendicular to the principal axis.
- C) It passes through the center of curvature of the mirror.
- D) It passes through the focal point of the mirror.
- E) It passes between the focal point and the center of curvature of the mirror.

Answer: D

Var: 1

33) A beam of light that is parallel to the principal axis strikes a convex mirror. What happens to the reflected beam of light?

- A) It also is parallel to the principal axis.
- B) It is perpendicular to the principal axis.
- C) It appears to be coming from the focal point on the other side of the mirror.
- D) It appears to be coming from the center of curvature of the mirror.
- E) It appears to be coming from a point between the focal point and the center of curvature of the mirror.

Answer: C

Var: 1

34) An upright object is 50 cm from a concave mirror of radius 60 cm. The character of the image is

- A) real and upright
- B) real and inverted
- C) virtual and upright
- D) virtual and inverted

Answer: B

Var: 1

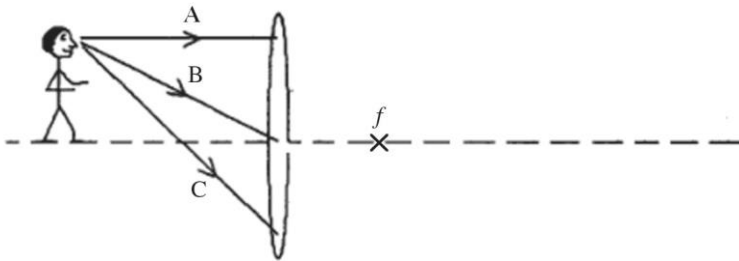
35) Suppose you wanted to start a fire using a mirror to focus sunlight. Which of the following statements is most accurate?

- A) It would be best to use a plane mirror.
- B) It would be best to use a convex mirror.
- C) It would be best to use a concave mirror, with the object to be ignited positioned at the center of curvature of the mirror.
- D) It would be best to use a concave mirror, with the object to be ignited positioned halfway between the mirror and its center of curvature.
- E) One cannot start a fire using a mirror, since mirrors form only virtual images.

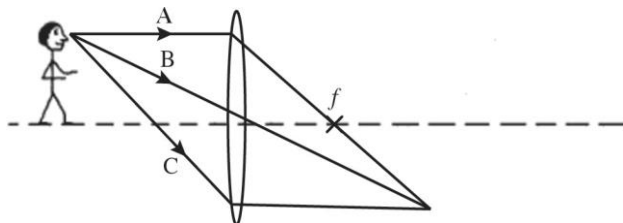
Answer: D

Var: 1

36) A thin lens projects an image of a man as shown in the figure. Rays marked A, B, and C travel to the lens from the man's ear. Draw the paths of these three rays after they have passed through the lens. Note that A is parallel to the principal axis, B goes through the center of the lens, C goes through the focal point on the left, and the point marked f is the focal point on the right of the lens.



Answer:



Var: 1

37) Which of the following terms describe lenses that are thinner at the center than at the edges?
(There could be more than one correct choice.)

- A) converging lenses
- B) diverging lenses
- C) concave lenses
- D) convex lenses

Answer: B, C

Var: 1

38) Which of the following terms describe lenses that are thicker at the center than at the edges?
(There could be more than one correct choice.)

- A) converging lenses
- B) diverging lenses
- C) concave lenses
- D) convex lenses

Answer: A, D

Var: 1

39) A convex lens has focal length f . If an object is located at "infinity" (very far away), the image formed is located at a distance from the lens

- A) of $2f$.
- B) between f and $2f$.
- C) of f .
- D) between the lens and f .
- E) of infinity.

Answer: C

Var: 1

40) A convex lens has focal length f . If an object is placed at a distance of $2f$ from the lens on the principal axis, the image is located at a distance from the lens

- A) of $2f$.
- B) between f and $2f$.
- C) of f .
- D) between the lens and f .
- E) of infinity.

Answer: A

Var: 1

41) A convex lens has focal length f . If an object is placed at a distance between f and $2f$ from the lens on the principal axis, the image is located at a distance from the lens

- A) of $2f$.
- B) between f and $2f$.
- C) of f .
- D) that is greater than $2f$.
- E) of infinity.

Answer: D

Var: 1

42) A convex lens has focal length f . If an object is placed at a distance beyond $2f$ from the lens on the principal axis, the image is located at a distance from the lens

A) of $2f$.

B) between f and $2f$.

C) of f .

D) between the lens and f .

E) of infinity.

Answer: B

Var: 1

43) If a object is placed between a convex lens and its focal point, the image formed is

A) virtual and upright.

B) virtual and inverted.

C) real and upright.

D) real and inverted.

Answer: A

Var: 1

44) Starting from very far away, an object is moved closer and closer to a converging lens, eventually reaching the lens. What happens to its image formed by that lens? (There could be more than one correct choice.)

A) The image gets closer and closer to the lens.

B) The image gets farther and farther from the lens.

C) The image eventually changes from virtual to real.

D) The image eventually changes from real to virtual.

E) The image keeps getting larger and larger.

Answer: D

Var: 1

45) Starting from very far away, an object is moved closer and closer to a diverging lens, eventually reaching the lens. What happens to its image formed by that lens? (There could be more than one correct choice.)

A) The image gets closer and closer to the lens.

B) The image gets farther and farther from the lens.

C) The image always remains virtual.

D) The image eventually changes from real to virtual.

E) The image keeps getting larger and larger.

Answer: A, C, E

Var: 1

46) Which of following statements about the image formed by a single converging lens are true?
(There could be more than one correct choice.)

- A) The image is always real.
- B) The image is always virtual.
- C) The image is always inverted.
- D) The image is always upright.
- E) None of the above choices are correct.

Answer: E

Var: 1

47) Which of following statements about the image formed by a single diverging lens are true?
(There could be more than one correct choice.)

- A) The image is always real.
- B) The image is always virtual.
- C) The image is always inverted.
- D) The image is always upright.
- E) The image is always smaller than the object.

Answer: B, D

Var: 1

48) If the magnification of a mirror or lens is negative, it means that

- A) the image is smaller than the object.
- B) the image is inverted and smaller than the object.
- C) the image is inverted.
- D) the object is farther from the mirror (or lens) than the image.
- E) the image is farther from the mirror (or lens) than the object.

Answer: C

Var: 1

49) Is it possible to see a virtual image?

- A) No, since the rays that seem to emanate from a virtual image do not in fact emanate from the image.
- B) No, since virtual images do not really exist.
- C) Yes because the rays that appear to come from a virtual image can be focused by the eye just like those from an object.
- D) Yes, but only by using an additional lens to form a real image before the light reaches the eye.

Answer: C

Var: 1

50) An object is placed on the left side of a thin lens, and the image of this object is formed on the left side of the lens. Which of the following statements *must* be true? (There could be more than one correct choice.)

- A) The lens must be a diverging lens, and the image is upright.
- B) The lens must be a converging lens, and the image is upright.
- C) The image is upright and virtual.
- D) The lens could be either a converging or a diverging lens, and the image is upright.
- E) The image is inverted and real.

Answer: C, D

Var: 1

51) If a single lens forms a virtual image of an object, then

- A) the lens must be a diverging lens.
- B) the lens must be a converging lens.
- C) the lens could be either a diverging or a converging lens.
- D) the image must be inverted.
- E) the object must be between the lens and its focal point.

Answer: C

Var: 1

52) Which statement about a single thin lens is correct?

- A) A converging lens always produces a real inverted image.
- B) A diverging lens always produces a virtual inverted image.
- C) A converging lens sometimes produces a real upright image.
- D) A diverging lens always produces a virtual upright image.
- E) A diverging lens produces a virtual upright image only if the object is located between the lens and its focal point.

Answer: D

Var: 1

53) An object is placed in front of a thin lens. Which statements are correct in describing the image formed by the lens? (There could be more than one correct choice.)

- A) If the lens is convex, the image will never be virtual.
- B) If the image is real, then it is also inverted.
- C) If the image is real, then it is also upright.
- D) If the lens is concave, the image must be virtual.
- E) If the lens is convex, the image must be real.

Answer: B, D

Var: 1

54) The image formed by a single concave lens

A) is always real.

B) is always virtual.

C) could be real or virtual, depending on whether the object distance is smaller or greater than the focal length.

D) could be real or virtual, but is always real when the object is placed at the focal point.

E) is always inverted.

Answer: B

Var: 1

23.2 Problems

1) Light having a speed in vacuum of 3.0×10^8 m/s enters a liquid of refractive index 2.0. In this liquid, its speed will be

A) 6.0×10^8 m/s

B) 3.0×10^8 m/s

C) 1.5×10^8 m/s

D) 0.75×10^8 m/s

E) 0.67×10^8 m/s

Answer: C

Var: 1

2) The speed of light in a certain material is measured to be 2.2×10^8 m/s. What is the index of refraction of this material? ($c = 3.0 \times 10^8$ m/s)

A) 1.1

B) 1.2

C) 1.4

D) 1.6

E) 1.8

Answer: C

Var: 1

3) The index of refraction of a certain glass is measured to be 1.5. What is the speed of light in that glass? ($c = 3.0 \times 10^8$ m/s)

A) 1.0×10^8 m/s

B) 2.0×10^8 m/s

C) 3.0×10^8 m/s

D) 4.0×10^8 m/s

E) 5.0×10^8 m/s

Answer: B

Var: 1

4) A thin laser beam traveling in air strikes the surface of a glass plate at 41.2° with the normal. In the plate, this beam makes an angle of 22.4° with the normal. What is the speed of light in this glass? ($c = 3.0 \times 10^8$ m/s)

Answer: 1.74×10^8 m/s

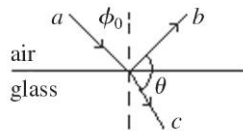
Var: 1

5) A plastic cube is immersed in water having an index of refraction of 1.33. A laser beam in the plastic strikes the interface at an angle of 14.5° with the normal in the plastic. In the water, this beam makes an angle of 21.8° with the normal. What is the speed of light in the plastic cube? ($c = 3.0 \times 10^8$ m/s)

Answer: 1.52×10^8 m/s

Var: 1

6) A ray of light (ray a) in air strikes a flat piece of glass at an angle of $\phi_0 = 84^\circ$ with respect to the normal, as shown in the figure. The index of refraction of the glass is 1.5. What is the angle θ between the reflected ray (ray b) and refracted ray (ray c) rays?



Answer: 54°

Var: 50+

7) A narrow light beam in vacuum contains light of two wavelengths, 480 nm and 700 nm. It strikes a flat piece of glass at an angle of incidence of 60.000° . The index of refraction of the glass is 1.4830 at 480 nm and 1.4760 at 700 nm. Determine the angle between the two wavelengths as the light travels in the glass.

Answer: 0.196°

Var: 1

8) The index of refraction for a certain material is 1.399 for red light and 1.432 for blue light. Light containing both of these colors is traveling in vacuum and strikes a flat sheet of this material. Find the angle separating the two colors in the refracted light in the sheet if the angle of incidence is 60.00° .

Answer: 1.03°

Var: 1

9) A thin beam of light enters a thick plastic sheet from air at an angle of 32.0° with the normal and continues in the sheet at an angle of 23.0° with the normal. What is the index of refraction of the plastic?

A) 0.74

B) 1.11

C) 1.28

D) 1.36

Answer: D

Var: 1

10) An oil layer that is 5.0 cm thick is spread smoothly and evenly over the surface of water on a windless day. A light ray from the air above enters the oil at 45° with the normal and then goes into the water. What is the angle of refraction of this ray in the water? The index of refraction for the oil is 1.15, and for water it is 1.33.

- A) 27°
- B) 32°
- C) 36°
- D) 39°

Answer: B

Var: 1

11) A beam of light, traveling in air, strikes a plate of transparent material at an angle of incidence of 56.0° . It is observed that the reflected and refracted beams form an angle of 90.0° . What is the index of refraction of this material?

- A) 1.40
- B) 1.43
- C) 1.44
- D) 1.48

Answer: D

Var: 1

12) A beam of light traveling in air strikes a slab of transparent material. The incident beam makes an angle of 40° with the normal, and the refracted beam make an angle of 26° with the normal. What is the speed of light in the transparent material? ($c = 3.0 \times 10^8$ m/s)

- A) 1.0×10^8 m/s
- B) 2.0×10^8 m/s
- C) 2.3×10^8 m/s
- D) 3.0×10^8 m/s
- E) 0.50×10^8 m/s

Answer: B

Var: 1

13) A light ray in air strikes a glass plate whose index of refraction is 1.42. Some of the light reflects off the surface of the plate, but most of it enters the glass. If the angle of refraction is one-half the angle of reflection, the angle of refraction is closest to which one of the following angles?

- A) 45°
- B) 43°
- C) 41°
- D) 39°
- E) 37°

Answer: A

Var: 50+

14) A thin flashlight beam traveling in air strikes a glass plate at an angle of 52° with the plane of the surface of the plate. If the index of refraction of the glass is 1.4, what angle will the beam make with the normal in the glass?

- A) 34°
- B) 64°
- C) 26°
- D) 56°
- E) 38°

Answer: C

Var: 1

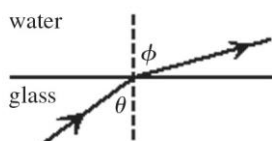
15) A glass plate with an index of refraction is 1.57 is immersed in an oil having a refractive index of 1.40. The surface of the glass is inclined at an angle of 54° with the vertical. A horizontal light ray in the glass strikes the interface. What is the angle that the refracted ray, in the oil, makes with the horizontal?

- A) 11°
- B) 5.6°
- C) 8.3°
- D) 14°
- E) 17°

Answer: A

Var: 50+

16) A light ray in glass arrives at the glass-water interface at an angle of $\theta = 48^\circ$ with the normal. The refracted ray in water makes an angle $\phi = 72^\circ$ with the normal, as shown in the figure. The index of refraction of water is 1.33. The angle of incidence is now changed to $\theta = 37^\circ$. What is the new angle of refraction ϕ in the water?

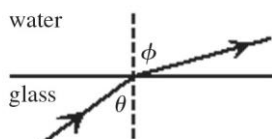


- A) 50°
- B) 48°
- C) 46°
- D) 52°
- E) 54°

Answer: B

Var: 50+

17) A light ray in glass arrives at the glass-water interface at an angle of $\theta = 48^\circ$ with the normal. The refracted ray in water makes an angle $\theta = 61^\circ$ with the normal, as shown in the figure. The index of refraction of water is 1.33. The angle of incidence is now changed to $\theta = 25^\circ$. What is the new angle of refraction ϕ in the water?

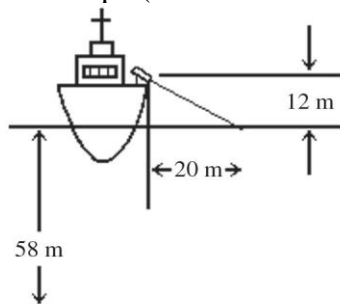


- A) 30°
- B) 56°
- C) 54°
- D) 60°
- E) 62°

Answer: A

Var: 1

18) As shown in the figure, a laser positioned on a ship is used to communicate with a small research submarine resting on the *bottom* of a lake. The laser is positioned 12 m above the surface of the water, and it strikes the water 20 m from the side of the ship. The water is 58 m deep and has an index of refraction of 1.33. How far horizontally is the submarine from the side of the ship? (Assume all numbers are accurate to three significant figures.)



- A) 69 m
- B) 49 m
- C) 89 m
- D) 59 m
- E) 79 m

Answer: A

Var: 1

19) A flashlight beam makes an angle of 60° with the plane of the surface of a calm lake before it enters the water. In the water what angle does the beam make with the plane of the surface? The index of refraction of water is 1.33.

- A) 0°
- B) 30°
- C) 60°
- D) 22°
- E) 68°

Answer: E

Var: 1

20) A beam of light in water (of refractive index of 1.33) enters a glass slab (of refractive index 1.50) at an angle of incidence of 60.0° . What is the angle of refraction in the glass?

- A) 27.5°
- B) 39.8°
- C) 60.0°
- D) 90.0°
- E) 50.2°

Answer: E

Var: 1

21) A beam of light in air enters a glass slab with an index of refraction of 1.40 at an angle of incidence of 30.0° . What is the angle of refraction?

- A) 20.9°
- B) 47.5°
- C) 51.8°
- D) 30.0°
- E) 14.9°

Answer: A

Var: 5

22) A thick slab of plastic lies at the bottom of a tank filled with water having an index of refraction of 1.33. A narrow laser beam is shone directly downward through the water on the plastic. You then gradually rotate the laser, thereby increasing the angle with respect to the normal that it strikes the plastic. You carefully note that at the instant the beam makes an angle of 66.5° with the normal in the water, no light enters the plastic, but it did enter for angles smaller than that. What is the speed of light in the plastic slab? ($c = 3.00 \times 10^8$ m/s)

Answer: 2.46×10^8 m/s

Var: 1

23) A ray of light traveling in air makes a 63.0° angle with respect to the normal of the surface of a liquid. It travels in the liquid at a 39.2° angle with respect to the normal. Find the critical angle for total internal reflection for this interface.

Answer: 45.2°

Var: 50+

24) A point source of light is positioned 20.0 m below the surface of a lake. What is the diameter of the largest circle on the surface of the water through which light can emerge into the air? The index of refraction of water is 1.33.

Answer: 45.6 m

Var: 1

25) A light ray enters a glass enclosed fish tank. From air it enters the glass at 20° with respect to the plane of the surface and then emerges into the water. The index for the glass is 1.50 and for water 1.33.

(a) What is the angle of refraction in the glass?

(b) What is the angle of refraction in the water?

(c) Is there any incident angle in air for which the ray will *not* enter the water due to total internal reflection? If so, find it.

Answer: (a) 39° (b) 45° (c) no

Var: 9

26) Light in a transparent material that has an index of refraction of 1.333 strikes the boundary with another transparent material for which the index of refraction is 1.010. What is the critical angle for total internal reflection between these two materials?

Answer: 49.26°

Var: 1

27) The critical angle for a substance in air is measured at 53.7° . If light enters this substance from air at 45.0° with the normal, at what angle with the normal will it continue to travel?

A) 34.7°

B) 45.0°

C) 53.7°

D) It will not continue, but will be totally reflected.

Answer: A

Var: 1

28) Light enters a substance from air at 30.0° to the normal. It continues within the substance at 23.0° to the normal. What is the critical angle for this substance when it is surrounded by air?

A) 53°

B) 51.4°

C) 36.7°

D) 12.6°

Answer: B

Var: 1

29) Light travels from crown glass, with a refractive index of 1.52, into water, having a refractive index of 1.33? The critical angle for this interface is closest to which one of the following angles?

- A) 42°
- B) 48°
- C) 53°
- D) 57°
- E) 61°

Answer: E

Var: 1

30) Lucite has an index of refraction of 1.50. What is its critical angle if it is in air?

- A) 1.16°
- B) 15°
- C) 41.8°
- D) 65.2°
- E) 87.4°

Answer: C

Var: 1

31) An optic fiber is made of clear plastic with an index of refraction of 1.50. For what range of angles of incidence θ with the lateral surface of the fiber will light remain inside the plastic "guide" if it is surrounded by air?

- A) $21.1^\circ < \theta < 90^\circ$
- B) $23.4^\circ < \theta < 90^\circ$
- C) $38.3^\circ < \theta < 90^\circ$
- D) $40.3^\circ < \theta < 90^\circ$
- E) $41.8^\circ < \theta < 90^\circ$

Answer: E

Var: 1

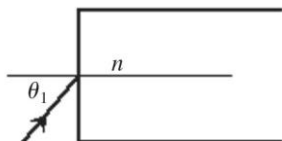
32) A glass plate having an index of refraction is 1.66 is immersed in a certain alcohol. The surface of the glass is inclined at an angle of 44° with the vertical. When a horizontal ray in the glass strikes the interface, you observe that it is at the critical angle. What is the index of refraction of the alcohol?

- A) 1.15
- B) 1.13
- C) 1.11
- D) 1.09
- E) 1.17

Answer: A

Var: 50+

33) During the investigation of a new type of optical fiber having an index of refraction $n = 1.21$, a laser beam is aimed at the flat end of a straight fiber, as shown in the figure. What is the maximum angle of incidence θ_1 if the beam is not to escape from the sides of the fiber if it is surrounded by air?



- A) 42.9°
- B) 39.8°
- C) 36.7°
- D) 33.6°
- E) 30.5°

Answer: A

Var: 30

34) A light beam is traveling inside a glass block that has an index of refraction of 1.46. As this light arrives at the surface of the block, it makes an angle of 53.0° with the normal. At what angle with the normal in the air will it leave the block?

- A) It will not leave.
- B) 59.1°
- C) 43.2°
- D) 33.2°

Answer: A

Var: 1

35) A scuba diver is 1.2 m beneath the surface of a still pond of water. At what angle relative to the normal at the surface must the diver shine a beam of light toward the surface in order for a person on a distant bank to be able to see it? The index of refraction for water is 1.33.

- A) 41°
- B) 48°
- C) 59°
- D) 90°
- E) 0°

Answer: B

Var: 1

36) A ray of light in glass strikes a water-glass interface at an angle of incidence equal to one-half the critical angle for that interface. The index of refraction for water is 1.33, and for the glass it is 1.43. What angle does the refracted ray in the water make with the normal?

- A) 37°
- B) 42°
- C) 47°
- D) 32°
- E) 27°

Answer: A

Var: 50+

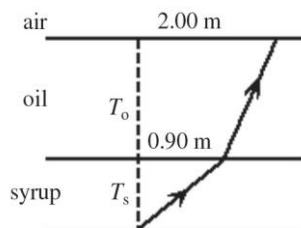
37) The speed of light in a material is $0.41c$. What is the critical angle of a light ray at the interface between the material and a vacuum?

- A) 24°
- B) 17°
- C) 19°
- D) 22°

Answer: A

Var: 31

38) A tank holds a layer of oil, of thickness $T_o = 1.43$ m, that floats on a layer of syrup of thickness $T_s = 0.640$ m, as shown in the figure. Both liquids are clear and do not mix together. A light ray, originating at the bottom of the tank at point P, crosses the oil-syrup interface at a point 0.90 m from the axis. The ray continues and arrives at the oil-air interface, 2.00 m to the right of P and at the critical angle. What is the index of refraction of the oil?

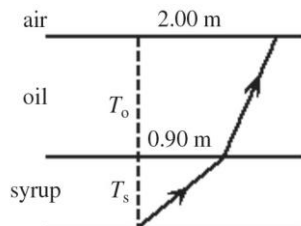


- A) 1.64
- B) 1.62
- C) 1.60
- D) 1.66
- E) 1.68

Answer: A

Var: 50+

39) A tank holds a layer of oil, of thickness $T_o = 1.65$ m, that floats on a layer of syrup of thickness $T_s = 0.830$ m, as shown in the figure. Both liquids are clear and do not mix together. A light ray, originating at the bottom of the tank at point P, crosses the oil-syrup interface at a point 0.900 m from the axis. The ray continues and arrives at the oil-air interface, 2.00 m to the right of P and at the critical angle. What is the index of refraction of the syrup?



- A) 1.36
- B) 1.25
- C) 1.94
- D) 1.75
- E) 1.54

Answer: A

Var: 50+

40) David stands 2.5 m in front of a plane mirror.

(a) How far from David is his image in the mirror?

(b) If David moves away from the mirror at 1.5 m/s, how fast are David and his image moving apart from each other?

(c) If David is 180 cm tall, how tall is his image in the mirror?

Answer: (a) 5.0 cm (b) 3.0 m/s (c) 180 cm

Var: 6

41) An object that is 75 cm tall is located 3.8 m in front of a plane mirror. The image formed by the mirror appears to be

- A) 1.9 m in front of the mirror.
- B) on the mirror's surface.
- C) 1.9 m behind the mirror's surface.
- D) 3.8 m in front of the mirror.
- E) 3.8 m behind the mirror's surface.

Answer: E

Var: 3

42) A laser beam strikes a plane mirror's reflecting surface with an angle of incidence of 43° . What is the angle between the incident ray and the reflected ray?

- A) 43°
- B) 86°
- C) 45°
- D) 90°
- E) 0°

Answer: B

Var: 3

43) A person jogs toward a plane mirror at a speed of 3 m/s. How fast is he approaching his image in the mirror?

- A) 1.5 m/s
- B) 3 m/s
- C) 4 m/s
- D) 5 m/s
- E) 6 m/s

Answer: E

Var: 5

44) Two plane mirrors make an angle of 30° with each other. A light ray enters the system and is reflected once off of each mirror. Through what angle is the ray turned?

- A) 60°
- B) 90°
- C) 120°
- D) 150°

Answer: A

Var: 50+

45) An object that is 3.4 mm tall is placed 25 cm from the vertex of a convex spherical mirror. The radius of curvature of the mirror has magnitude 73 cm.

- (a) How far is the image from the vertex of the mirror?
- (b) What is the height of the image?

Answer: (a) 15 cm (b) 2.0 mm

Var: 50+

46) A statue that is 2.3 cm tall is placed 15 cm in front of a *convex* mirror. The magnitude of the radius of curvature of the mirror is 18 cm.

- (a) Is the image real or virtual?
- (b) How far is the image from the mirror?
- (c) Is the image upright or inverted?
- (d) How tall is the image?

Answer: (a) virtual (b) 5.6 cm (c) upright (d) 0.86 cm

Var: 6

47) A statue that is 3.0 cm tall statue is 24 cm in front of a *concave* mirror. The magnitude of the radius of curvature of the mirror is 20 cm.

- (a) Is the image real or virtual?
- (b) How far is the image from the mirror?
- (c) Is the image upright or inverted?
- (d) How tall is the image?

Answer: (a) real (b) 17 cm (c) inverted (d) 2.1 cm

Var: 6

48) An object 2.0 cm tall is placed 24 cm in front of a convex mirror having a focal length of magnitude 30 cm.

(a) Where is the image formed and how far is it from the mirror?

(b) How tall is the image?

Answer: (a) 13 cm behind the mirror (b) 1.1 cm

Var: 1

49) An object that is 4.0 cm tall is placed 15 cm in front of a concave mirror of focal length 20 cm.

(a) Where is the image formed and how far is it from the mirror?

(b) How tall is the image?

Answer: (a) 60 cm behind the mirror (b) 16 cm

Var: 1

50) When an object is 12 cm in front of a concave mirror, the image is 3.0 cm in front of the mirror? What is the focal length of the mirror?

A) -0.25 cm

B) 15 cm

C) 4.0 cm

D) 2.4 cm

E) -1.3 cm

Answer: D

Var: 3

51) An object that is 4.00 cm tall is placed 18.0 cm in front of a concave mirror having a focal length of 20.0 cm. What is the location of its image in relation to the mirror and what are its characteristics?

A) 180 cm on the other side of mirror, real, 6.00 times bigger

B) 10 cm on the other side of mirror, virtual, 10.0 times bigger

C) 18 cm on the same side of mirror, virtual, 2.25 times bigger

D) 20 cm on the same side of mirror, real, 10.0 times bigger

E) 180 cm on the other side of mirror, virtual, 10.0 times bigger

Answer: E

Var: 5

52) An object that is 2.0 cm tall is placed at the center of curvature in front of a concave mirror. How tall is its image?

A) 0.50 cm

B) 1.0 cm

C) 1.5 cm

D) 2.0 cm

E) infinite

Answer: D

Var: 5

53) An object is placed 50 cm in front of a concave mirror with a focal length of 25 cm. What is the magnification produced by the mirror?

- A) -0.50
- B) -1.0
- C) +1.5
- D) -2.0
- E) +1.0

Answer: B

Var: 5

54) An object that is 10.0 cm tall is placed 37.0 cm in front of a concave mirror of focal length 18.5 cm. How tall is the image?

- A) 2.5 cm
- B) 5.0 cm
- C) 7.5 cm
- D) 20.0 cm
- E) 10.0 cm

Answer: E

Var: 5

55) Tan's face is 20 cm in front of a concave shaving mirror. If he observes his image to be twice as big and upright, what is the focal length of the mirror?

- A) 10 cm
- B) -40 cm
- C) -50 cm
- D) 40 cm
- E) 50 cm

Answer: D

Var: 1

56) Reza's face is 20 cm in front of a concave shaving mirror having a focal length of magnitude 30 cm. How large is the image of his face?

- A) half as large as his face
- B) of the same size as his face
- C) twice as large as his face
- D) three times as large as his face
- E) four times as large as his face

Answer: D

Var: 1

57) A concave mirror having a focal length of magnitude 5.0 cm forms an image 4.0 cm behind the mirror. Where is the object for this image?

- A) 2.2 cm in front of the mirror
- B) 2.2 cm behind the mirror
- C) 9.0 cm in front of the mirror
- D) 1.0 cm behind the mirror
- E) 20 cm behind the mirror

Answer: A

Var: 1

58) A concave spherical mirror with a radius of curvature of 20 cm creates a real image 30 cm from the mirror. How far is the object from the mirror?

- A) 20 cm
- B) 15 cm
- C) 7.5 cm
- D) 5.0 cm

Answer: B

Var: 1

59) When an object is 12 cm in front of a concave spherical mirror, the image is formed 3.0 cm in front of the mirror. What is the focal length of the mirror?

- A) 15 cm
- B) 4.0 cm
- C) 2.4 cm
- D) 1.3 cm

Answer: C

Var: 3

60) An object is 10 cm in front of a concave spherical mirror with a focal length of magnitude 3.0 cm. Where is the image?

- A) 13 cm from the mirror
- B) 7.0 cm from the mirror
- C) 4.3 cm from the mirror
- D) 3.3 cm from the mirror

Answer: C

Var: 1

61) A concave spherical mirror has a focal length of magnitude 20 cm. An object is placed 10 cm in front of the mirror on the mirror's axis. Where is the image located?

- A) 20 cm behind the mirror
- B) 20 cm in front of the mirror
- C) 6.7 cm behind the mirror
- D) 6.7 cm in front of the mirror

Answer: A

Var: 1

62) A concave spherical mirror has a focal length of magnitude 20 cm. An object is placed 30 cm in front of the mirror on the mirror's axis. Where is the image located?

- A) 12 cm behind the mirror
- B) 12 cm in front of the mirror
- C) 60 cm behind the mirror
- D) 60 cm in front of the mirror

Answer: D

Var: 1

63) An object is 5.7 cm from a spherical concave mirror. If the image is 4.7 cm tall and 10 cm from the mirror, how tall is the object?

- A) 12 cm
- B) 11 cm
- C) 8.2 cm
- D) 2.7 cm

Answer: D

Var: 1

64) An object is placed 15 cm from a spherical concave mirror with a focal length of magnitude 20 cm. If the object is 4.0 cm tall, how tall is the image?

- A) 1.0 cm
- B) 2.0 cm
- C) 8.0 cm
- D) 16 cm

Answer: D

Var: 1

65) An object that is 47.5 cm tall forms an image that is 38.6 cm tall and 14.8 cm from a spherical mirror. How far is the object from the mirror?

- A) 124 cm
- B) 47.6 cm
- C) 18.2 cm
- D) 12.0 cm

Answer: C

Var: 1

66) A 1.4-cm tall flower is 4.0 cm from a spherical concave mirror. If the image of the flower is 4.0 cm tall, how far is the image from the mirror?

- A) 11 cm
- B) 9.4 cm
- C) 1.4 cm
- D) 0.090 cm

Answer: A

Var: 1

67) A plant that is 4.0 cm tall is placed 15 cm from a concave spherical mirror having a focal length of magnitude 20 cm. Where is the image located?

- A) 12 cm behind the mirror
- B) 12 cm in front of the mirror
- C) 60 cm behind the mirror
- D) 60 cm in front of the mirror

Answer: C

Var: 1

68) When a person stands 40 cm in front of a cosmetic (concave) spherical mirror, the upright image is twice the size of the object. What is the focal length of the mirror?

- A) 27 cm
- B) 40 cm
- C) 80 cm
- D) 160 cm

Answer: C

Var: 1

69) A person's face is 30 cm in front of a concave spherical shaving mirror. If the image is an erect image that is 1.5 times as large as the object, what is the focal length mirror?

- A) 20 cm
- B) 50 cm
- C) 70 cm
- D) 90 cm

Answer: D

Var: 1

70) An object is in front of a concave spherical mirror, and its image is 4.0 cm behind the mirror. If the focal length of the mirror has a magnitude of 5.0 cm, where is the object?

- A) 2.2 cm in front of the mirror
- B) 2.2 cm behind the mirror
- C) 9.0 cm in front of the mirror
- D) 1.0 cm behind the mirror

Answer: A

Var: 1

71) A convex spherical mirror has a focal length of magnitude 20 cm. If an object is placed 10 cm in front of the mirror on the mirror's axis, where is the image located?

- A) 20 cm behind the mirror
- B) 20 cm in front of the mirror
- C) 6.7 cm behind the mirror
- D) 6.7 cm in front of the mirror

Answer: C

Var: 1

72) A toy is 14 cm in front of a convex spherical mirror. If the image of the toy is 5.8 cm behind the mirror, what is the focal length of the mirror?

- A) -4.1 cm
- B) +20 cm
- C) -9.9 cm
- D) -20 cm
- E) +9.9 cm

Answer: C

Var: 1

73) A cell phone that is 8.90 cm tall is placed in front of a convex mirror. The image of the phone is 7.80 cm tall and is located 14.8 cm from a mirror. What is the mirror's focal length?

- A) -120 cm
- B) -105 cm
- C) +16.9 cm
- D) -13.0 cm
- E) +120 cm

Answer: A

Var: 1

74) An object is 50 cm from a concave mirror of radius of curvature of magnitude 60 cm. How far is the image from the mirror?

- A) 19 cm
- B) 35 cm
- C) 60 cm
- D) 75 cm
- E) 120 cm

Answer: D

Var: 1

75) An object is 50 cm from a concave mirror with radius of curvature of magnitude 60 cm. What is the lateral magnification produced by the mirror?

- A) +0.40
- B) +0.70
- C) +1.5
- D) -0.70
- E) -1.5

Answer: E

Var: 1

76) An object is placed near a concave mirror having a radius of curvature of magnitude 60 cm. How far should you place the object from the mirror so that the lateral magnification produced by the mirror will be +2.5?

- A) 18 cm
- B) 24 cm
- C) 30 cm
- D) 36 cm
- E) 42 cm

Answer: A

Var: 1

77) When an object is placed 118 cm from a thin *diverging* lens, its image is found to be 59 cm from the lens. The lens is removed, and replaced by a thin *converging* lens whose focal length has the same magnitude as the diverging lens. This second lens is at the original position of the first lens. Where is the image of the object now?

Answer: at infinity

Var: 50+

78) A 3.0-cm tall statue is 48 cm in front of a convex lens having a focal length of magnitude 20 cm.

- (a) Is the image of the statue real or virtual?
- (b) How far is the image from the lens?
- (c) Is the image upright or inverted?
- (d) How tall is the image?

Answer: (a) real (b) 34 cm (c) inverted (d) 2.1 cm

Var: 1

79) A slide projector is set up with its lens 6.0 m from the screen. The projected image on the screen is 1.5 m square for a slide (the object) that is 2.5 cm square.

- (a) How far is the slide from the lens?
- (b) What is the focal length of the projector lens?

Answer: (a) 10 cm (b) 9.8 cm

Var: 1

80) A certain slide projector has a lens of focal length 15.0 cm. This lens forms an image measuring 100 cm \times 100 cm on the screen when a slide whose dimensions are 50.0 mm \times 50.0 mm is being magnified. How far from the lens should the screen be placed?

Answer: 3.15 m

Var: 1

81) How far from a converging lens of focal length 30 cm must an object be placed so the image will be virtual and 3.0 times as large as the object?

Answer: 20 cm

Var: 1

82) An object is placed 9.5 cm in front of a convex lens with a focal length of magnitude 24 cm.

(a) Where is the image formed and how far is it from the lens?

(b) What is the magnification produced by the lens?

Answer: (a) 16 cm in front of the lens (b) 1.7

Var: 1

83) A 4.0-cm tall apple is 20 cm in front of a plano-convex lens of focal length 75 cm.

(a) Find the location of the image of the apple. Is it a real or a virtual image?

(b) How tall is the image of the apple? Is it upright or inverted?

Answer: (a) 27 cm in front of the lens, virtual (b) 5.5 cm, upright

Var: 1

84) A cell phone is placed 40 cm in front of a converging lens with a focal length of magnitude 20 cm. How far is the image of this phone from the lens?

A) 40 cm

B) 20 cm

C) 13 cm

D) 60 cm

E) 10 cm

Answer: A

Var: 1

85) A coin is 12 cm in front of a converging lens with focal length of magnitude 4.0 cm. Where is the image?

A) 8.0 cm behind the lens

B) 6.0 cm in front of the lens

C) 6.0 cm behind the lens

D) 4.0 cm in front of the lens

Answer: C

Var: 1

86) A seed is 15 mm in front of a converging lens, and the image of the seed is 4.0 mm behind the lens. What is the focal length of the lens?

A) 11 mm

B) 5.5 mm

C) 3.8 mm

D) 3.2 mm

Answer: B

Var: 2

87) A 14-mm tall postage stamp is 4.0 mm from a converging lens. If the image of the stamp is 4.0 mm tall, how far is it from the lens?

- A) 14 mm
- B) 8.7 mm
- C) 1.4 mm
- D) 1.1 mm

Answer: D

Var: 1

88) When a flower petal is 4.0 cm in front of a converging lens, the inverted image is half the height of the petal. What is the focal length of this lens?

- A) 1.3 cm
- B) 2.0 cm
- C) 4.0 cm
- D) 5.3 cm

Answer: A

Var: 1

89) An image is 4.0 mm in front of a converging lens with focal length of magnitude 5.0 mm. Where is the object for this image?

- A) 2.2 mm in front of the lens
- B) 2.2 mm behind the lens
- C) 9.0 mm behind the lens
- D) 20 mm in front of the lens

Answer: A

Var: 1

90) A plant that is 4.1 cm tall is 10.3 cm from a converging lens. You observe that the image of this plant is virtual and 6.2 cm tall. What is the focal length of the lens?

- A) 6.8 cm
- B) -30 cm
- C) 16 cm
- D) 30 cm
- E) -16 cm

Answer: D

Var: 1

91) A lab specimen is 15.2 mm from a converging lens. The image is 4.0 mm tall and 9.0 cm from the lens. How tall is the specimen?

- A) 6.8 mm
- B) 5.4 mm
- C) 1.7 mm
- D) 0.68 mm

Answer: D

Var: 1

92) A wrench is placed at 30 cm in front of a diverging lens with a focal length of magnitude 10 cm. What is the magnification of the wrench?

- A) 0.25
- B) -0.25
- C) 0.67
- D) -0.67
- E) 4.0

Answer: A

Var: 1

93) A statue that is 10.4 cm tall is placed 4.8 cm in front of a concave lens. The image is 4.0 cm from the lens. How tall is the image?

- A) 13 cm
- B) 8.7 cm
- C) 5.4 cm
- D) 1.8 cm

Answer: B

Var: 1

94) A cup that is 6.0 cm tall is in front of a concave lens. The image of the cup is 2.5 cm tall and 7.5 cm from the lens. What is the focal length of the lens?

- A) -6.0 cm
- B) -7.5 cm
- C) -13 cm
- D) +18 cm
- E) +6.0 cm

Answer: C

Var: 1

95) A drawing is placed 40 cm in front of a thin lens. If a virtual image forms at a distance of 50 cm from the lens, on the same side as the drawing, what is the focal length of the lens?

- A) -45 cm
- B) 75 cm
- C) 90 cm
- D) 200 cm
- E) +45 cm

Answer: D

Var: 1

96) How far from a lens having a focal length of +50 mm must the object be placed if it is to form a virtual image that is 3.0 times the size of the object?

- A) 33 mm
- B) 42 mm
- C) 48 mm
- D) 54 mm

Answer: A

Var: 1

97) How far from a +50-mm focal length lens, such as is used in many 35-mm cameras, must an object be placed so it will form a real image that is 3.0 times the size of the object?

- A) 46 mm
- B) 52 mm
- C) 58 mm
- D) 67 mm

Answer: D

Var: 1

98) An object is placed 15 cm to the left of a double-convex lens of focal length 20 cm. Where is the image of this object located?

- A) 60 cm to the right of the lens
- B) 60 cm to the left of the lens
- C) 8.6 cm to the right of the lens
- D) 8.6 cm to the left of the lens
- E) 30 cm to the left of the lens

Answer: B

Var: 1

99) A 4.0-cm tall object is placed 60 cm in front of a converging lens of focal length of magnitude 30 cm. What are the nature and location of the image?

- A) The image is real, 2.5 cm tall, 30 cm on the same side as object.
- B) The image is virtual, 2.5 cm tall, 30 cm on the other side of the lens.
- C) The image is virtual, 2.0 cm tall, 15 cm on the other side of the lens.
- D) The image is virtual, 4.0 cm tall, 60 cm on the same side as object.
- E) The image is real, 4.0 cm tall, 60 cm on the other side of the lens.

Answer: E

Var: 5

100) An object is placed 10 cm from a convex lens with a focal length of magnitude 20 cm. What is the magnification?

- A) 0.50
- B) -2.0
- C) 1.5
- D) 2.0
- E) -2.5

Answer: D

Var: 1

101) An object is placed 60 cm from a convex lens with a focal length of magnitude 10 cm. What is the magnification?

- A) -0.10
- B) 0.10
- C) 0.15
- D) 0.20
- E) -0.20

Answer: E

Var: 1

102) A 4.0-cm-tall object is placed 50.0 cm from a diverging lens having a focal length of magnitude 25.0 cm. What is the nature and location of the image?

- A) A real image, 4.0 cm tall, 20 cm other side of the object
- B) A virtual image, 4.0 cm tall, 20 cm other side of the object
- C) A virtual image, 2.0 cm tall, 10 cm other side of the object
- D) A virtual image, 1.3 cm tall, 16.7 cm same side as the object
- E) A real image, 1.3 cm tall, 16.7 cm same side as the object

Answer: D

Var: 5

103) An object is placed 21 cm from a concave lens having a focal length of magnitude 25 cm. What is the magnification?

- A) -0.54
- B) 0.54
- C) -0.32
- D) -0.22
- E) 0.22

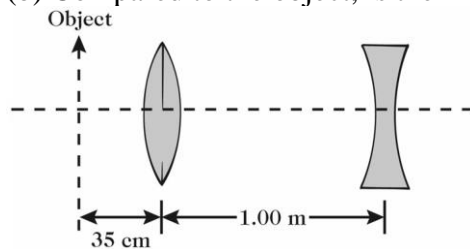
Answer: B

Var: 5

104) Two thin lenses, one a converging lens and the other a diverging lens, are separated by 1.00 m along the same principal axis, as shown in the figure. The magnitude of the focal length of the converging lens is 25 cm, while the magnitude of the focal length of the diverging lens is 40 cm. An object 8.25 cm tall is placed 35 cm to the left of the converging lens.

(a) Where is the final image produced by this combination of lenses? (Give your answer relative to the diverging lens.)

(b) Compared to the object, is the final image upright or inverted? Is it real or virtual?



Answer: (a) 9.5 cm to the left of the diverging lens, (b) inverted, virtual

Var: 1

105) As part of a piece of optical apparatus to be used in air, you need to design a thin lens having faces with radii of curvature of magnitude 24 cm each. When an object 32 mm tall is placed 30 cm from this lens, it must form a real image 60 cm from the lens.

(a) What must be the index of refraction of the lens material?

(b) What is the height of the image of the object? Is it upright or inverted; is it real or virtual?

Answer: (a) 1.6 (b) 64 mm, inverted, real

Var: 1

106) A converging lens with the same curvature on both faces and a focal length of 25 cm is to be made from crown glass having a refractive index of 1.52. What radius of curvature is required for each face?

Answer: 26 cm

Var: 1

107) The curved surface of a 50-cm focal length plano-convex lens has a radius of curvature of 30 cm. What is the refractive index of the glass?

Answer: 1.6

Var: 1

108) A certain camera uses a double-convex lens made of glass with an index of refraction of 1.60. This lens has a radius of curvature of magnitude 12 cm for the first surface and one of magnitude 24 cm for the second surface. What is the focal length of this lens?

Answer: 13 cm

Var: 1

109) A double convex lens has faces with radii of magnitudes 18.0 cm and 20.0 cm. When an object is placed 24.0 cm in front of the lens, a real image is formed 32.0 cm from the lens.

(a) What is the focal length of this lens?

(b) What is the index of refraction of the material from which the lens is made?

Answer: (a) 13.7 cm (b) 1.69

Var: 1

110) A double-convex thin lens has radii of curvature of magnitude 46 cm, and it is made of glass of index of refraction 1.60. What is the focal length of this lens?

A) infinite

B) 38 cm

C) -30 cm

D) 18 cm

E) -19 cm

Answer: B

Var: 1

111) A double-convex lens made of glass having a refractive index of 1.50 has a radius of magnitude 40 cm on the front side and one of magnitude 30 cm on the back side. What is the focal length of this lens?

- A) 11 cm
- B) 34 cm
- C) 80 cm
- D) -240 cm
- E) -11 cm

Answer: B

Var: 1

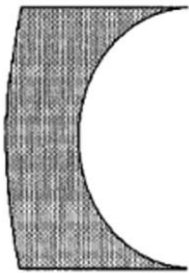
112) A double-convex lens is formed from a piece of plastic with an index of refraction of 1.70. The radius of the front surface has magnitude 20 cm, and the radius of the back surface has magnitude 30 cm. What is the focal length of this lens?

- A) 17 cm
- B) 86 cm
- C) -86 cm
- D) -17 cm
- E) 43 cm

Answer: A

Var: 1

113) The figure (which is exaggerated somewhat for clarity) illustrates a thin lens. This lens is made of a material with an index of refraction of 1.48, and has radii of magnitudes 6.0 cm and 4.0 cm. What is the focal length of the lens?



- A) +25 m
- B) -5.0 cm
- C) -4.0 m
- D) +5.0 m
- E) -25 cm

Answer: E

Var: 1

114) A plano-convex lens is to have a focal length of magnitude 40 cm, and it is made of glass of index of refraction 1.65. What radius of curvature is required?

- A) 13 cm
- B) 26 cm
- C) 32 cm
- D) 36 cm

Answer: B

Var: 1

115) The radius of curvature of the curved side of a plano-convex lens made of glass, having index of refraction 1.64, is 33 cm. What is the focal length of the lens?

- A) 52 cm
- B) -52 cm
- C) 21 cm
- D) -21 cm

Answer: A

Var: 39

116) A double-concave lens has equal radii of curvature of magnitudes 15.1 cm. An object placed 14.2 cm from the lens forms a virtual image 5.00 cm from the lens. What is the index of refraction of the lens material?

- A) 1.98
- B) 2.06
- C) 1.90
- D) 1.84

Answer: A

Var: 50+

117) A thin double-convex lens is intended to focus the image of an object onto a screen so that the image is life-sized on the screen. The lens has equal-magnitude radii of 83 cm and a refractive index of 1.6.

(a) What is the distance d from the image to the screen?

(b) What is the total distance L between the object and the image?

- A) (a) $d = 138$ cm
- (b) $L = 276$ cm
- B) (a) $d = 276$ cm
- (b) $L = 552$ cm
- C) (a) $d = 69$ cm
- (b) $L = 35$ cm
- D) (a) $d = -138$ cm
- (b) $L = -276$ cm

Answer: A

Var: 50+

118) A double-convex thin glass lens has equal-magnitude radii of curvature. The focal length of the lens is +37.3 cm and the index of refraction of the glass is 1.52. What is the magnitude of the radius of curvature of each convex surface?

- A) 39 cm
- B) 35 cm
- C) 31 cm
- D) 43 cm
- E) 46 cm

Answer: A

Var: 50+

119) A double-convex thin glass lens has equal-magnitude radii of curvature. The focal length of this lens is +31.2 cm and the index of refraction of the glass is 1.52. The lens is to be replaced with a plano-convex glass lens of the same focal length and thickness. The radius of curvature of the convex surface of the replacement lens is 13.0 cm. What should be the index of refraction of the glass of the plano-convex lens?

- A) 1.42
- B) 1.44
- C) 1.40
- D) 1.38
- E) 1.36

Answer: A

Var: 50+

120) An amateur astronomer grinds a double convex lens whose surfaces have radii of curvature of magnitudes 40 cm and 60 cm. The glass has an index of refraction of 1.54. What is the focal length of this lens when used in the night air?

- A) 43 cm
- B) 130 cm
- C) 89 cm
- D) 44 cm
- E) 220 cm

Answer: D

Var: 1