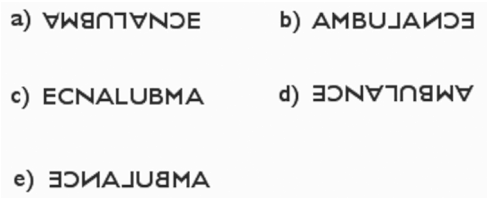
1) A light beam has speed c in vacuum and speed v in a certain plastic. The index of refraction n of this plastic is
A) $n = cv$. B) $n = v/c$. C) $n = c/v$. D) $n = (c/v)^2$. E) $n = (v/c)^2$.

2) Light enters air from water. The angle of refraction will be
A) less than the angle of incidence.
B) greater than the angle of incidence.
C) equal to the angle of incidence.

3) Light enters glass from air. The angle of refraction will be
A) greater than the angle of incidence.
B) less than the angle of incidence.
C) equal to the angle of incidence.

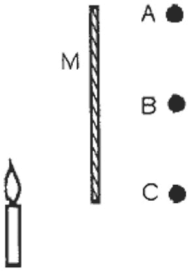
4) The critical angle for a beam of light passing from water into air is 48.8°. This means that all light rays with an angle of incidence in the water that is greater than 48.8° will be
A) totally transmitted. B) totally reflected.
C) partially reflected and partially transmitted. D) totally absorbed by the water.

5) 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) a B) b C) c D) d E) e

6) 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)

7) Which one of the following numbers is the correct magnification produced by a plane mirror?
A) 1 B) 2 C) 3/2 D) 1/4 E) 1/2

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

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

10) Which statements about images are correct? (There could be more than one correct choice.)
A) Mirrors always produce real images because they reflect light.
B) A virtual image cannot be formed on a screen.
C) A real image must be erect.
D) A virtual image cannot be viewed by the unaided eye.
E) A virtual image cannot be photographed.

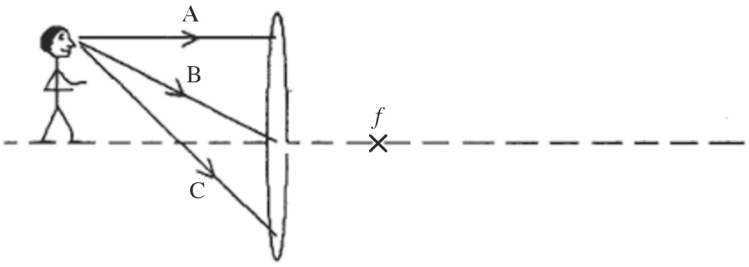
11) A negative magnification for a mirror means that
A) the image is upright, and the mirror is convex.
B) the image is inverted, and the mirror is concave.
C) the image is upright, and the mirror could be either concave or convex.
D) the image is inverted, and the mirror is convex.
E) the image is inverted,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

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

13) If you stand in front of a convex mirror, at the same distance from it as its radius of curvature,
A) you will see your image and it will be the same size as you except upside down.
B) you will see your image and you will appear smaller than you.
C) you will see your image and you will appear larger than you.
D) you won't see your image because there is none.
E) you won't see your image because it is focused at infinity.

14) 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 passes through the focal point of the mirror.
C) It passes between the focal point and the center of curvature of the mirror.
D) It is perpendicular to the principal axis.
E) It passes through the center of curvature of the mirror.

15) 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.



16) A convex lens has focal length *f*. If an object is placed at a distance of 2*f* from the lens on the principal axis, the image is located at a distance from the lens
A) of *f*.
B) of infinity.
C) between *f* and 2*f*.
D) of 2*f*.
E) between the lens and *f*.

17) If a object is placed between a convex lens and its focal point, the image formed is
A) real and upright.
B) virtual and upright.
C) virtual and inverted.
D) real and inverted.

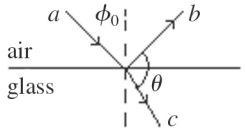
18) Starting from very far away, an object is moved closer and closer to a converging lens, eventually reaching the lens. What happens to its image formed by that lens? (There could be more than one correct choice.)
A) The image eventually changes from virtual to real.
B) The image keeps getting larger and larger.
C) The image gets farther and farther from the lens.
D) The image gets closer and closer to the lens.
E) The image eventually changes from real to virtual.

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

20) The image formed by a single concave lens
A) could be real or virtual, but is always real when the object is placed at the focal point.
B) could be real or virtual, depending on whether the object distance is smaller or greater than the focal length.
C) is always real.
D) is always inverted.
E) is always virtual.

21) 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)

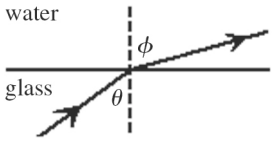
22) A ray of light (ray *a*) in air strikes a flat piece of glass at an angle of $\phi_0 = 84°$ with respect to the normal, as shown in the figure. The index of refraction of the glass is 1.5. What is the angle θ between the reflected ray (ray *b*) and refracted ray (ray *c*) rays?



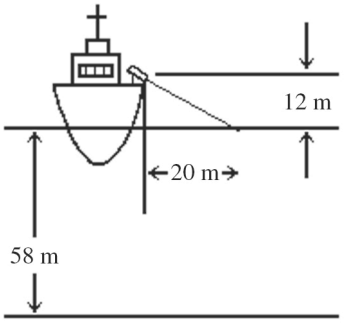
23) A narrow light beam in vacuum contains light of two wavelengths, 480 nm and 700 nm. It strikes a flat piece of glass at an angle of incidence of 60.000°. The index of refraction of the glass is 1.4830 at 480 nm and 1.4760 at 700 nm. Determine the angle between the two wavelengths as the light travels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

24) 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)

25) A light ray in glass arrives at the glass–water interface an an angle of $\theta = 48°$ with the normal. The refracted ray in water makes an angle $\phi = 72°$ angle 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 $\theta = 37°$. What is the new angle of refraction ϕ in the water?



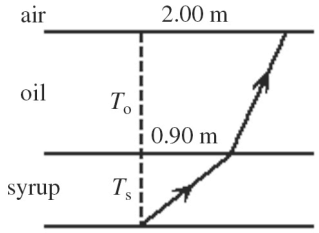
26) As shown in the figure, a laser positioned on a ship is used to communicate with a small research submarine resting on the *bottom* of a lake. The laser is positioned 12 m above the surface of the water, and it strikes the water 20 m from the side of the ship. The water is 58 m deep and has an index 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.)



27) 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?

28) 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?

29) 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 0.900 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 oil?



30) 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?

31) A 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?

32) 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?

33) 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?

34) 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?

35) 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?

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

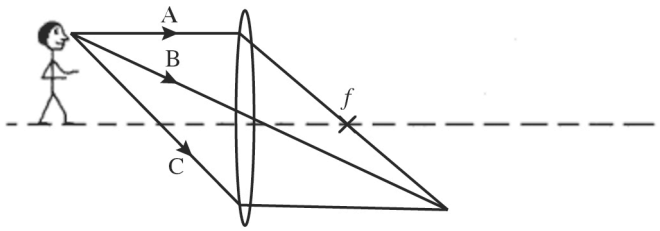
37) An object is placed 9.5 cm in front of a convex lens with a focal length of magnitude 24 cm.
(a) Where is the image formed and how far is it from the lens?
(b) What is the magnification produced by the lens?

38) 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?

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

Answer Key
Testname: CH23_LIGHT_RAYS

1) C
2) B
3) B
4) B
5) E
6) C
7) A
8) B
9) E
10) B
11) B
12) C, D
13) B
14) B
15)



16) D
17) B
18) E
19) A
20) E
21) 1.52×10^8 m/s
22) 54°
23) 0.196°
24) 2.0×10^8 m/s
25) 48°
26) 69 m
27) 49.26°
28) $41.8° < \theta < 90°$
29) 1.64
30) (a) 15 cm (b) 2.0 mm
31) (a) real (b) 17 cm (c) inverted (d) 2.1 cm
32) 40 cm
33) 20 cm behind the mirror
34) 6.7 cm behind the mirror
35) at infinity
36) 3.15 m
37) (a) 16 cm in front of the lens (b) 1.7
38) 33 mm
39) 0.54