Geometric Optics Practice Items

1. When an object is placed before a plane mirror the image created is

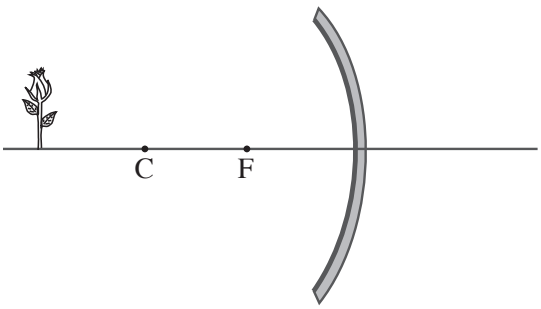
A. inverted, real, diminished
B. upright, real, the same size
C. inverted, virtual, the same size
D. upright, virtual, the same size

2. Which of these in a single lens or mirror system could produce a virtual image with a magnification of 0.7?

A. convex mirror
B. concave mirror
C. converging lens
D. convex lens

3. A flower is placed before a concave mirror as shown in the figure below. The image produced by the mirror is

A. virtual, upright, diminished
B. real, upright, enlarged
C. real, inverted, diminished
D. virtual, inverted, enlarged

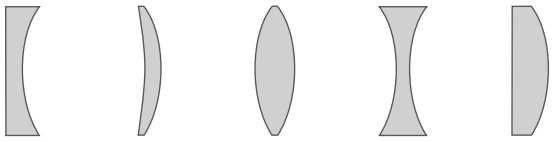


4. An object is placed at the center of the curvature, C, in front of a concave mirror with focal length, F. The image is located

A. the distance I = C
B. the distance I < F
C. the distance I = F
D. no image is formed

5. Which of the lenses shown in the figure above are converging lenses?

A. **I** and **IV**
B. **II**, **III** and **V**
C. **I** only
D. **III** and **V**



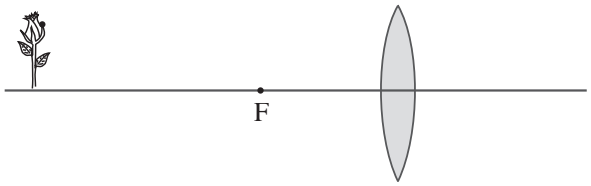
I **II** **III** **IV** **V**

6. Referring to the same figure above as in the preceding question, which of the lenses are diverging lenses?

A. **I** and **IV**
B. **II**, **III** and **V**
C. **I** only
D. **III** and **V**

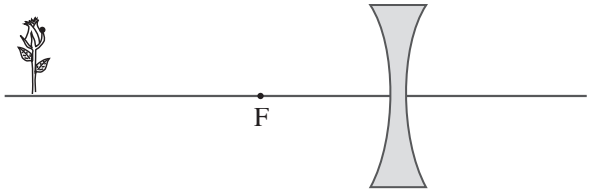
7. A flower is placed before a converging lens as shown in the figure below. The image produced by the lens is

A. virtual, upright, diminished
B. real, upright, enlarged
C. real, inverted, diminished
D. virtual, inverted, enlarged



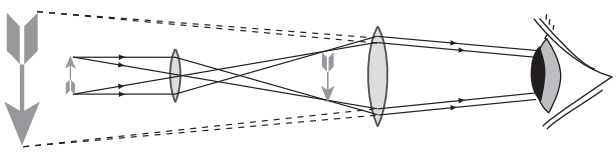
8. A flower is placed before a diverging lens as shown in the figure below. The image produced by the lens is

A. virtual, upright, diminished
B. real, upright, enlarged
C. real, inverted, diminished
D. virtual, inverted, enlarged



9. What type of optical instrument is represented by the ray diagram below?

A. compound microscope
B. simple magnifier
C. astronomical telescope
D. slide projector



10. A converging lens has a focal length of F. An object is placed at distance F from the lens on the axis. The image formed is

A. F distance from the lens.
B. 2F distance from the lens.
C. between F and 2F distance from the lens.
D. at infinity.

11. An object is placed at a distance of 8 cm from a 25 diopter positive lens. The magnification of the image is

A. –0.32
B. –1.0
C. +32
D. +200

12. Examining the scene in the conservatory, the detective holds the magnifying glass 20cm over the candlestick, magnifying a fingerprint 5×. What is the focal length of the magnifier?

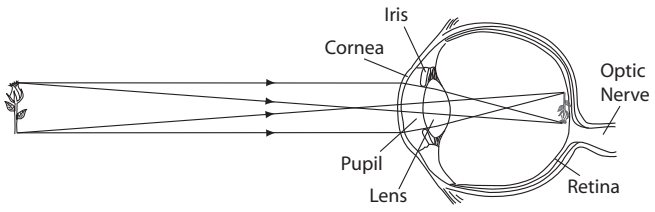
A. 4 cm
B. 10 cm
C. 25 cm
D. 100 cm

13. Chromatic aberration is a common problem with

A. convex mirrors.
B. lenses made with homogeneous glass.
C. lenses made with layers of salt glass and crown glass.
D. concave mirrors.

The following passage pertains to questions # - #.

The total optical power of the relaxed human eye is approximately 60 diopters. The cornea accounts for approximately two thirds of this refractive power and the crystalline lens contributes the remaining third. In focusing, the ciliary muscle contracts to reduce the tension or stress transferred to the lens by the suspensory ligaments. This results in increased convexity of the lens which in turn increases the optical power of the eye. As humans age, the amplitude of accommodation reduces from approximately 15 to 20 diopters in the very young, to about 10 diopters at age 25, to around 1 diopter at 50 and over.



The fact that optical powers are approximately additive enables an optometrist to prescribe corrective lenses as a simple correction to the eye's optical power, rather than doing a detailed analysis of the entire optical system (the eye and the lens).

However, the design of a proper optical treatment may be complicated if the patient suffers from astigmatism. Astigmatism is an optical defect in which vision is blurred due to the inability of the optics of the eye to focus a point object into a sharp focused image on the retina. This may be due to an irregular or toric curvature of the cornea or lens. The two types of astigmatism are regular and irregular. Irregular astigmatism is often caused by a corneal scar or scattering in the crystalline lens, and cannot be corrected by standard spectacle lenses, but can be corrected by contact lenses. The more common regular astigmatism arising from either the cornea or crystalline lens can be corrected by eyeglasses or toric lenses. A 'toric' surface resembles a section of the surface of a football where there are two regular radii, one smaller than the other one. This optical shape gives rise to astigmatism in the eye.

The refractive error of the astigmatic eye stems from a difference in degree of curvature refraction of the two different meridians (i.e., the eye has different focal points in different planes). For example, the image may be clearly focused on the retina in the horizontal plane, but not in the vertical plane. Astigmatism causes difficulties in seeing fine detail resulting in blurred vision. Three options exist for the treatment of astigmatism: spectacles, contact lenses (either hard contact lenses or toric contact lenses), and refractive surgery.

14. According to the information in the passage which of the following represents an approximate value of the focal length of the relaxed human eye?

A. 6 mm
B. 15 mm
C. 24 mm
D. 30 mm

15. Hyperopia, also known as farsightedness, is often caused by

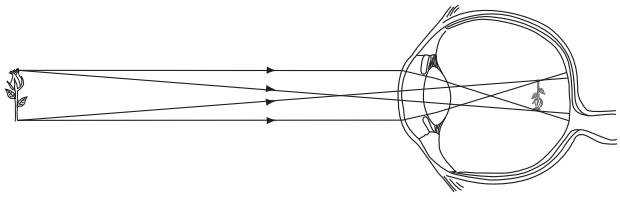
A. a cornea that is too rounded.
B. edematous swelling of the lens.
C. excessive contraction of the ciliary body.
D. an eye that is too short.

16. Ciliary muscle contraction

A. decreases the refractive power of the lens.
B. permits the eye to focus on more distant objects.
C. increases the radius of curvature of the lens.
D. allows the lens to obtain a more rounded shape.

17. The figure below shows an eye that suffers from the condition of

A. presbyopia
B. myopia
C. hyperopia
D. astigmatism



18. If a person with normal vision looked through a pair of glasses designed to correct astigmatism where the curvature of the horizontal meridian of the eye is too great (like a football lying on its side), they would see

A. aio

B. aio

C. aio

D. aio

19. Typical glasses for mild myopia will have a power of

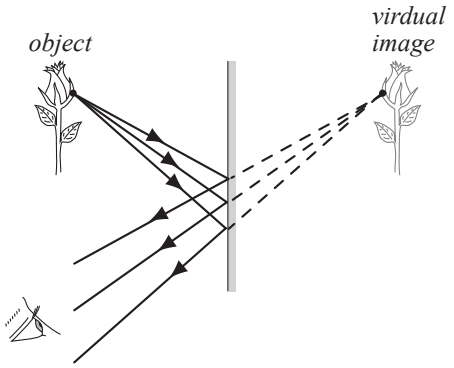
A. –1.0 to –3.0 diopters
B. 1.0 to 5.0 diopters
C. 10 to 20 diopters
D. 20 to 60 diopters

Geometric Optics

Answers and Explanations

1. D

A plane mirror creates a virtual image, located behind the mirror. With a virtual image, the rays of light do not intersect at the image point. The rays of light appear to originate from the image, diverging from the image point.

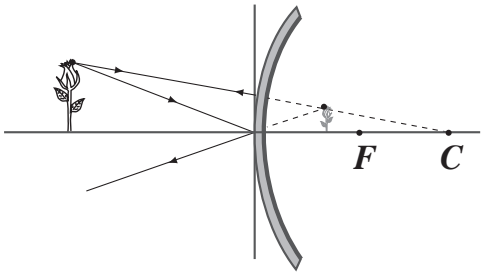


2. A

The magnification of the image produced by a lens or mirror is determined using the following formula where I is the distance of the image along the optical axis from the optical device and O is the object distance.

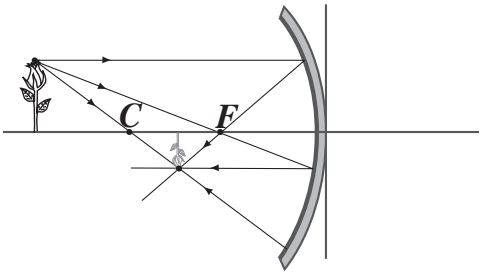
$$M = \frac{-I}{O}$$

If magnification is positive, the image is upright. If the absolute value of the magnification is less than 1, the image is diminished. In other words, with a magnification of 0.7, the optical device is producing an image which is diminished, upright, and virtual. This is the type of image produced by either a diverging lens or a convex mirror.



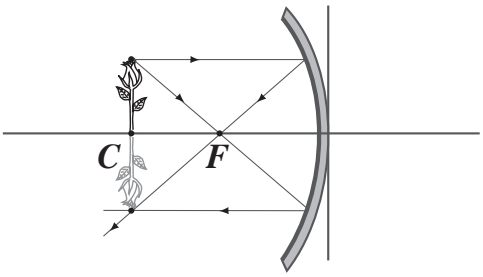
3. C

If the object distance with a concave mirror is greater than the center of curvature of the mirror, C (which also equals $2F$), the image produced will be real, inverted, and diminished.



4. A

If the object distance with a concave mirror is equal to the center of curvature of the mirror, C (which also equals $2F$), the image produced will be real, inverted, and same sized. The image distance will equal C.



5. B

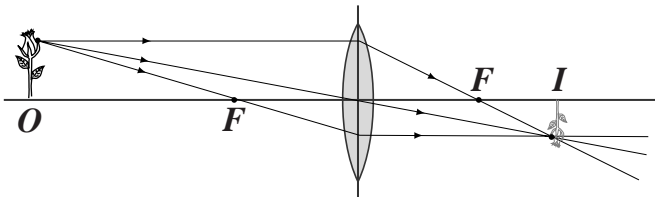
Although there is variety in the shape, converging lenses are thicker in the middle and thin at their upper and lower edges. Converging lenses have a positive focal length.

6. A

Diverging lenses are thinner in the middle. Diverging lenses have a negative focal length.

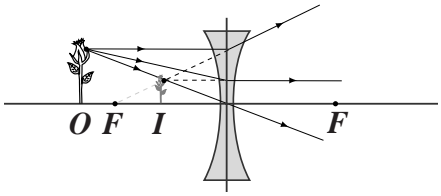
7. C

If the object distance with a converging lens is greater than 2*F*, the image produced will be real, inverted, and diminished.



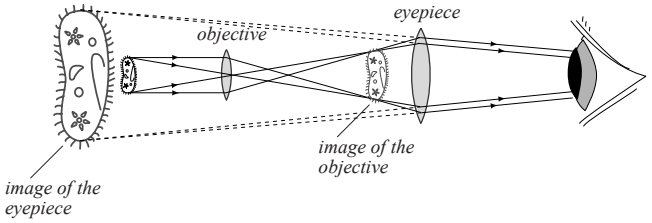
8. A

The image produced by a single diverging lens is always diminished, upright and virtual (DUV).



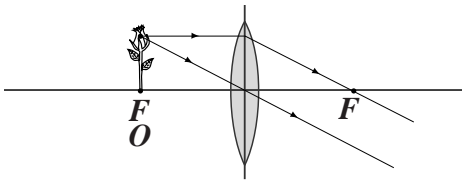
9. A

To understand systems of two or more lenses such as the compound microscope, take it one step at a time. The image of the first lens serves as the 'object' of the second. A compound microscope consists of two converging lenses, an objective lens and an eyepiece lens. The object is situated just beyond the focal length of the objective lens, producing a real inverted image. This image serves as the 'object' for the eyepiece lens, just within its focal length. The eyepiece produces a enlarged virtual image of the inverted real image of the objective.



10. D

When the distance of the object from a converging lens is equal to the focal length, no image is formed.



11. C

The lens equation relates the focal length, image distance, and object distance for an optical device.

$$\frac{1}{F} = \frac{1}{I} + \frac{1}{O}$$

Alternatively, we can express $1/F$ as the power of the lens, D, in diopters (m^{-1}). The lens equation is often expressed:

$$D = \frac{1}{I} + \frac{1}{O}$$

For our problem then:

$$25\ m^{-1} = \frac{1}{I} + \frac{1}{.08\ m}$$

$$25\ m^{-1} = \frac{1}{I} + 12.5\ m^{-1}$$

$$\frac{1}{I} = 12.5\ m^{-1}$$

$$I = .08\ m$$

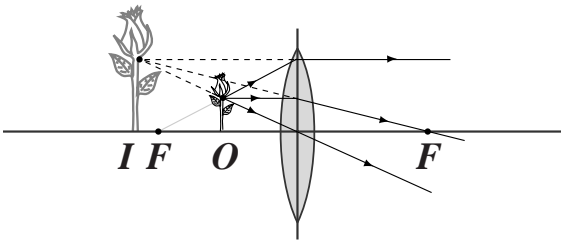
To determine magnification:

$$M = \frac{-I}{O} = \frac{-.08m}{.08m} = -1$$

Note that with a power of 25 diopters, our lens has a focal length of 4cm. When the object distance is equal to 2*F* with a converging lens (positive focal length), the image is real, inverted and same sized.

12. C

A magnifying glass is a converging lens. To observe an object, you position a magnifying glass above the object so that the object is nearer to the lens than the focal length of the lens. For an object placed nearer to the converging lens than the focus, the image produced is enlarged, upright, and virtual.



In our problem, the magnifier is placed 20cm above the object, and it is magnified 5×. This corresponds to an image distance of -100cm. (A negative image is a virtual image).

$$M = 5 = \frac{-I}{O} = \frac{-1.0\ \text{m}}{.20\ \text{m}}$$

Knowing the image distance for a given object, we can determine the focal length of the magnifying glass to be 25cm.

$$\frac{1}{F} = \frac{1}{I} + \frac{1}{O}$$

$$\frac{1}{F} = \frac{-1}{1.0\ \text{m}} + \frac{1}{.20\ \text{m}}$$

$$F = .25\ \text{m}$$

13. B

Chromatic aberration is a failure of a lens to focus all colors to the same point. It is caused by dispersion, ie. the refractive index of the lens varies with the frequency of light. Chromatic aberration manifests itself as "fringes" of color along boundaries within the image. Chromatic aberration can be minimized by assembling a compound lens from materials with differing dispersion properties. The most common type is an achromatic doublet, with elements made of crown and flint glass.

14. B

The optical power of the relaxed human eye is approximately 60 diopters (m^{-1}), a fact presented in the passage. The focal length of a lens is the reciprocal of its power in diopters.

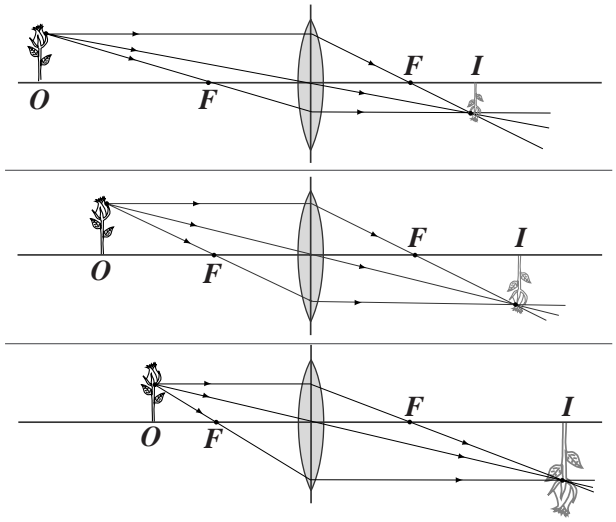
$$D = \frac{1}{F}$$

$$60\ \text{m}^{-1} = \frac{1}{F}$$

$$F = \frac{1}{60}\ \text{m} \sim 15\ \text{mm}$$

15. D

An individual with hyperopia has difficulty seeing near objects. To understand hyperopia, it's very helpful to visualize what occurs with image distance (the real inverted image formed by a converging lens) as the object is moved closer to the lens. Notice as the object is moved closer, the image moves further away from the lens on the other side.



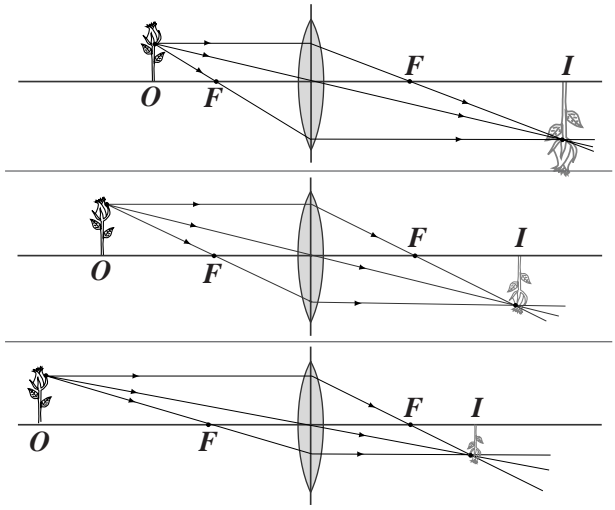
The cause of hyperopia is often that the eyeball is too short. In other words, the distance between the refractive elements (corena and lens) and the retina is too short, so for near objects the focused real image would be behind the retina. Accommodation is not sufficient to shorten the focal length of the eye and pull the image forward onto the retina. Light that originated from the same object point instead is landing at different locations on the retina. The result is blurry vision.

16. D

Contraction of the ciliary muscle reduces the tension on the fibers of the ciliary zonule and causes the lens to curve or become more spherical. This increases the optical power of the eye, accommodating for near vision.

17. D

An individual with myopia has difficulty seeing far objects. To understand myopia, it's very helpful to visualize what occurs with image distance as the object is moved further away from the lens. Notice as the object is moved further away, the image moves closer to the lens on the other side.



The cause of myopia is often that the eyeball is too long (or the eye has too short a focal length). For far objects, the retina would need to be further in for a focused image to land on it. Light that originated from the same object point instead is landing at different locations on the retina. The result is blurry vision for far objects.

18. C

To repair the astigmatism, the corrective lenses adjust the focal length in the horizontal plane to match the vertical focal length. To a person with normal vision the glasses would appear out of focus in the horizontal plane but not in the vertical plane.

19. A

Myopia or nearsightedness is the inability of the eye to focus on distant objects. It is the result of either a bulging cornea or too long an eyeball. With myopia the image distance for distant objects is in front of the retina.

The cure for the nearsighted eye is to equip it with a diverging lens. This spreads the light rays, shifting the focal length further back, so that the image will land on the retina. A diverging lens has a negative focal length, so its power in diopters will likewise be negative. –1.0 to –3.0 diopters is the range of the typical prescription for mild myopia.