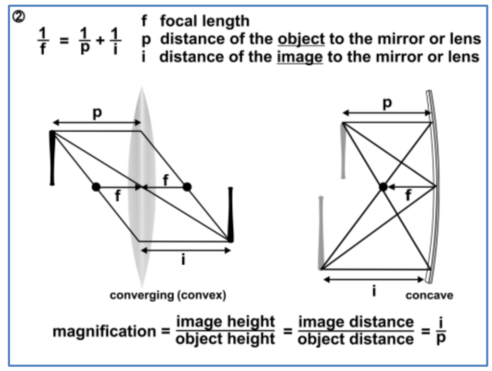
1. For flat mirrors, the angle of incidence equals the angle of reflection.

This 6 foot gentleman wants to buy a mirror that allows him to see his entire body. What is the smallest mirror he can buy, where should the top of the mirror be hung, and how far away from him should it be hung?

(A) The minimum length of the mirror is ¾ of his height. The top of the mirror should be even with the top of his head. The mirror should be 3 feet in front of him.
(B) The minimum length of the mirror is ½ his height. The top of the mirror should be even with the top of his head. The mirror should be 3 feet in front of him.
(C) The minimum length of the mirror is ½ the distance from his eyes to his feet. The top of the mirror should be even with the middle of his forehead. The mirror should be 3 feet in front of him.
(D) The minimum length of the mirror is ½ the distance from his eyes to his feet. The top of the mirror should be even with the middle of his forehead. The mirror can be any distance in front of him.
(E) The minimum length of the mirror is ½ his height. The top of the mirror should be even with his eyes. The mirror should be 3 feet in front of him.

**Introduction to Question 2**




The lens formula is $\frac{1}{f} = \frac{1}{p} + \frac{1}{i}$. One over the focal length equals one over the object distance plus 1 over the image distance. The lens formula applies to both mirrors and lenses.

f is the focal length of the mirror or lens. f is negative for a diverging lens or a convex mirror. For spherical mirrors and lenses, f is one-half the radius of curvature.

p measures how far the object is from the mirror or lens. Since p is always in front of the mirror or lens, p is always positive.

i measures how far the image forms from the mirror or lens. A positive i means the image forms where, so to speak, it should form -- in front of the mirror or behind a lens.

A negative i means the image forms where it shouldn't, namely, behind the mirror or in front of the lens. Images that form behind the mirror or in front of the lens are called "virtual" images. Virtual images cannot be projected onto a screen.

Only a convex lens can form a real image. A concave lens always forms virtual images.

Magnification is the ratio of image height over object height, which is the same ration is image distance over object distance, i over p.

To determine the image's orientation, whether it's upright or inverted, recall that for converging lenses and concave mirrors, images are always inverted until the object is brought inside the focal point, and then the image becomes upright.

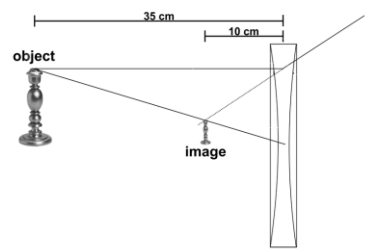
For diverging lenses and convex mirrors, the image is always upright.

Objects and their images can be graphed out using a number of different rays. One ray runs horizontally from the top of the object to the mirror or lens and then through the focal point.

Another ray passes from the top of the object through the focal point to the mirror or lens and then horizontally from there. For mirrors , this ray is slightly off because of the curvature of the mirror, a problem called spherical aberration.

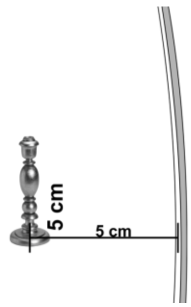
A third ray passes from the top of the object straight through the center of the lens without deflecting at all. For mirrors, the ray passes from the top of the object to the center of the mirror and reflects back at the same angle.

2. What focal length lens is needed to form a virtual image 10 cm in front of the lens when the object is placed 35 cm in front of the lens?




(A) a converging lens with a focal length of 14 cm
(B) a diverging lens with a focal length of 14 cm
(C) a converging lens with a focal length of 25 cm
(D) a diverging lens with a focal length of 25 cm
(E) a diverging lens with a focal length of 10 cm

3. A 5 cm object is placed 5 cm in front of a concave spherical mirror with a focal length of 10 cm. Where does the image form, how high is it, and is it upright or upside down?




(A) 10 cm tall, 10 cm behind the mirror, and upright
(B) 10 cm tall, 10 cm behind the mirror, and upside down
(C) 5 cm tall, 5 cm behind the mirror, and upright
(D) 5 cm tall, 5 cm behind the mirror, and upside down
(E) 10 cm tall, 10 cm in front of the mirror, and upright

4. The following problem demonstrates the problem of spherical aberration.

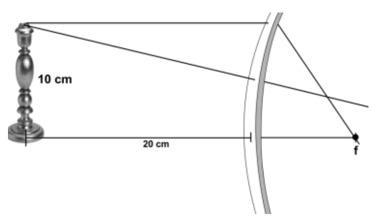
What is the magnification of a concave mirror with a focal length of 25 cm when a 10 cm object is placed 20 cm in front of the mirror?

(A) 2
(B) 3
(C) 4
(D) 5
(E) 6

5. A 10 cm object 40 cm from a concave mirror with a focal length of 30 cm creates an image that's __________.

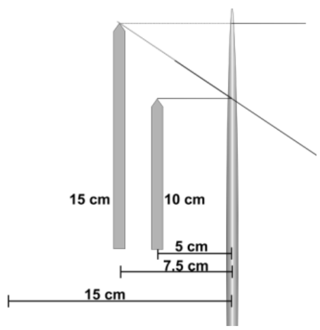
(A) 60 cm behind the mirror, 30 cm tall, upright
(B) 60 cm in front of the mirror, 15 cm tall, inverted
(C) 120 cm in front of the mirror, 15 cm tall, inverted
(D) 120 cm behind the mirror, 30 cm tall, upright
(E) 120 cm in front of the mirror, 30 cm tall, inverted

6. A 10 cm object is placed 20 cm in front of a convex mirror with a focal length of 10 cm. Where does the image form, how tall is it, and is it upright or upside down?



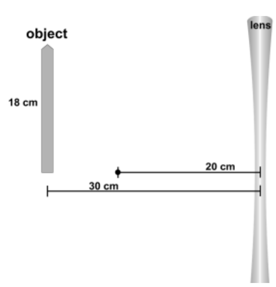

(A) $\frac{10}{3}$ cm tall in front of the mirror and upright
(B) $\frac{10}{3}$ cm tall in front of the mirror and upside down
(C) $\frac{10}{3}$ cm tall behind the mirror and upright
(D) $\frac{10}{3}$ m tall behind the mirror and upside down
(E) $\frac{20}{3}$ cm tall in front of the mirror and upright

7. A 10 cm object is placed 5 cm in front of a converging lens with a focal length of 15 cm. Where does the image form, how tall is the image, and is it upright or upside down?



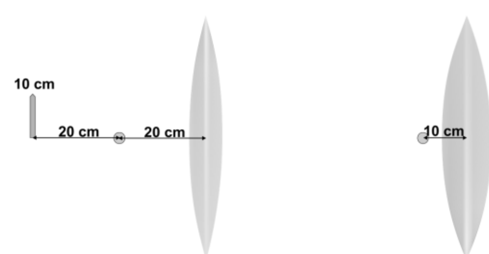

(A) 10 cm tall in front of the mirror and upright
(B) 10 cm tall in front of the mirror and upside down
(C) 15 cm tall behind the mirror and upright
(D) 15 cm tall behind the mirror and upside down
(E) 15 cm tall in front of the mirror and upright

8. Here is a diverging lens with a focal length of -- because it's a diverging lens -20 cm. An 18 cm tall object is placed 30 cm in front of the lens. Where does the image form, how tall is the image, and is it upright or upside down?




(A) 12 cm tall, 7.2 cm in front of the mirror and upright
(B) 12 cm tall, 7.2 cm in front of the mirror and upside down
(C) 7.2 cm tall, 12 cm in front of the mirror and upright
(D) 7.2 cm tall, 12 cm behind the mirror and upright
(E) 7.2 cm tall, 12 cm behind the mirror and upside down

9. Here are two lenses 60 cm apart. The first lens has a focal length of 20 cm and the second lens, 10 cm. A 10 cm object is placed 40 cm to the left of the first lens. Where does the image form, how high is it, and is it upright or upside down?




(A) 10 cm to the right of the second lens, 10 cm tall, upright
(B) 10 cm to the right of the second lens, 10 cm tall, upside down
(C) 20 cm to the right of the second lens, 10 cm tall, upside down
(D) 20 cm to the right of the second lens, 10 cm tall, upright
(E) 20 cm to the right of the second lens, 20 cm tall, upright

10. In 1801, Thomas Young showed that he could determine the wavelength of light by passing a beam of light through two slits and recording their interference pattern at a distance L from the slits.

All he had to do was measure the distance between the two slits and the distance from the central interference band to the one next to it.

So if Young placed the slits 0.4 mm apart, and L was 1 meter, and the first interference band 2.5 mm from the midline, what was the wavelength of the light in nanometers?

(A) 525 nm
(B) 750 nm
(C) 1000 nm
(D) 1250 nm
(E) 1450 nm