

Workshop Tutorials for Physics

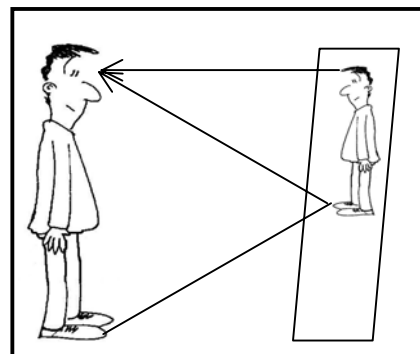
Solutions to WR7: Mirrors

A. Qualitative Questions:

1. You want to buy a mirror but you don't want to spend a lot of money getting a bigger mirror than you actually need.

a. The angle of reflection is equal to the angle of incidence, so a ray coming from your toes to your eyes reflects off the mirror at half your height. The lower half of a full length mirror only shows the floor. A mirror only needs to be half your height, so you can see all of yourself, plus a little bit to allow for your eye height being a little less than your full height.

b. The mirror should be mounted so that the top is level with the top of your head.

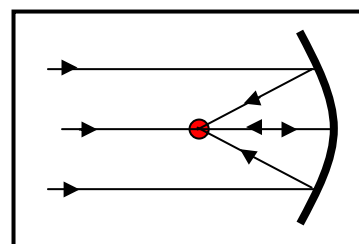


c. In your reflection left and right seem to be reversed, but not up and down. This is because of the way we define left and right as relative to ourselves, not our surroundings. For example, "towards the wall" and "away from the wall" are not reversed, just as up and down are not reversed. Up and down are defined externally, usually relative to the ground. It is important to know how your coordinate systems are defined, and whether they change as you move!

2. Dish antennas, whether for satellite TV reception, radar signals or radio-telescopes, have a particular shape.

a. Dish antennas have a parabolic shape. The parabolic shape reflects all incident rays into the focal point of the dish where a receiver is mounted.

b. We have assumed that the emitter is a very long way away so that all the rays are approximately parallel. This is a reasonable assumption for emitters such as satellites or radio sources many kilometers away.

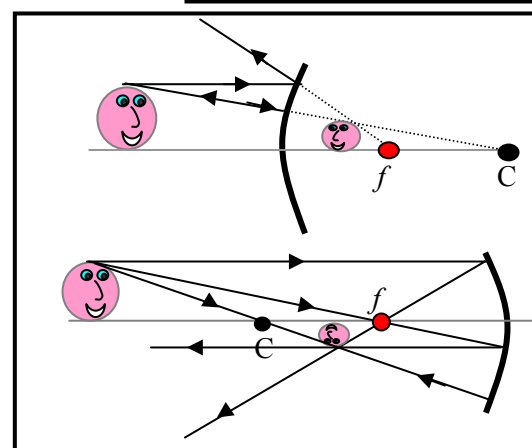


B. Activity Questions:

1. Curved mirrors

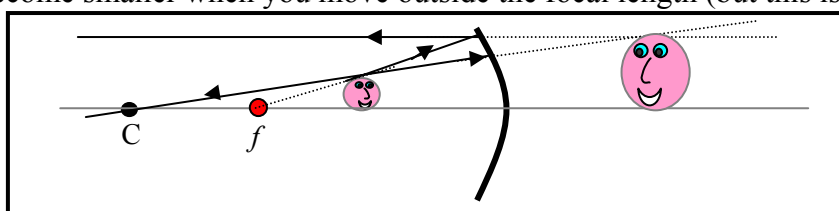
See diagrams opposite. C is the center of curvature of the mirror, f is the focal point.

A convex mirror produces a virtual, upright, reduced image. A concave mirror will give you a real, inverted and reduced image unless the image is within the focal length. In which case the image is virtual, upright and enlarged.



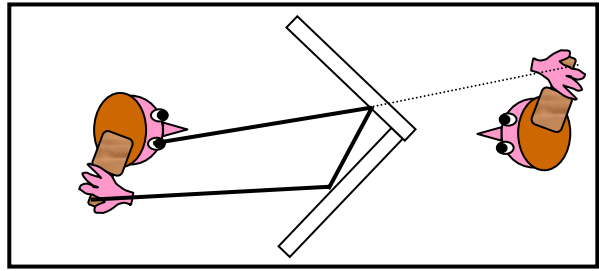
2. Shaving Mirror

A shaving mirror gives an enlarged image. The mirror is concave. You must have your face within the focal length of the mirror, to get an upright and enlarged image. If you move far enough away from the mirror your reflection will invert and become smaller when you move outside the focal length (but this is a long way).



3. Right angled mirrors

You see an image of yourself as seen by others. Depth inversion occurs twice, once in each mirror, so unlike in a flat mirror, left and right are not reversed.



4. Kaleidoscope

The three mirror kaleidoscope makes an endlessly repeating pattern. The two mirror kaleidoscope makes a circular pattern. Kaleidoscopes with four mirrors produce a line of images.

C. Quantitative Questions:

1. Some car side mirrors have a warning on them that says: “Caution: objects in mirrors may appear further away than they are”.

a. Car mirrors are convex – they produce a reduced upright image. This provides an enlarged field of view.

b. The image from these mirrors is virtual.

A spherical convex driving mirror in a car has a radius of curvature of 1.5 m. The driver looks in the mirror and sees the car behind. The car behind is 1.5 m high, and is 13 m away from the mirror.

c. See diagram opposite.

d. The mirror equation relates the image distance and the object distance to the focal length:

$\frac{1}{f} = \frac{1}{s} + \frac{1}{s'}$, where s is the object distance and s' is the image distance, f is the focal length.

The focal length is negative.

Solve for s' : $\frac{1}{s'} = \frac{1}{f} - \frac{1}{s} = \frac{-1}{0.75\text{m}} - \frac{1}{13\text{m}} = -1.4\text{ m}^{-1}$, so $s' = 1/-1.4\text{m}^{-1} = -0.71\text{ m} = -71\text{ cm}$.

The image appears to be 71 cm behind the mirror.

e. This is a virtual image.

f. To find the height of the image we use: $\frac{h_i}{h_o} = -\frac{s'}{s}$,

rearranging for h_i gives $h_i = h_o \times -\frac{s'}{s} = 1.5\text{ m} \times -\frac{-0.71\text{m}}{13\text{m}} = 0.08\text{ m} = 8\text{ cm}$.

2. A concave shaving mirror has a focal length of 450 mm.

See diagram opposite.

The image distance is negative because the image is behind the mirror and virtual. We want a magnification of 2, so that $\frac{-s'}{s} = 2$, so $s' = -2s$.

We can use the mirror formula: $\frac{1}{f} = \frac{1}{s} + \frac{1}{s'}$, and substitute for s' to get: $\frac{1}{f} = \frac{1}{s} + \frac{1}{-2s}$

and hence $s = \frac{1}{2}f = \frac{1}{2} \times 450\text{ mm} = 225\text{ mm}$.

