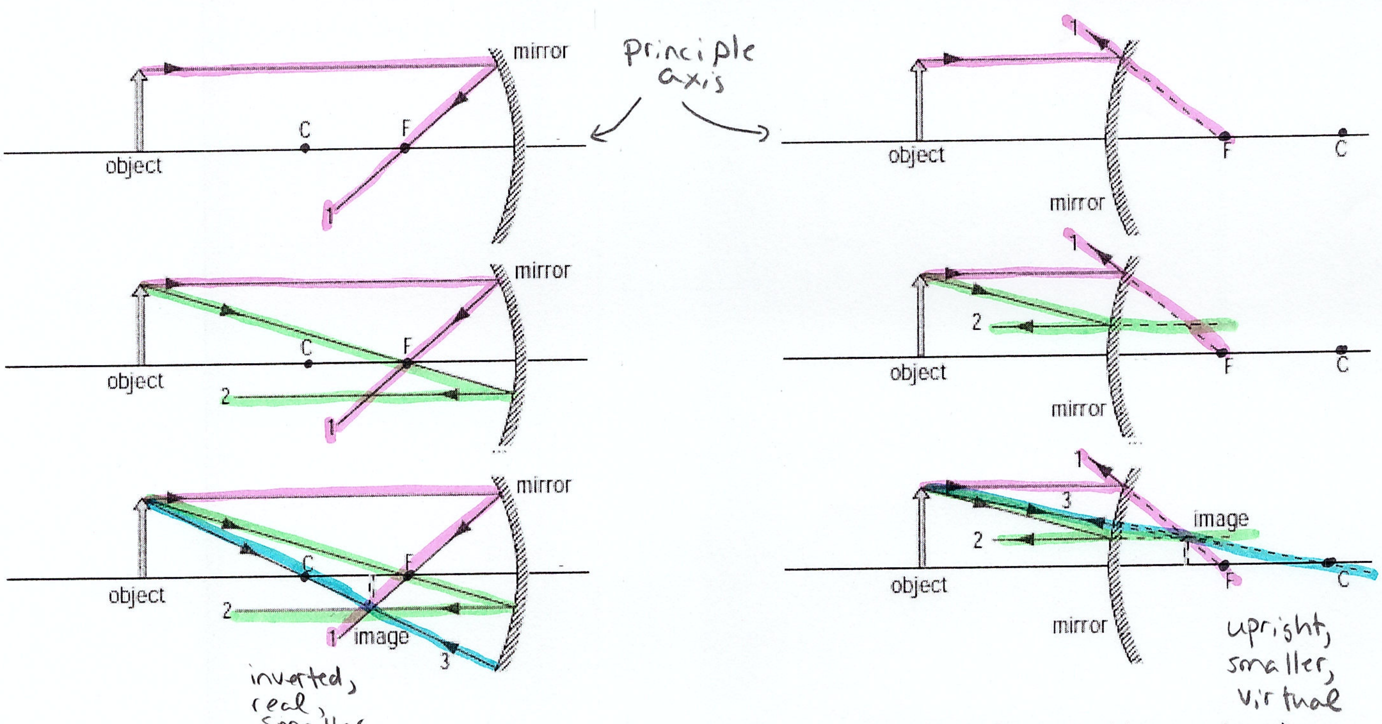
Mirrors

- ✳ Lenses are very similar to mirrors, the major difference is that *mirrors reflect light whereas lenses refract light*
- When drawing ray diagrams for curved mirrors, you must *also* included
  - the center of curvature (C) (ie. the center of the circle if the mirror was a complete circle)
  - ✳ The focal point occurs half way between the center of curvature and the mirror ($C = 2f$ or $f = \frac{C}{2}$)
- ✳ There are two types of mirrors. **Convex mirrors** are spherical mirrors that bow or bulge out toward the object. **Concave mirrors** are spherical mirrors that bow or bend away from the object.

Rules for Ray Diagrams for Mirrors

1. The ray parallel to the principle axis will *reflect* through (or appear to diverge from) the focal point
2. The ray through the focal point will reflect back parallel to the principle axis
3. The ray through the center of curvature will reflect back along the same path

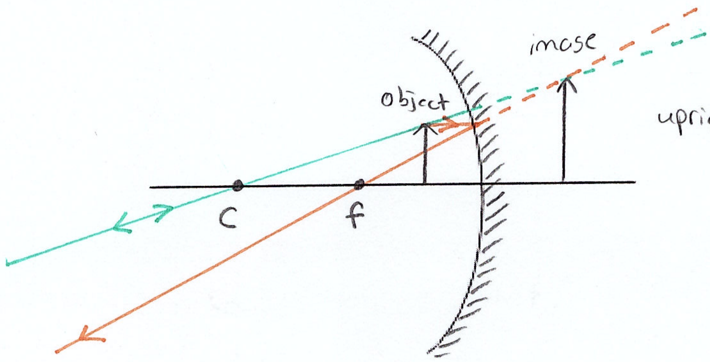
Concave Mirrors **Convex Mirrors**



- ✳ The characteristics of the images produced (size, orientation, and image type) are the same as for lenses, however, since mirrors are designed to *reflect* light, real images are found on the same side of the mirror as the object and virtual images are found on the opposite side of the mirror.

EXAMPLES: Draw the ray diagrams for the following mirrors and use the diagram to identify the characteristics of the image produced.

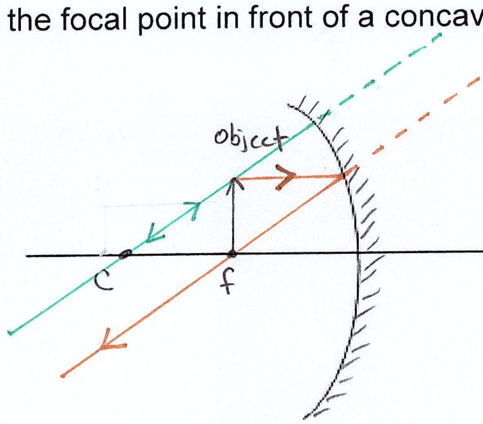
1. An object is placed anywhere between the focal length and a concave mirror.



upright, virtual, larger

rays will not converge/ intersect ∴ extend reflected rays back

2. An object is placed at the focal point in front of a concave mirror.



parallel rays ∴ no image will be seen!

3. An object is placed anywhere in front of a convex mirror.

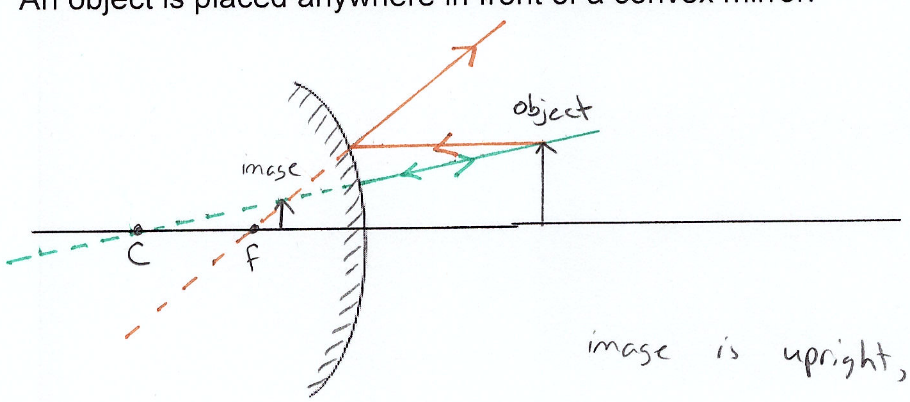


image is upright, virtual, smaller

*****Now try pg. 226 #1, 2, 3a, 4a (don't do the dimensions chart)*****

- The formulas for mirrors are the same as the ones used for lenses

$$\frac{1}{f} = \frac{1}{d_i} + \frac{1}{d_o} \quad \text{and} \quad m = \frac{h_i}{h_o} = -\frac{d_i}{d_o}$$

where d_i is the distance of image from the mirror

d_o is the distance of object from the mirror

f is the focal length/point (ie. the distance from the mirror to the focal point)

h_i is the height of image

h_o is the height of object

m is the magnification of image (no units)

  - A magnification (*m*) value larger than the absolute value of one (1) means the image is enlarged

- Sign conventions

Variable	Positive (+)	Negative (-)
d_o	Always positive	N/A
d_i	Positive for real images (real images occur when the image and object are found on the same side of a mirror because mirrors reflect light)	Negative for virtual images (virtual images occur when the image is found on the opposite side of the mirror as the object)
f	Positive for real images (ie. for all concave mirrors when the object is placed farther away than the focal length)	Negative for virtual images (ie. all convex mirrors & when an object is placed in between the focal length and the mirror for concave mirrors)
h_i	Positive for upright images	Negative for inverted images
h_o	Always positive	N/A
m	Positive for upright images	Negative for inverted images

Only one different from lenses! (→ row f)

EXAMPLES:

always "−" f

1. An object is 2.0m tall and is located 7.0m in front of a convex mirror that has a focal length of 3.0m.
    a. What is the size of the image produced?
    b. What are the characteristics of the image produced?

$h_o = +2.0m$

$d_o = +7.0m$

$f = -3.0m$

$h_i = ?$

② $\frac{h_i}{h_o} = \frac{-d_i}{d_o}$

① $\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$

① $\frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o} = \frac{1}{(-3.0m)} - \frac{1}{(+7.0m)} = -0.47619... m^{-1}$

$\therefore d_i = \frac{1}{-0.47619... m^{-1}} = -2.1m$

↑ virtual image

② $h_i = \frac{-d_i h_o}{d_o} = \frac{-(-2.1m)(+2.0m)}{(+7.0m)} = +0.60m$

↑ upright image

& smaller image b/c $h_i < h_o$

$h_i = 0.60m$

2. An object 3.00cm tall is placed 10.0cm in front of a mirror. What type of mirror is being used if the inverted image is 1.29cm tall?

↳ h_i is "−"

$h_o = +3.00cm$

$d_o = +10.0cm$

$h_i = -1.29cm$

∴ need to find f or d_i

$$\frac{h_i}{h_o} = -\frac{d_i}{d_o}$$

$$d_i = \frac{-h_i d_o}{h_o} = -\frac{(-1.29cm)(+10.0cm)}{(+3.00cm)}$$

$d_i = +4.3m$

↗ real image, which can only occur with concave mirrors!

*****Now try pg. 228 #8, Practice Problems #1 (acceptable), P.P. #2-4 (intermediate), P.P. #5 (excellence)*****

Practice Problems

1. A 6.5cm high object is 15cm from a concave mirror that has a 20.0cm radius. Identify the characteristics of the image. **[inverted, real, larger]**

2. An object is placed 20cm from a spherical concave mirror that has a focal length of 60cm. What is the distance between the object and the virtual image? **[35 cm]**

3. A 3.0cm tall object is placed 6.0cm in front of a mirror. The upright image that is produced is 1.0cm tall.
   a. Identify the type of mirror used. **[Concave]**
   b. Determine the focal length of the mirror. **[3.0cm]**

4. A 5.0cm tall object is placed 4.0cm in front of a mirror. If the distance of the virtual image from the mirror is 2.4cm, what is the focal length and type of mirror used? **[A convex or concave mirror with a focal length of 6.0cm]**

5. A convex mirror has a radius of curvature of 12.0cm. If the image is a quarter of the size of the object, how far is the object from the mirror? **[18.0cm]**