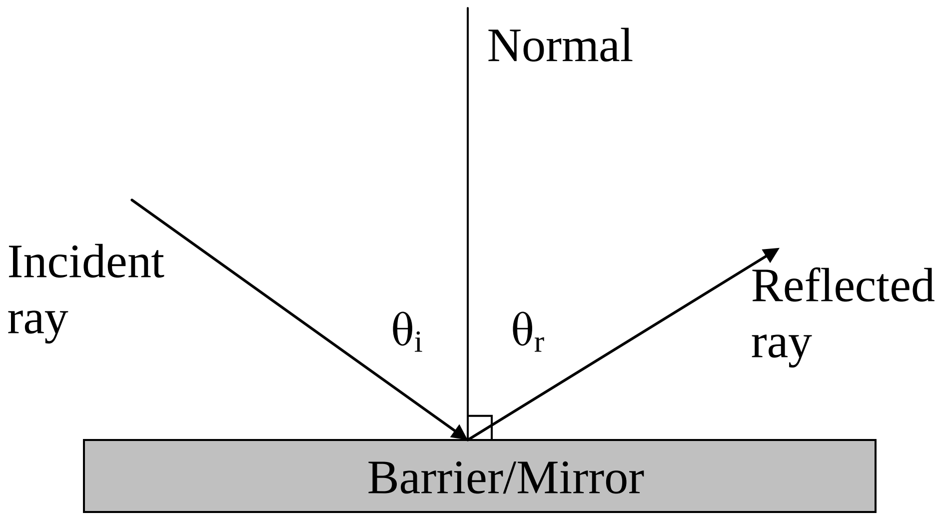
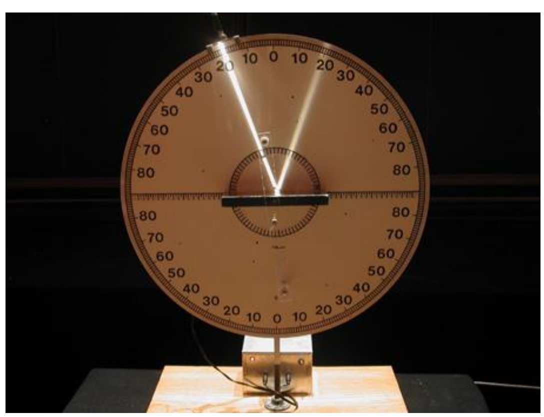
Mirrors and the Reflection of Light



$$\theta_i = \theta_r$$

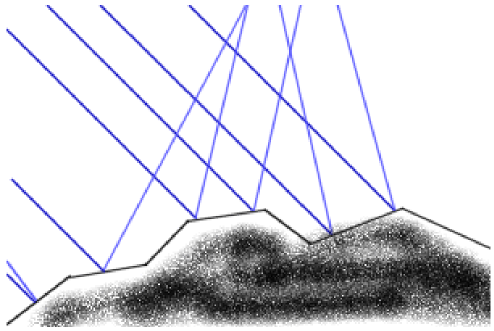
- Incident ray: a ray approaching a surface.
- Point of incidence: where incident ray strikes a surface.
- Normal: It is a line drawn perpendicular to the surface at the point of incidence.
- Reflected Ray: The portion of the incident ray that leaves the surface at the point of incidence.
- Angle of Incidence: The angle between the incident ray and the normal.
- Angle of Reflection: The angle between the reflected ray and the normal.
- Laws of Reflection:
  - The angle of incidence is equal to the angle of reflection.
  - The incident ray, the normal, and the reflected ray are coplanar.



www.fas.harvard.edu/.../ OpticsDisk04.jpg

- The above image is an example of specular reflection. The surface is very smooth so incident parallel rays reflect as parallel rays.

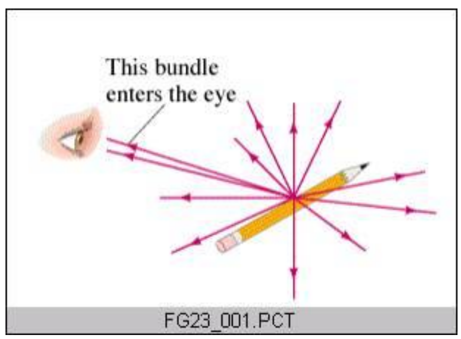
- If parallel rays strike a rough surface (on the microscopic level) they will not be reflected in parallel. This is called diffuse reflection.
- Both specular and diffuse reflection obeys the laws of reflection.



library.thinkquest.org/ 27356/p_reflection.htm

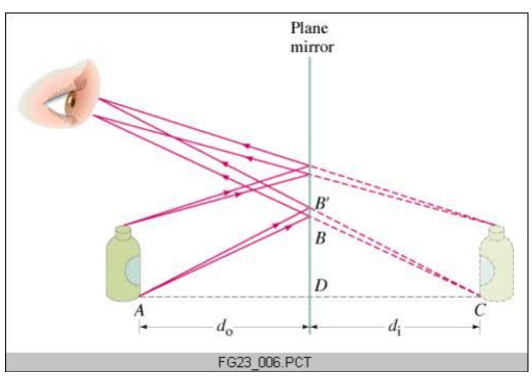
Images in a Plane Mirror

- When you look into a plane mirror, your image appears to be behind the surface of the mirror. To understand why, and find the position of objects in a plane mirror, we need to consider how light is seen in the eye.
- Light emanates from an object in all directions, but the eye only sees a diverging cone of rays.



physics.usc.edu/.../ LightOptics.html

- When you see an object in the mirror, the mirror reflects the cone of rays.
- You cannot see that light was reflected, and assumes the cone of rays originated behind the mirror.



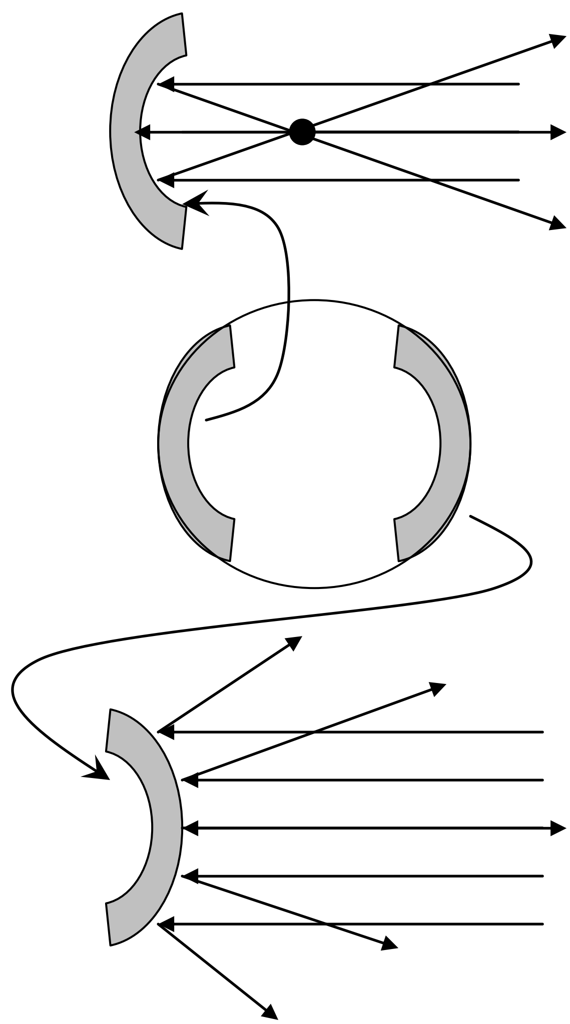
physics.usc.edu/.../ LightOptics.html

- The resulting image is called a virtual image. That is because the image is produced at the point where the reflected rays, extended behind the mirror, intersect.
- A real image (like the one formed with the pinhole camera), is an image that can be formed on a screen (where the actual rays intersect).

- Images in plane mirrors are <u>laterally inverted</u> → What was on the right now appears to be on the left from the mirrors perspective.
- When drawing rays that don't actually exist, draw them as dotted lines. Rays that do exist are solid lines

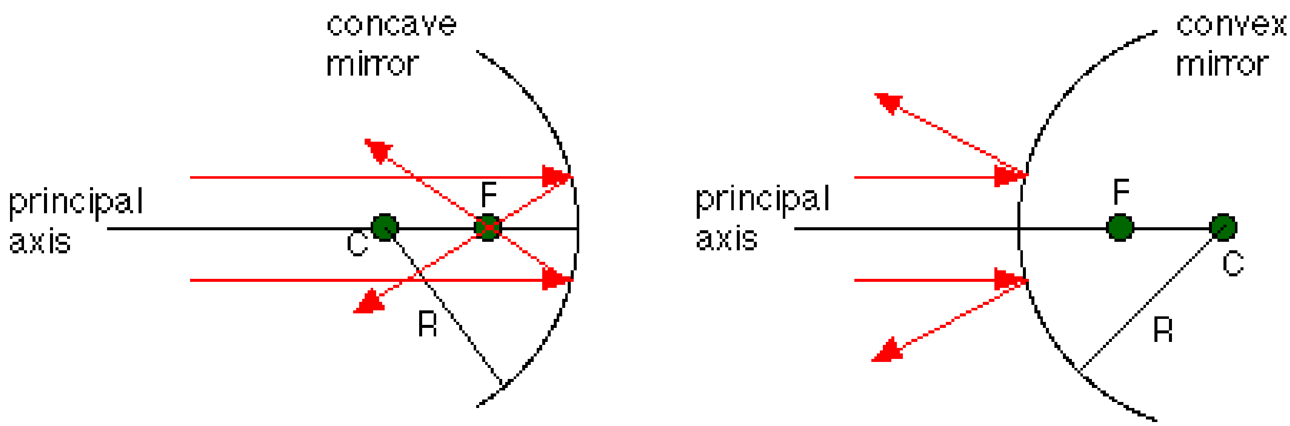
Curved Mirrors

- <u>Converging mirror</u>: Are concave in shape and focus parallel rays at a single point.
- <u>Diverging mirror</u>: Is convex in shape and makes parallel rays diverge.
- Both types can be thought of as a section of a spherical mirror.



Geometry and Terminology of Spherical Mirrors

- The centre of a curved reflecting surface is called the centre of curvature, *C*, and the radius of curvature is the shortest distance from the centre to the curved surface.
- The geometric centre of the curved mirror is called the vertex, *V*.
- The straight line passing through V and C is called the principal axis.



physics.bu.edu/~duffy/ PY106/Reflection.html

Reflection in a Converging Mirror

- Rays that are parallel to the principal axis will reflect and converge at the same point called the principal focus, F.
- The principal focus will be halfway between V and C.
- Rays that are not parallel to the P.A. but parallel to each other will meet at a focus (not the principal focus). The line connecting all the focal points is called the focal plane.

Images in a Converging Mirror

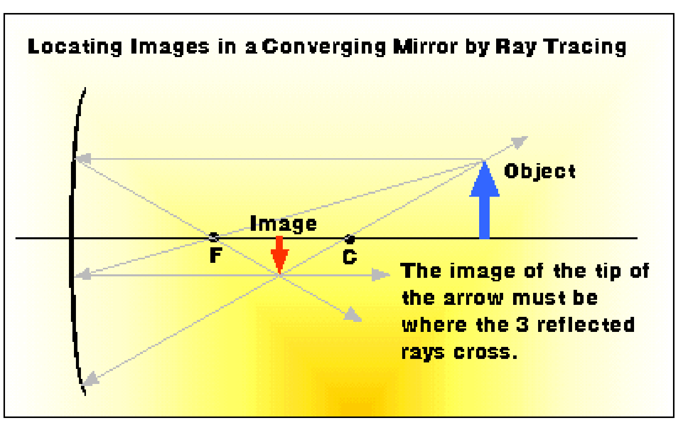
- Image beyond principal focus:
  - Inverted & real.
- Image between principal focus and vertex:
  - Erect & virtual.
- The further the object is from the vertex, the smaller the image.

⇨ To determine the position of an image in a converging mirror, it is necessary to use only two rays that intersect.

⇨ We use two rays that emanate from the tip of the object.
  - One that is parallel to the principal axis, and one that passes through F.
  - Another ray is the ray along the radius of curvature.

Rules for Rays in a Converging Mirror

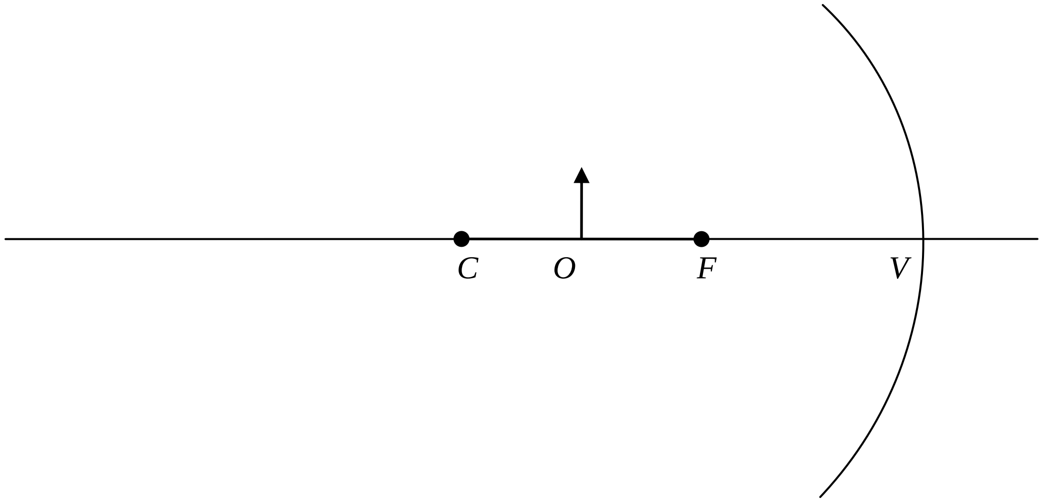
1. A ray that is parallel to the principal axis is reflected through the principal focus.
2. A ray that passes through the principal focus is reflected parallel to the principal axis.
3. A ray the passes through the centre of curvature is reflected back along the same path.



www.batesville.k12.in.us/ physics/PhyNet/Optic..

Physics 112 Mirrors Mr. MacDonald

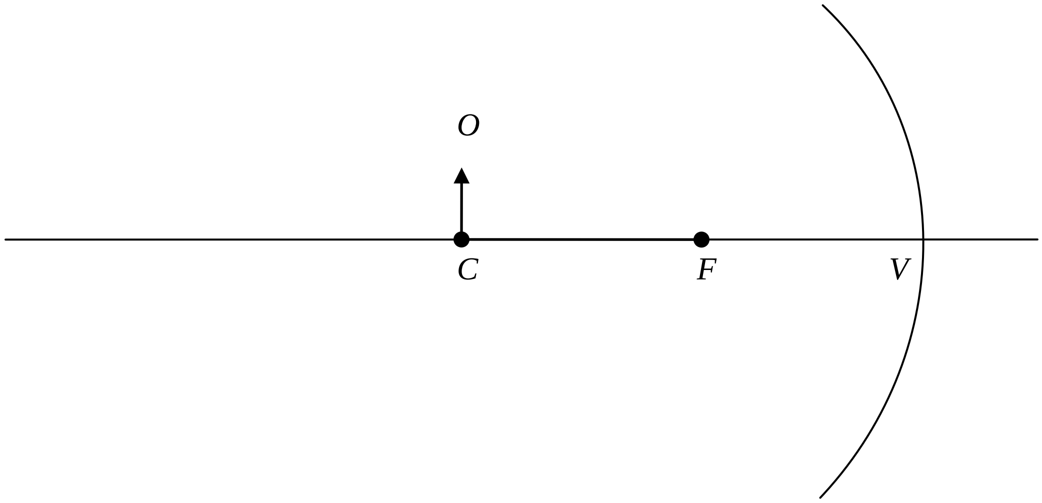
1. Object between *F* and *C*.



Characteristics

→

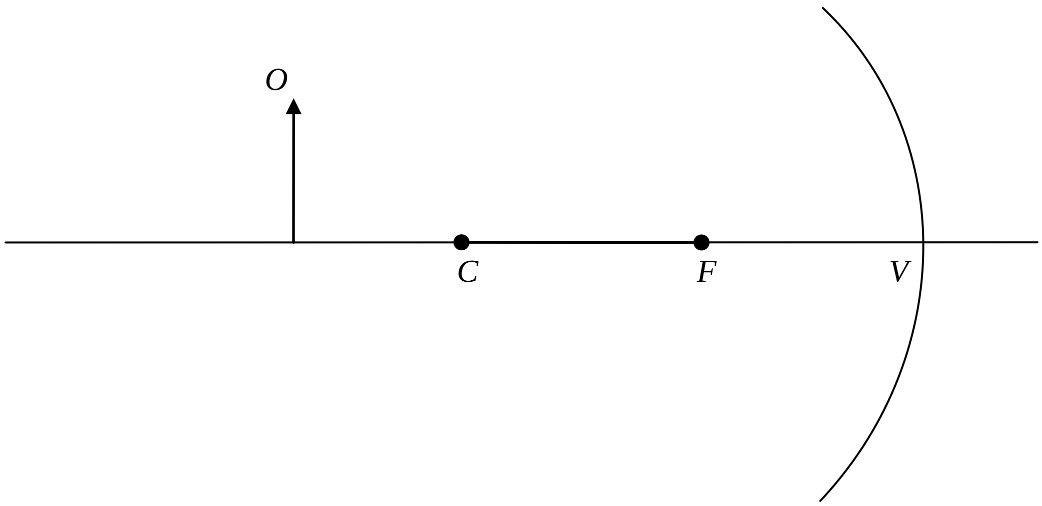
2. Object at C.



Characteristics

→

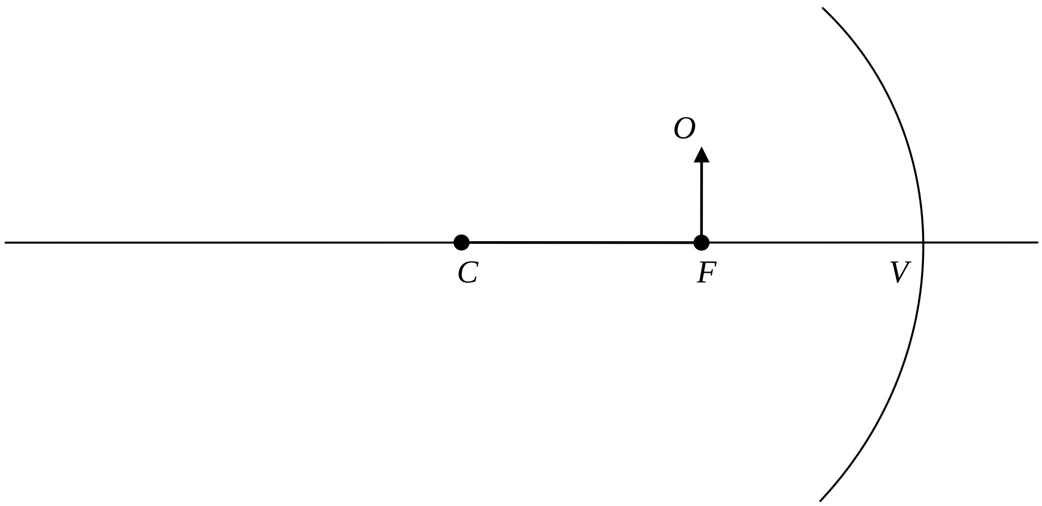
3. Object beyond C.



Characteristics

→

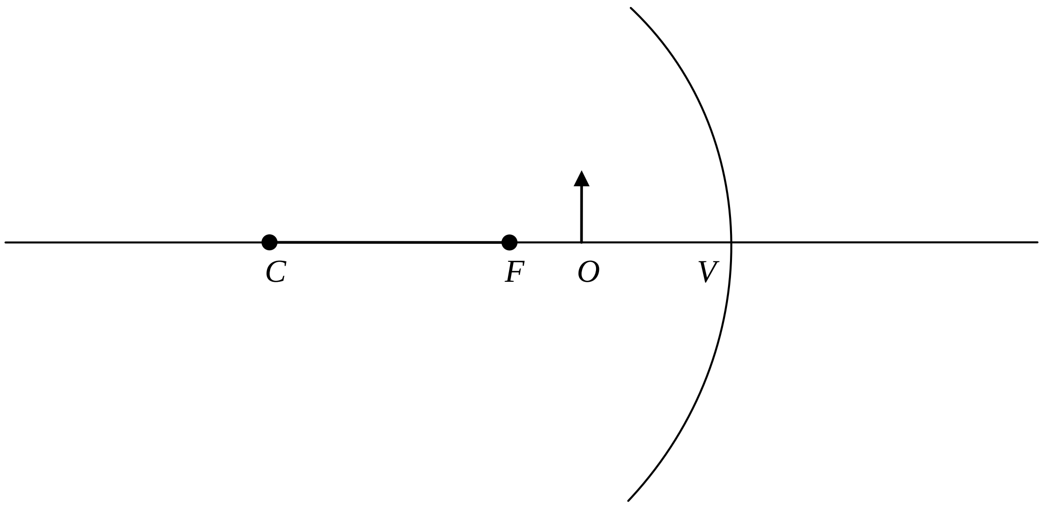
4. Object at *F*.



Characteristics

→

5. Object between *F* and *V*.



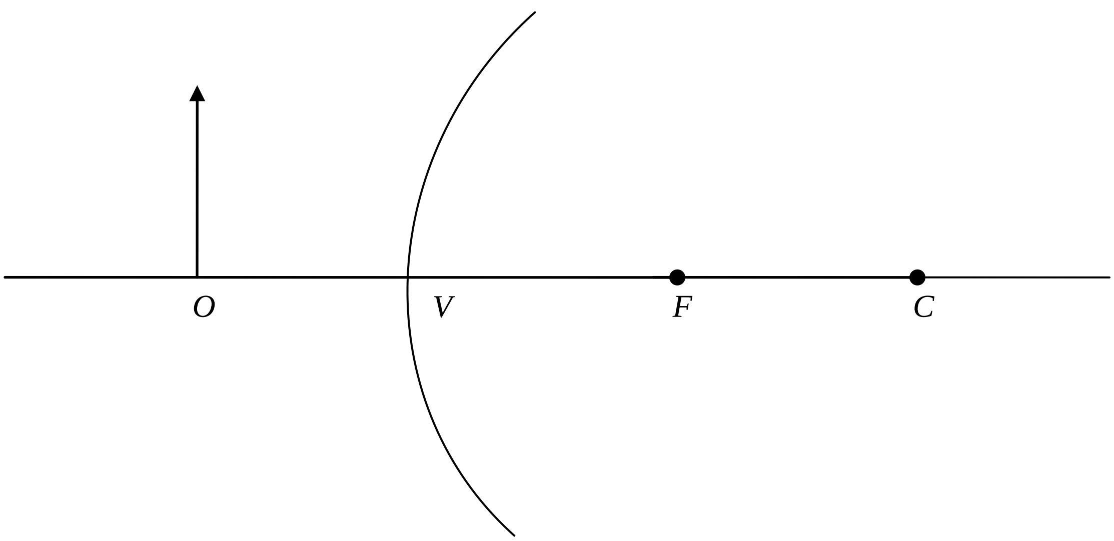
Characteristics

→

Images Formed by Diverging Mirrors

- The principal focus and centre of curvature are virtual.
- Rays directed towards the virtual principal focus are reflected parallel to the P.A.
- Rays directed parallel to the P.A. are reflected in such a way that, when extended into the mirror, they go through the principal focus.
- Rays directed towards the centre of curvature are reflected back along the same path.

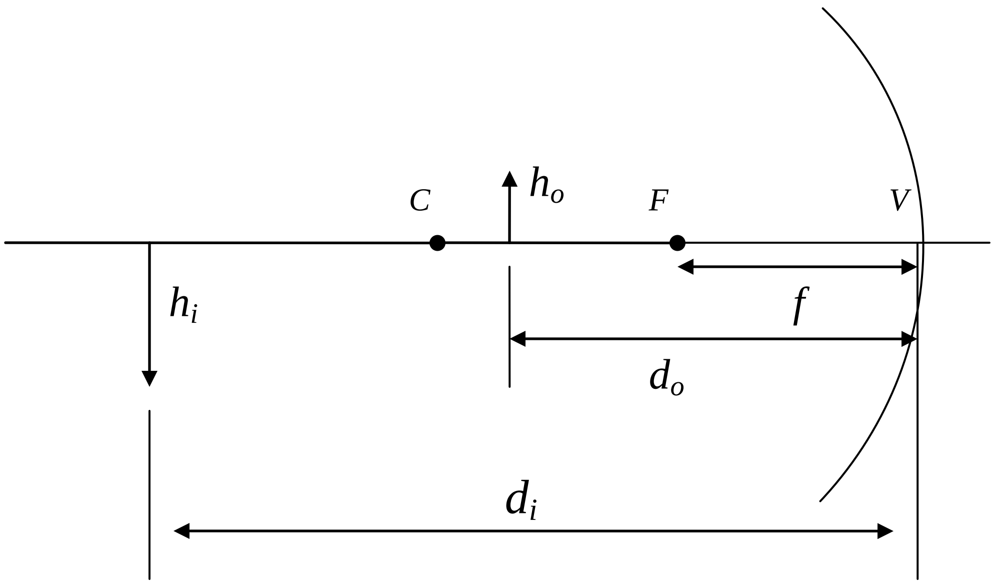
Finding the Image in a Diverging Mirror



- Images are always virtual, erect, smaller than the object, and located between the vertex and the principal focus.

Equations for Curved Mirrors

Consider the following diagram:



f = the focal length of the mirror.
d_o = the distance from the vertex to the object.
d_i = the distance from the vertex to the image.
h_o = the height of the object.
h_i = the height of the image.

⇨ Using the geometric properties of similar triangles we can arrive at the following:

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

⇨ This is called the mirror equation.

Sign Convention

1. All distances are measured from the vertex of the curved mirror.
2. Distances of real objects and images are positive.
3. Distances of virtual images are negative.
4. Object heights and image heights are positive when measured upward and negative when measured downward from the principal axis.

⇨ To take into account the sign convention, the magnification equation becomes:

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

⇨ A negative magnification means that the image is inverted from the original orientation.

Example 1

An object is located 30.0 cm from a converging mirror with a radius of curvature of 10.0 cm.
(a) At what distance from the mirror will the image be formed?

(b) If the object is 4.0 cm tall, how tall is the image?

Example 2

A diverging mirror with a focal length of $f = -5.0$ cm produces an image of an object. If the object is located 15.0 cm from the mirror then,
(a) What is the distance of the image from the mirror?

(b) What is the magnification?