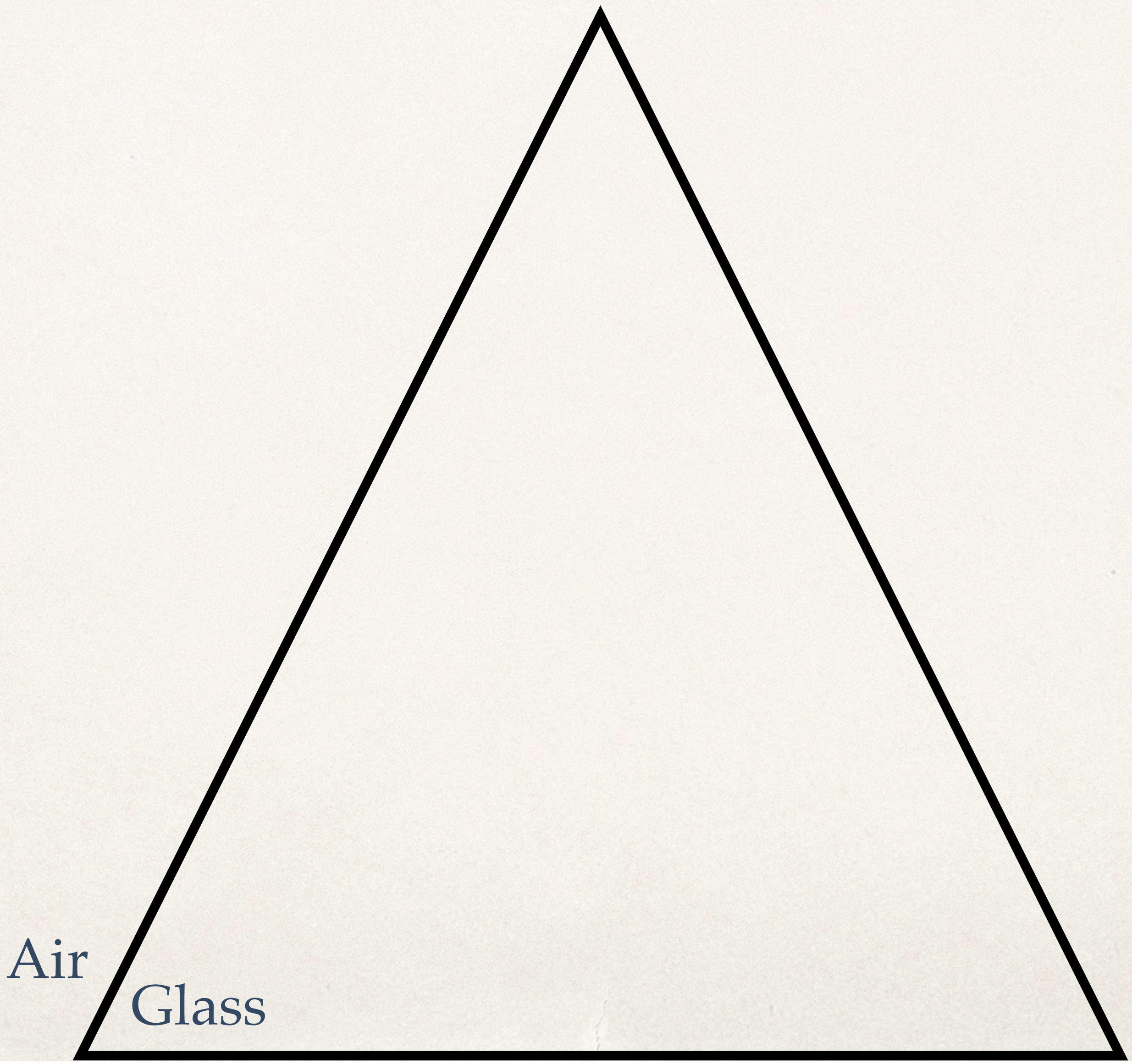
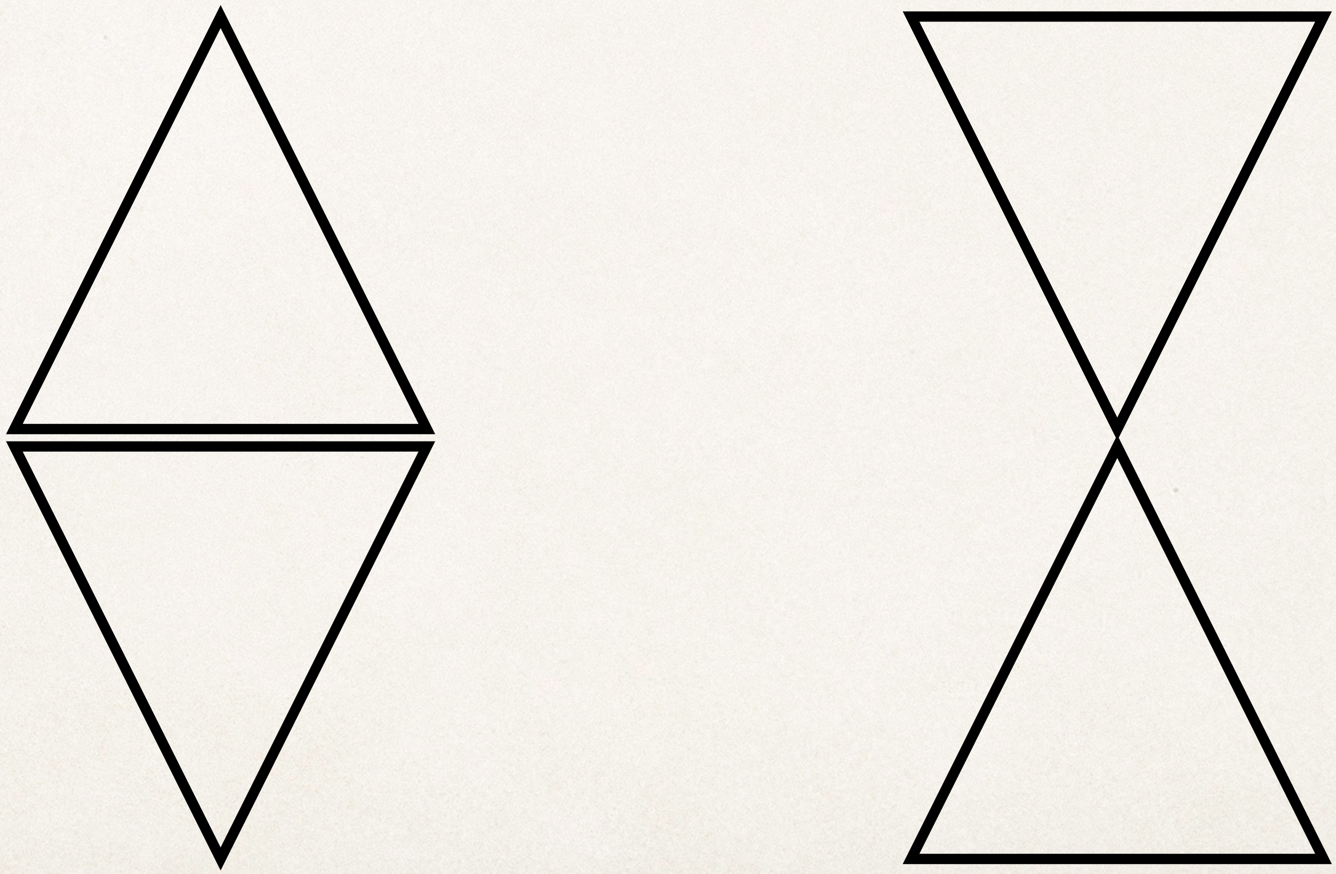
Index of Refraction



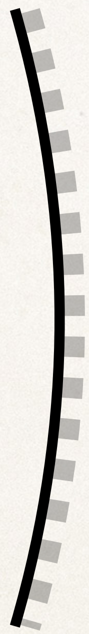
Index of Refraction



NOTES: Know, Learn, Live…

- Mirrors
  - Ray Diagram Rules
  - Sign Conventions
- Lenses
  - Ray Diagram Rules
  - Sign Conventions

Spherical Mirrors



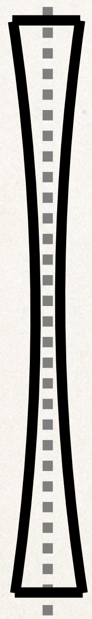
Concave

Convergent

Convex

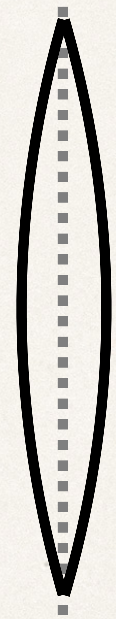
Divergent

Lenses



Concave

Divergent

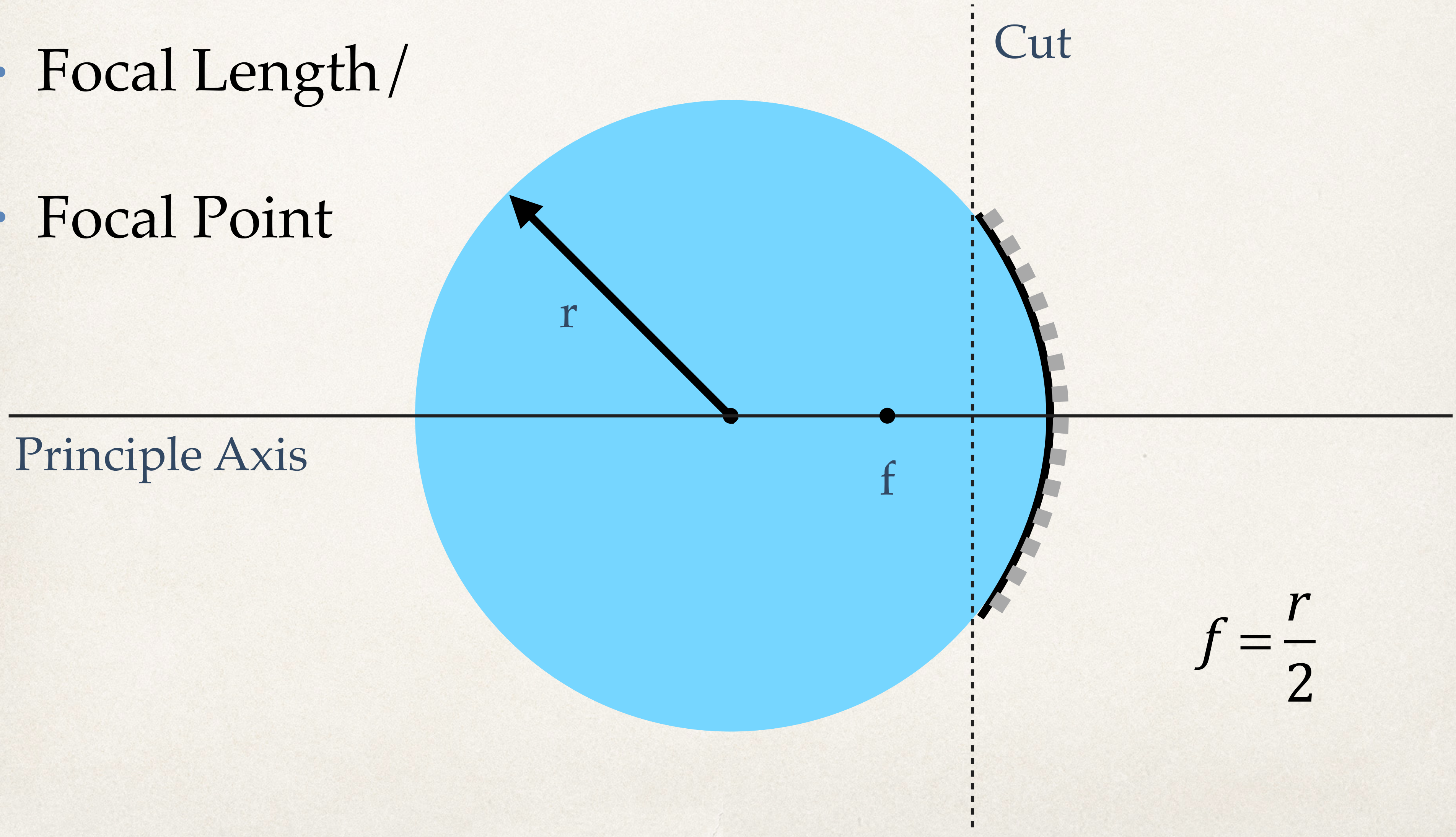


Convex

Convergent

Spherical Mirrors

- Focal Length/
- Focal Point

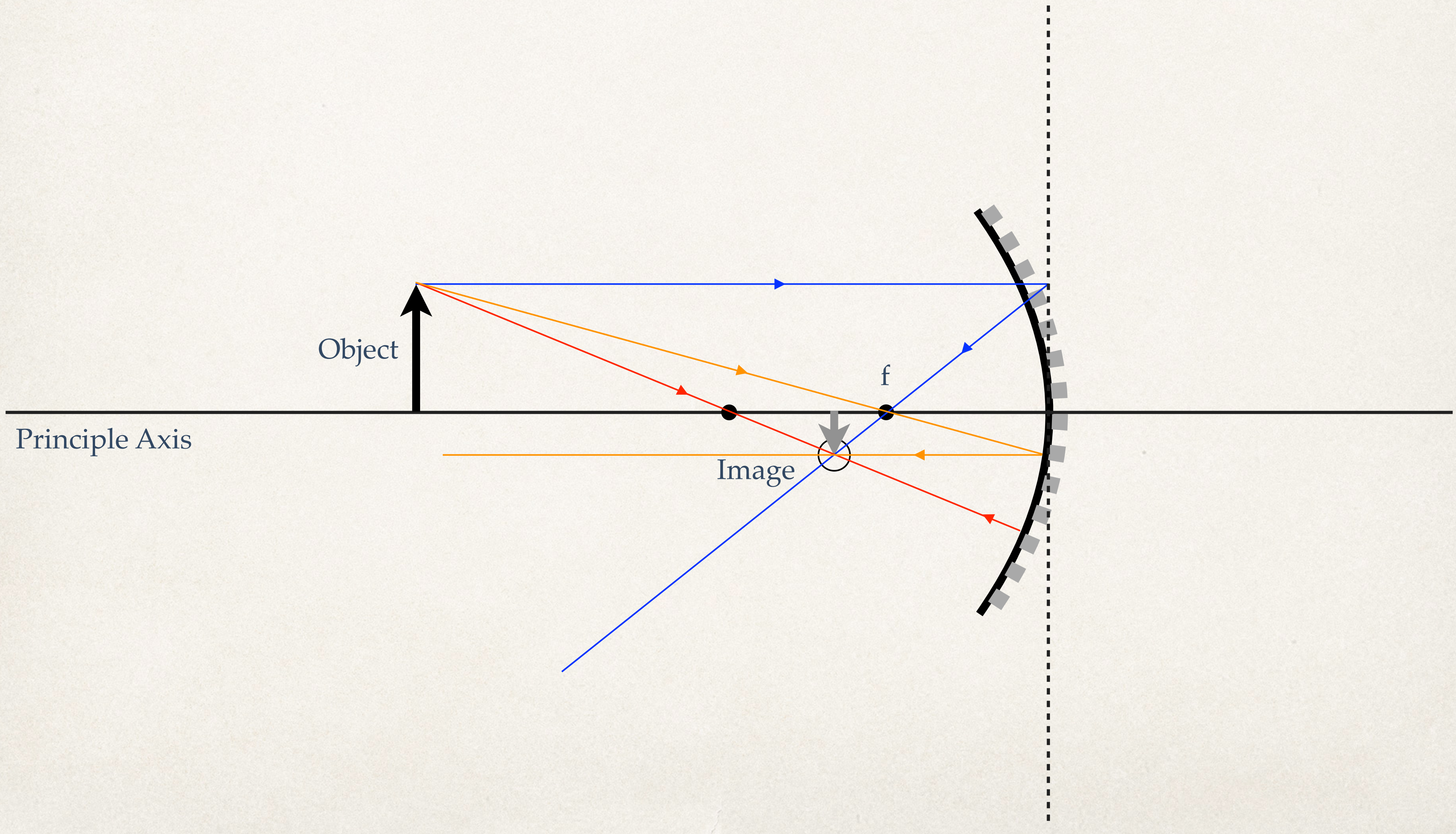


$$f = \frac{r}{2}$$

Mirror Ray Diagrams

- 1) A ray parallel to the principle axis will be reflected through the focal point.
- 2) A ray passing through the focal point will reflect parallel to the principle axis.
- 3) A ray drawn along the radius will hit the mirror perpendicular to the surface and reflect back along the radius.

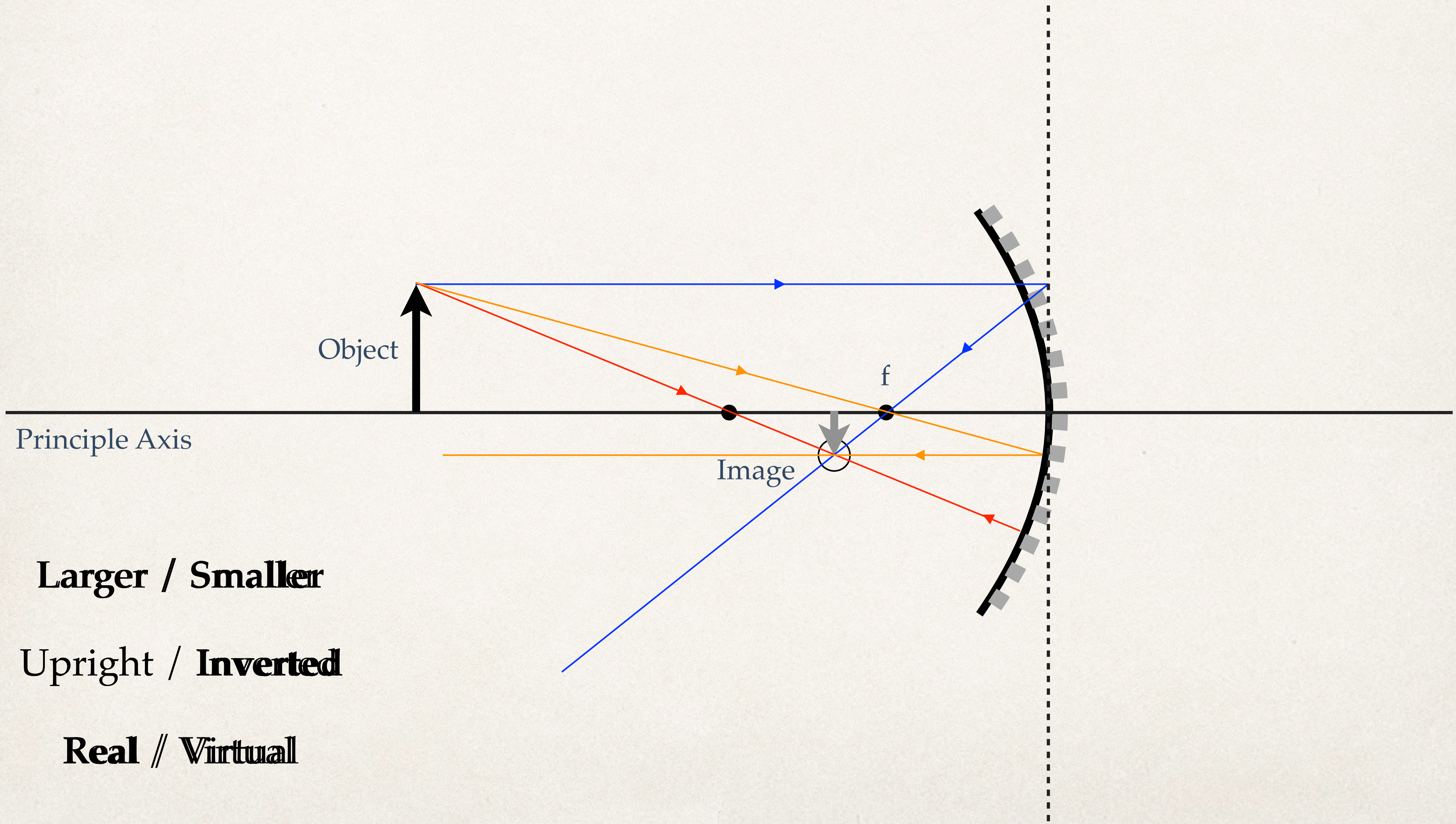
Spherical Mirrors



Images

- Description of images are based on the relationship to the object.
  - Larger / Smaller
  - Upright / Inverted
  - Real / Virtual

Spherical Mirrors

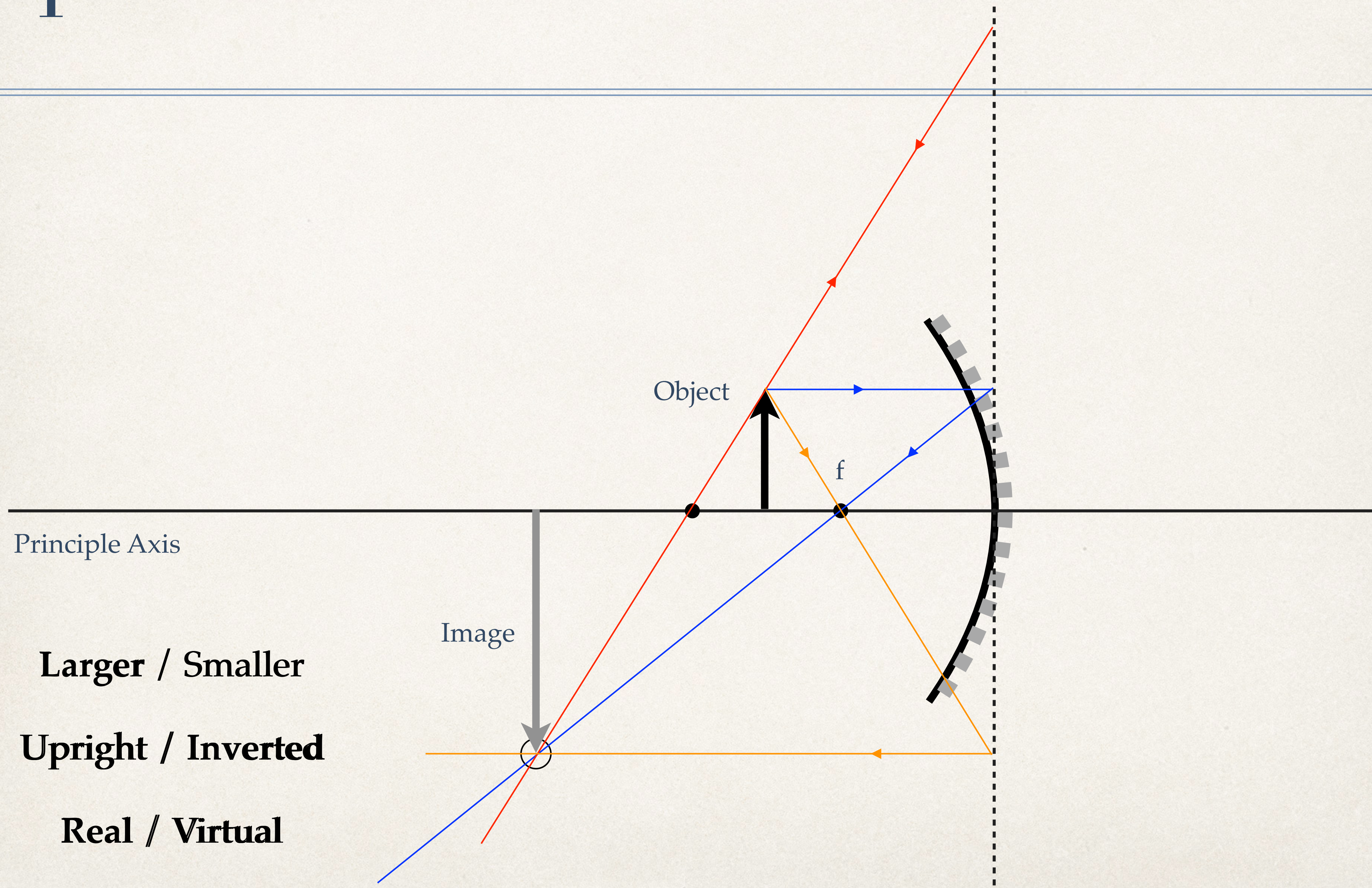


Larger / Smaller

Upright / **Inverted**

Real / Virtual

Spherical Mirrors

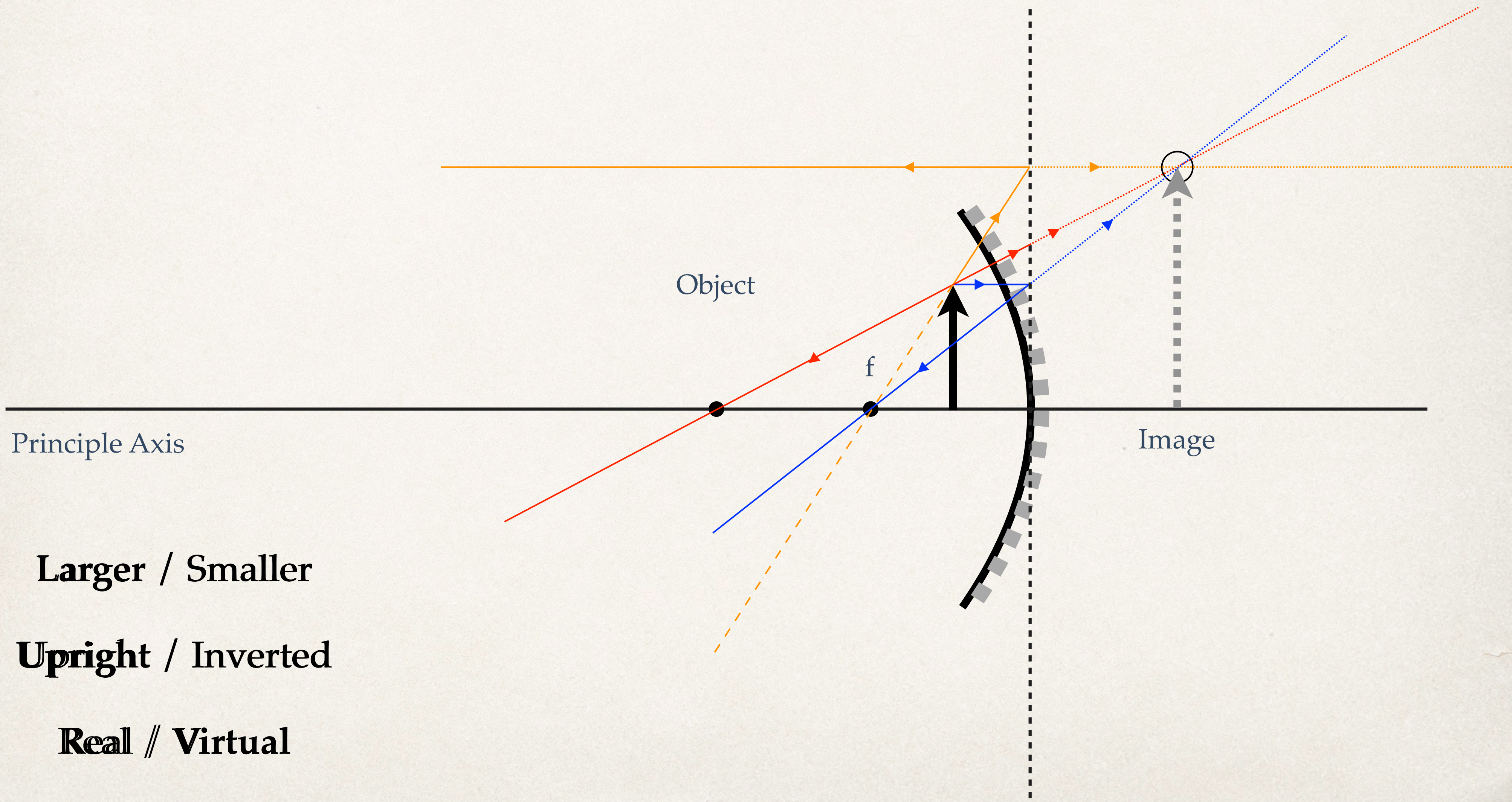


Larger / Smaller

Upright / Inverted

Real / Virtual

Spherical Mirrors

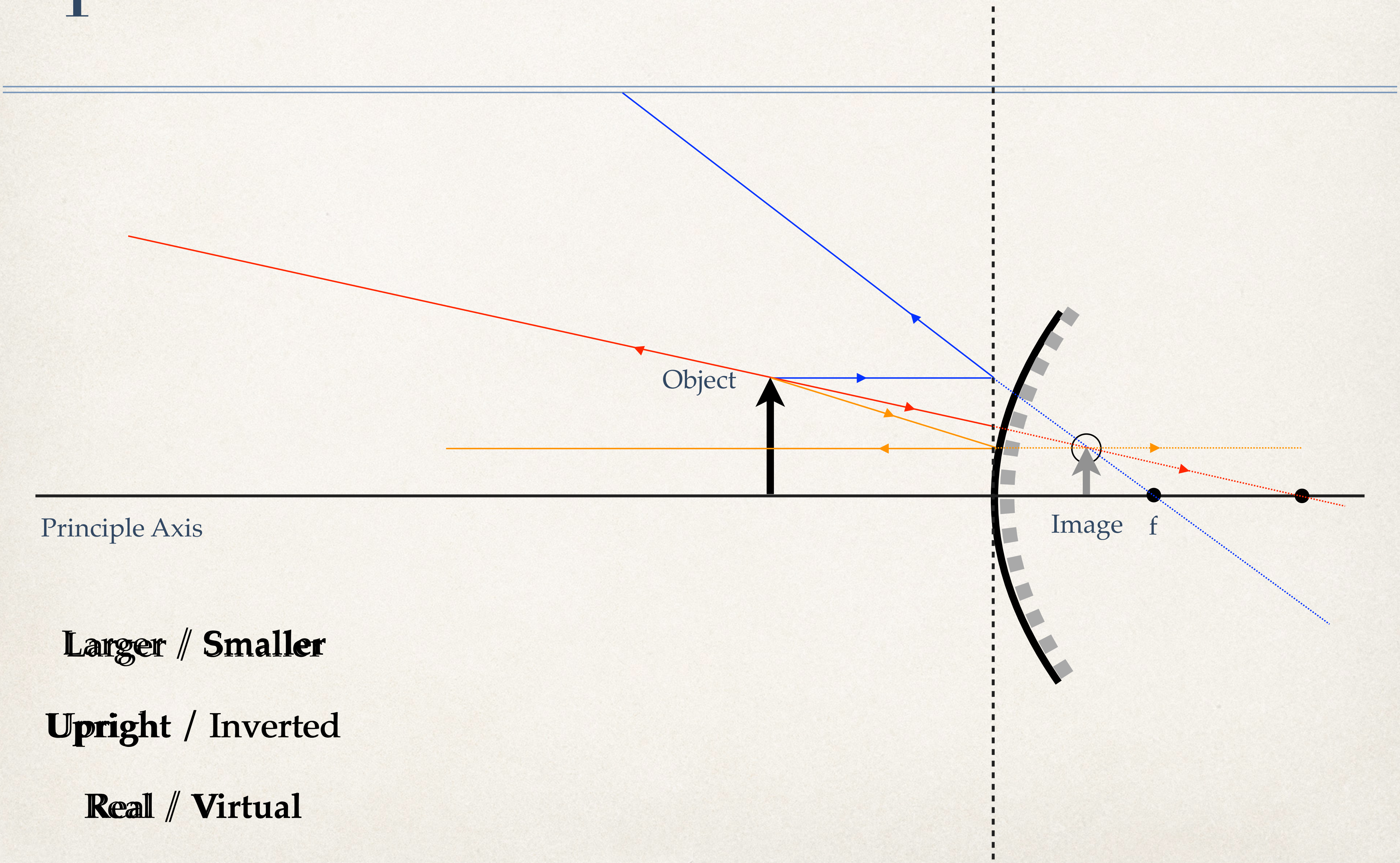


Larger / Smaller

Upright / Inverted

Real / **Virtual**

Spherical Mirrors

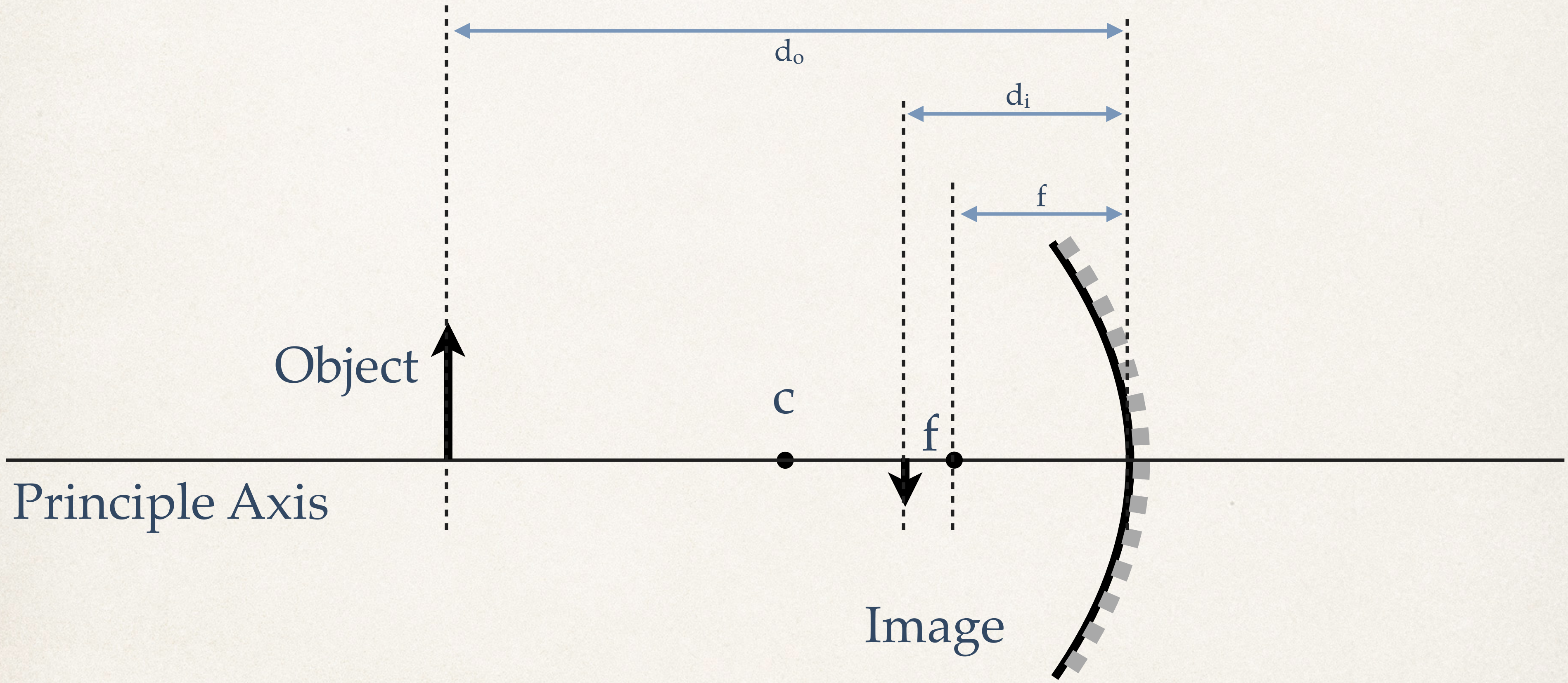


Larger / **Smaller**

Upright / Inverted

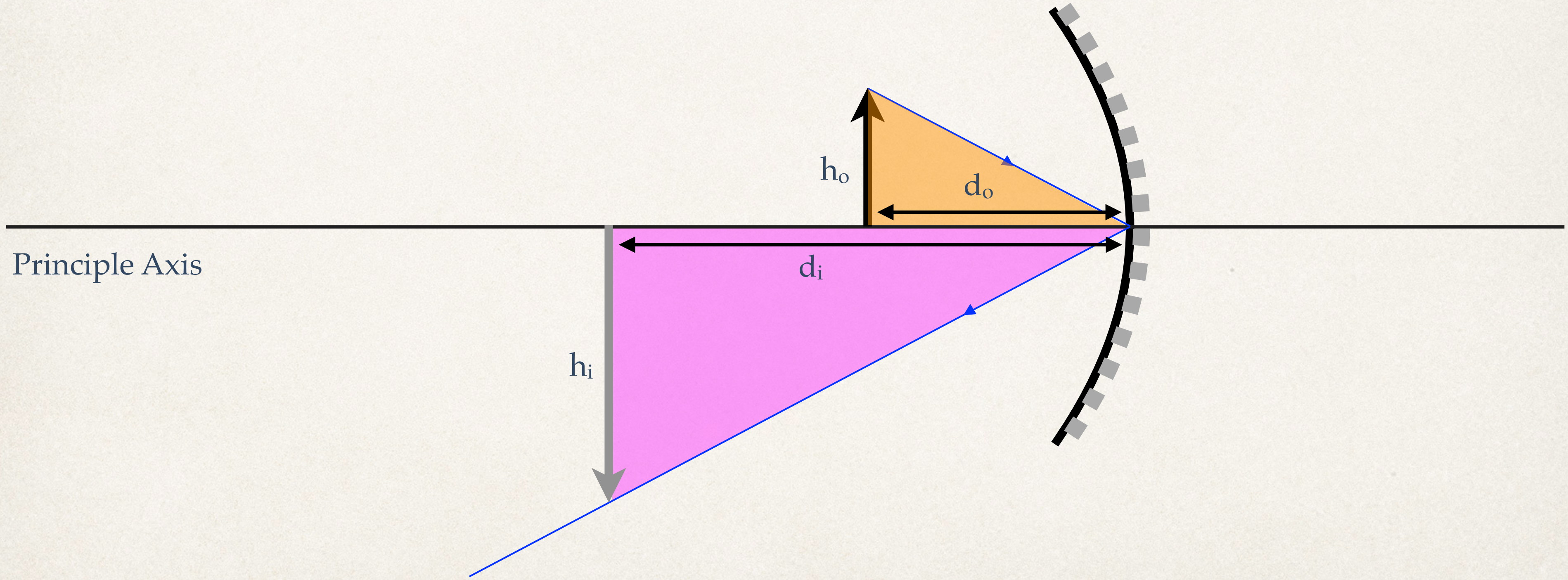
Real / **Virtual**

Spherical Mirrors



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

Mirror Equation

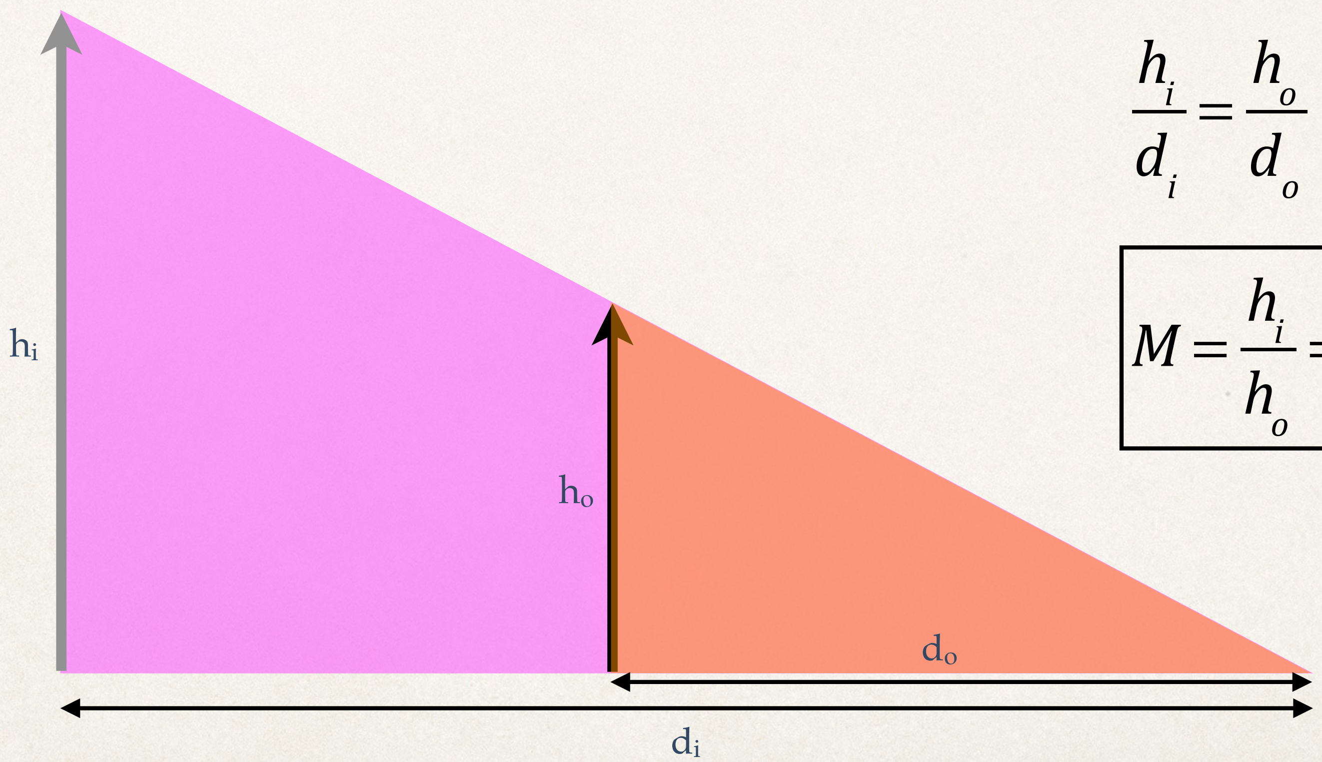


Mirror Equation

$$\mathrm{Tan}\,\theta = \frac{h_o}{d_o} \qquad \mathrm{Tan}\,\theta = \frac{h_i}{d_i}$$

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

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



Magnitude Only

Mirror Equations

- Assumptions:
  - slightly curved, spherical mirror… r ≠ small

$$f = \frac{r}{2}$$

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

$$M = \frac{h_i}{h_o} = \left(-\frac{d_i}{d_o} \right)$$

Example

- A small spherical, convex mirror ($r = 20$ cm) produces an image of a 5.0 cm tall matchstick. If the matchstick is 30 cm from the mirror, find the image distance, size, and magnification.

Example

- A small spherical, convex mirror (r = 20 cm) produces an image of a 5.0 cm tall matchstick. If the matchstick is 30 cm from the mirror, find the image distance, size, and magnification.

$f = -0.10$ m (convex mirror)
$d_o = +0.30$ m (object is real)
$d_i = ?$
$h_o = +0.05$ m (above axis)
$h_i = ?$
$M = ?$

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

$$\frac{1}{0.30\ m} + \frac{1}{d_i} = \frac{1}{-0.10\ m}$$

$$\frac{1}{d_i} = \frac{1}{-0.10\ m} - \frac{1}{0.30\ m}$$

$$\boxed{d_i = -0.075\ m}$$

Example

- A small spherical, convex mirror (r = 20 cm) produces an image of a 5.0 cm tall matchstick. If the matchstick is 30 cm from the mirror, find the image distance, size, and magnification.

$f = -0.10$ m (convex mirror)
$d_o = +0.30$ m (object is real)
$d_i = -0.075$ m
$h_o = +0.05$ m (above axis)
$h_i = ?$
$M = ?$

$$M = \left(-\frac{d_i}{d_o}\right)$$

$$M = \left(-\frac{(-0.075\ m)}{(0.30\ m)}\right)$$

$$\boxed{M = 0.25}$$

$$M = \frac{h_i}{h_o}$$

$$h_i = (M)(h_o)$$

$$h_i = (0.25)(0.05\ m)$$

$$\boxed{h_i = 0.0125\ m}$$

Example

- A small spherical, convex mirror (r = 20 cm) produces an image of a 5.0 cm matchstick that is 30 cm from the mirror. Describe the image qualitatively.

$f = -0.20$ m
$d_o = +0.30$ m
$d_i = -0.12$ m
$h_o = +0.05$ m
$h_i = 0.0125$ m
$M = 0.25$

Larger / Smaller

Upright / Inverted

Real / Virtual

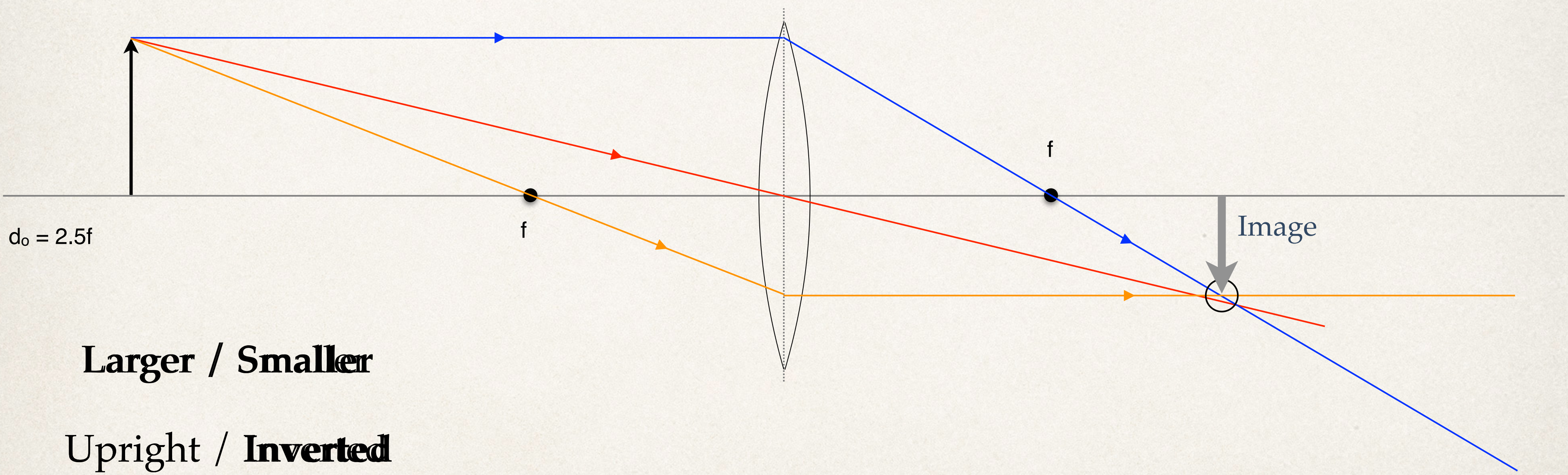
Examples to prepare…

- Convex & Concave Mirrors
- $d_o >> f$
- $d_o > f$
- $d_o = f$
- $d_o < f$

Lens Ray Diagrams

- 1) A ray parallel to the principle axis will be refracted by the lens to go through the far focal point.
- 2) A ray passing through the near focal point will refracted by the lens to parallel to the principle axis.
- 3) A ray drawn through the geometric center of the lens will continue in a straight line (not refracted) through the lens

Lens Ray Diagrams



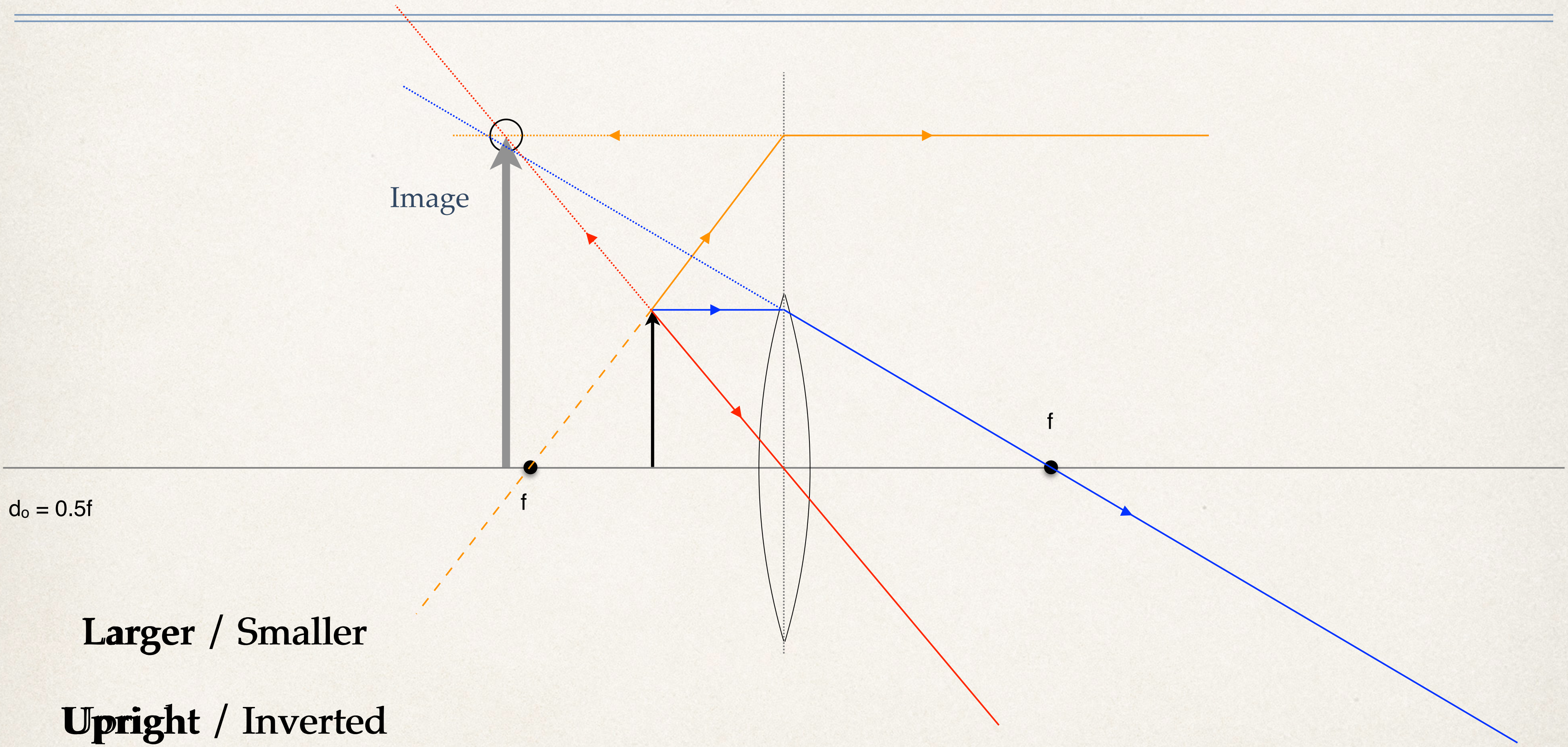
$d_o = 2.5f$

Larger / Smaller

Upright / **Inverted**

Real / Virtual

Lens Ray Diagrams



Larger / Smaller

Upright / Inverted

Real / **Virtual**

Lens Equations

- Assumptions:
  - slightly curved, spherical lens… r ≠ small

$$f = \frac{r}{2}$$

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

$$m = \frac{h_i}{h_o} = \left(-\frac{d_i}{d_o}\right)$$

Example

- A convex lens has a focal length of 45 cm and an object placed at 30 cm. Find the image distance. What is the magnification of this lens? Sketch a picture of this situation. What if the object distance is 15 cm?

Example

- A convex lens has a focal length of 20 cm and an object placed at 30 cm. Find the image distance. What is the magnification of this lens? Sketch a picture of this situation. What if the object distance is 10 cm?

$f = +0.20$ m (convex lens)
$d_o = +0.30$ m (object is real)
$d_i = ?$
$h_o =$ not given
$h_i =$ not given
$M = ?$

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

$$\frac{1}{0.30\ m} + \frac{1}{d_i} = \frac{1}{0.20\ m}$$

$$\frac{1}{d_i} = \frac{1}{0.20\ m} - \frac{1}{0.30\ m}$$

$$\boxed{d_i = 0.60\ m}$$

Example

- A convex lens has a focal length of 20 cm and an object placed at 30 cm. Find the image distance. What is the magnification of this lens? Sketch a picture of this situation. What if the object distance is 10 cm?

$f = +0.20$ m (convex lens)
$d_o = +0.30$ m (object is real)
$d_i = +0.60$ m (image is real)
h_o = not given
h_i = not given
$M = \ ?$

$$M = \left(-\frac{d_i}{d_o} \right)$$

$$M = \left(-\frac{(0.60\ m)}{(0.30\ m)} \right)$$

$$\boxed{M = -2.00}$$

Larger / Smaller

Upright / Inverted

Real / Virtual