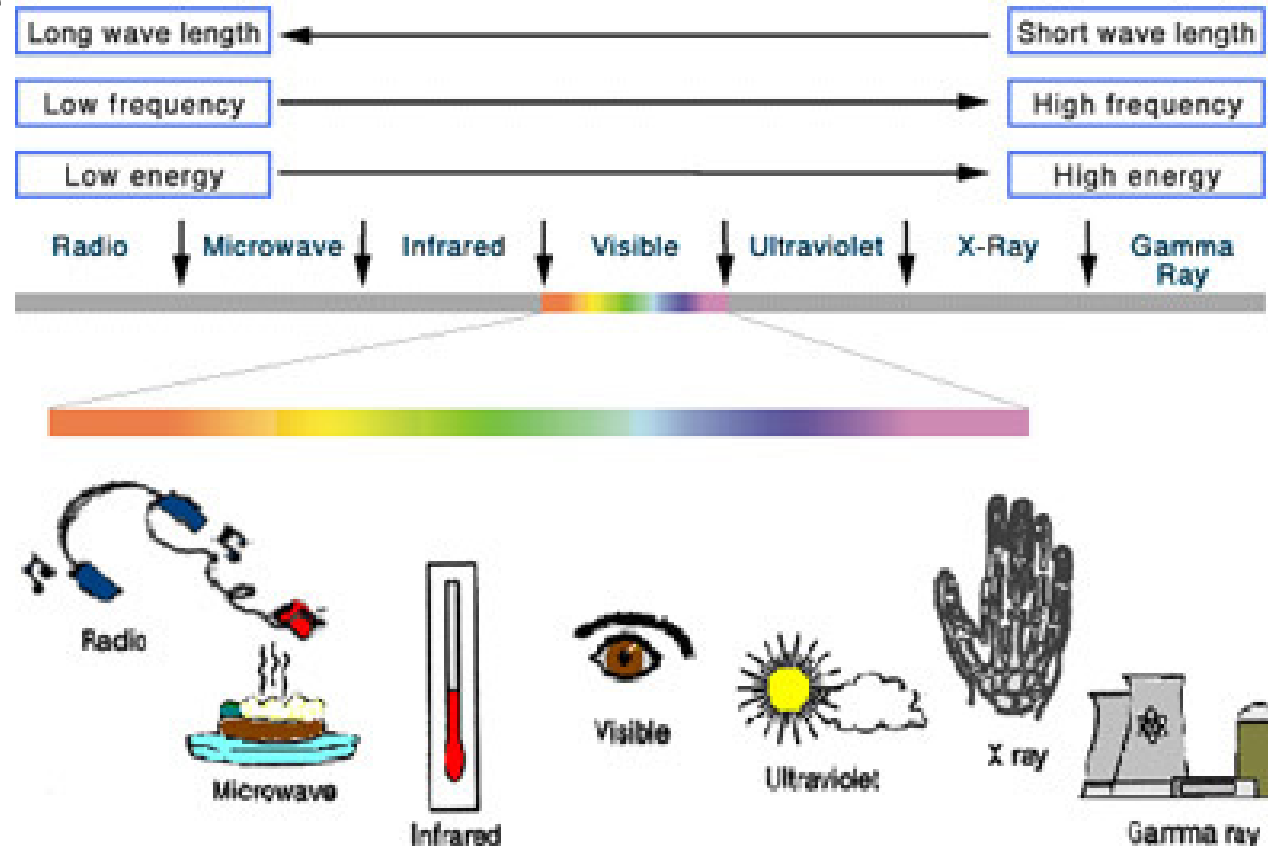

Light, Reflection, & Mirrors

Honors Physics

Facts about Light

- It is a form of Electromagnetic Energy
- It is a part of the Electromagnetic Spectrum and the only part we can really see



Facts about Light

The speed of light, c , is constant in a vacuum.

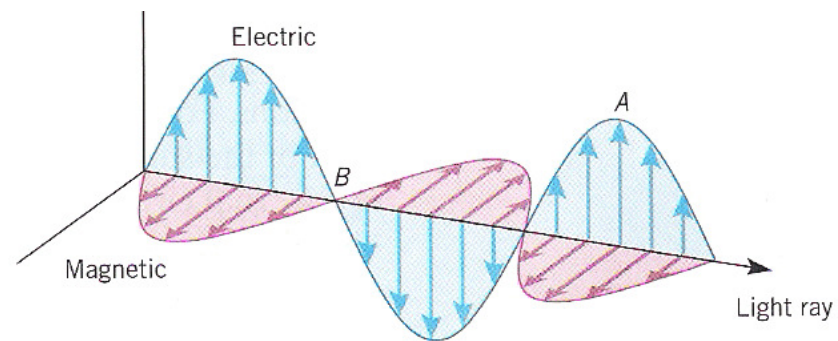
Speed of Light

$$c = 3.0 \times 10^8 \text{ m/s}$$

Light can be:

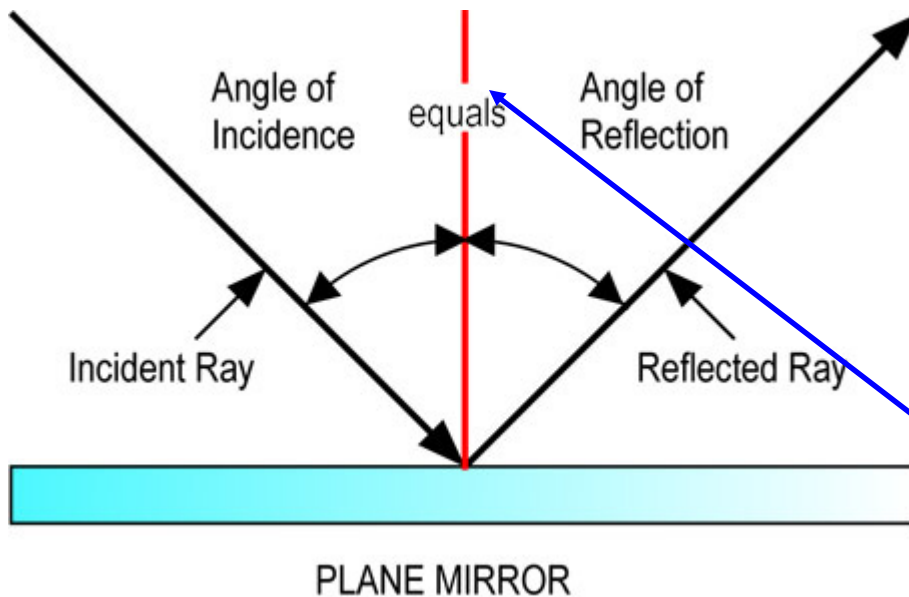
- REFLECTED
- ABSORBED
- REFRACTED

Light is an electromagnetic wave in that it has wave like properties which can be influenced by electric and magnetic fields.



The Law of “REFLECTION”

The **Law of Reflection** states that- "***the angle of incidence (incoming ray) equals the angle of reflection (outgoing ray)***"



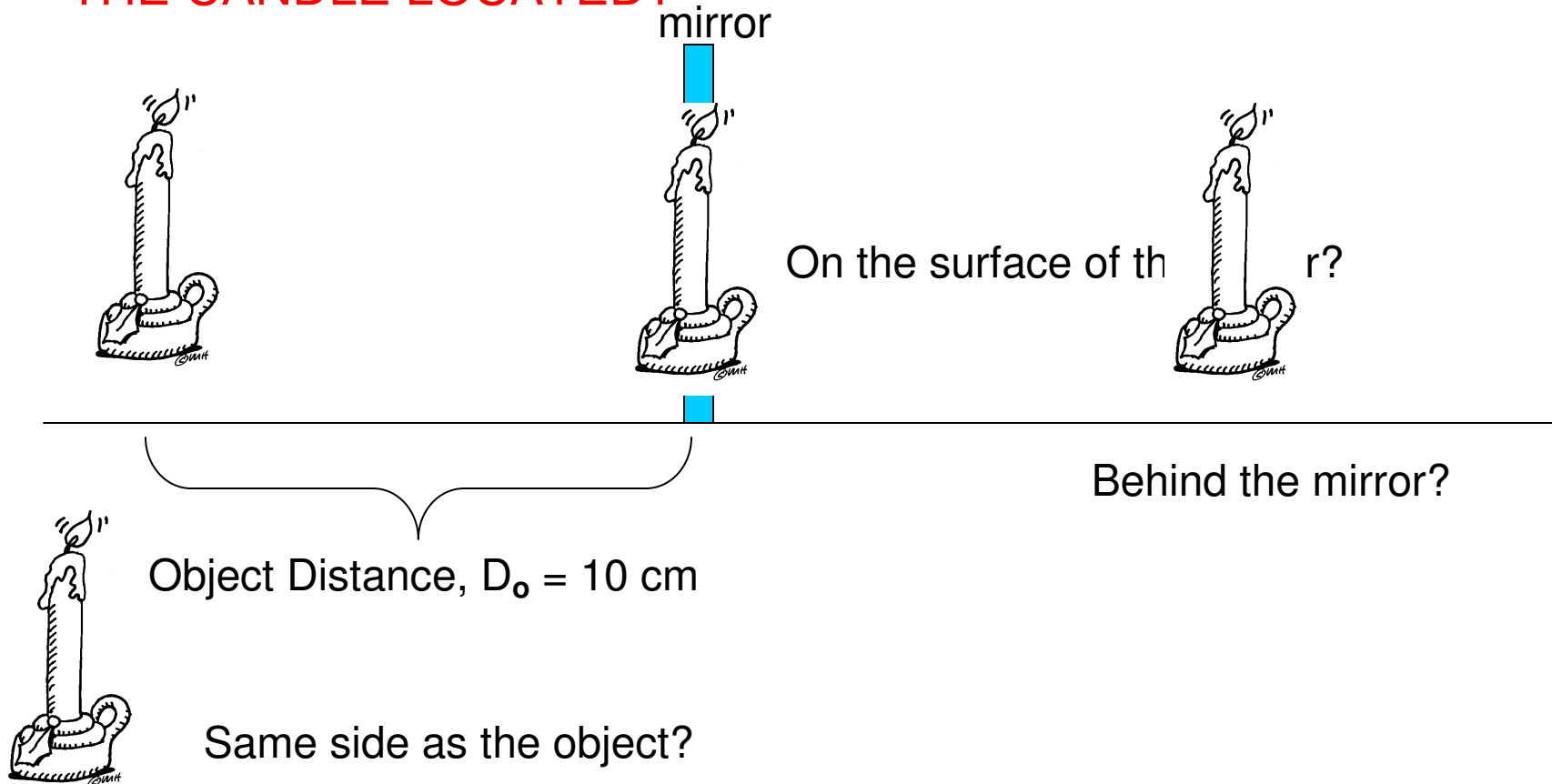
The law works for FLAT, PLANE surfaces only.

The angles are measured from a perpendicular line to the surface called a NORMAL.

NORMAL

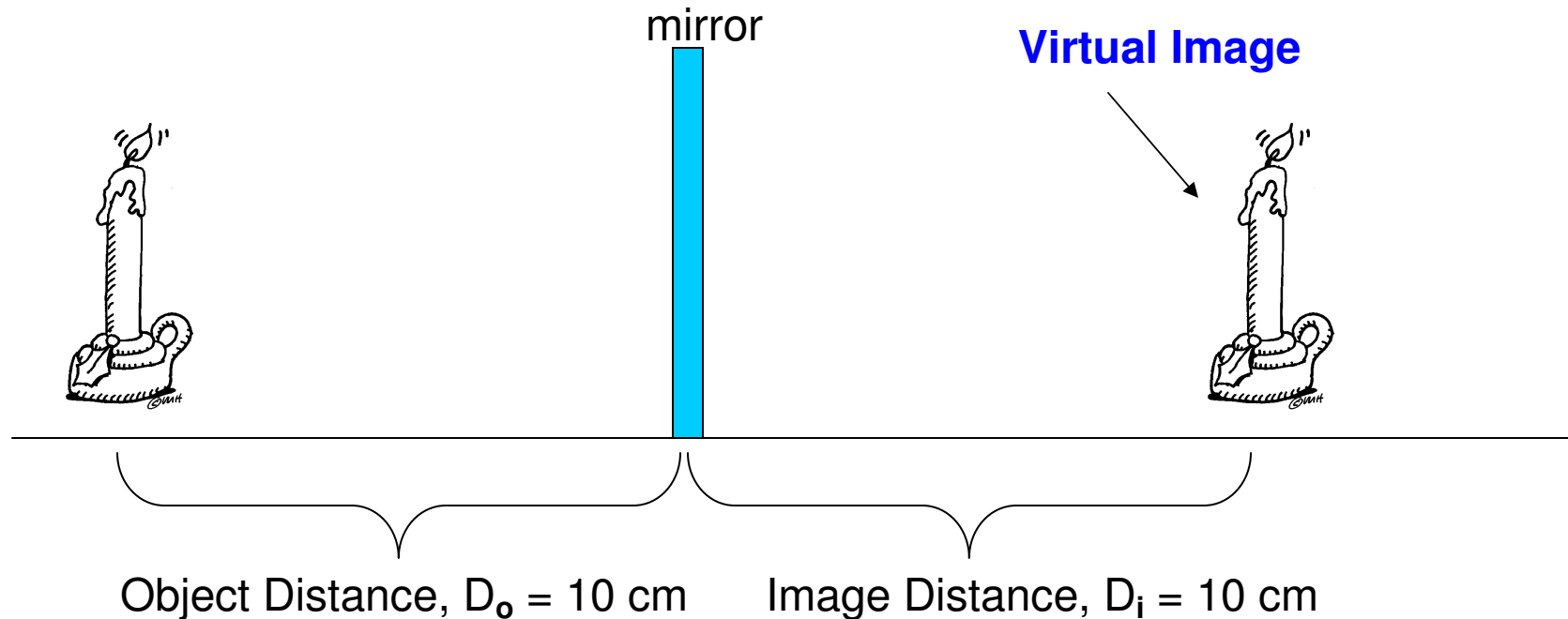
Plane Mirror

Suppose we had a flat, plane mirror mounted vertically. A candle is placed 10 cm in front of the mirror. **WHERE IS THE IMAGE OF THE CANDLE LOCATED?**



Plane Mirror

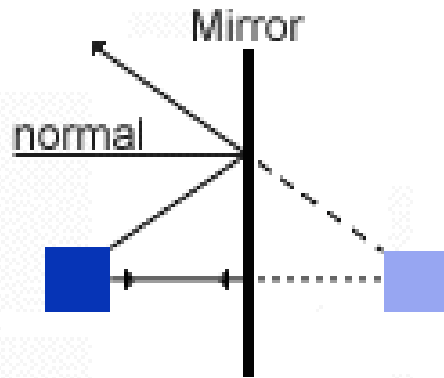
Suppose we had a flat, plane mirror mounted vertically. A candle is placed 10 cm in front of the mirror. **WHERE IS THE IMAGE OF THE CANDLE LOCATED?**



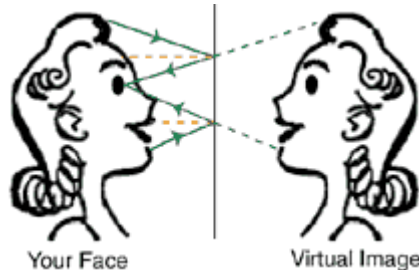
$D_o = D_i$, and the heights are equal as well

Virtual Images

Virtual Images are basically images which cannot be visually projected on a screen.



If this box gave off light, we could project an image of this box on to a screen provided the screen was on the **SAME SIDE** as the box.



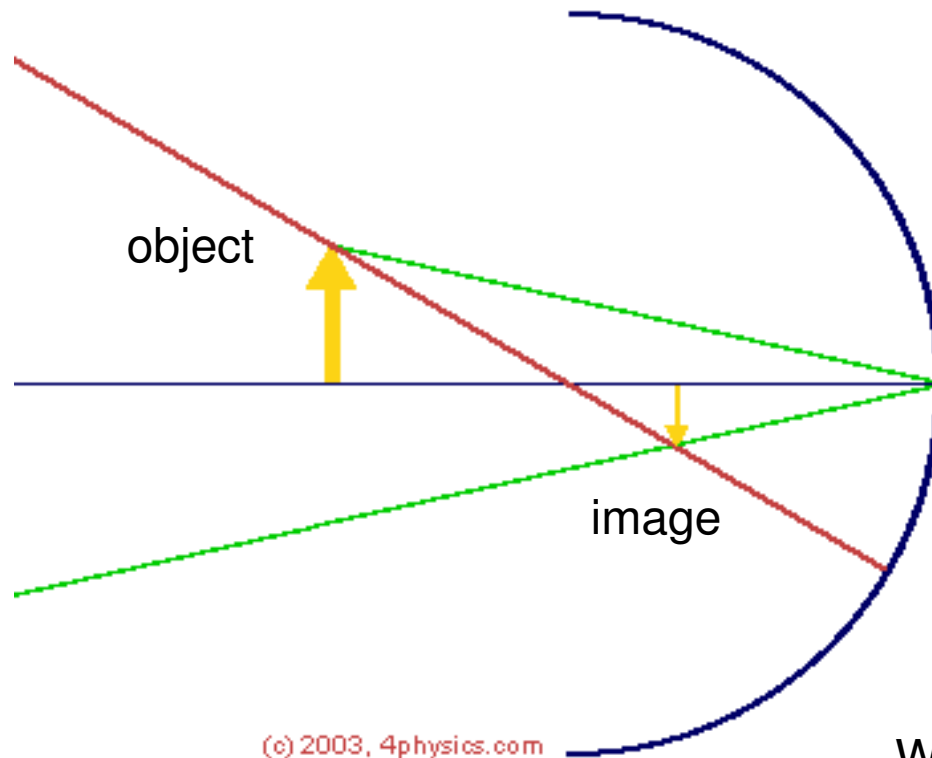
You would not be able to project the image of the vase or your face in a mirror on a screen, therefore it is a virtual image.

CONCLUSION: VIRTUAL IMAGES are ALWAYS on the **OPPOSITE** side of the mirror relative to the object.

Real Image

Real Images are ones you can project on to a screen.

For MIRRORS they always appear on the **SAME SIDE** of the mirror as the object.

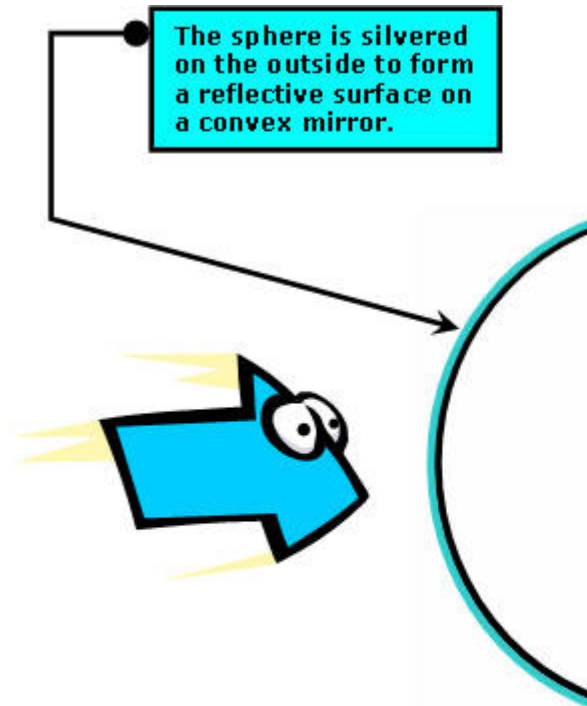


The characteristics of the image, however, may be different from the original object. These characteristics are:

- **SIZE** (reduced, enlarged, same size)
- **POSITION** (same side, opposite side)
- **ORIENTATION** (right side up, inverted)

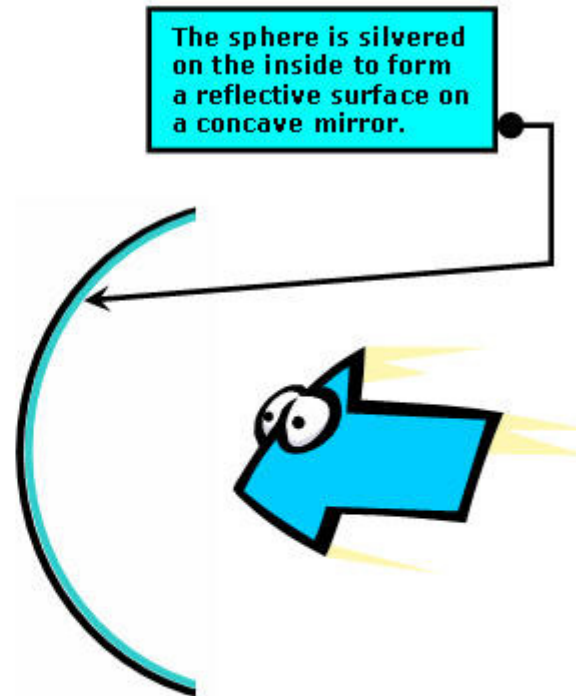
What if the mirror isn't flat?

Spherical Mirrors – Concave & Convex



**CONVEX
Mirror**

Also called DIVERGING mirror



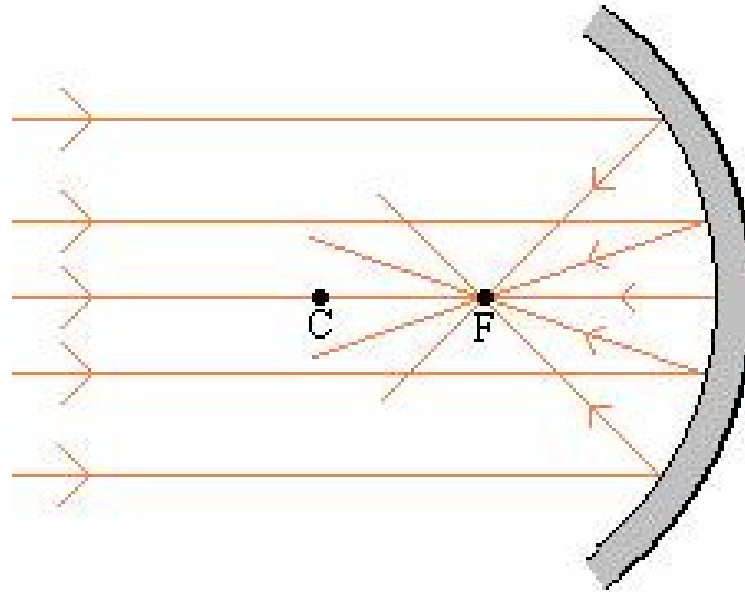
**Concave
Mirror**

Also called CONVERGING mirror

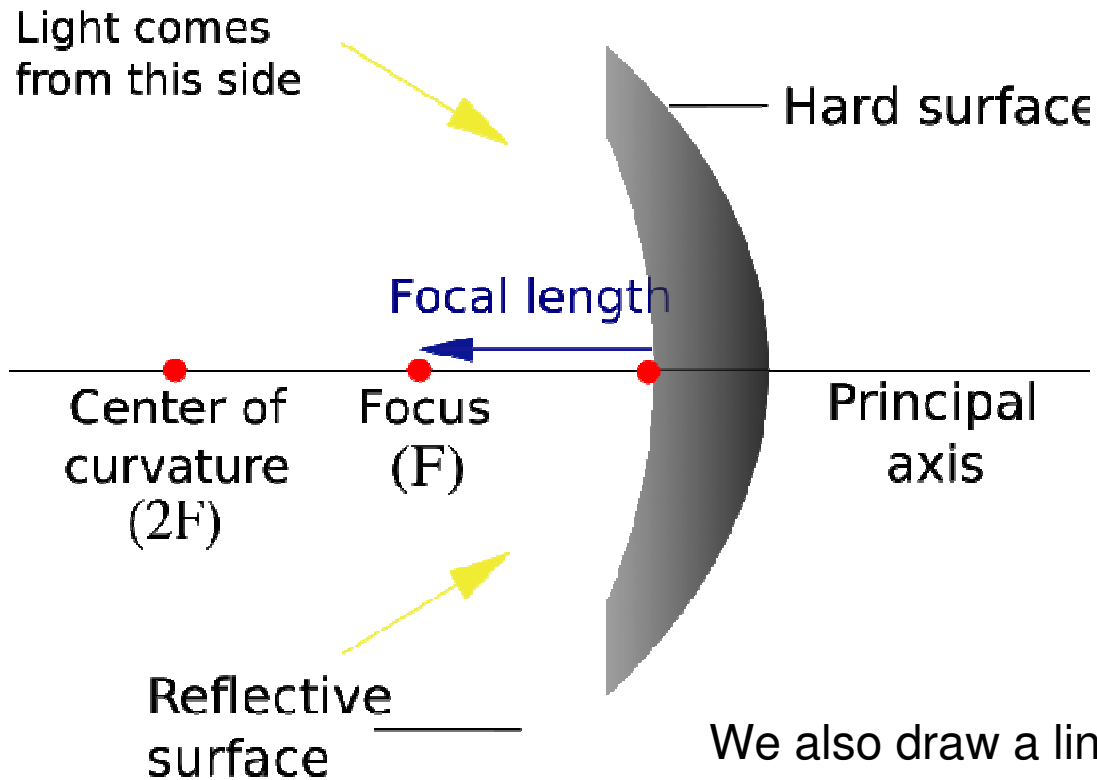
Converging (Concave) Mirror

A converging mirror is one that is spherical in nature by which it can FOCUS parallel light rays to a point directly in front of its surface. Every spherical mirror can do this and this special point is at a “fixed” position for every mirror. **We call this point the FOCAL POINT.** To find this point you MUST use light from “infinity”

Light from an “infinite” distance, most likely the sun.



Converging (Concave) Mirror



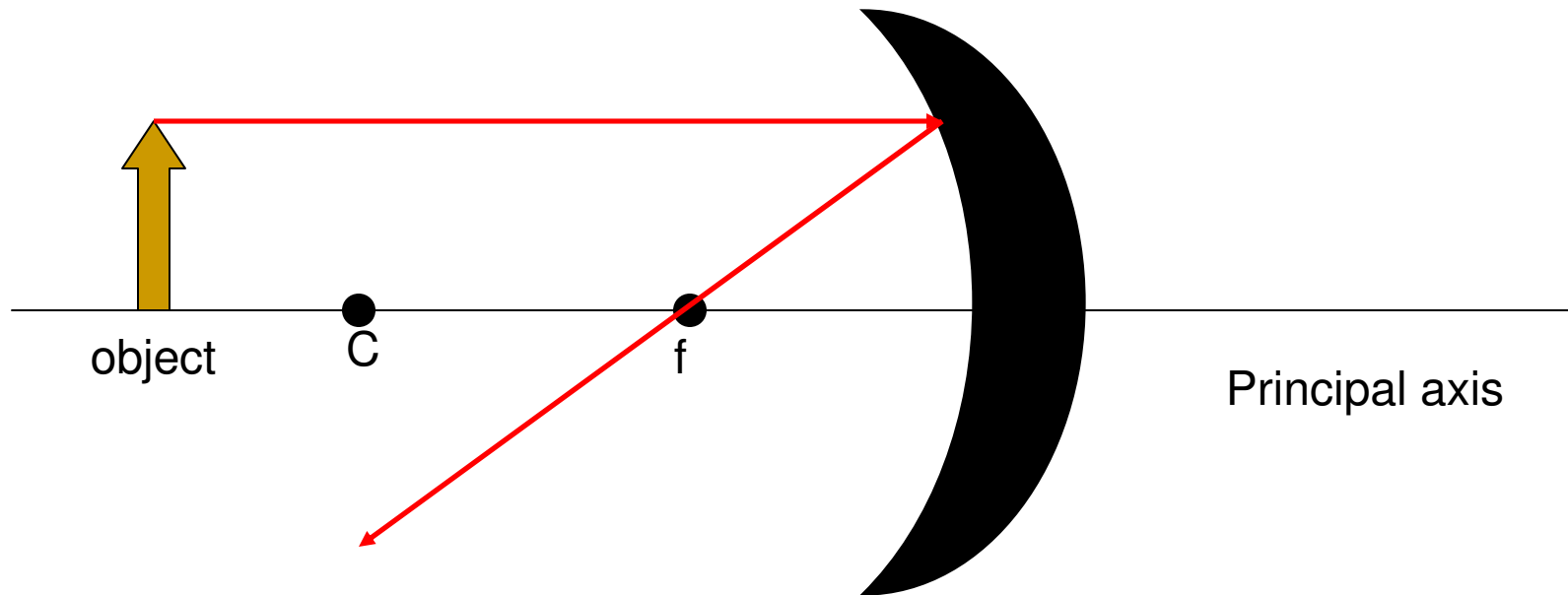
Since the mirror is spherical it technically has a **CENTER OF CURVATURE, C**. The focal point happens to be HALF this distance.

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

We also draw a line through the center of the mirror and call it the **PRINCIPAL AXIS**.

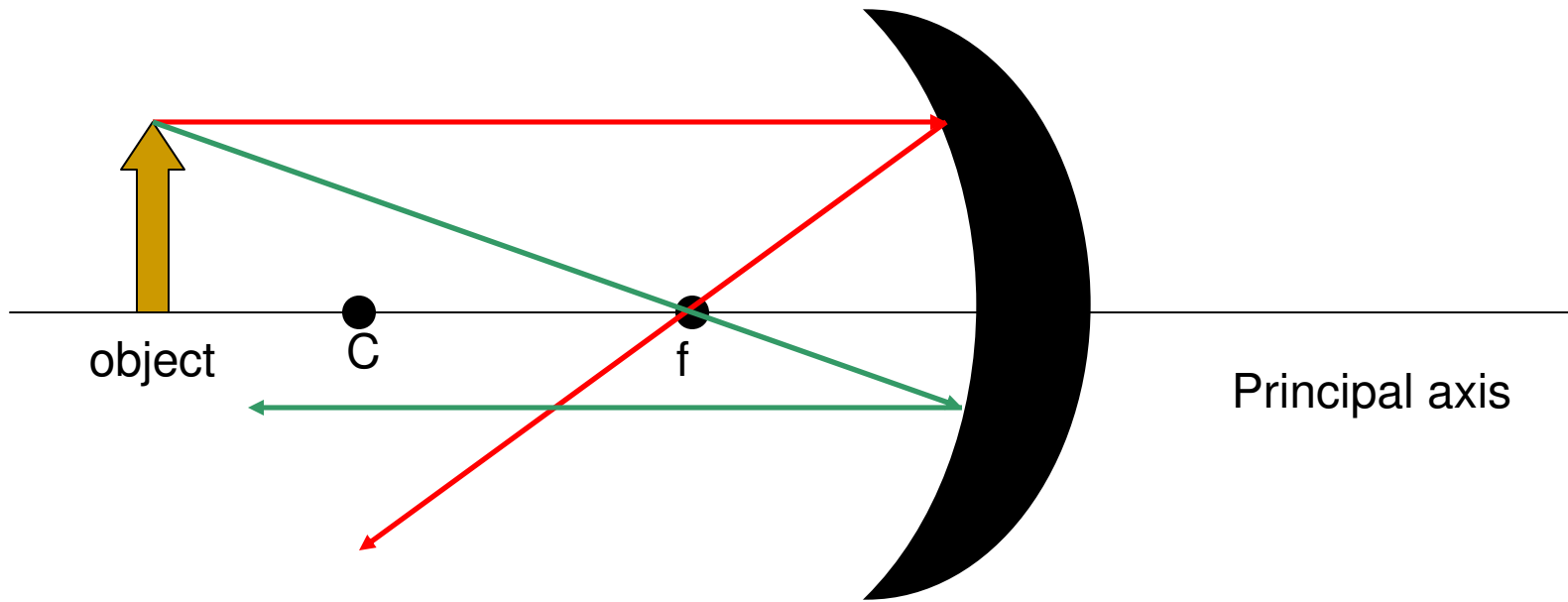
Ray Diagram

A ray diagram is a pictorial representation of how the light travels to form an image and can tell you the characteristics of the image.



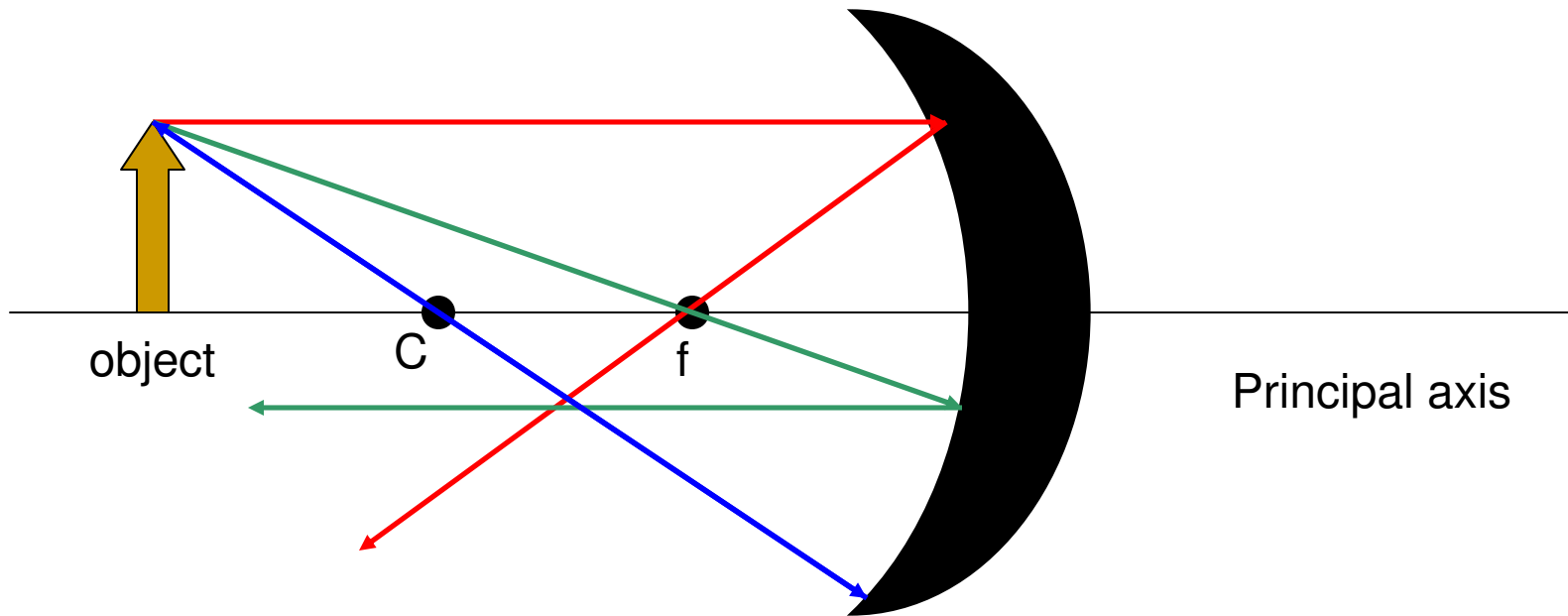
Rule One: Draw a ray, starting from the top of the object, parallel to the principal axis and then through “f” after reflection.

Ray Diagrams



Rule Two: Draw a ray, starting from the top of the object, through the focal point, then parallel to the principal axis after reflection.

Ray Diagrams

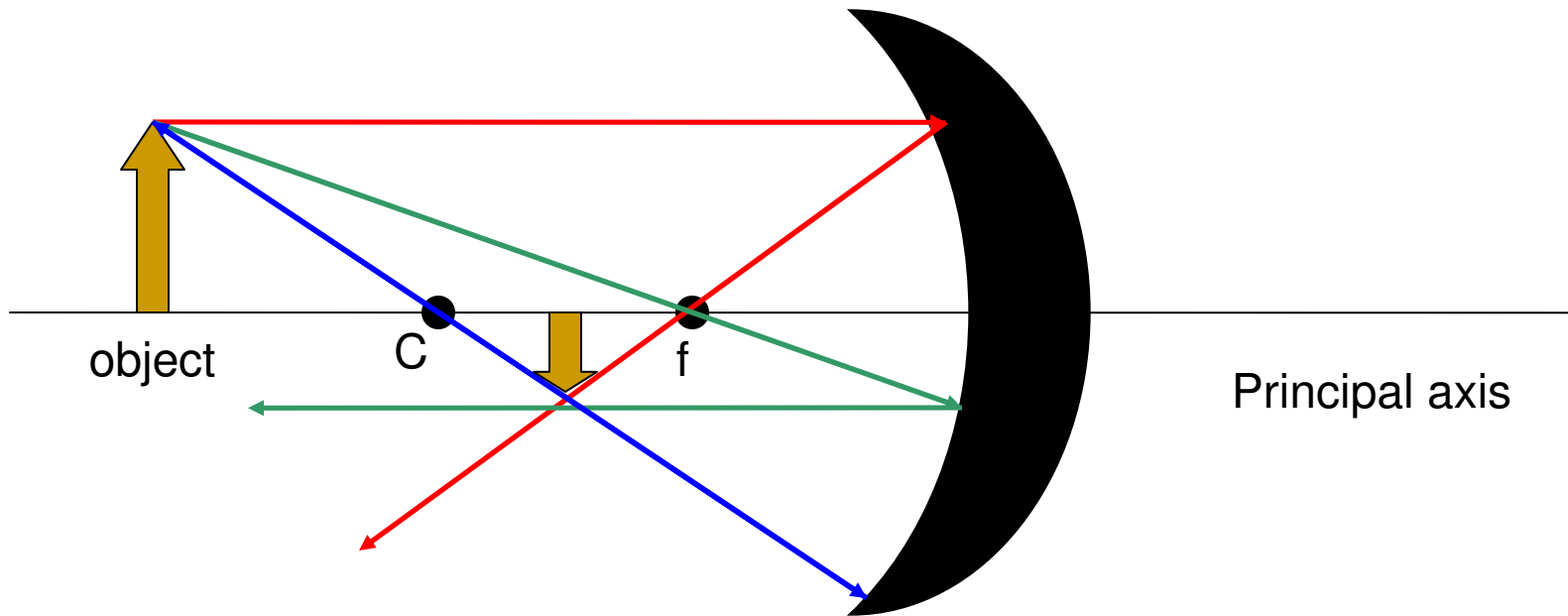


Rule Three: Draw a ray, starting from the top of the object, through C, then back upon itself.

What do you notice about the three lines? **THEY INTERSECT**

The intersection is the location of the image.

Ray Diagram – Image Characteristics



After getting the intersection, draw an arrow down from the principal axis to the point of intersection. Then ask yourself these questions:

1) Is the image on the SAME or OPPOSITE side of the mirror as the object?

Same, therefore it is a REAL IMAGE.

2) Is the image ENLARGED or REDUCED?

3) Is the image INVERTED or RIGHT SIDE UP?

The Mirror/Lens Equation

Is there any OTHER way to predict image characteristics besides the ray diagram? **YES!**

One way is to use the MIRROR/LENS equation to CALCULATE the position of the image.

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

Mirror/Lens Equation

Assume that a certain concave spherical mirror has a focal length of 10.0 cm. Locate the image for an object distance of 25 cm and describe the image's characteristics.

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} \rightarrow \frac{1}{10} = \frac{1}{25} + \frac{1}{d_i}$$

$$d_i = \mathbf{16.67 \text{ cm}}$$

What does this tell us? First we know the image is BETWEEN “C” & “f”. Since the image distance is POSITIVE the image is a **REAL IMAGE**.

Real image = positive image distance

Virtual image = negative image distance

What about the size and orientation?

Magnification Equation

To calculate the orientation and size of the image we use the **MAGNIFICATION EQUATION**.

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

$$M = -\frac{16.67}{25}$$

$$M = -0.67x$$

Here is how this works:

- If we get a **POSITIVE** magnification, the image is **UPRIGHT**.
- If we get a **NEGATIVE** magnification, the image is **INVERTED**.
- If the magnification value is **GREATER** than 1, the image is **ENLARGED**.
- If the magnification value is **LESS** than 1, the image is **REDUCED**.
- If the magnification value is **EQUAL** to 1, the image is the **SAME SIZE** as the object.

Using our previous data we see that our image was **INVERTED**, and **REDUCED**.

Example

Assume that a certain concave spherical mirror has a focal length of 10.0 cm. Locate the image for an object distance of 5 cm and describe the image's characteristics.

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} \rightarrow \frac{1}{10} = \frac{1}{5} + \frac{1}{d_i}$$

$$d_i = \mathbf{-10 \text{ cm}}$$

Characteristics?

$$M = -\frac{d_i}{d_o} = \mathbf{2x}$$

- **VIRTUAL (opposite side)**
- **Enlarged**
- **Upright**