Do Now

- Check the answers to the homework.
- Get out a notebook, pencil and straight edge (does not need to be a ruler).

Today

- Ray diagrams for concave mirrors.
- Snell's law of refraction.

Tonight

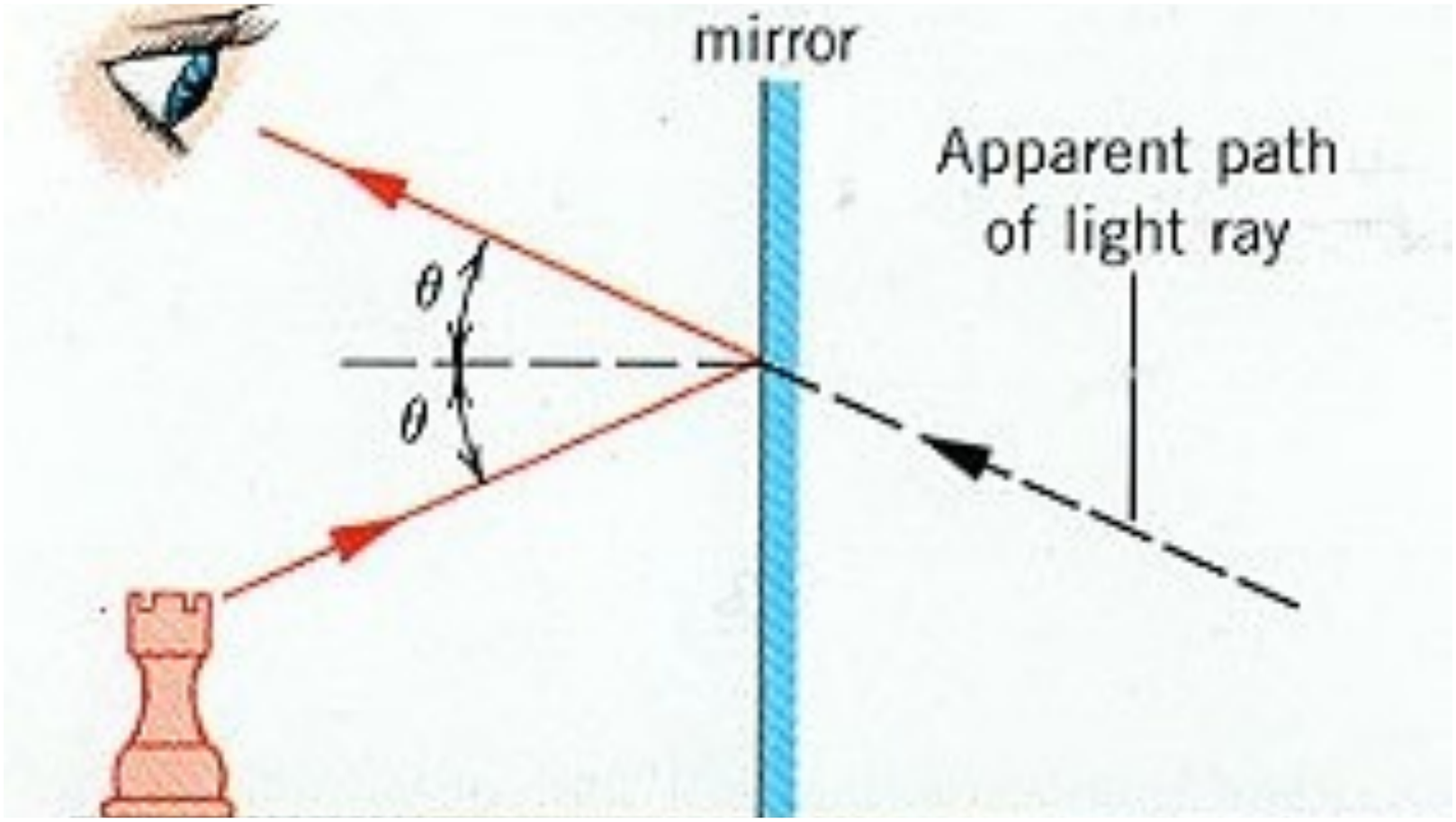
- physicsclassroom.com
- Read and take notes:
  - Reflection and the ray model of light
  - Lesson 3: Concave Mirrors
  - Sections: A-F

This week

- T: Ray Diagrams and Snell's law
- W: Concave mirror lab
- R: Convex mirror equations
- F: Color and Light

Ray Diagrams

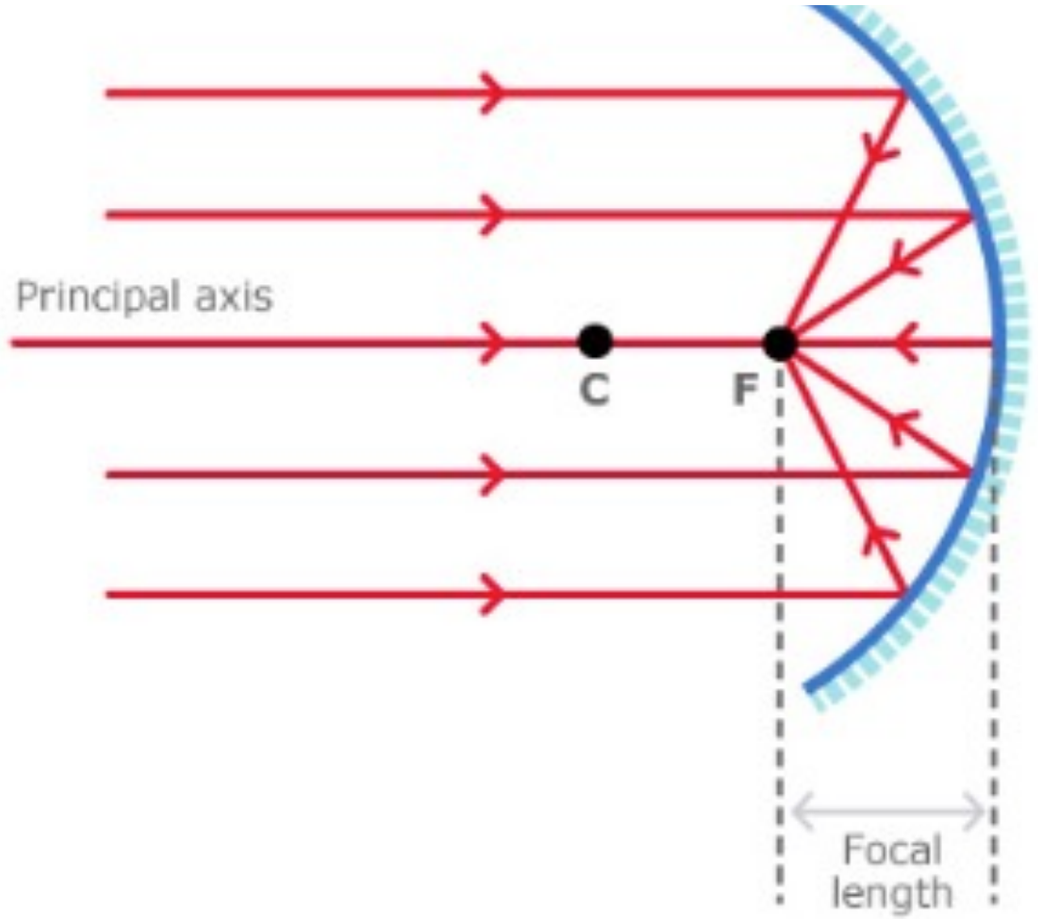
- Light leaves an object and hits a mirror.
- It is reflected off of the mirror.
- The angle of incidence is equal to the angle of reflection.



$$\theta_i = \theta_r$$

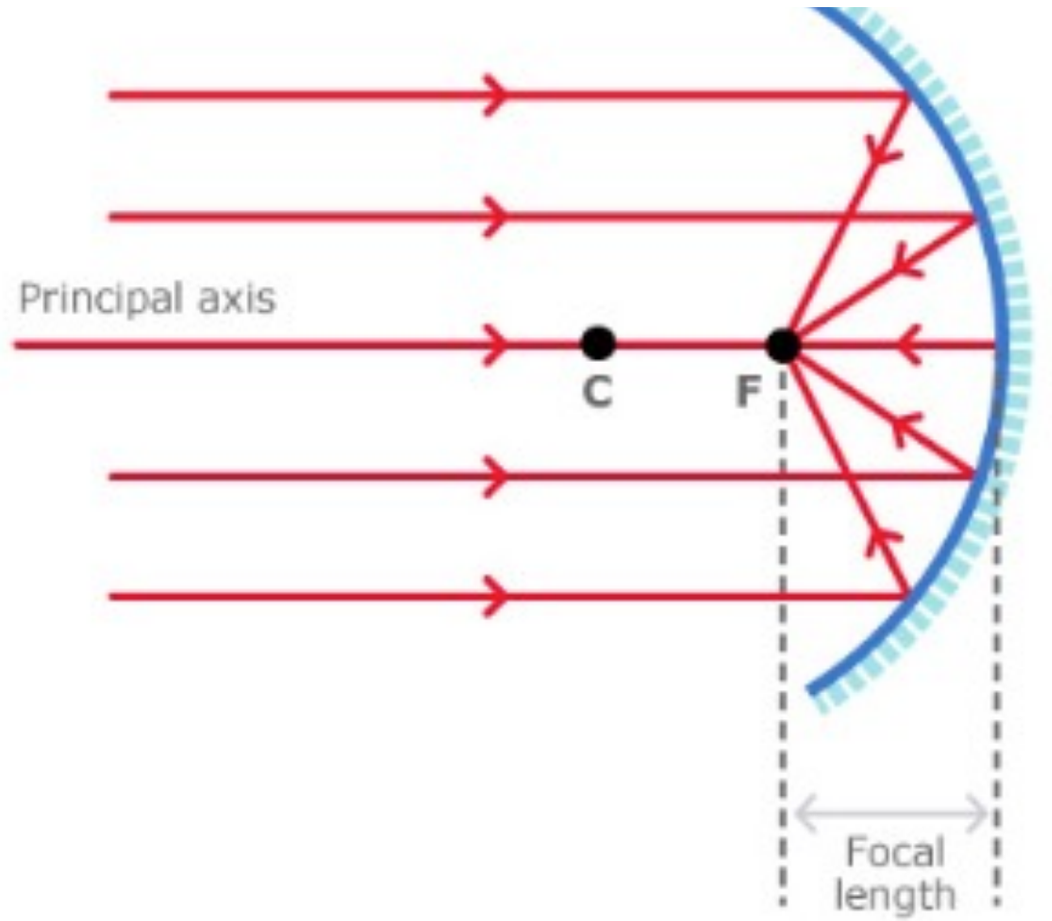
Rays on a Concave Mirror

- Rays of light reflect off of a concave mirror.
- All light parallel to the principal axis go through the focal point.

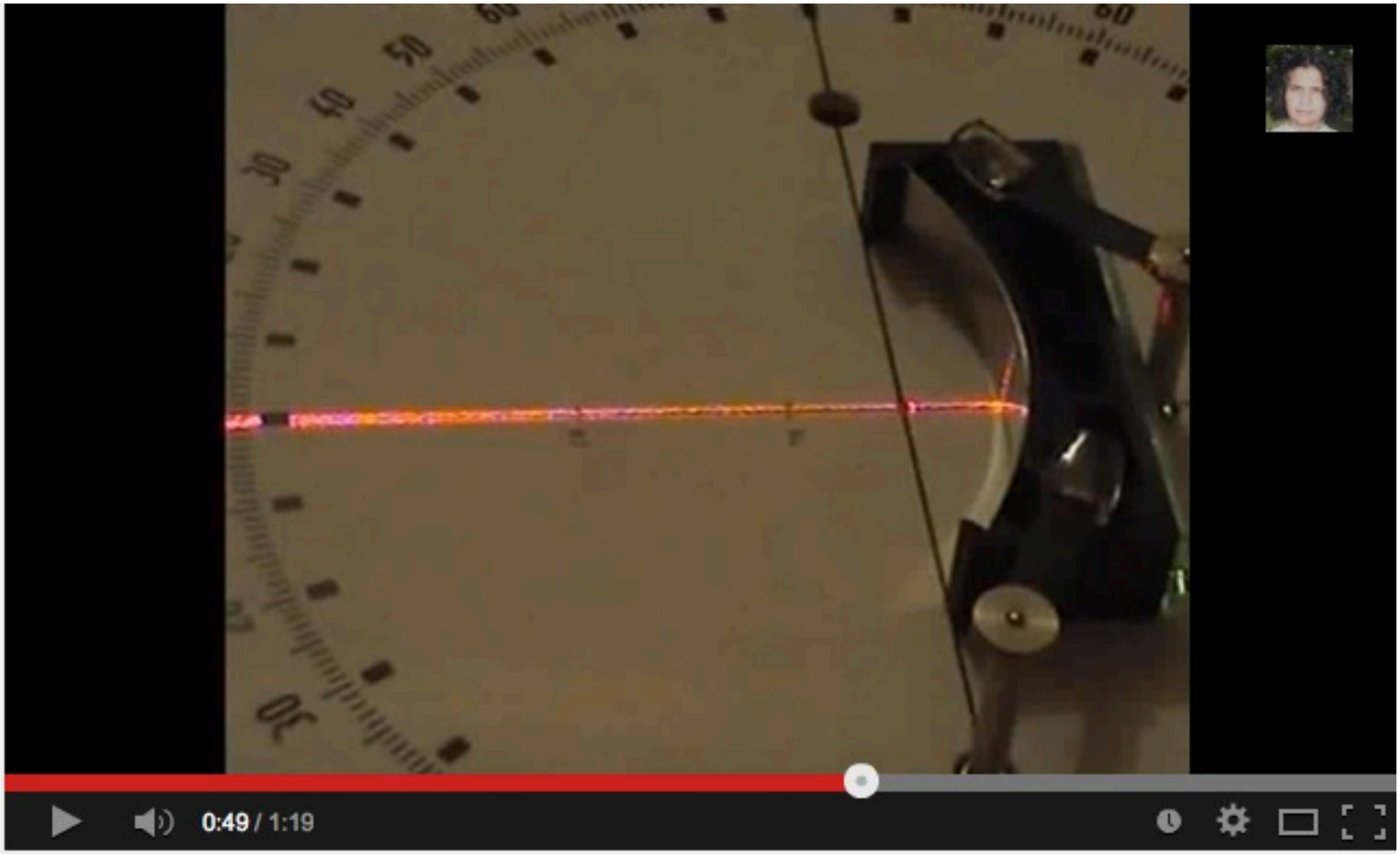


Anatomy of a Ray Diagram

- C - The center point (radius) of the mirror.

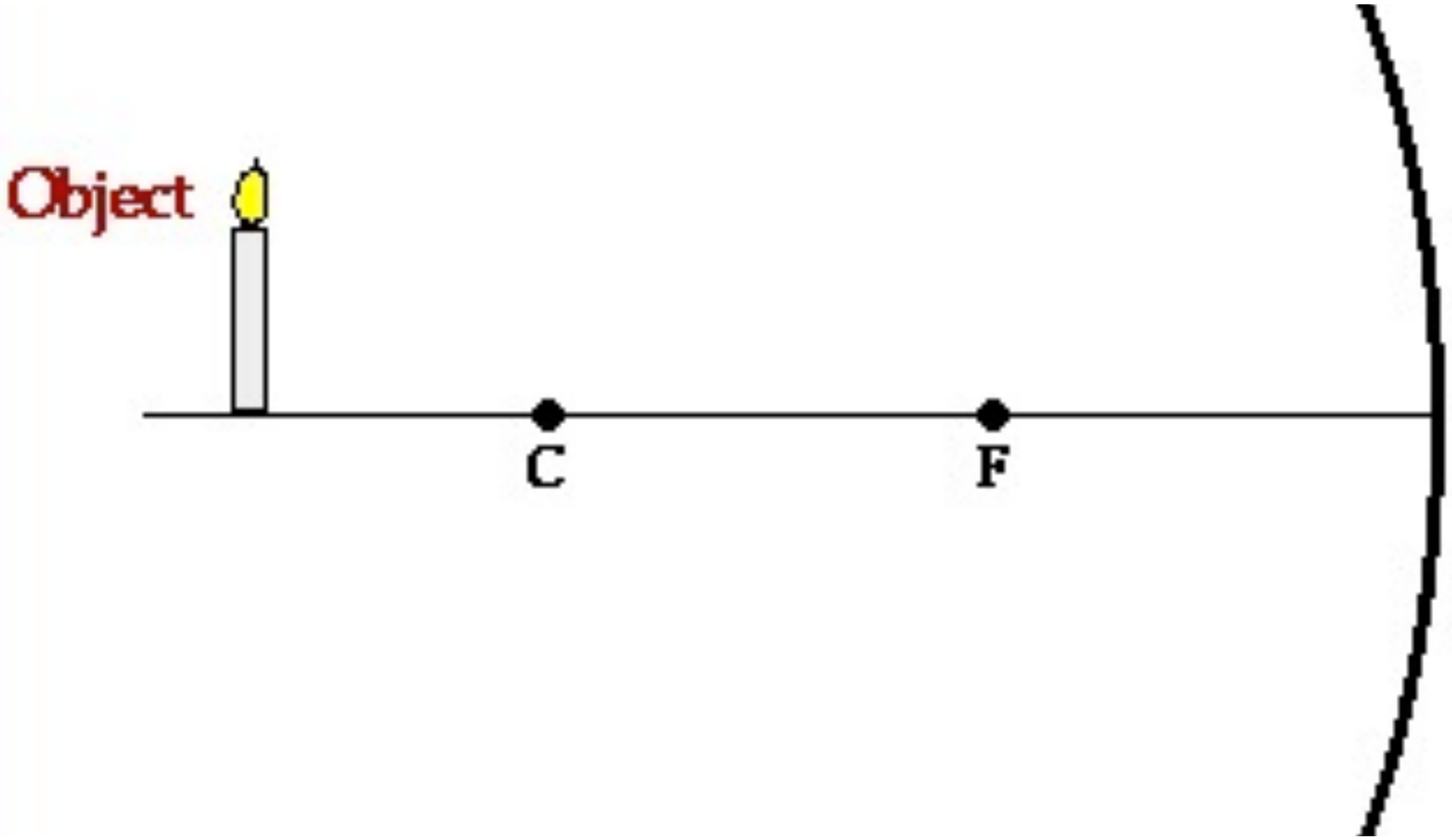


- F - The Focal point of the mirror.
- C = 2F



Focal point of a concave mirror

Video Demo



Where's the Image?

Locating the image

- From the source: draw a ray to the mirror that is parallel to the principal axis.
- The ray then reflects off of the mirror and through the focal point.

Locating the image

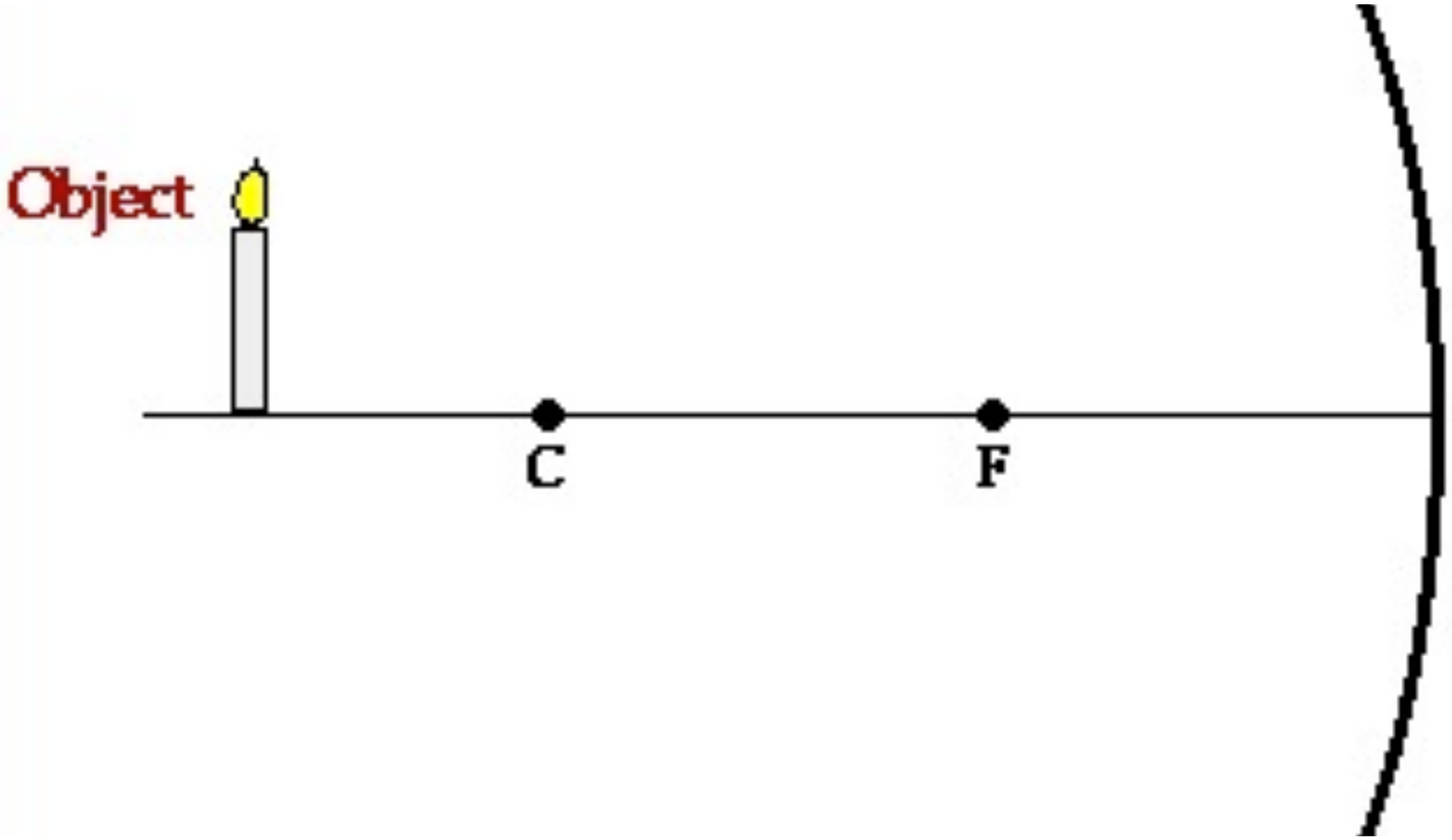
- Draw a second ray from the source through the focal point.
- The ray will reflect off the mirror parallel to the principle axis.

Locating the Image

- The final ray needs to be drawn from the source through the center point and beyond.
- There should be a place where all 3 rays meet.

Meeting place

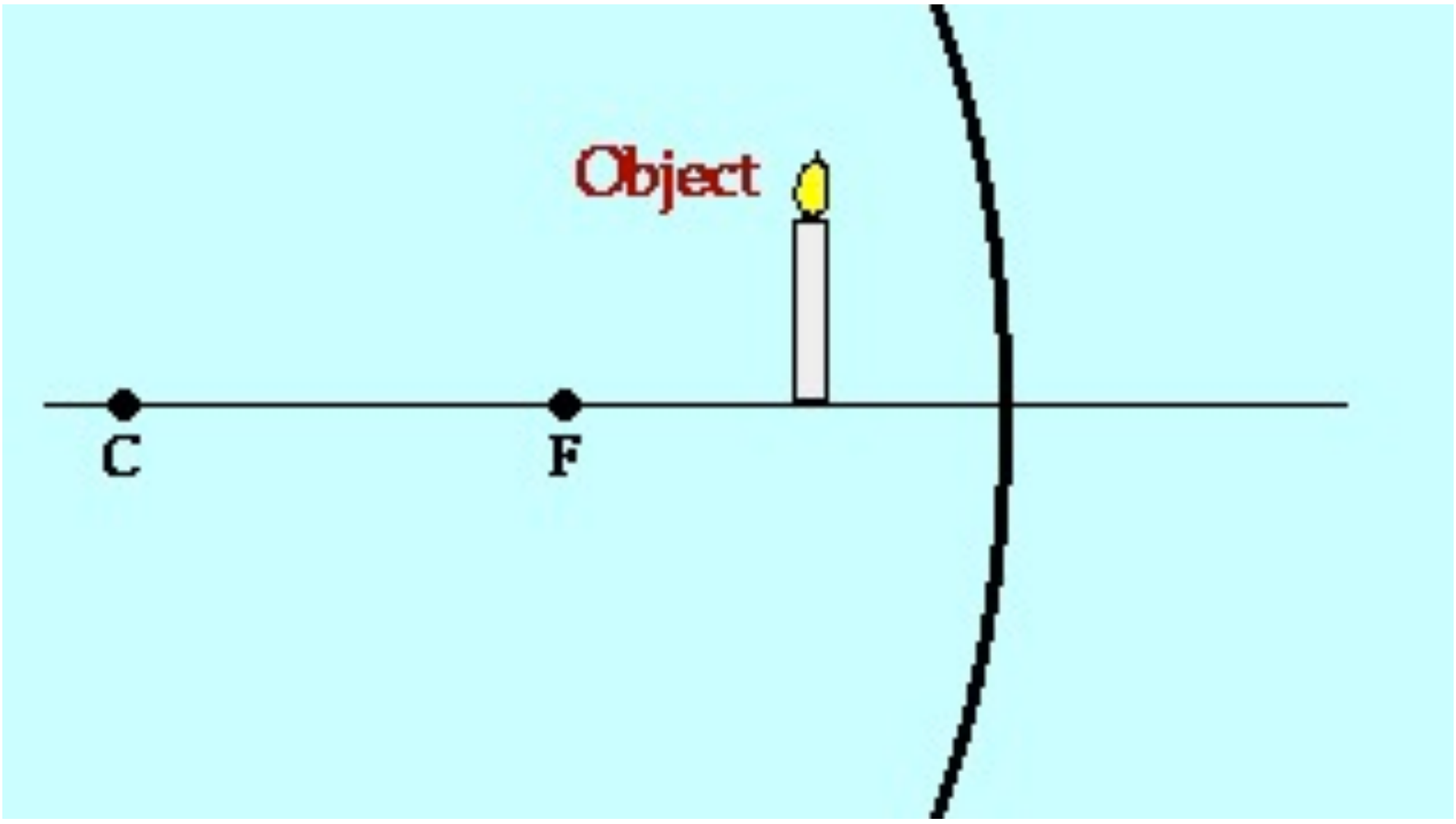
- All three rays meet is the location of the image.
- If the meeting point is below the principal axis, the image is inverted.
- It is on the same side of the mirror as the object, so we call this a **real image**.



Where's the Image?

Inside the Focal Point

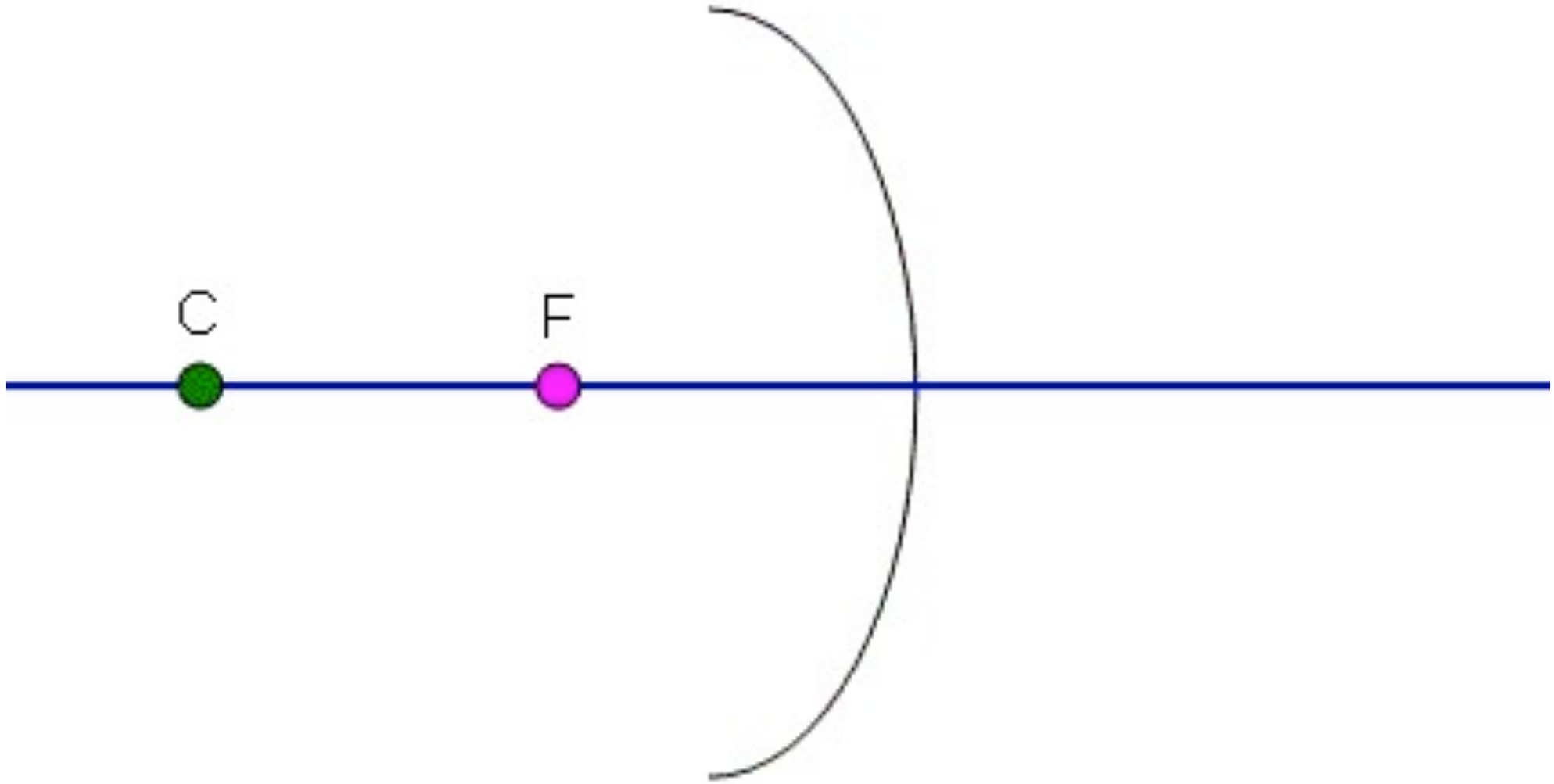
- If an object is placed inside of the focal point of a concave mirror, it will be magnified.
- The image will be upright, but exist on the opposite side of the mirror.
- This makes it a **virtual image**.



Virtual Image

Caution

- The actual rays of light do not meet in real space.
- We must extend them into the mirror.
- Because light does not actually travel there it is a **virtual image**.

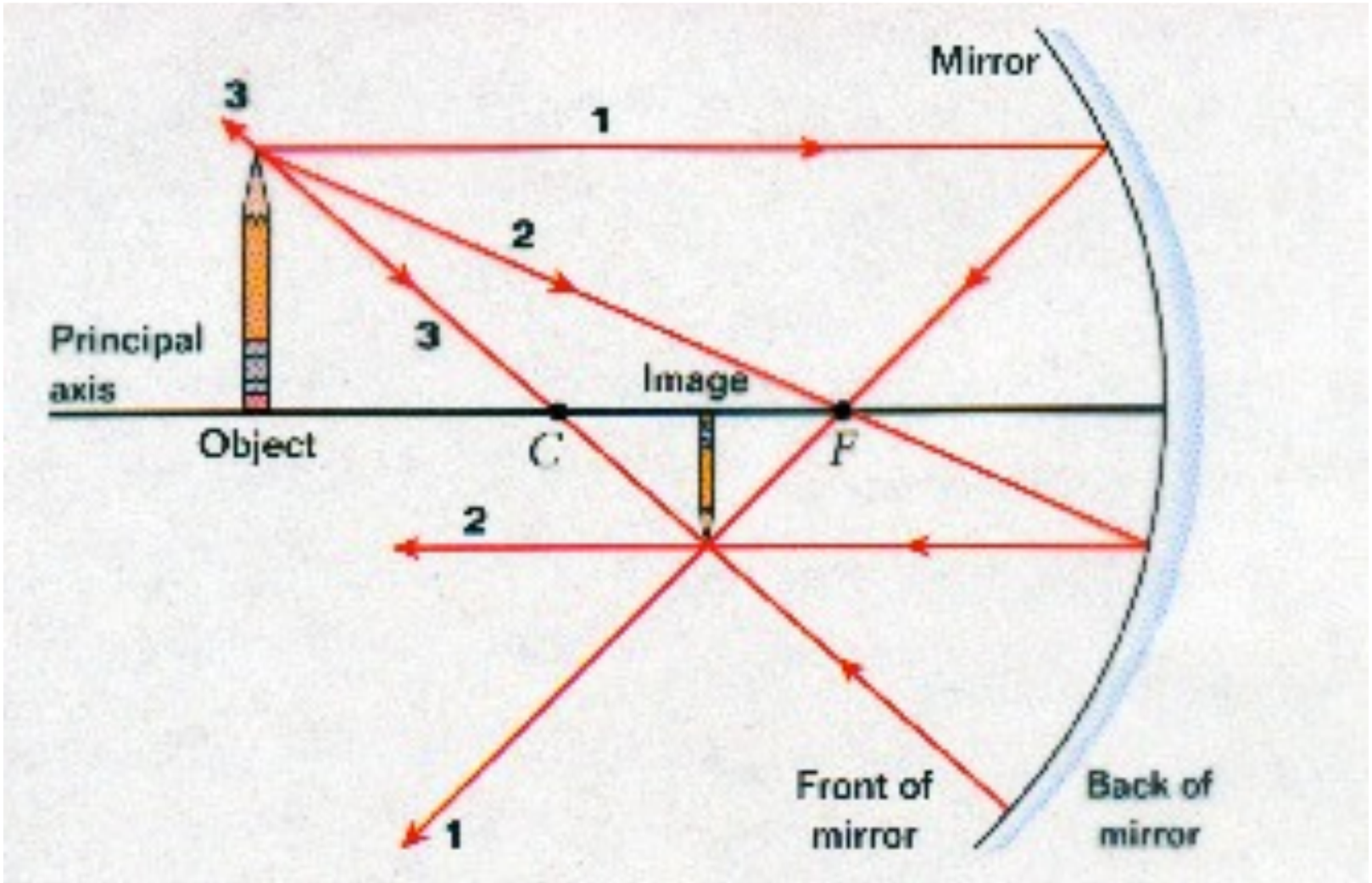


Find the Image

Determining the Focal Point

- 1/f = 1/Do + 1/Di
- The inverse of the focal length is equal to the inverse of the distance of the object to the mirror plus the inverse of the distance from the image to the mirror.
- “If I do I di.”

A pencil is 50cm from a concave mirror.
The image is 25cm from the mirror.
What is the focal length of the mirror?



An object is 10cm from a mirror. It's image is -13cm from the mirror. What is the focal length of the mirror?

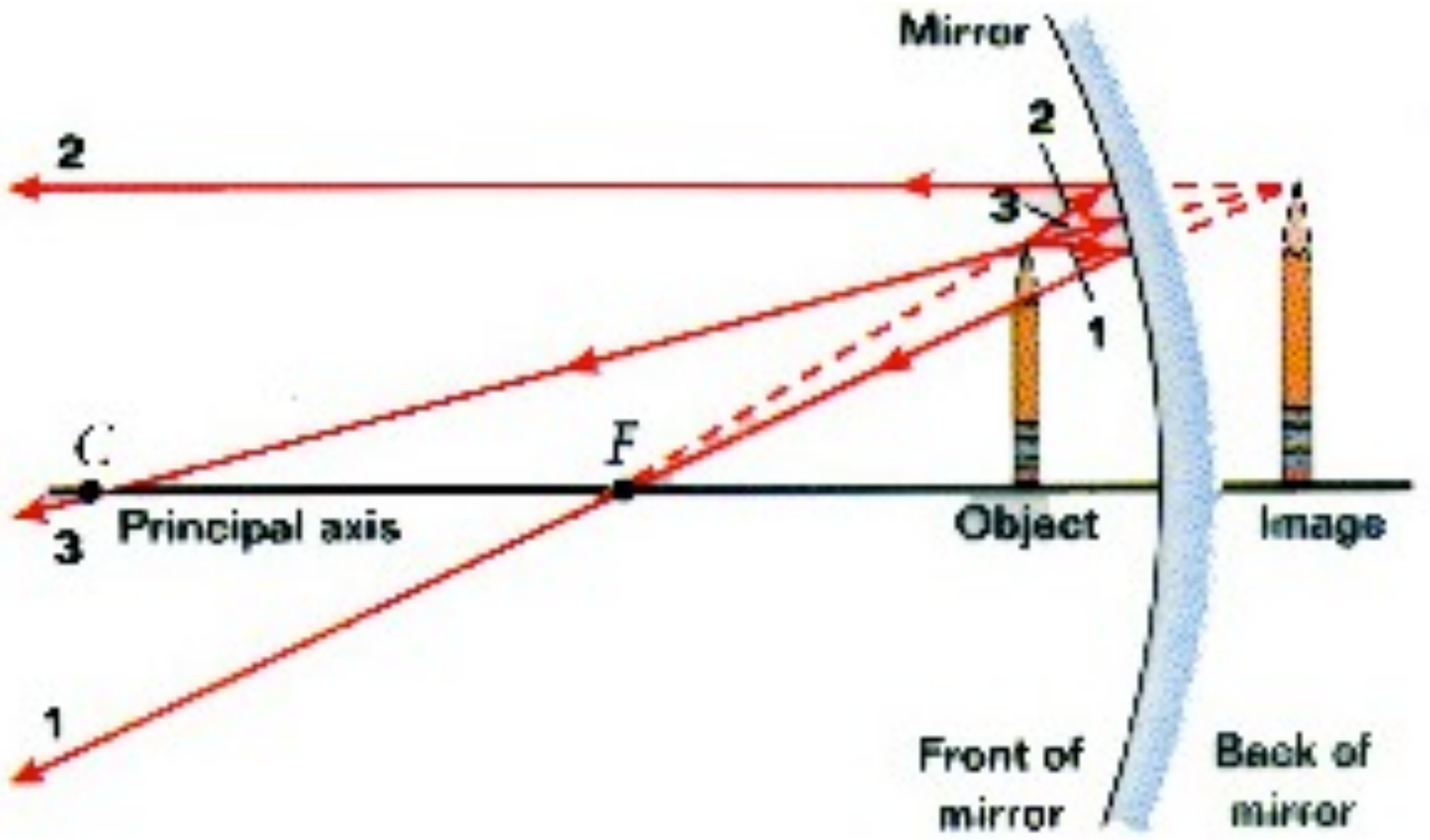


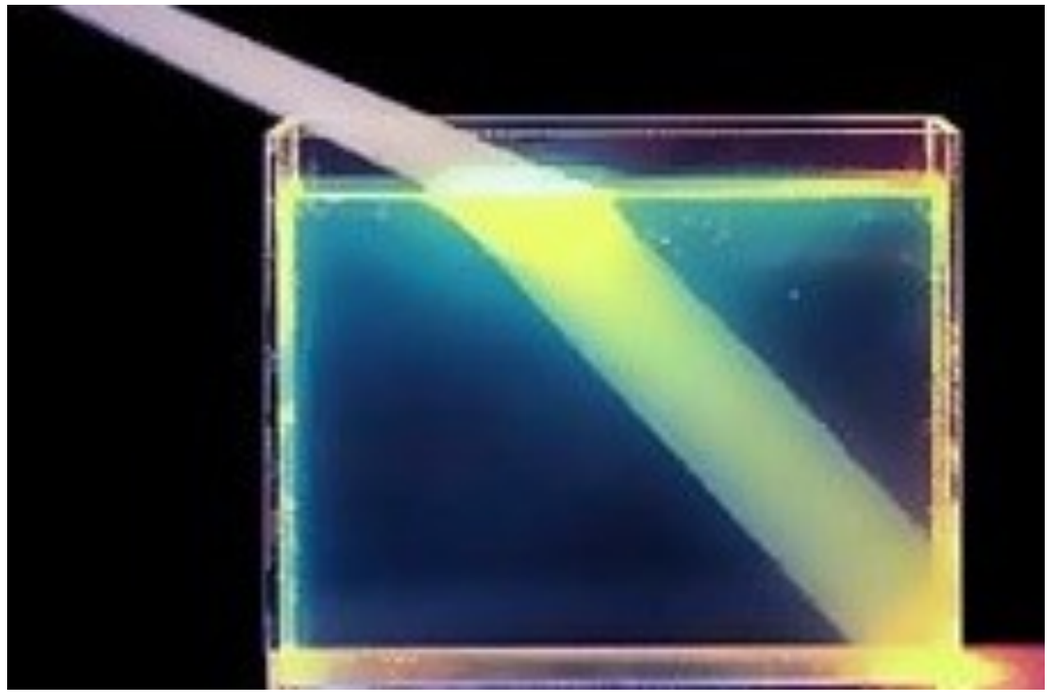
Image Demo

Snell's Law of Refraction

Bending Light

- Light crossing from one medium to another bends.

- This happens where the mediums meet.



Why???

- Light crossing a boundary changes speed and wavelength.
- Assuming that the light crosses the medium at an angle refraction is observed.

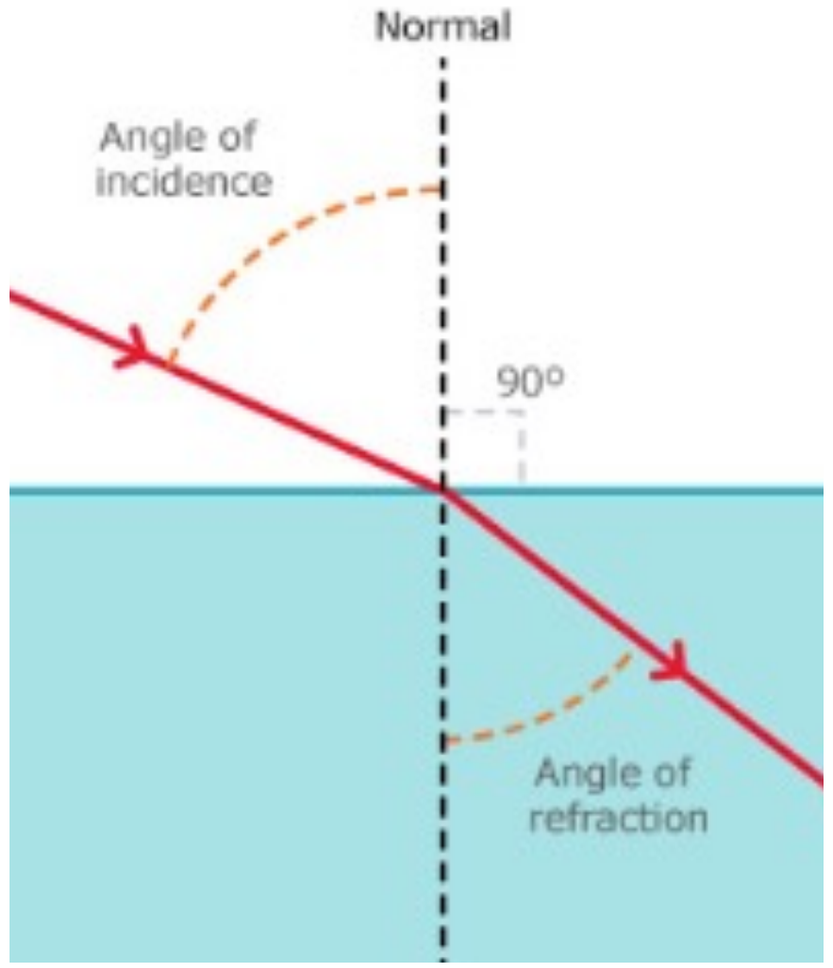
Index of Refraction [n]

- The ratio of the speed of light in a vacuum to the speed of light in a given material.
- Index of refraction of glass: speed of light in a vacuum/speed of light in glass. $n_{glass} = 1.55$
- n is a ratio - no units.

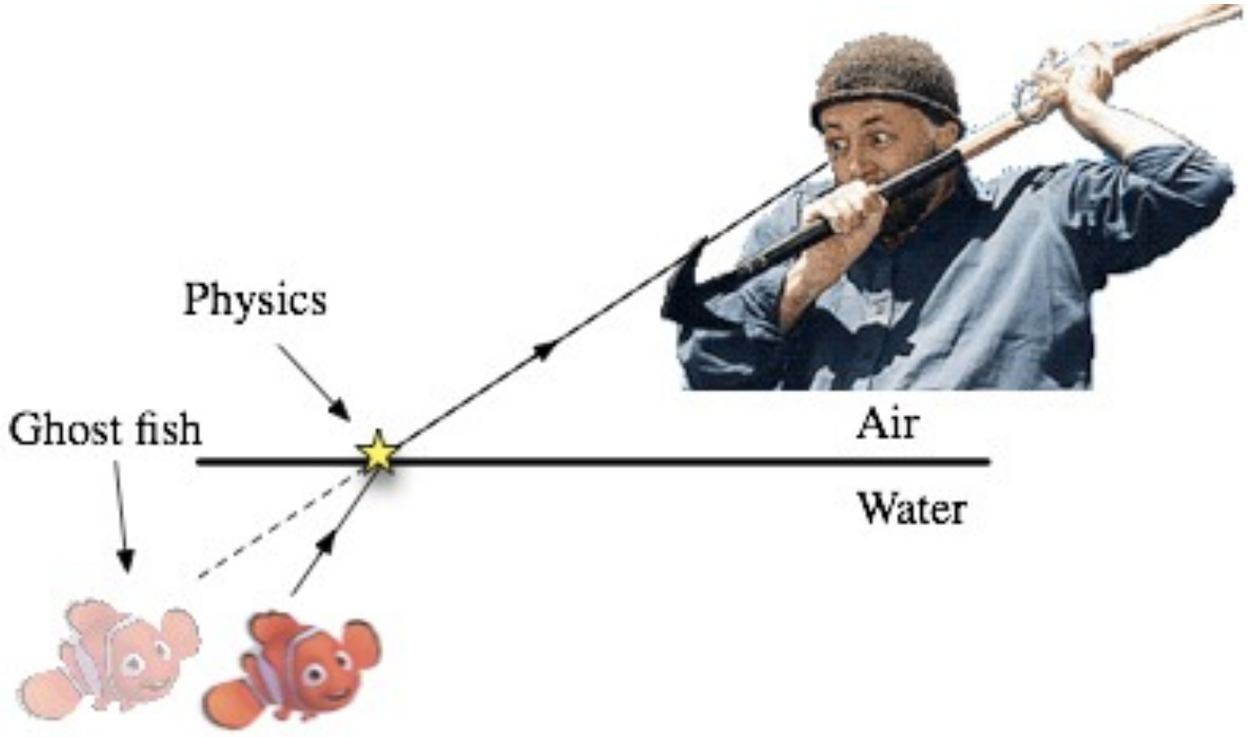
$$n_i \sin\theta_i = n_r \sin\theta_r$$

- Measure θi and θr perpendicular to the surface.
- There are only 4 unknowns.
- They are:

Light crosses from air to glass. The light hits the water at an angle of 60 degrees. If n_{air} is about 1 and n_{glass} is 1.6, what is the angle of refraction?



A fisherman is trying to spear Nemo. He throws his spear through the air (n=1) at an angle of 60 degrees. The spear misses Nemo by 20 degrees. What is the index or refraction of water?



The angle of incidence (the angle the light hits the medium) from air to an unknown material is 75 degrees, if the angle of refraction in the material is 40º what is the index of refraction for this material (n = 1 for air)?

The angle of incidence from air to a material is 40 degrees, what is the index of refraction in the material if the angle is 22º?

The angle of incidence from air to a material is 40 degrees, what is the index of refraction in the material if the angle is 22º?

Snell's Homework

- Snell's Law WS: 1, 4 & 5