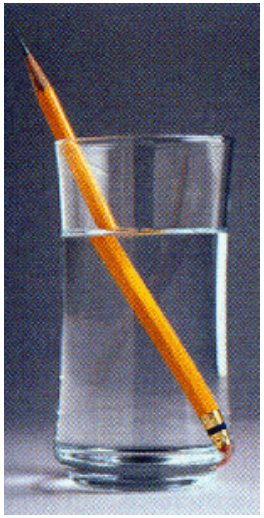
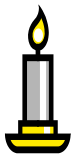
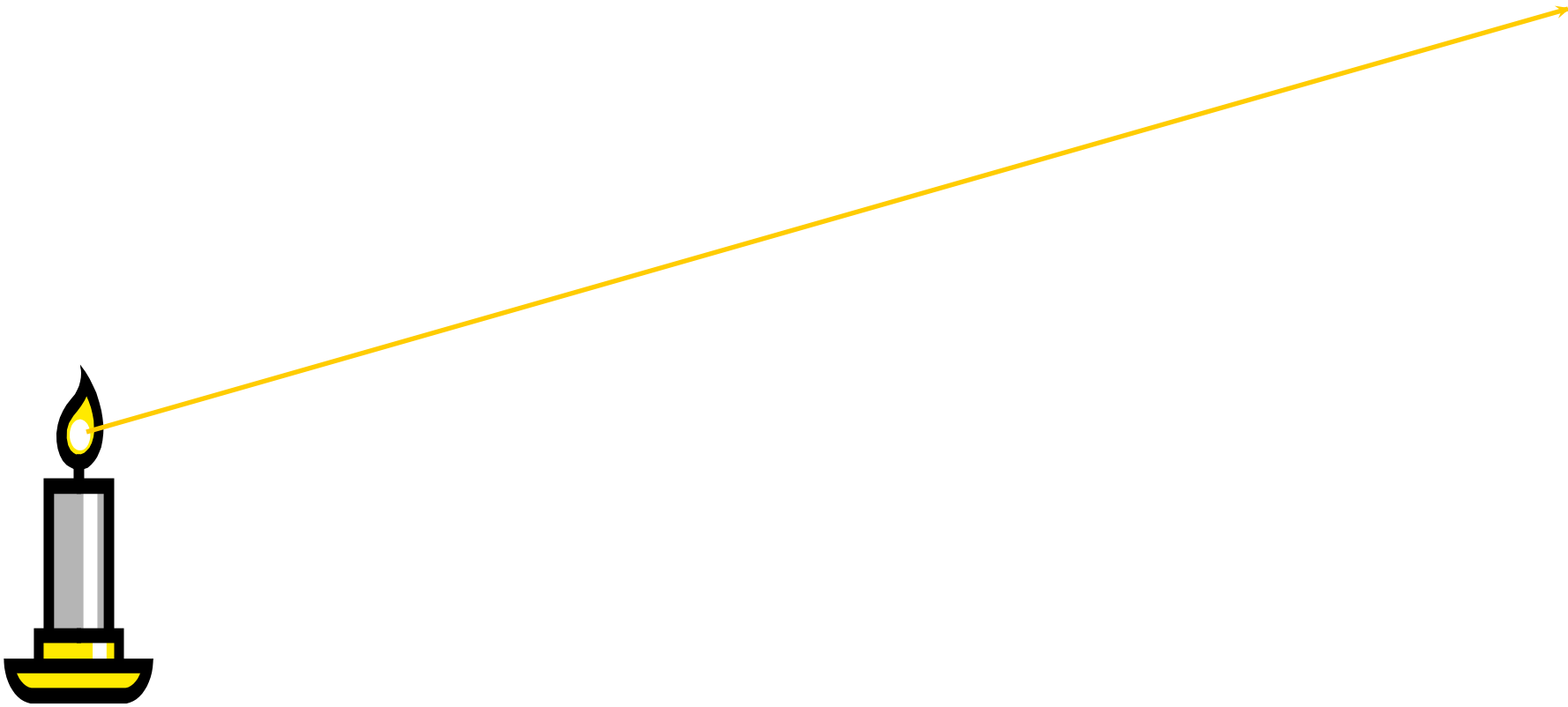
- Basics
- Reflection
- Mirrors
  - Plane mirrors
  - Spherical mirrors
    - Concave mirrors
    - Convex mirrors
- Refraction
- Lenses
  - Concave lenses
  - Convex lenses



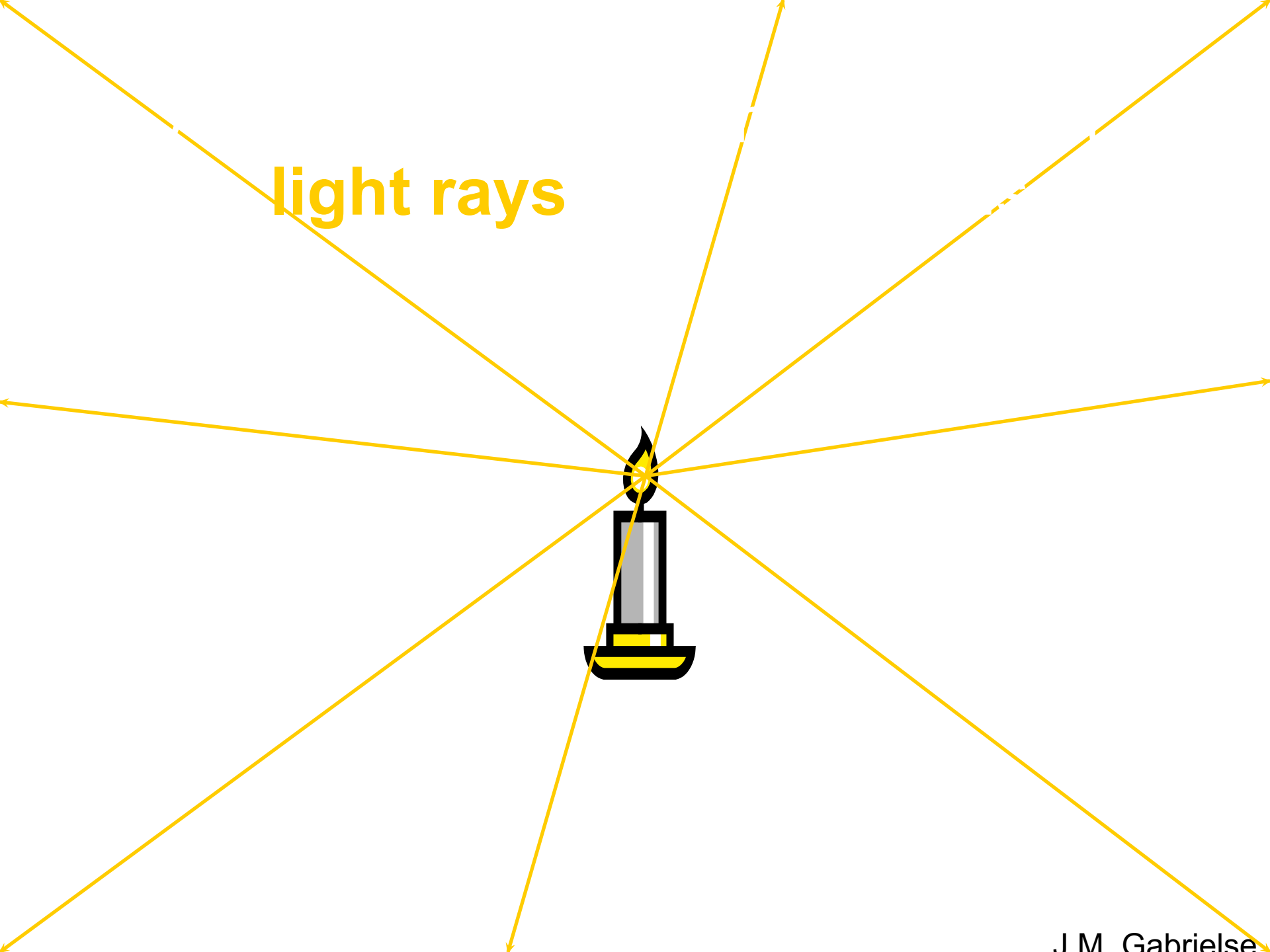


J.M. Gabrielse

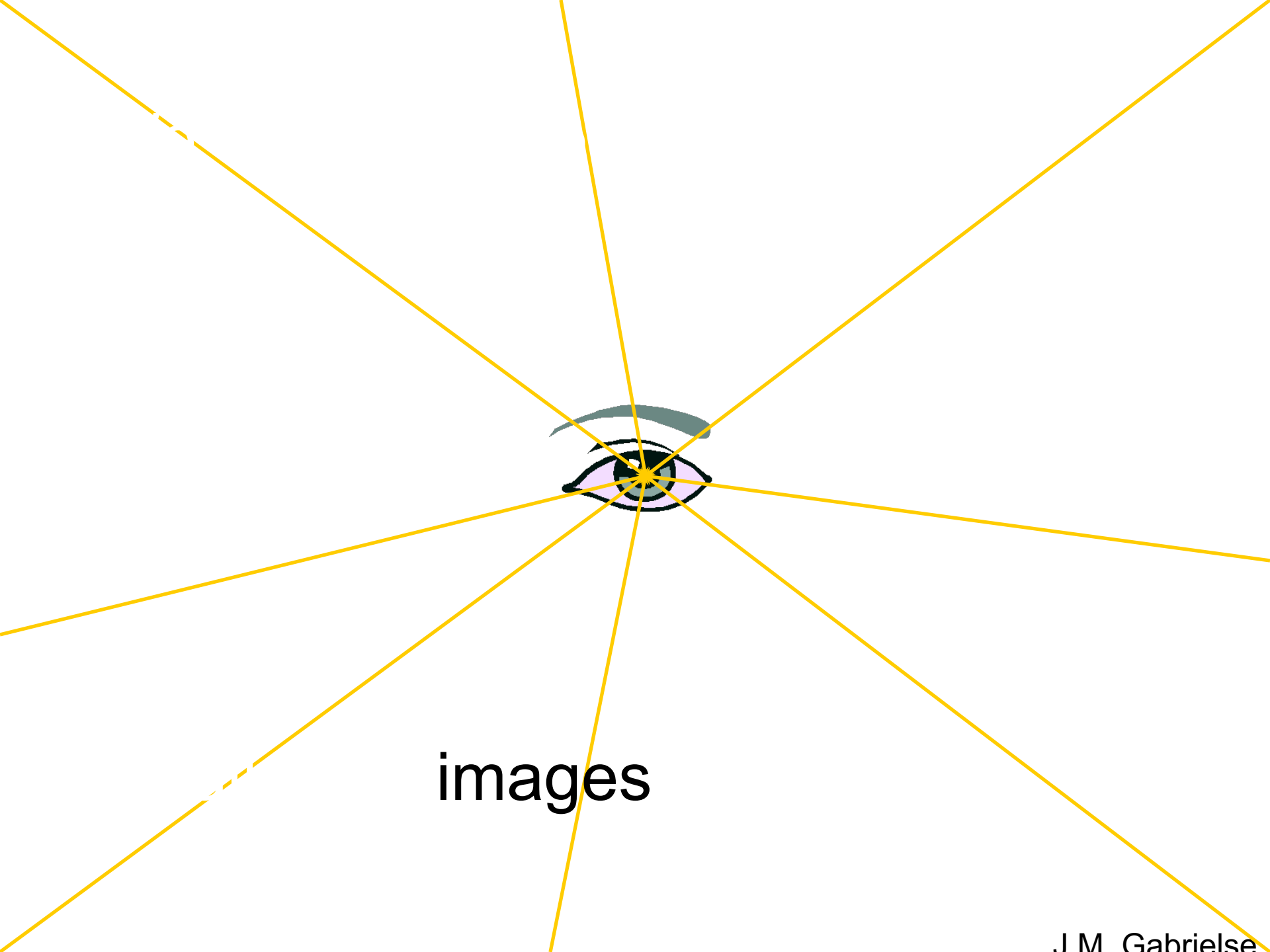
ray of light



light rays

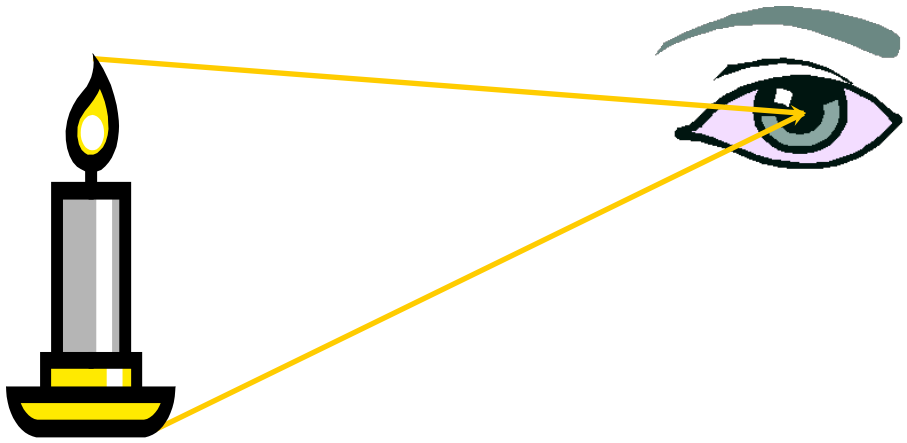


light rays


images

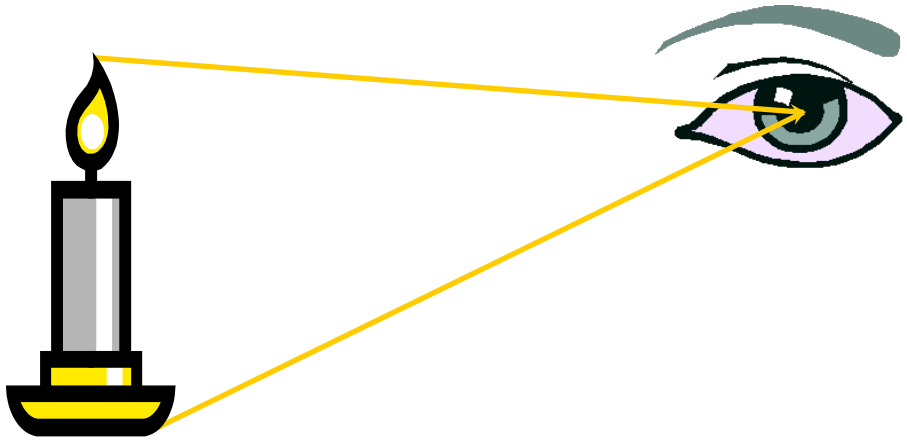
Images

light rays



light rays

image



image

Mirrors

images

light rays

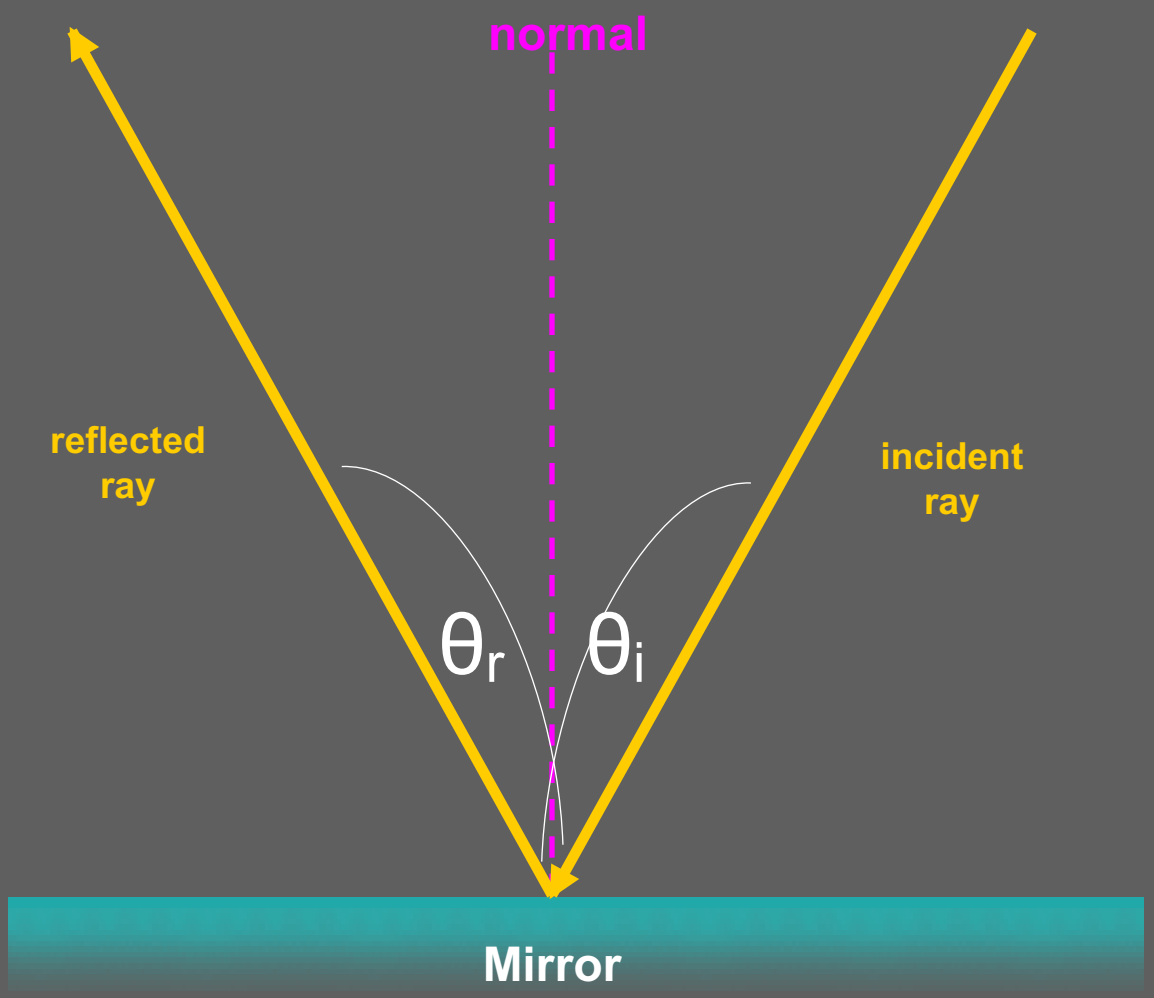
mirrors

Reflection
(bouncing light)

Reflection is when light changes direction by bouncing off a surface.

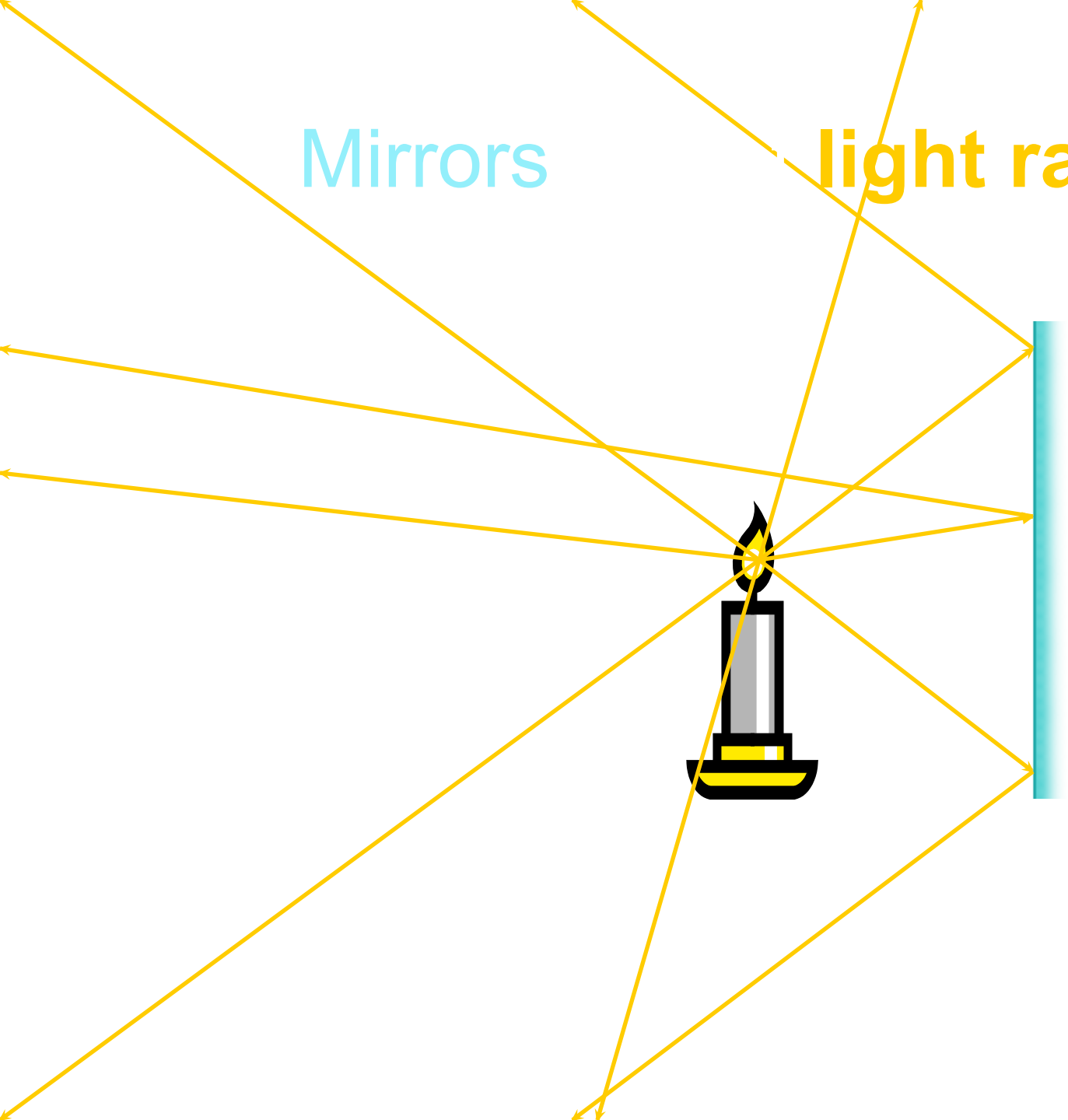
When light is **reflected** off a mirror, it hits the mirror at the same angle (θ_i, the incidence angle) as it **reflects** off the mirror (θ_r, the reflection angle).

The normal is an imaginary line which lies at right angles to the mirror where the ray hits it.

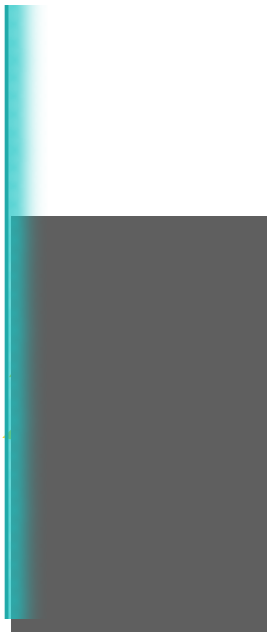


Mirrors

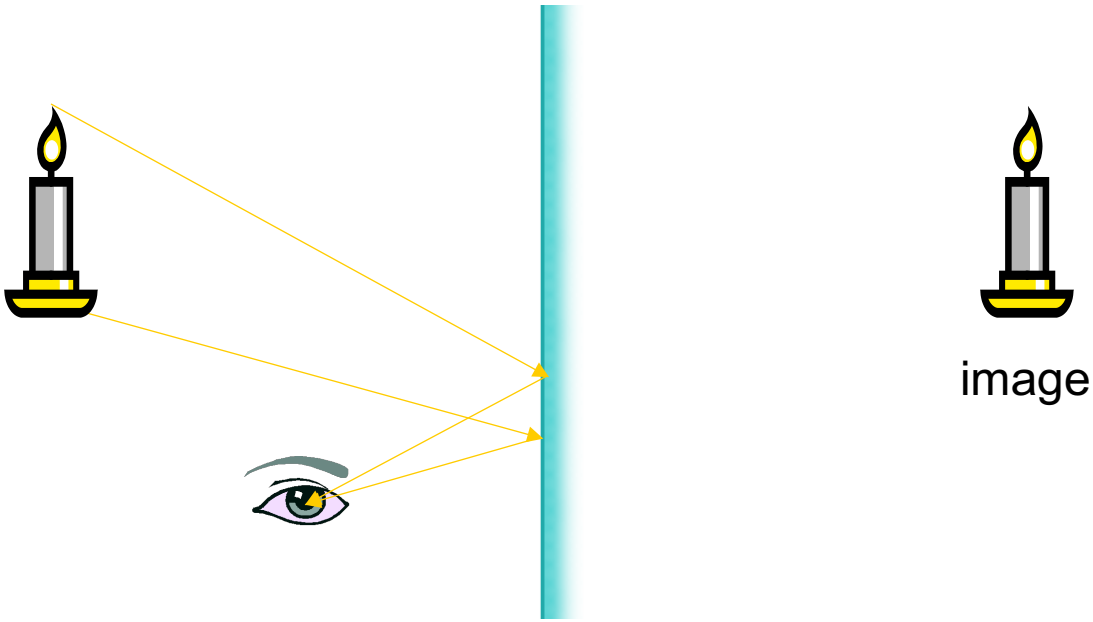
light rays



images mirrors



images mirrors

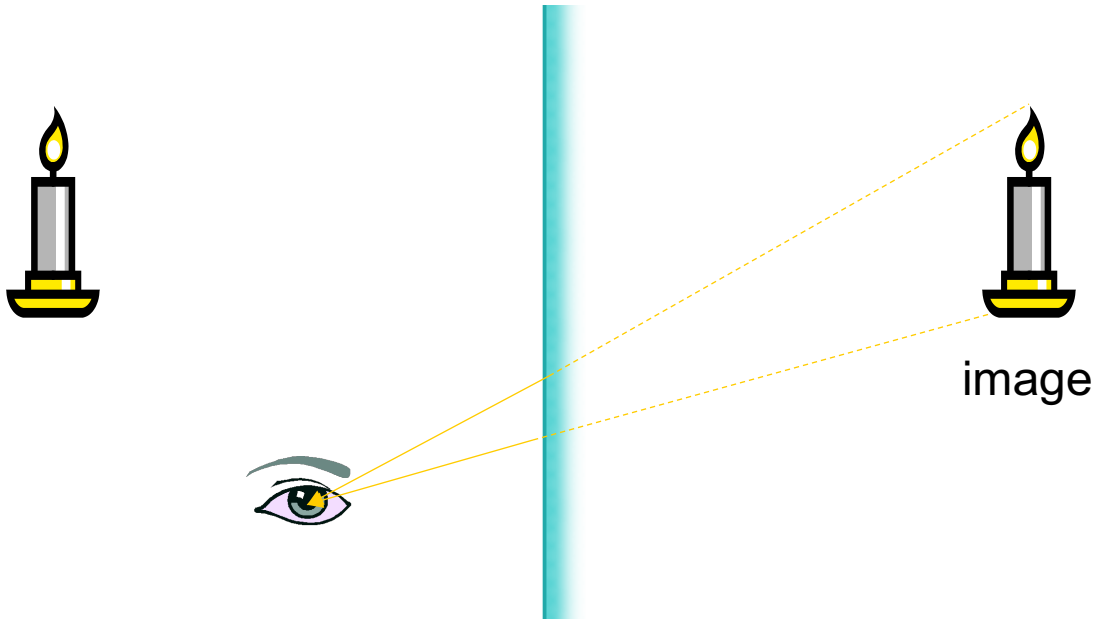


Light

mirror

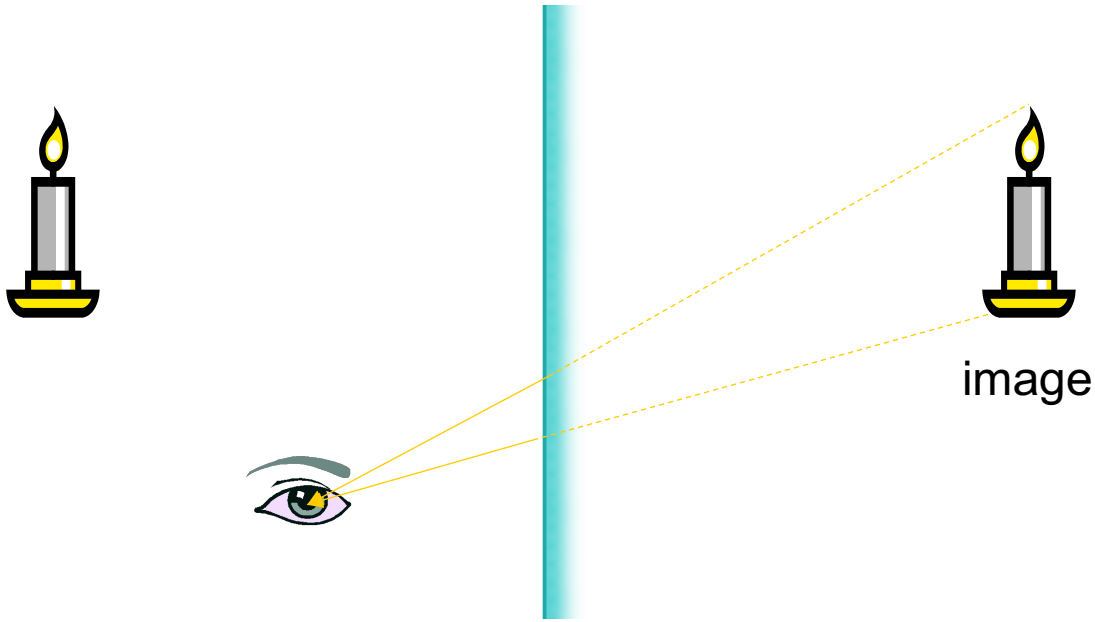
image

Sight Lines



The imaginary light rays that we think we see are called *sight lines*.

Sight Lines

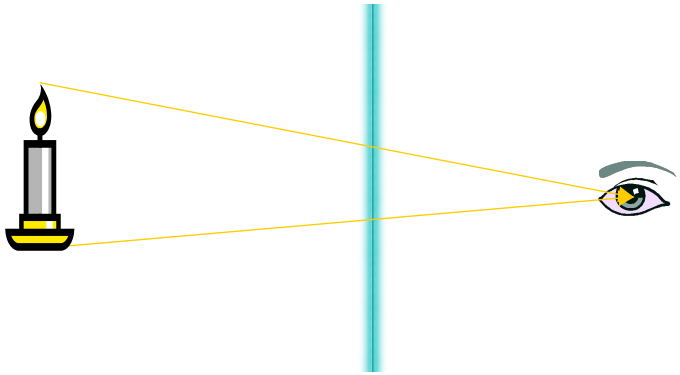


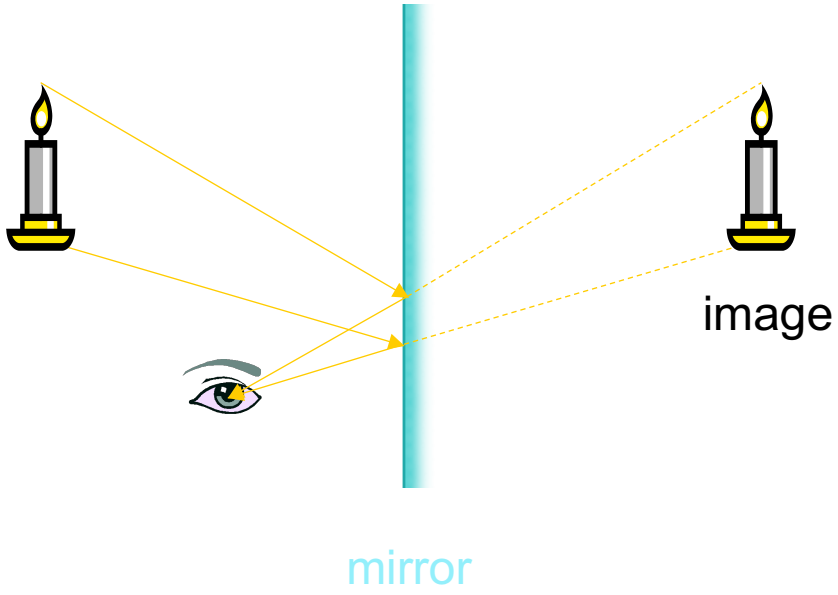
We perceive all light rays as if they come straight from an object.

light rays

sight lines

Image





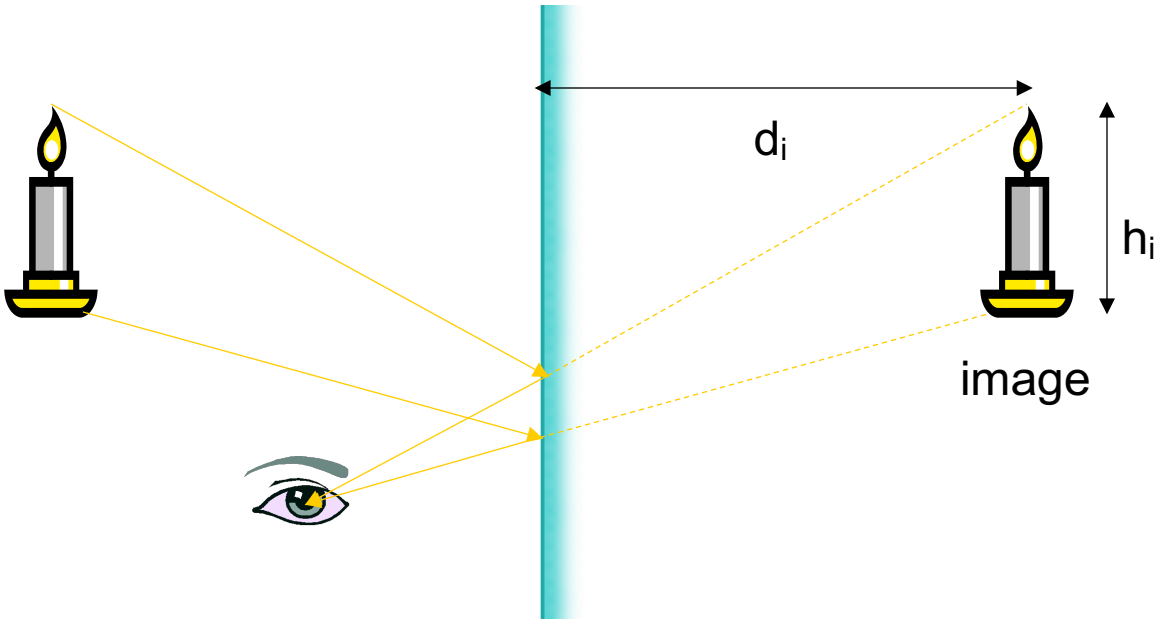
Real images

Virtual images

light rays

sight lines

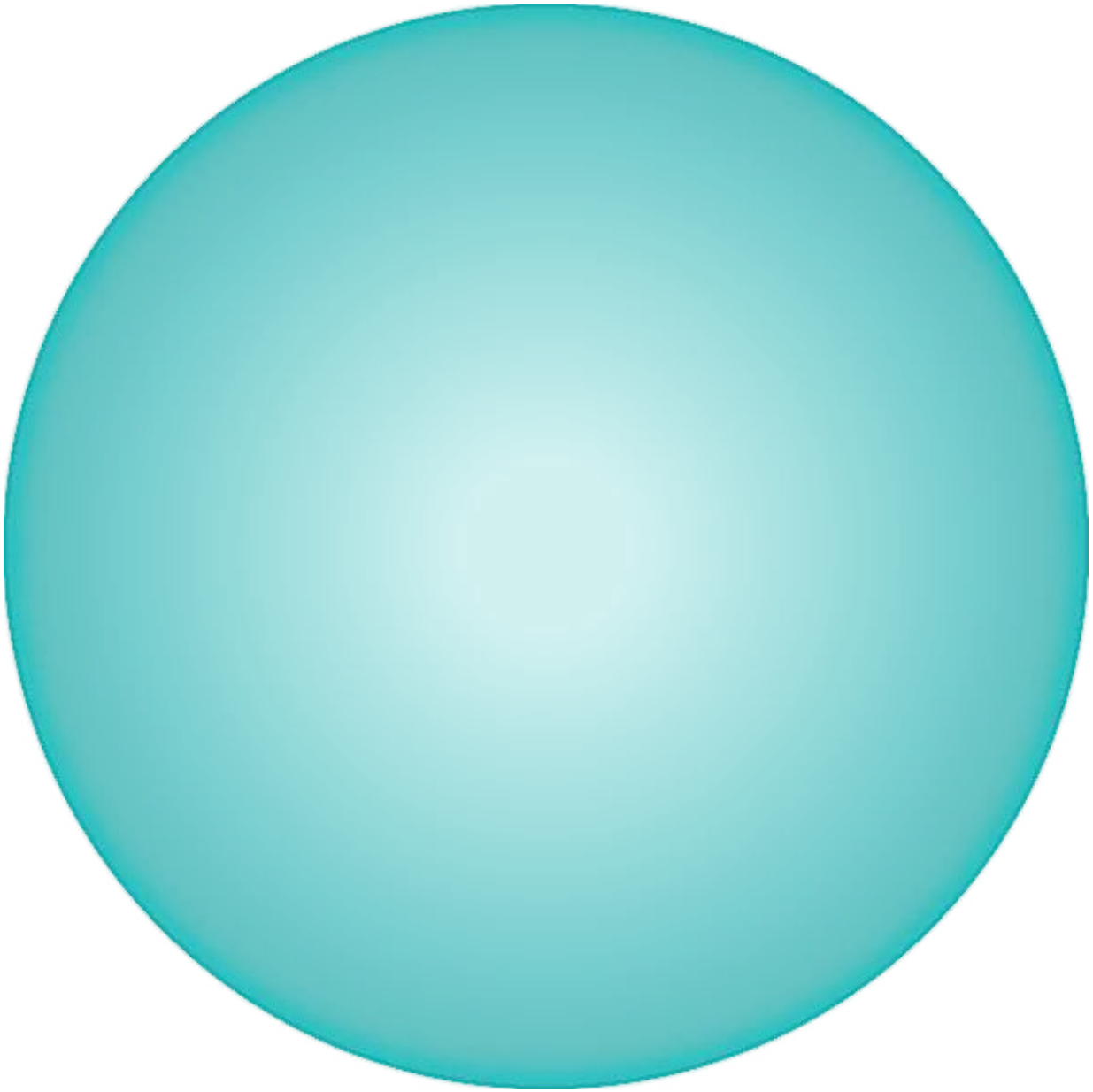
Plane (flat) Mirrors



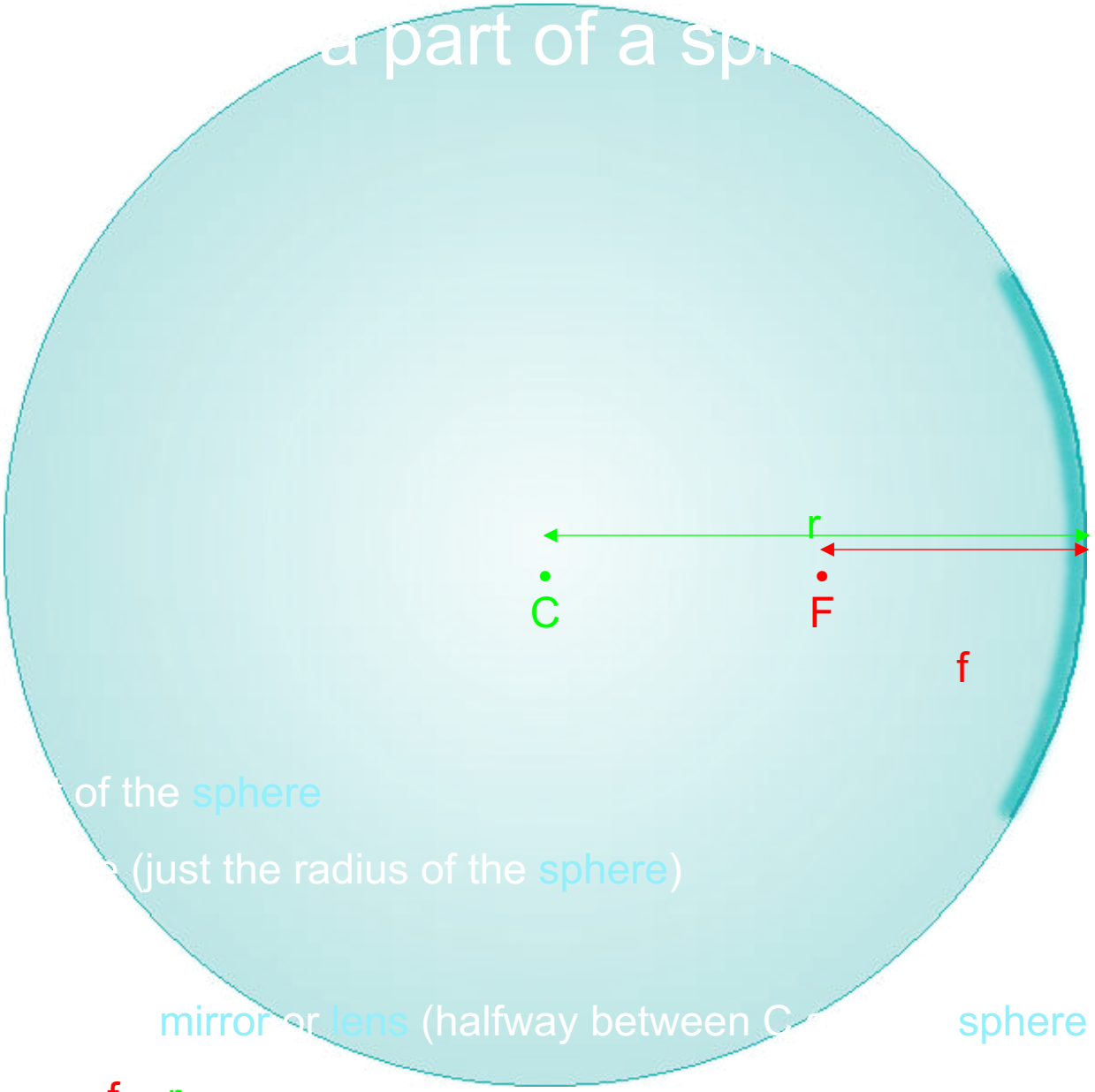
Images *sight lines*

image height (h_i)

image distance (d_i).



J.M. Gabrielse



C of the sphere

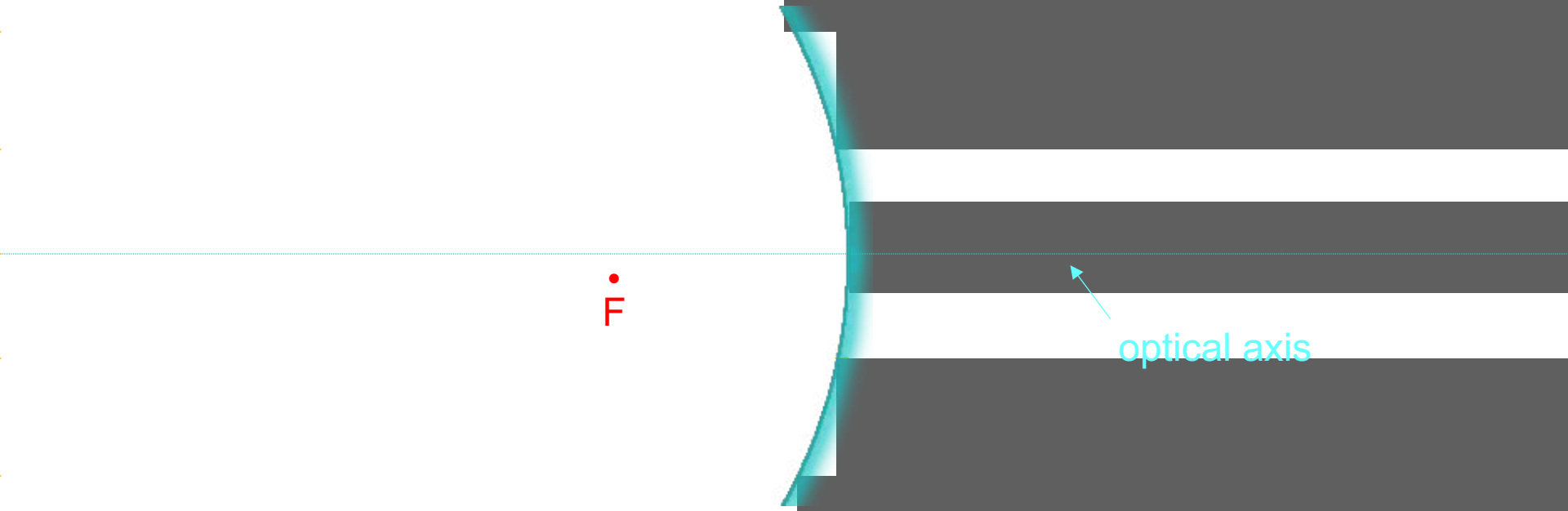
r (just the radius of the sphere)

F mirror or lens (halfway between C sphere

f f r

Concave Mirrors

ed in)

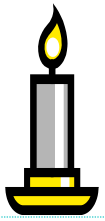


Light rays optical axis reflect through the focal point.

J.M. Gabrielse

Concave Mirror

nple)

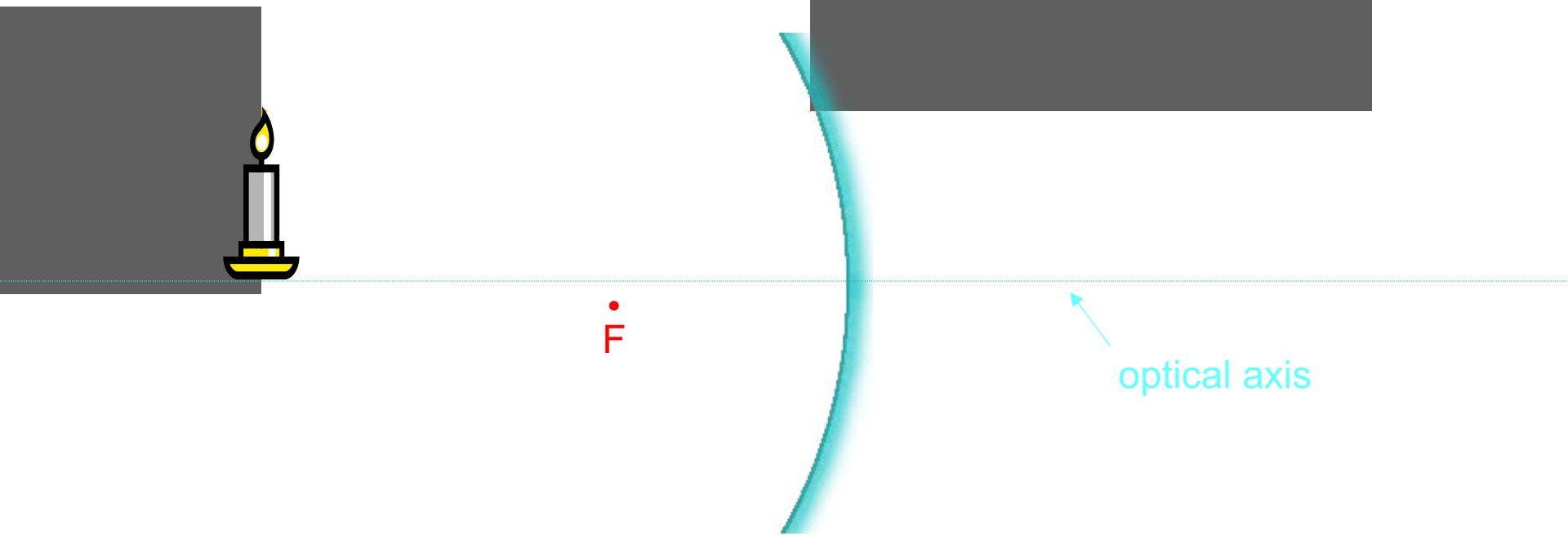


F

optical axis

Concave Mirror

nple)

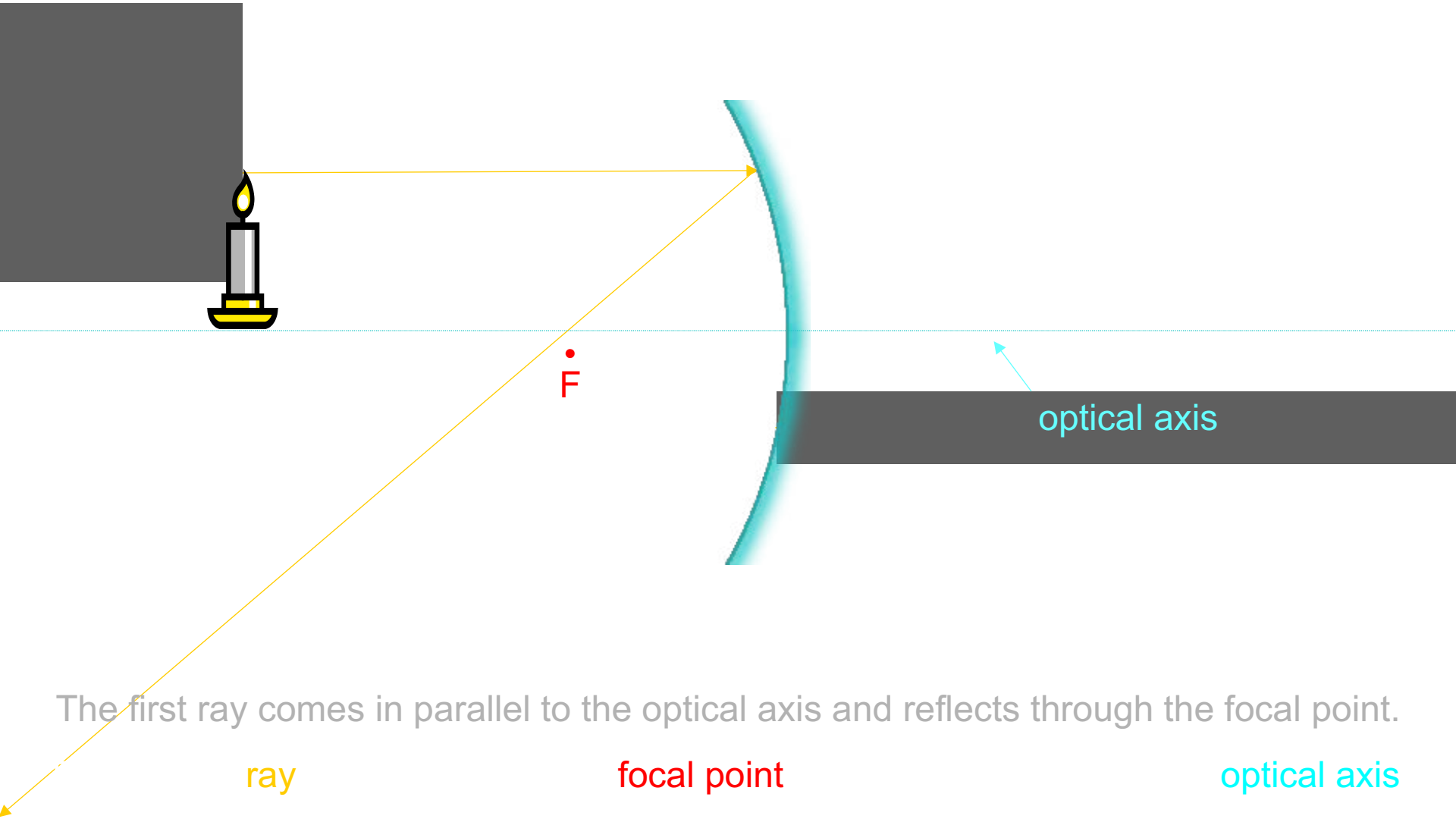


ray

optical axis

focal point

Concave Mirror



The first ray comes in parallel to the optical axis and reflects through the focal point.

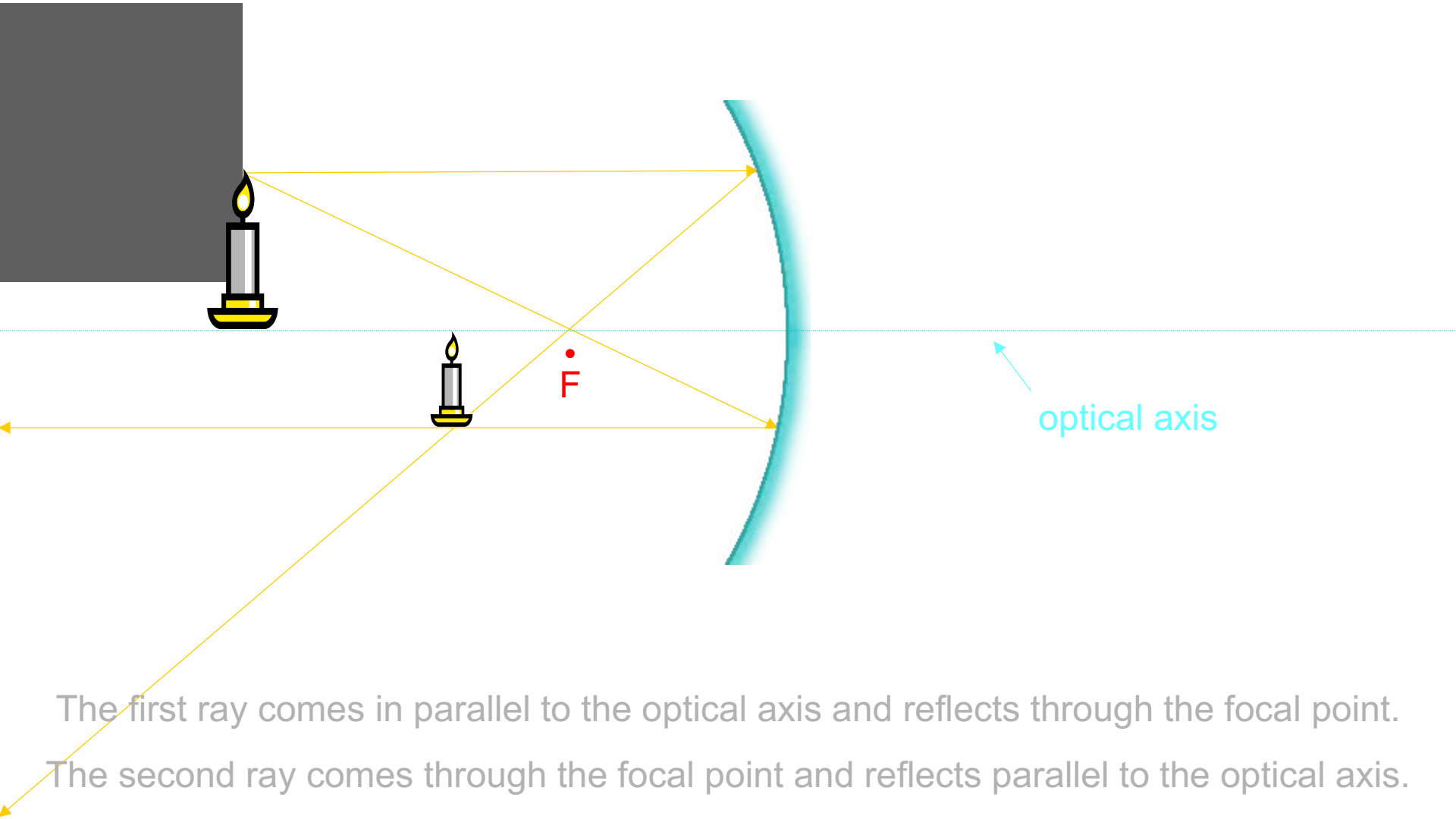
ray

focal point

optical axis

J.M. Gabrielse

Concave Mirror



The first ray comes in parallel to the optical axis and reflects through the focal point.

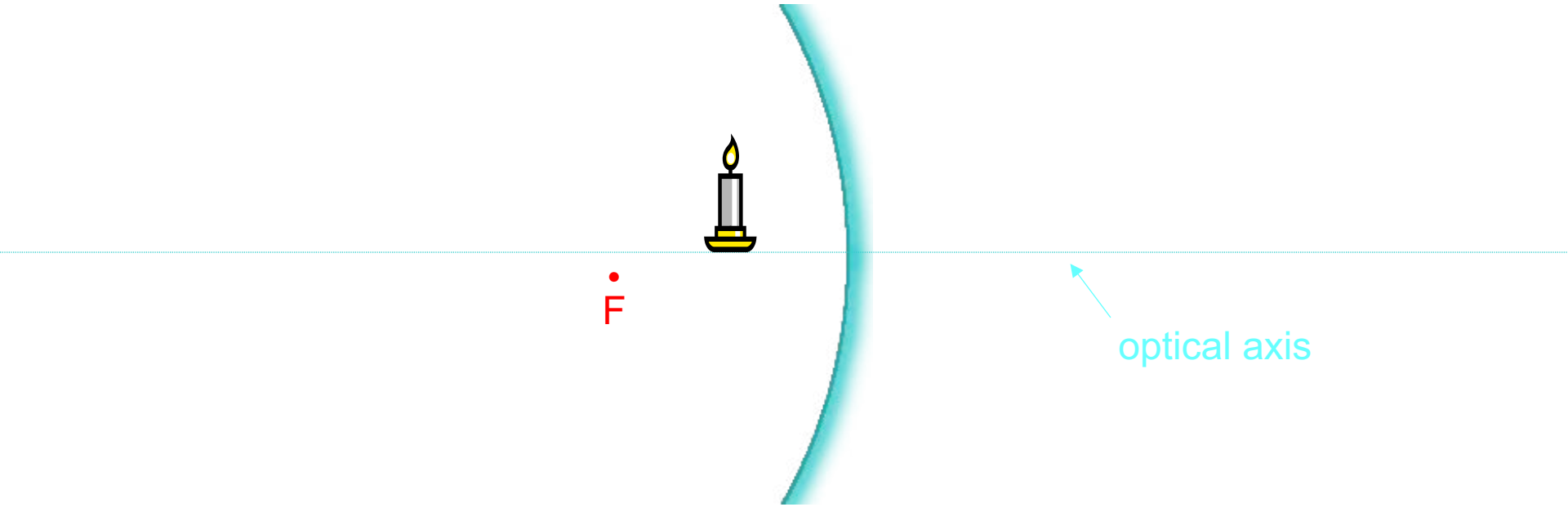
The second ray comes through the focal point and reflects parallel to the optical axis.

real image

light rays

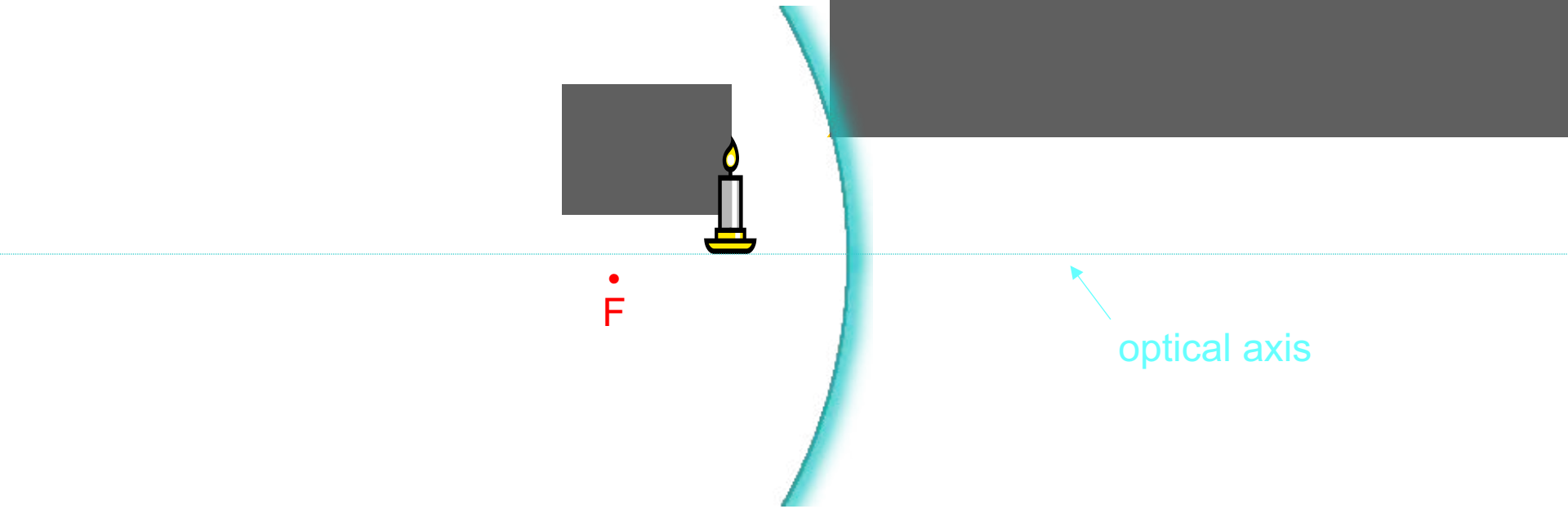
J.M. Gabrielse

Concave Mirror



Concave Mirror

le 2)



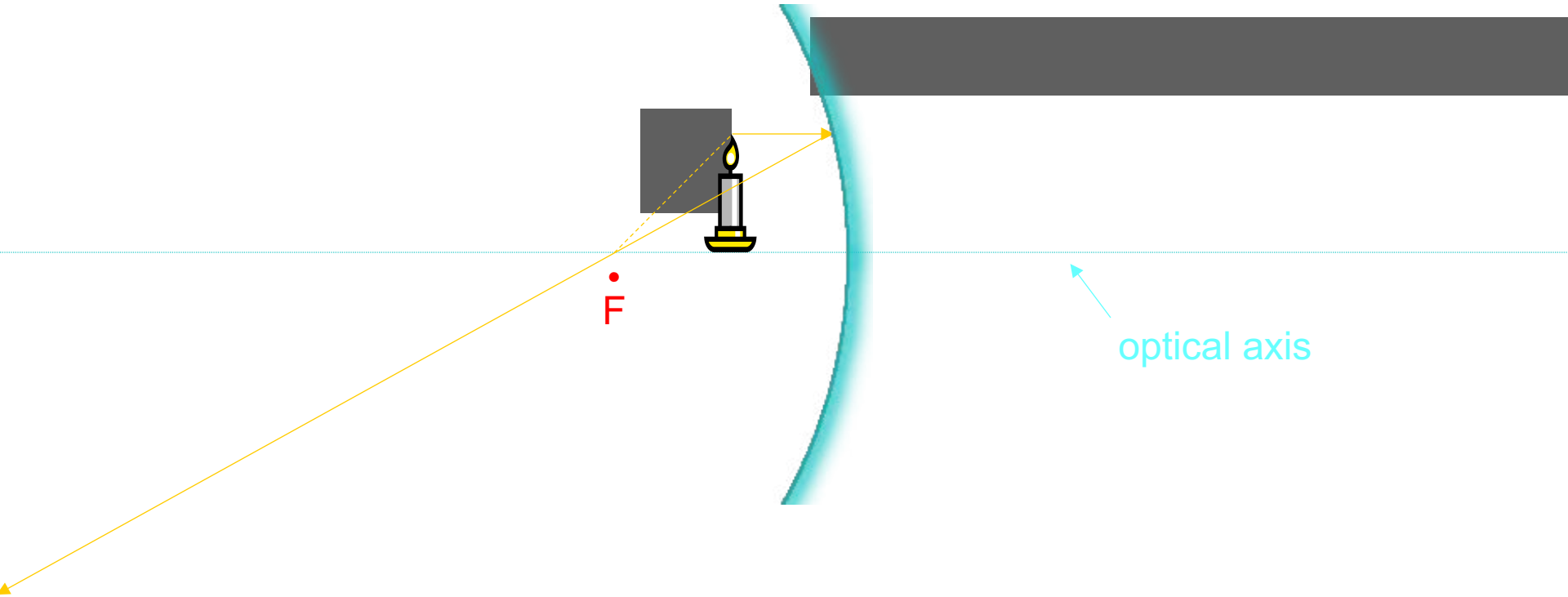
ray

optical axis

focal point

J.M. Gabrielse

Concave Mirror



The first ray comes in parallel to the optical axis and reflects through the focal point.

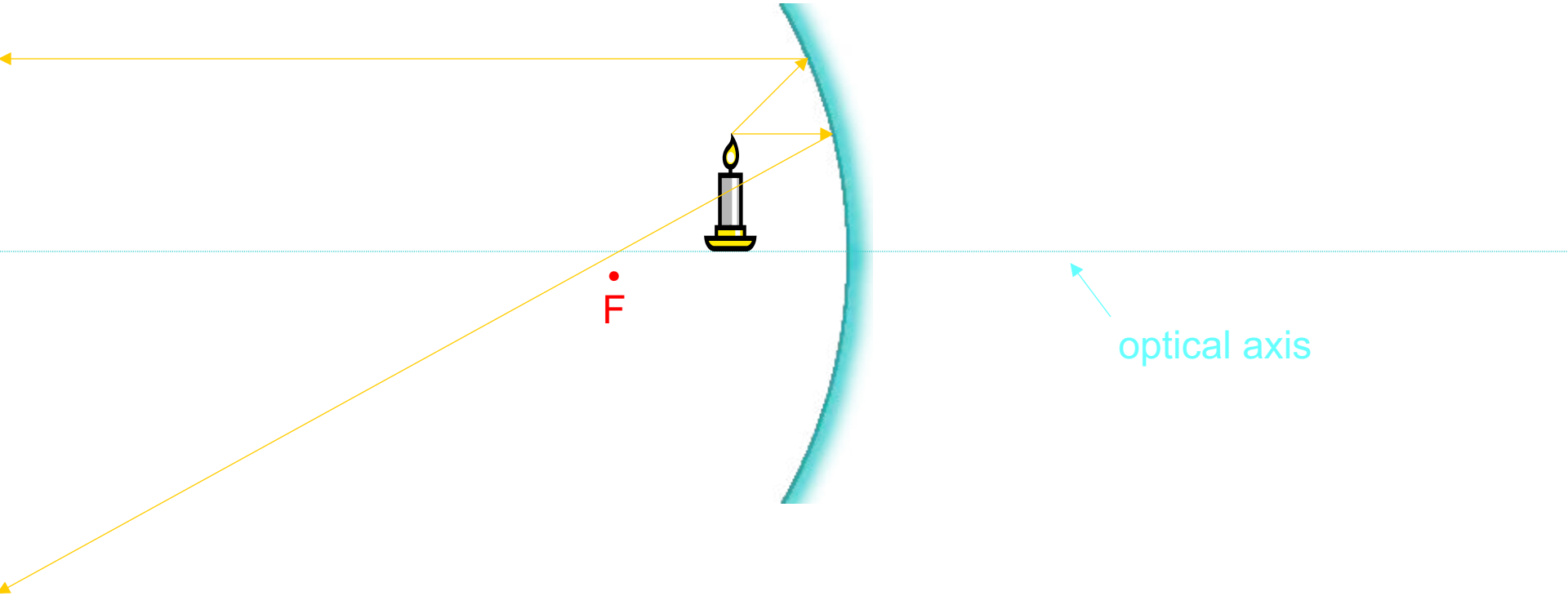
ray

focal point

optical axis

J.M. Gabrielse

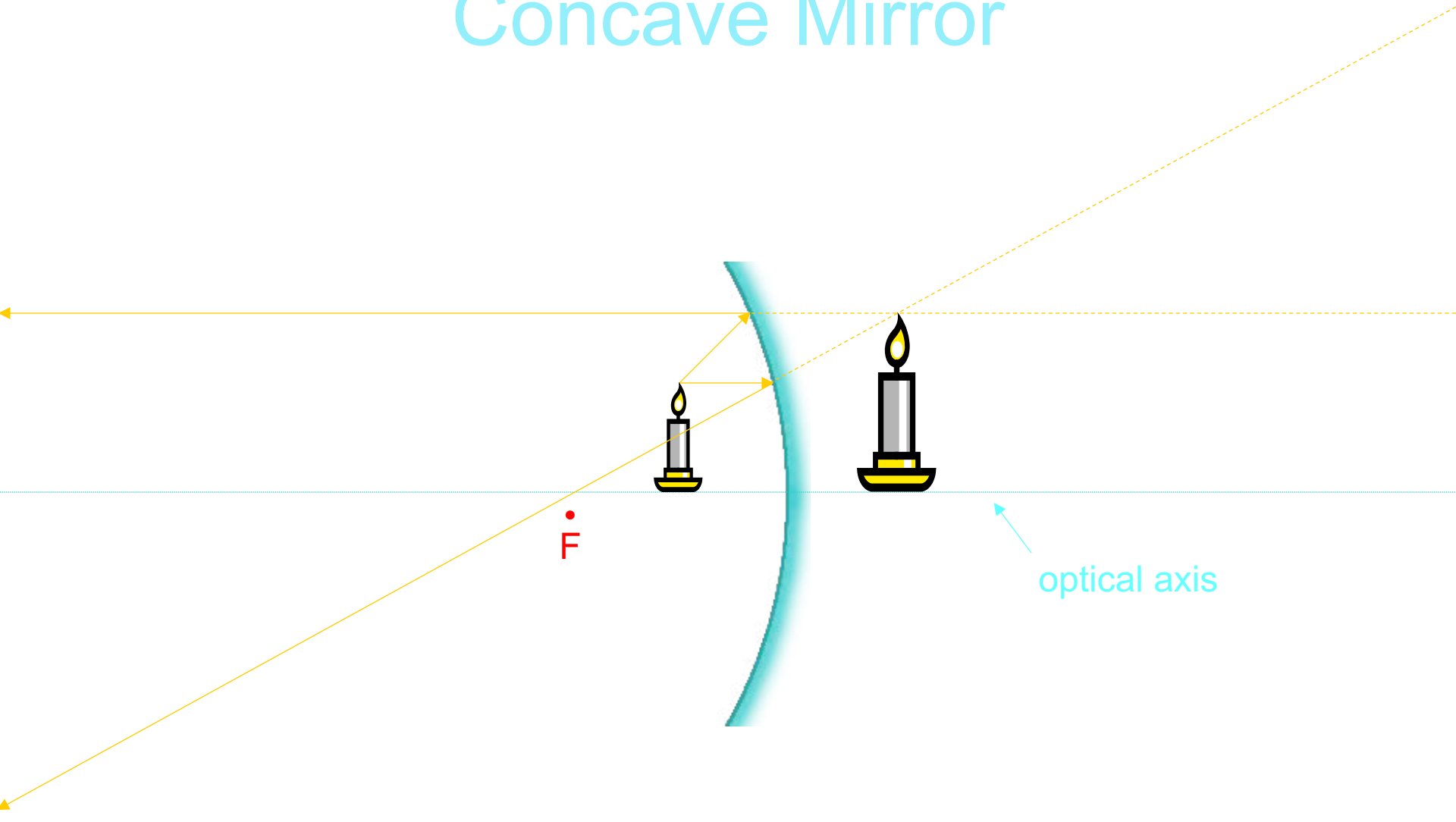
Concave Mirror



The first ray comes in parallel to the optical axis and reflects through the focal point.

The second ray comes through the focal point and reflects parallel to the optical axis.

Concave Mirror

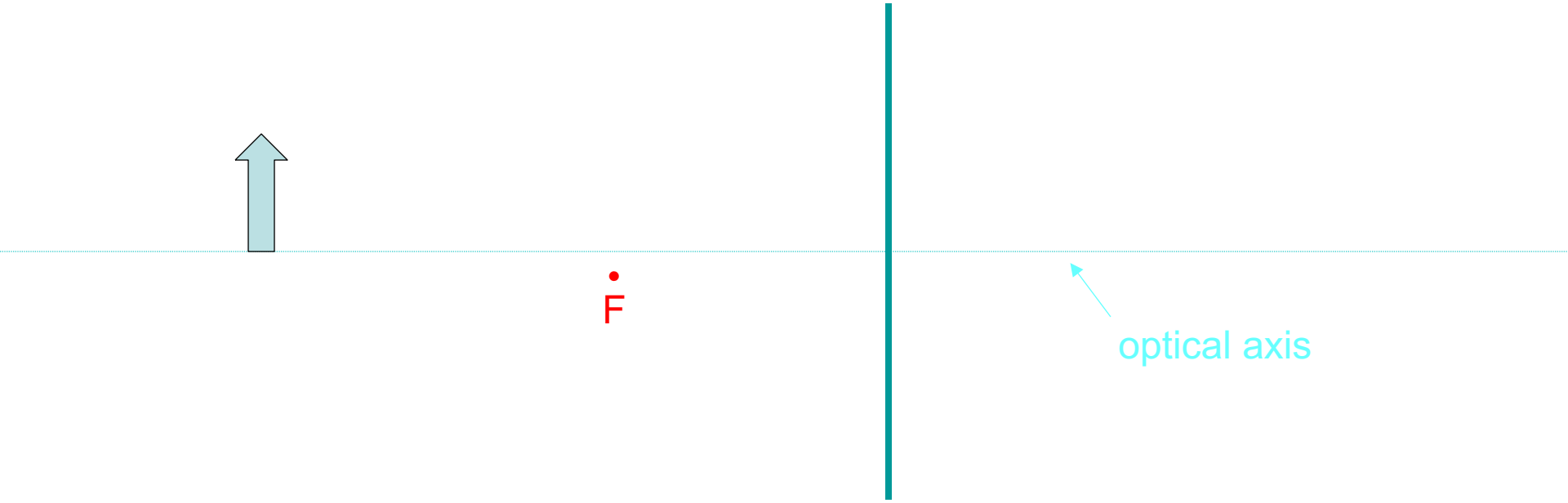


The first ray comes in parallel to the optical axis and reflects through the focal point.

The second ray comes through the focal point and reflects parallel to the optical axis.

virtual image *sight rays* J.M. Gabrielse

Concave Mirror



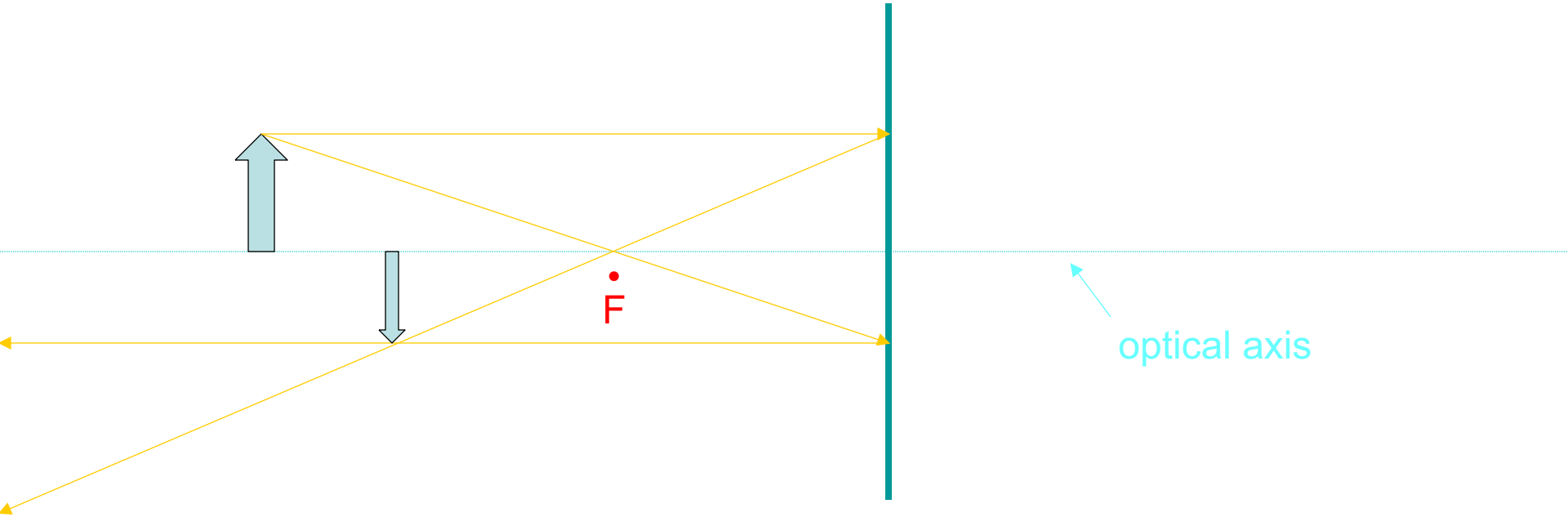
mirrors

mirror

image

J.M. Gabrielse

Concave Mirror

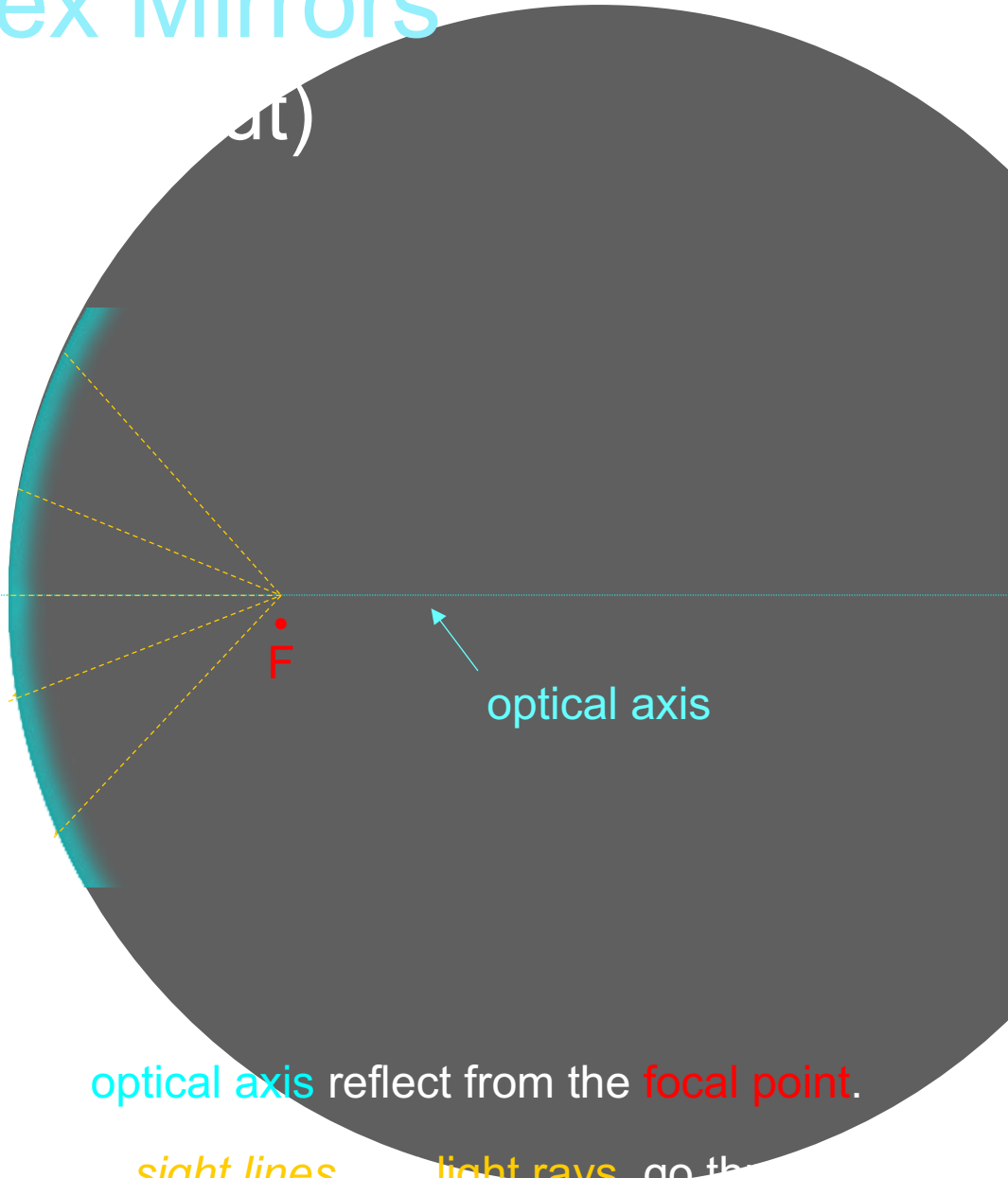


mirrors lenses

mirror lens

image

Convex Mirrors

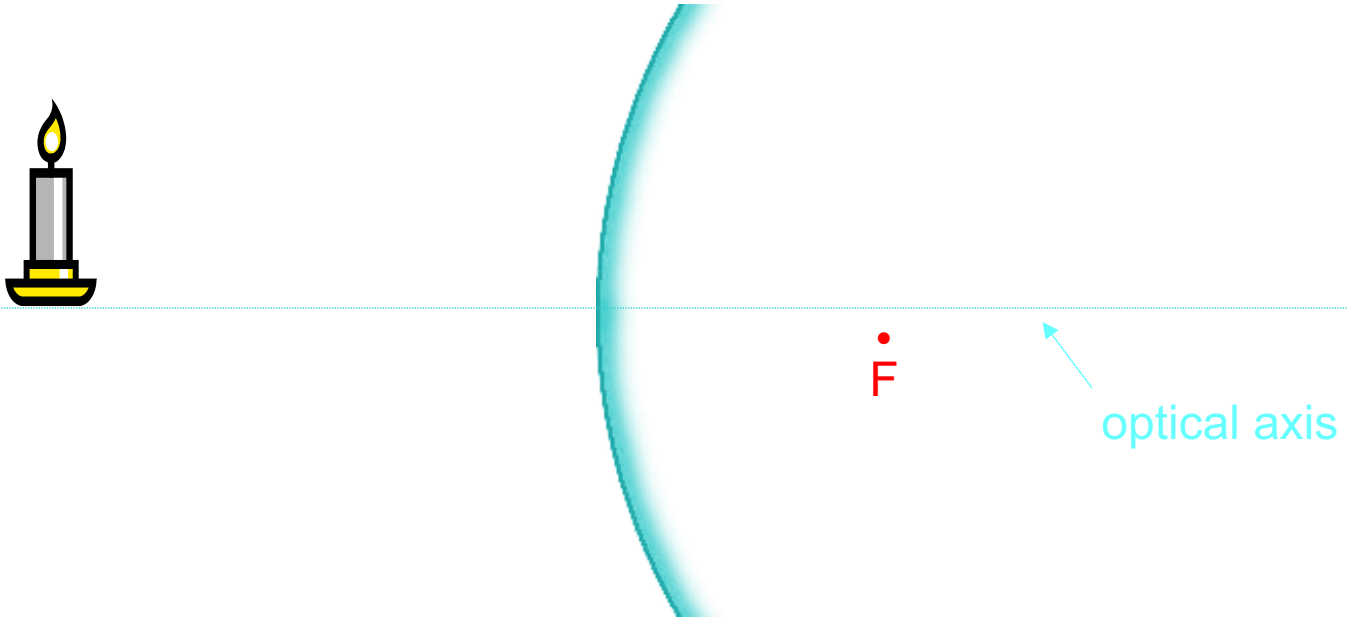


Light rays optical axis reflect from the focal point.

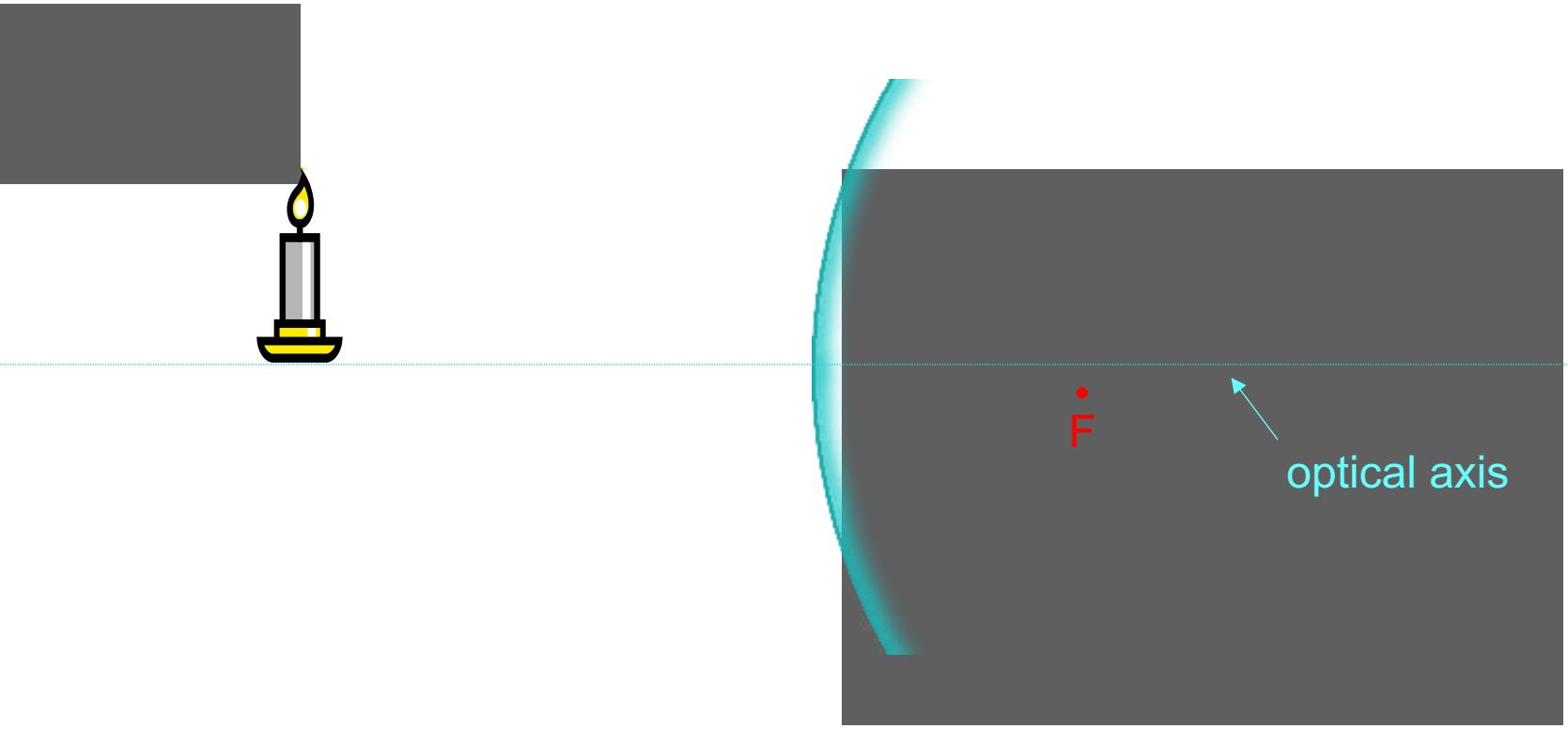
focal point *sight lines* light rays go th

J.M. Gabrielse

Convex Mirror



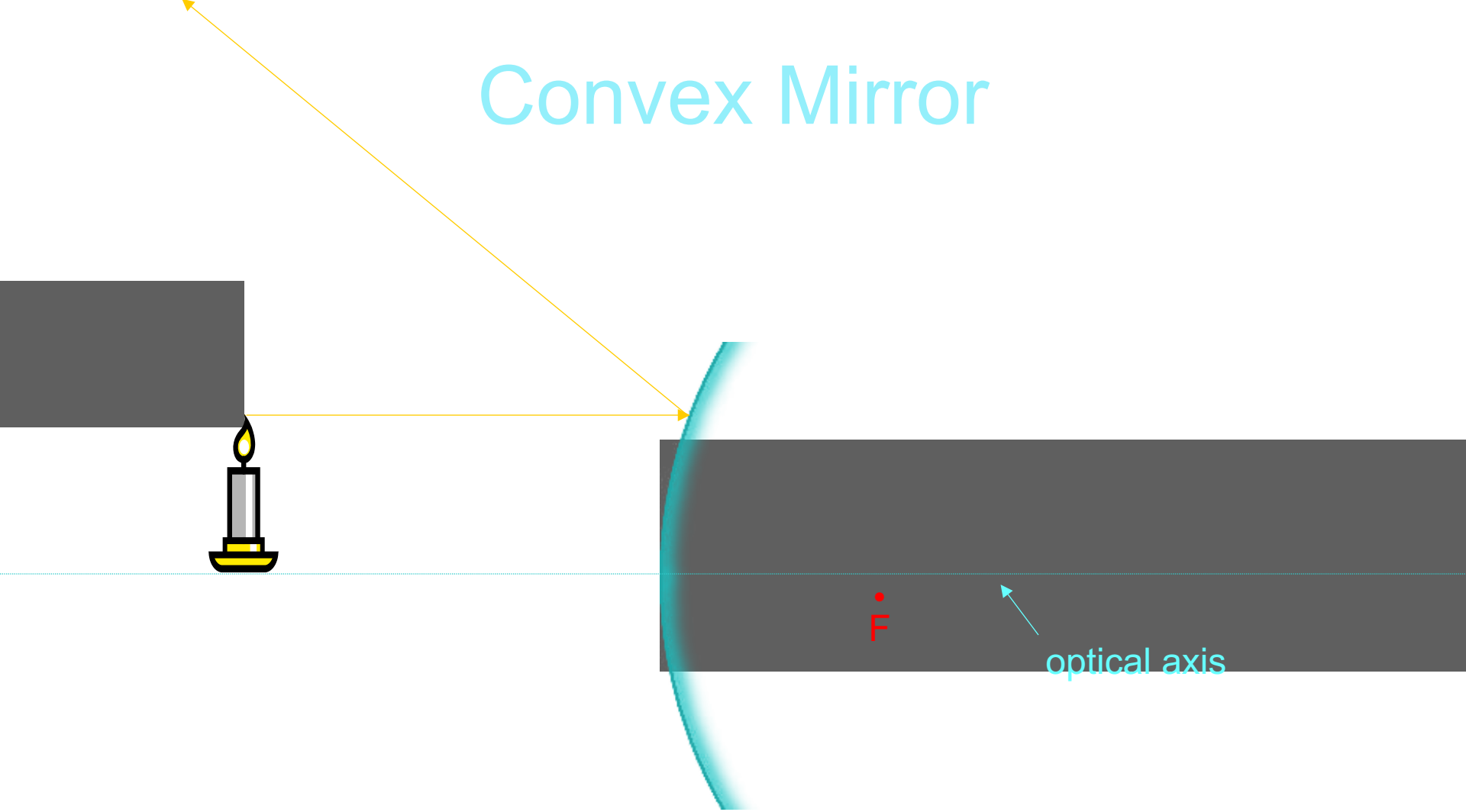
Convex Mirror



ray optical axis focal point

J.M. Gabrielse

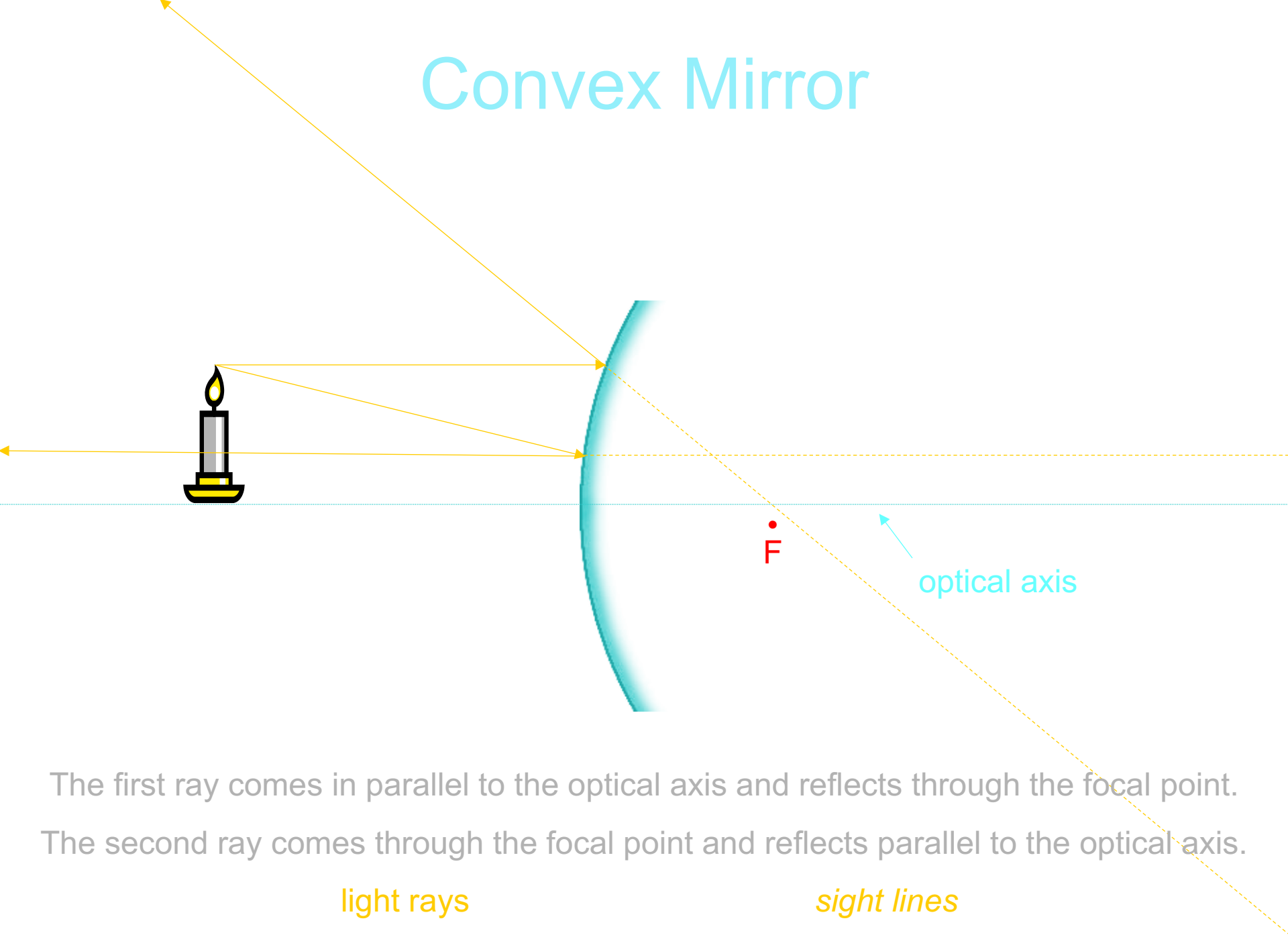
Convex Mirror



The first ray comes in parallel to the optical axis and reflects through the focal point.

ray focal point optical axis

Convex Mirror



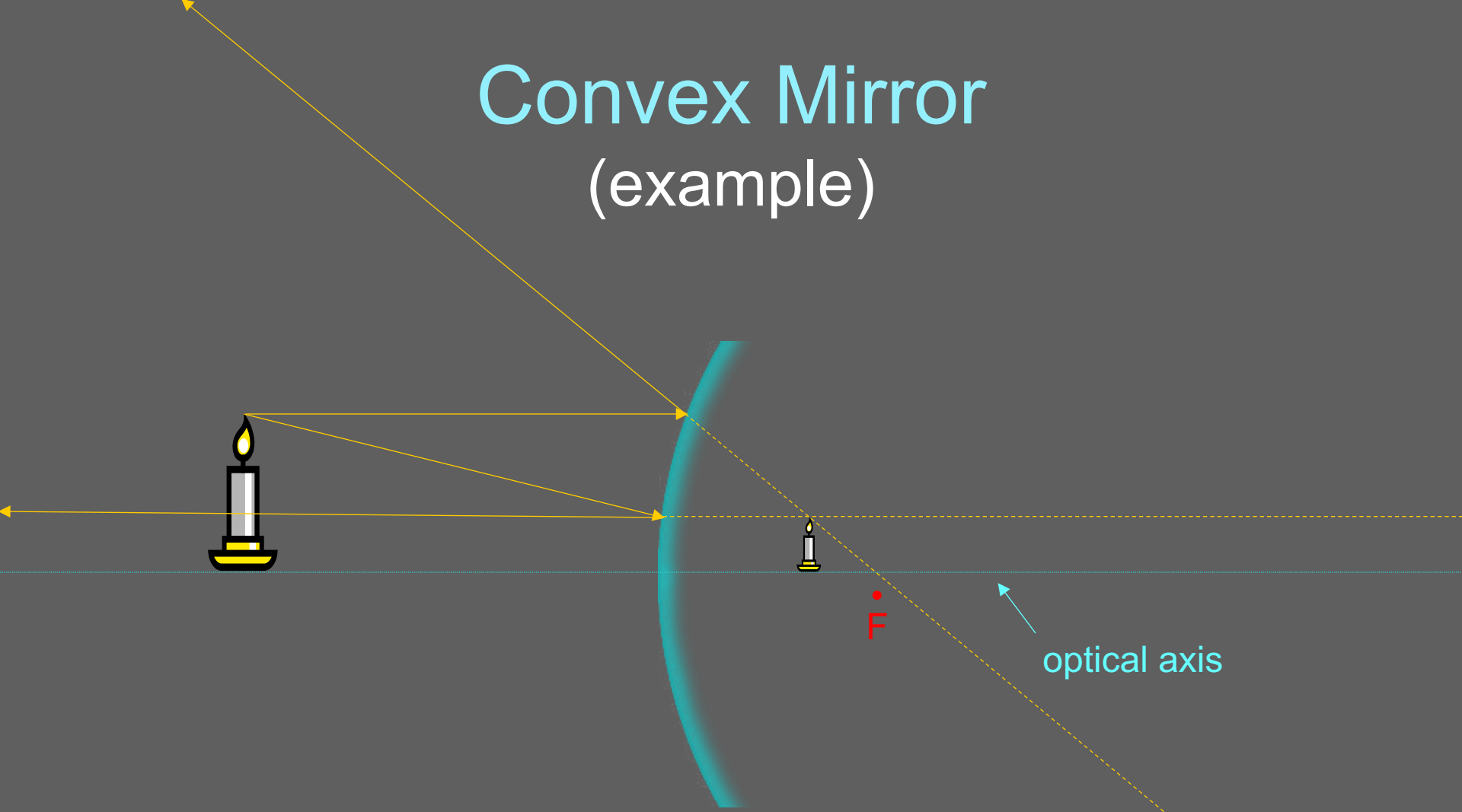
The first ray comes in parallel to the optical axis and reflects through the focal point.

The second ray comes through the focal point and reflects parallel to the optical axis.

light rays *sight lines*

J.M. Gabrielse

Convex Mirror
(example)



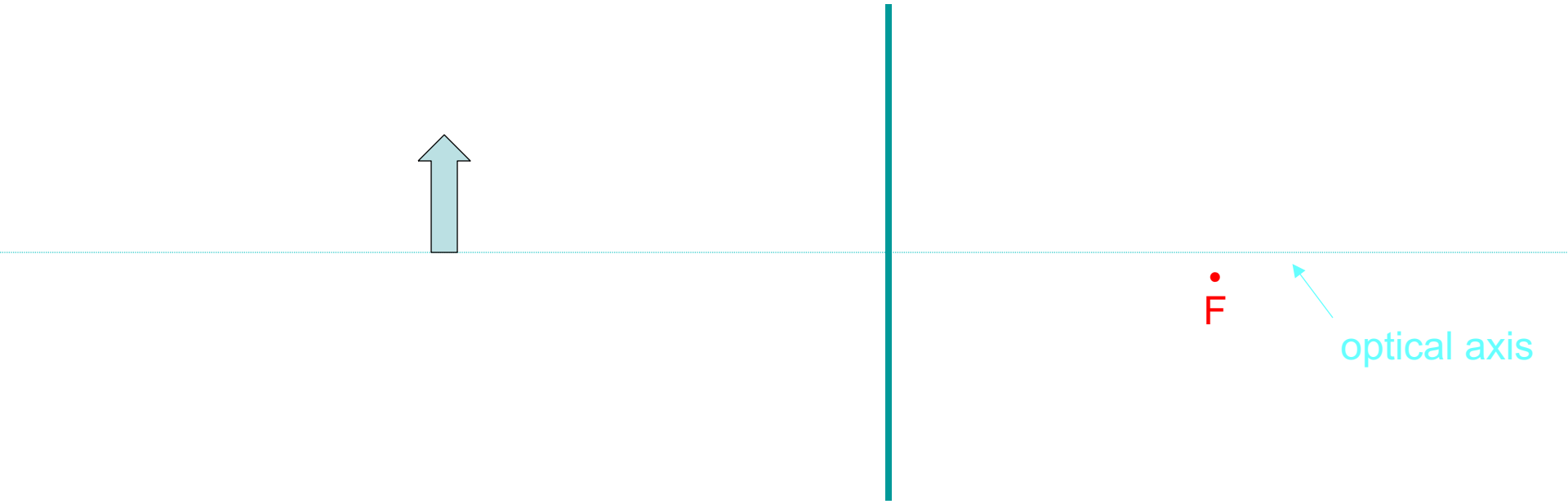
The first ray comes in parallel to the optical axis and reflects through the focal point.

The second ray comes through the focal point and reflects parallel to the optical axis.

The light rays don't converge, but the *sight lines* do.

A virtual image forms where the *sight lines* converge.

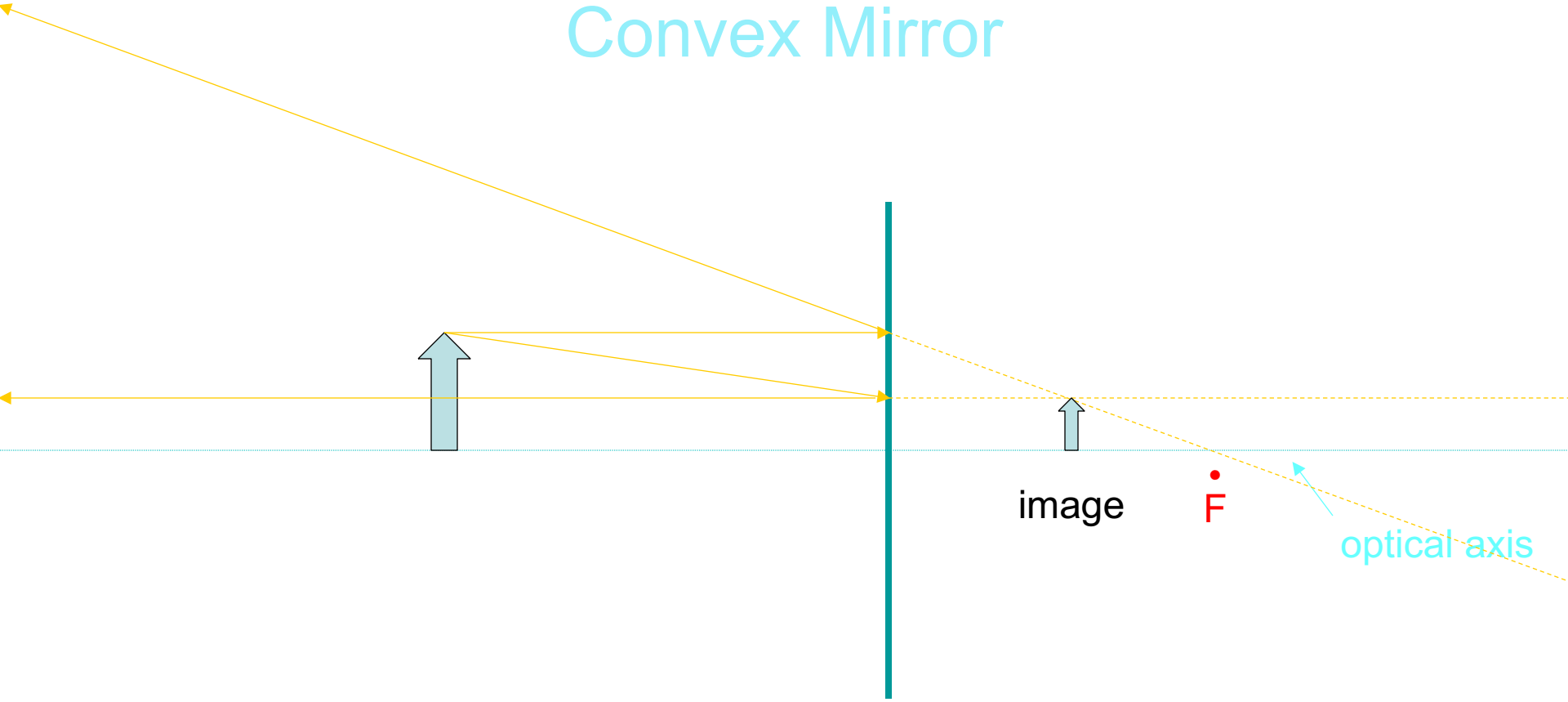
Convex Mirror



mirrors

image

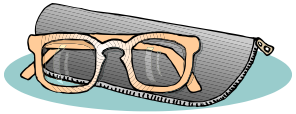
Convex Mirror



mirrors

image

J.M. Gabrielse



Lens Mirror

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

f = focal length
d_o = object distance
d_i = image distance

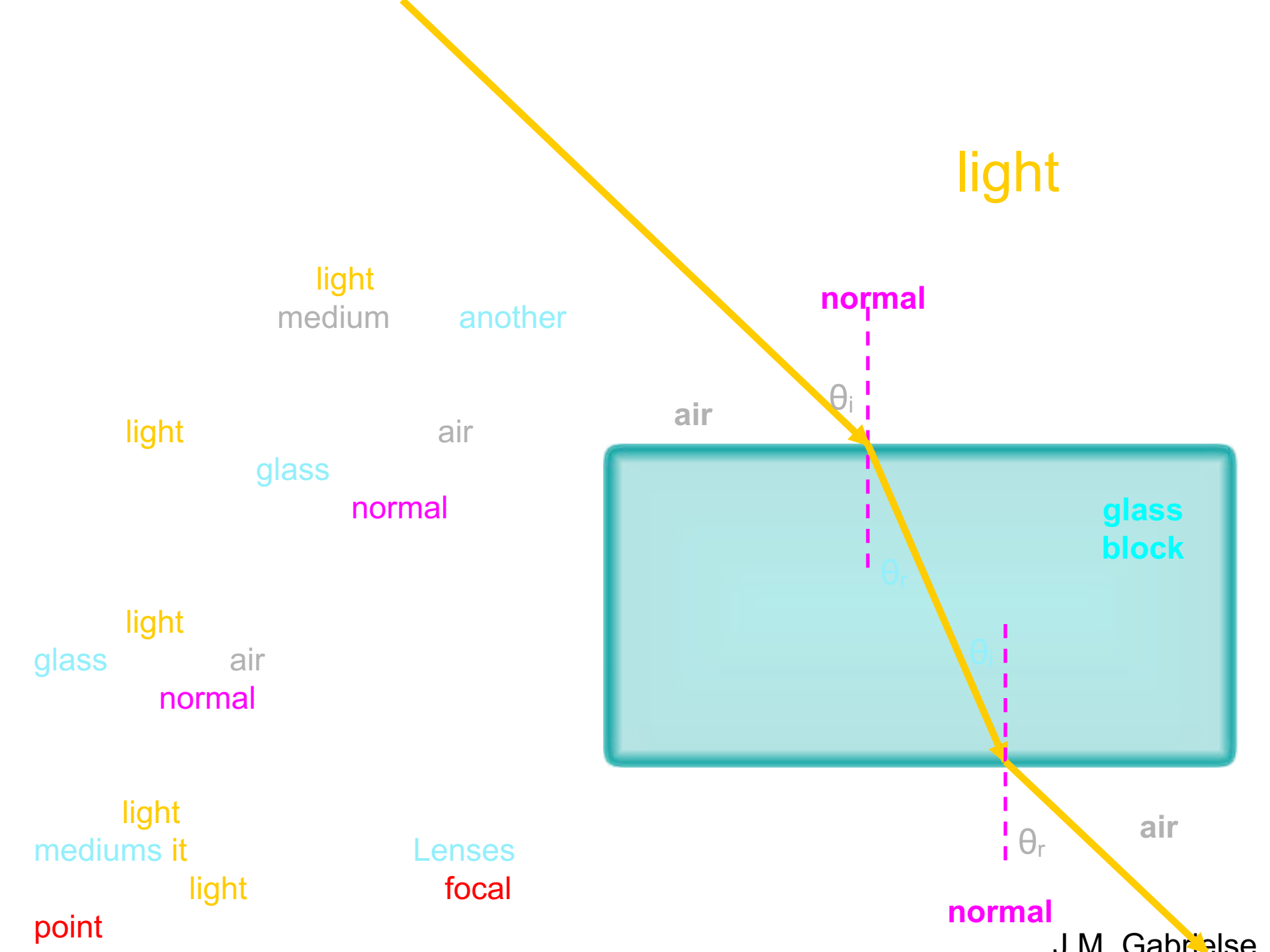
f is negative for diverging mirrors and lenses
d_i is negative when the image is behind the lens or mirror

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

m = magnification
h_i = image height
h_o = object height

If height is negative the image is upside down

if the magnification is negative
the image is inverted (upside down)



light
medium another

light air
glass
normal

light
glass air
normal

light
mediums it Lenses
light focal
point

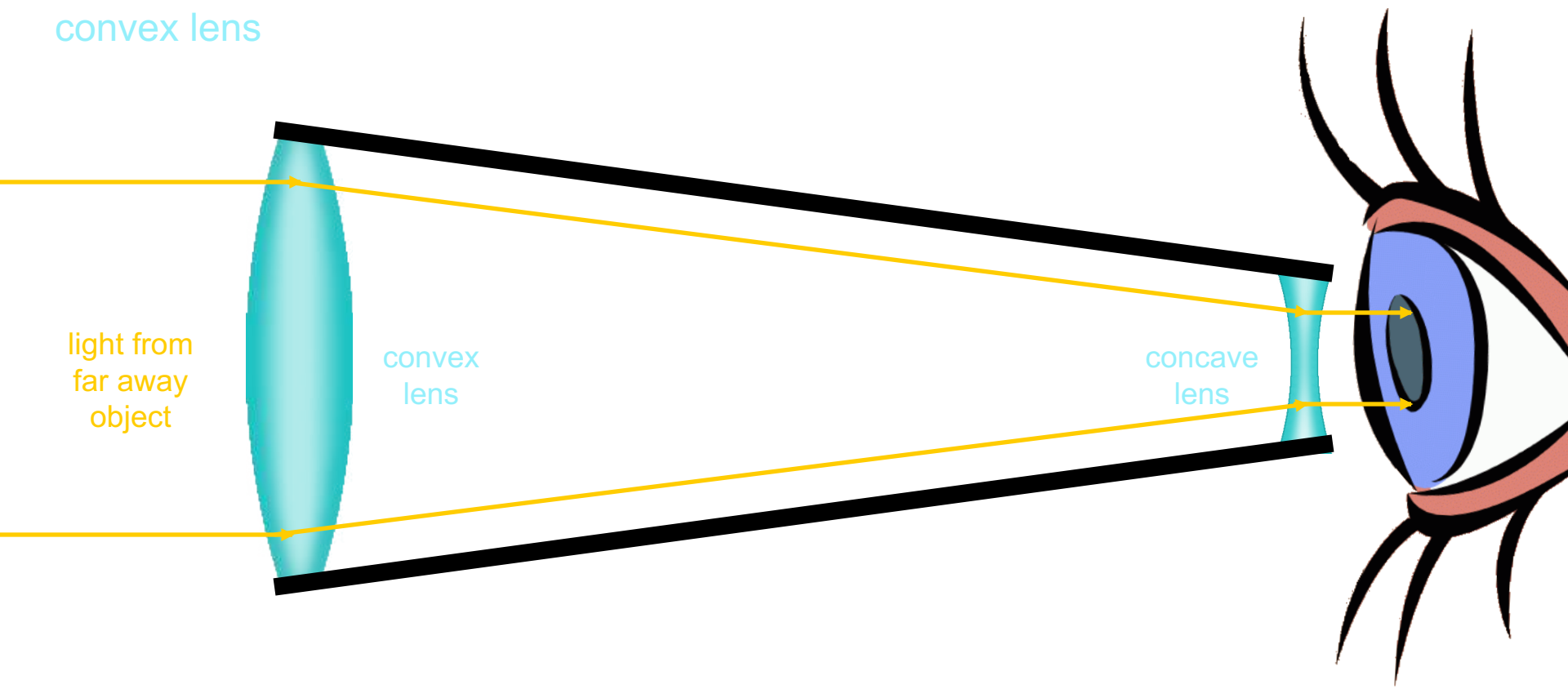
Lenses

lenses

light

concave lens

convex lens

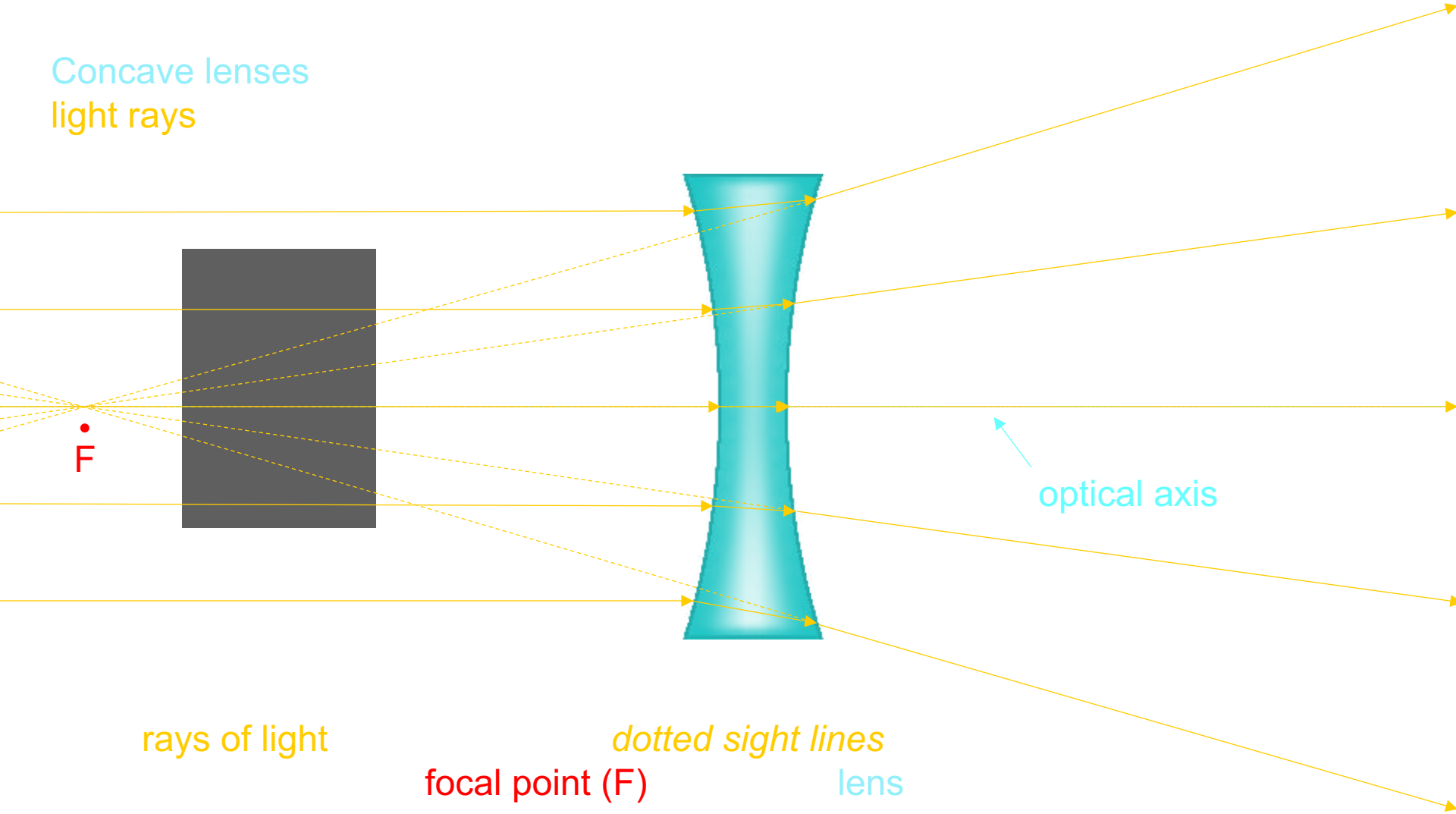


Light rays

J.M. Gabrielse

Concave Lenses

Concave lenses
light rays



rays of light

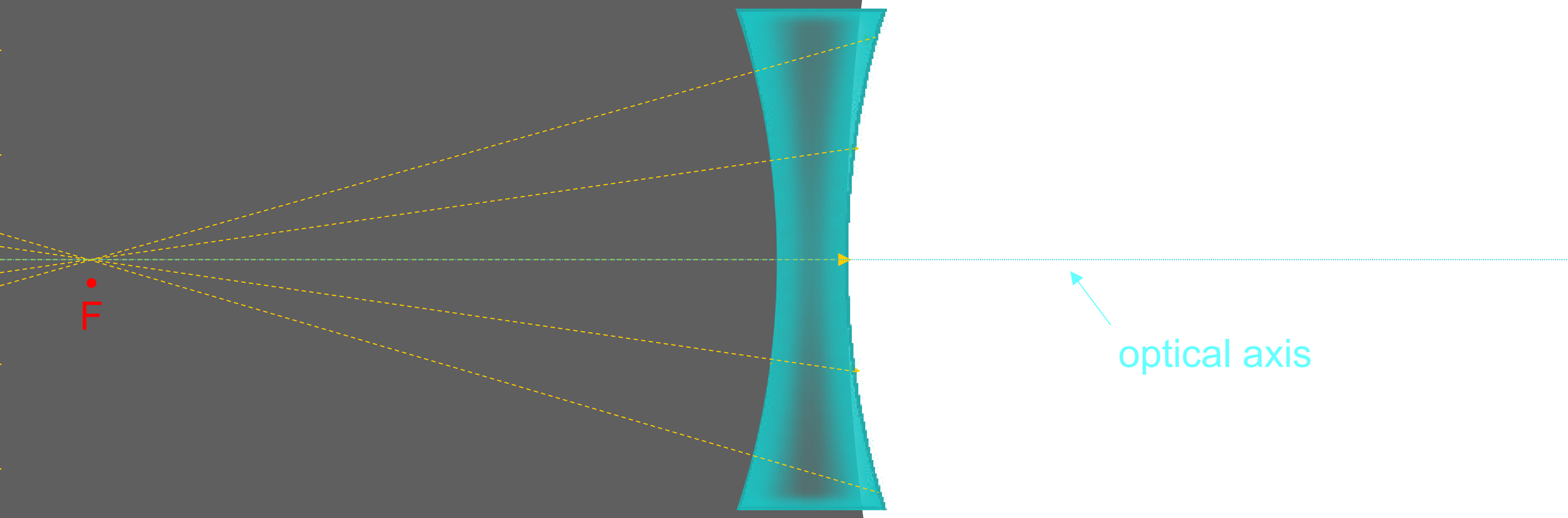
dotted sight lines

focal point (F)

lens

J.M. Gabrielse

Concave Lenses



Light rays that come in parallel to the optical axis

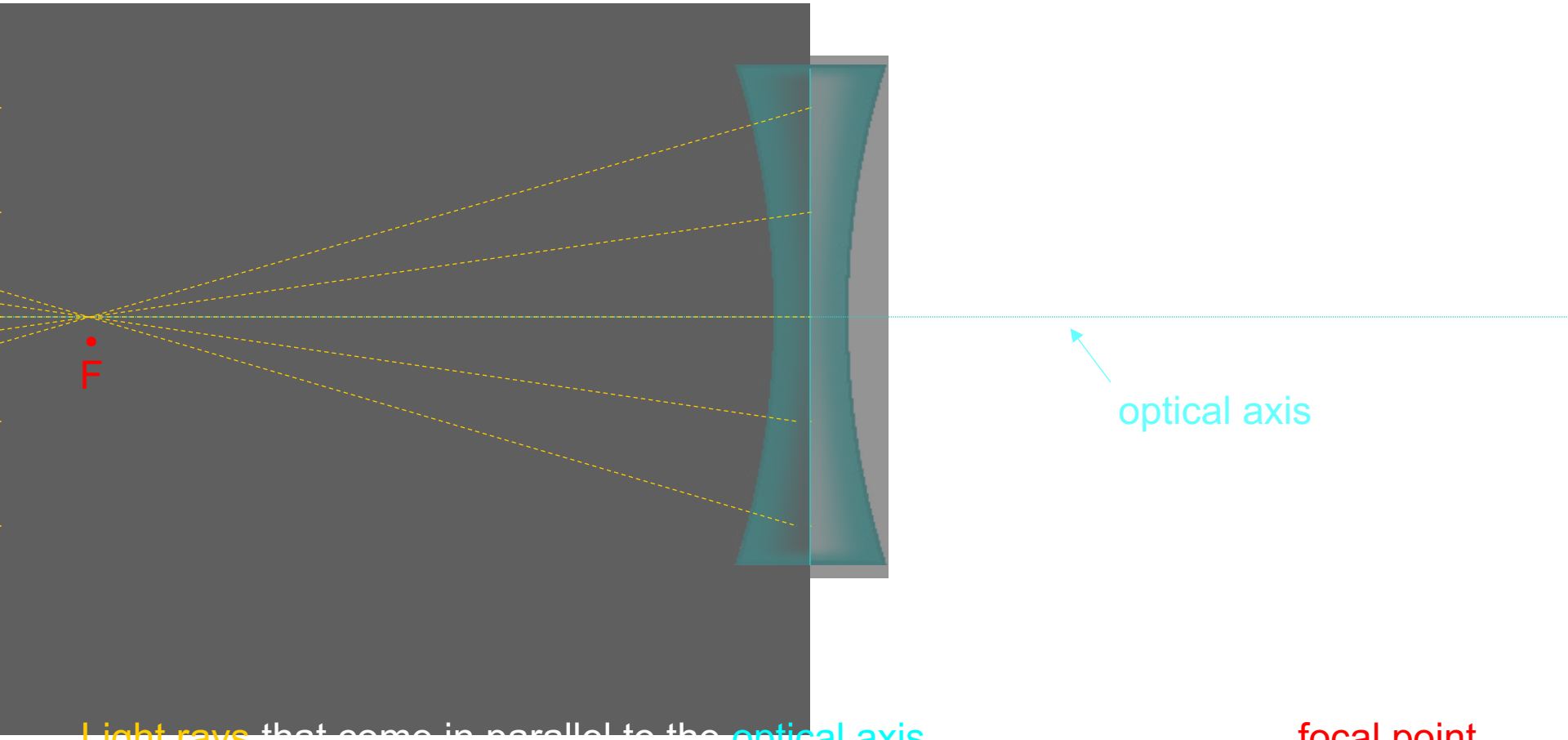
The light rays behave the same way if we

focal point

lens

J.M. Gabrielse

Concave Lenses

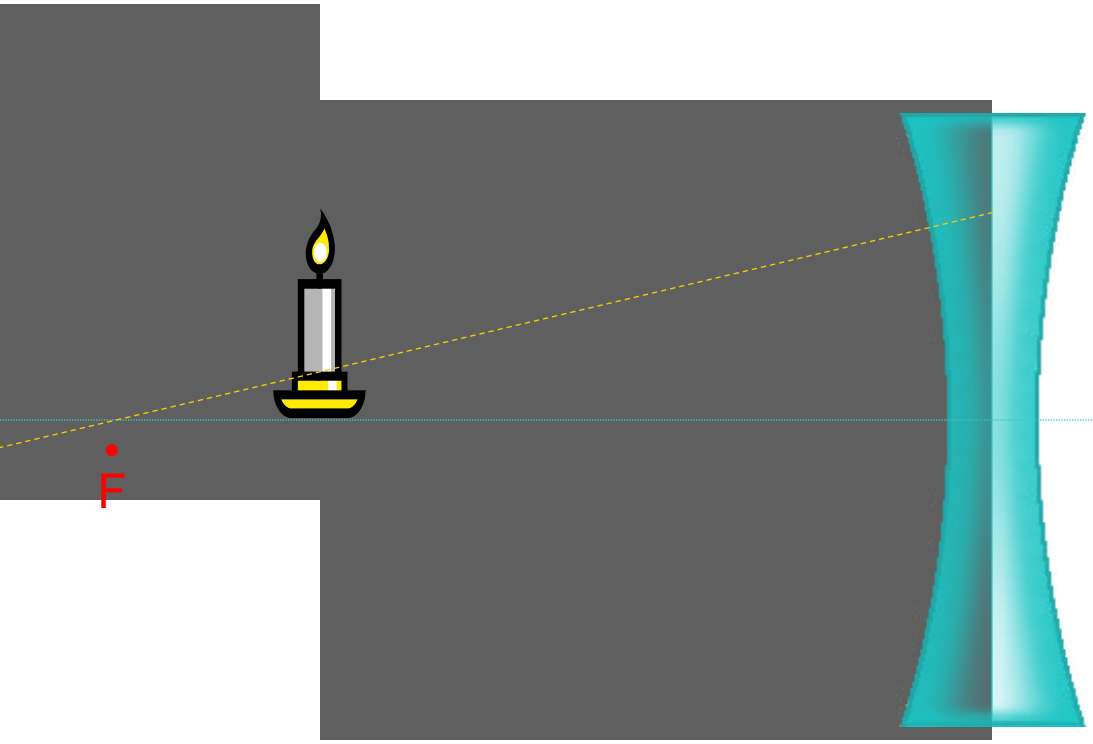


Light rays that come in parallel to the optical axis

focal point

J.M. Gabrielse

Concave Lens



optical axis

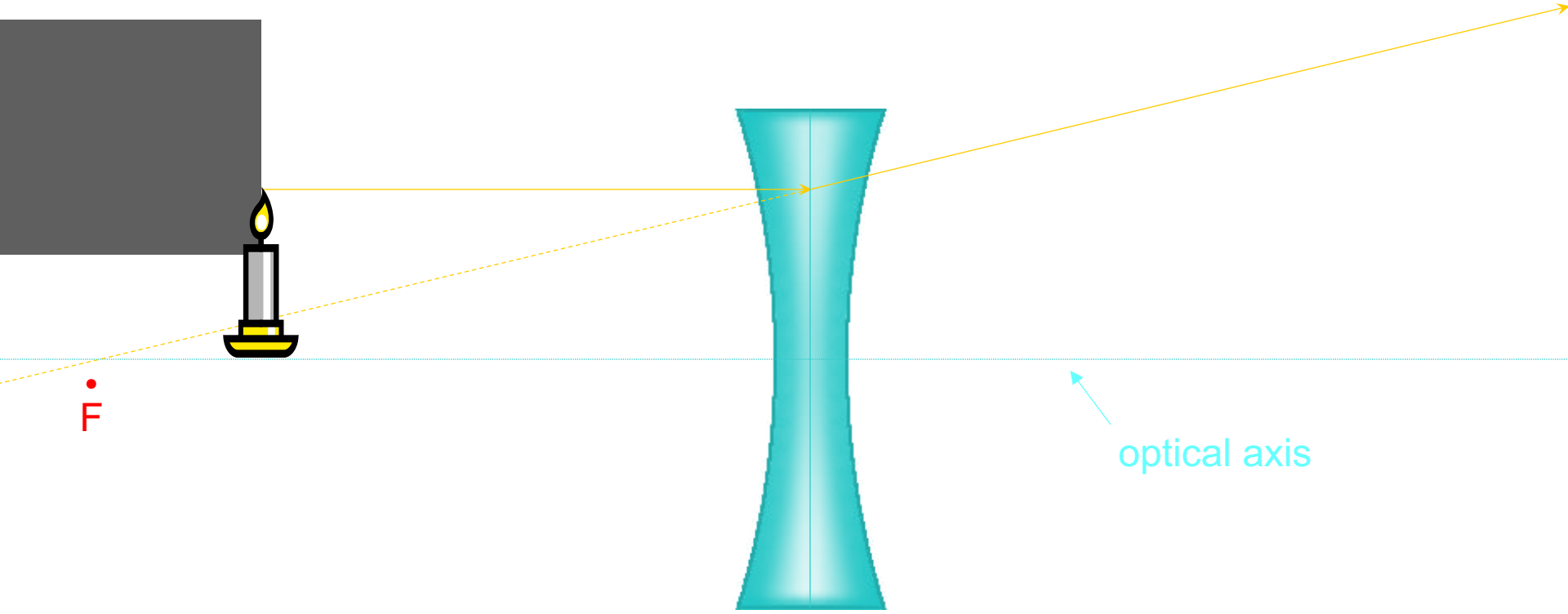
ray

optical axis

focal point

J.M. Gabrielse

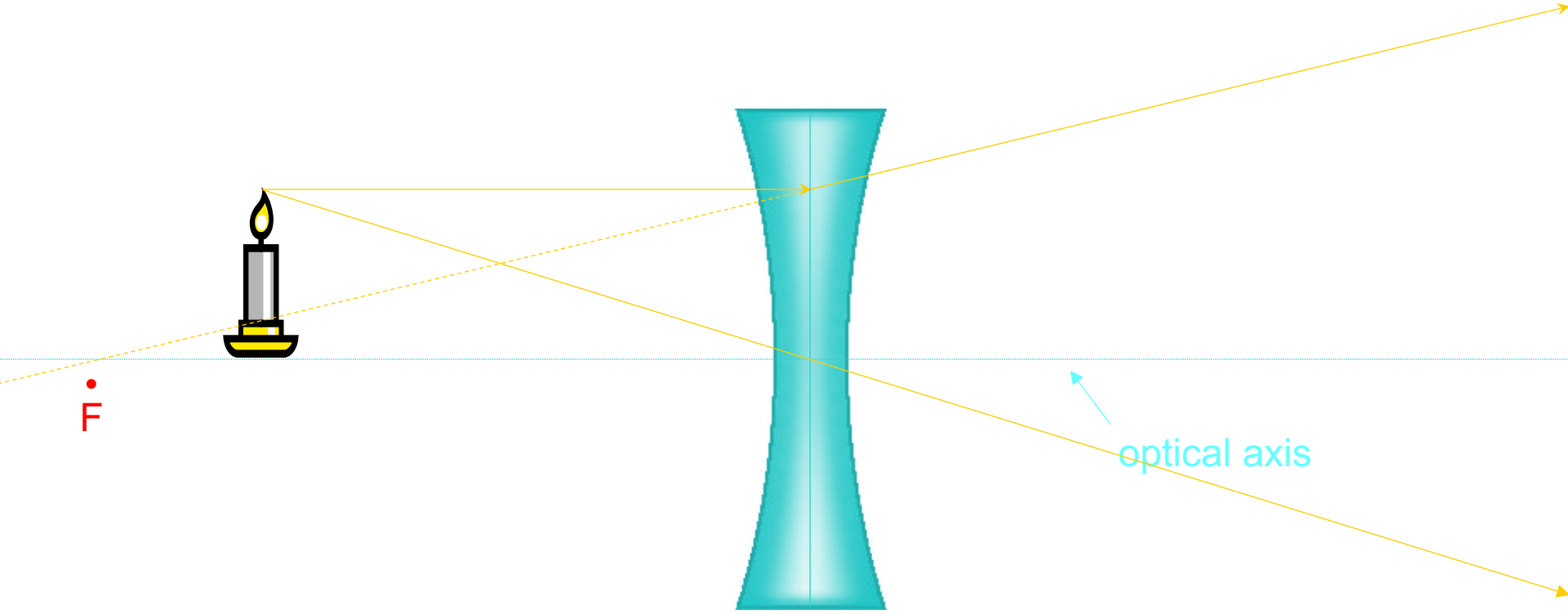
Lens



The first ray comes in parallel to the optical axis and refracts from the focal point.

ray lens.

Concave Lens



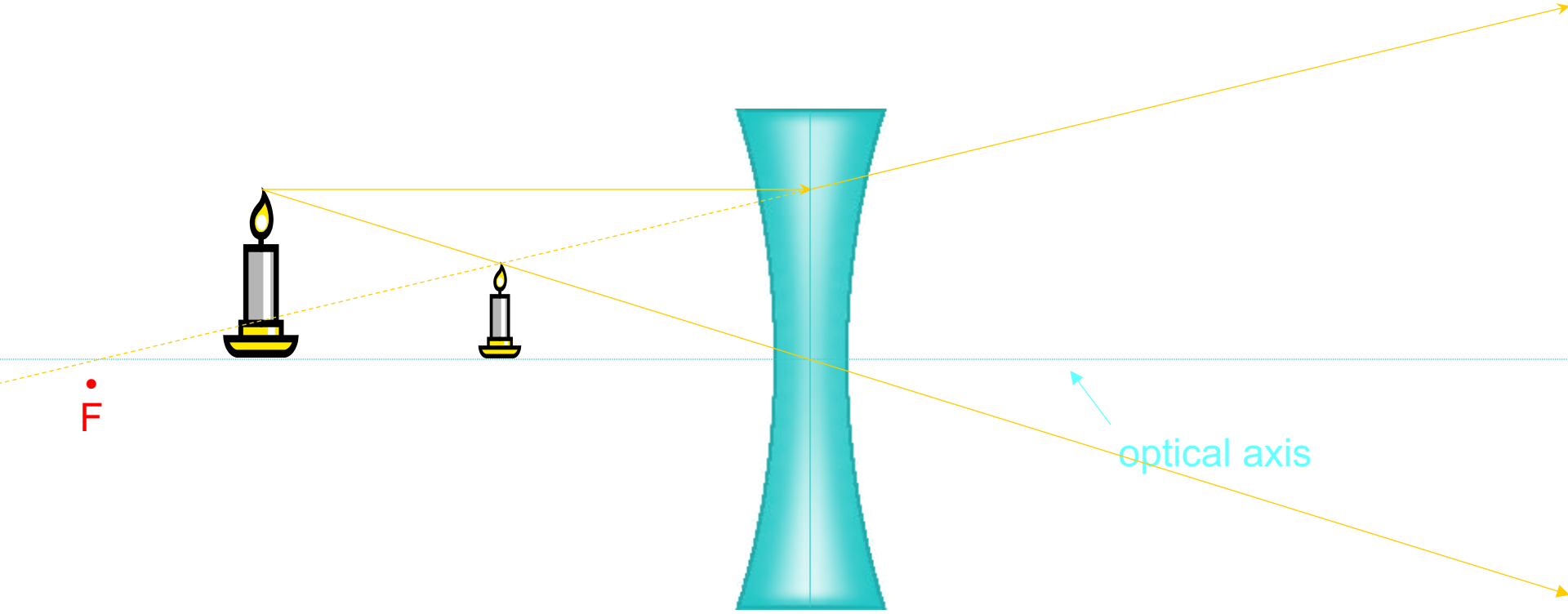
The first ray comes in parallel to the optical axis and refracts from the focal point.

The second ray goes straight through the center of the lens.

light rays *sight lines*

J.M. Gabrielse

Concave Lens



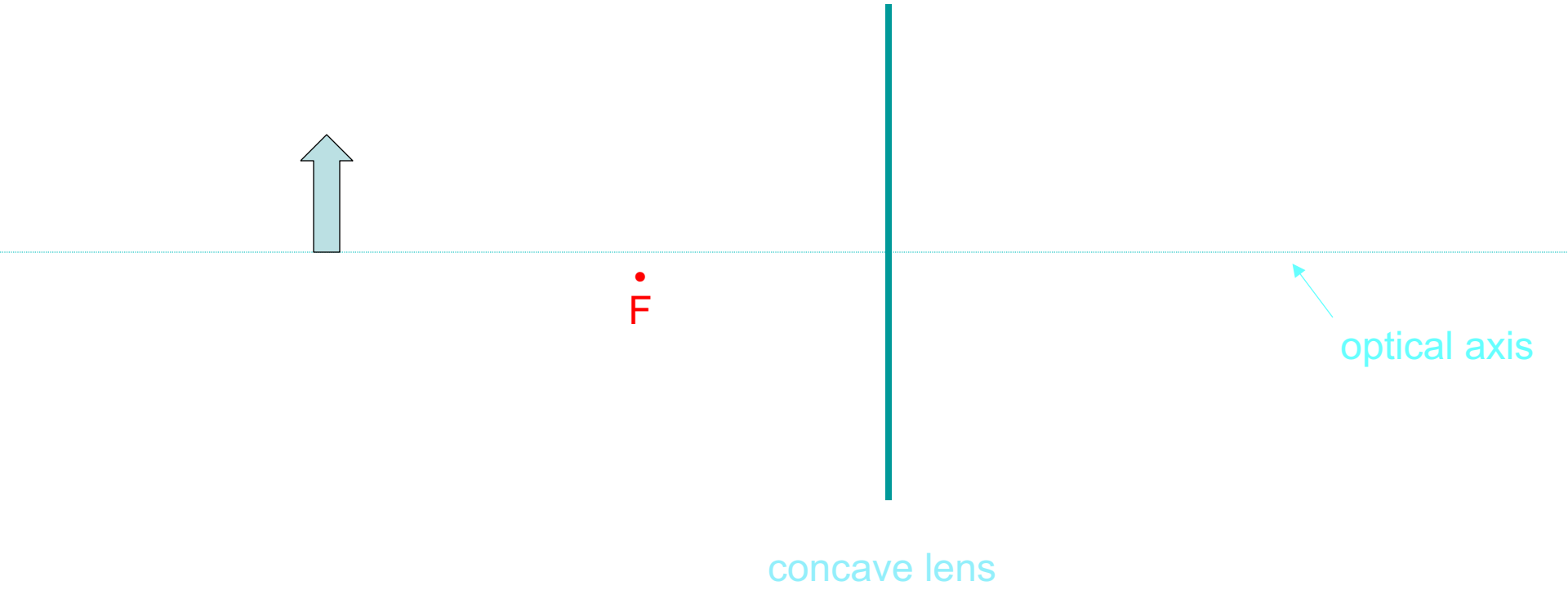
The first ray comes in parallel to the optical axis and refracts from the focal point.

The second ray goes straight through the center of the lens.

The light rays don't converge, but the *sight lines* do.

image *sight lines* J.M. Gabrielse

Concave Lens



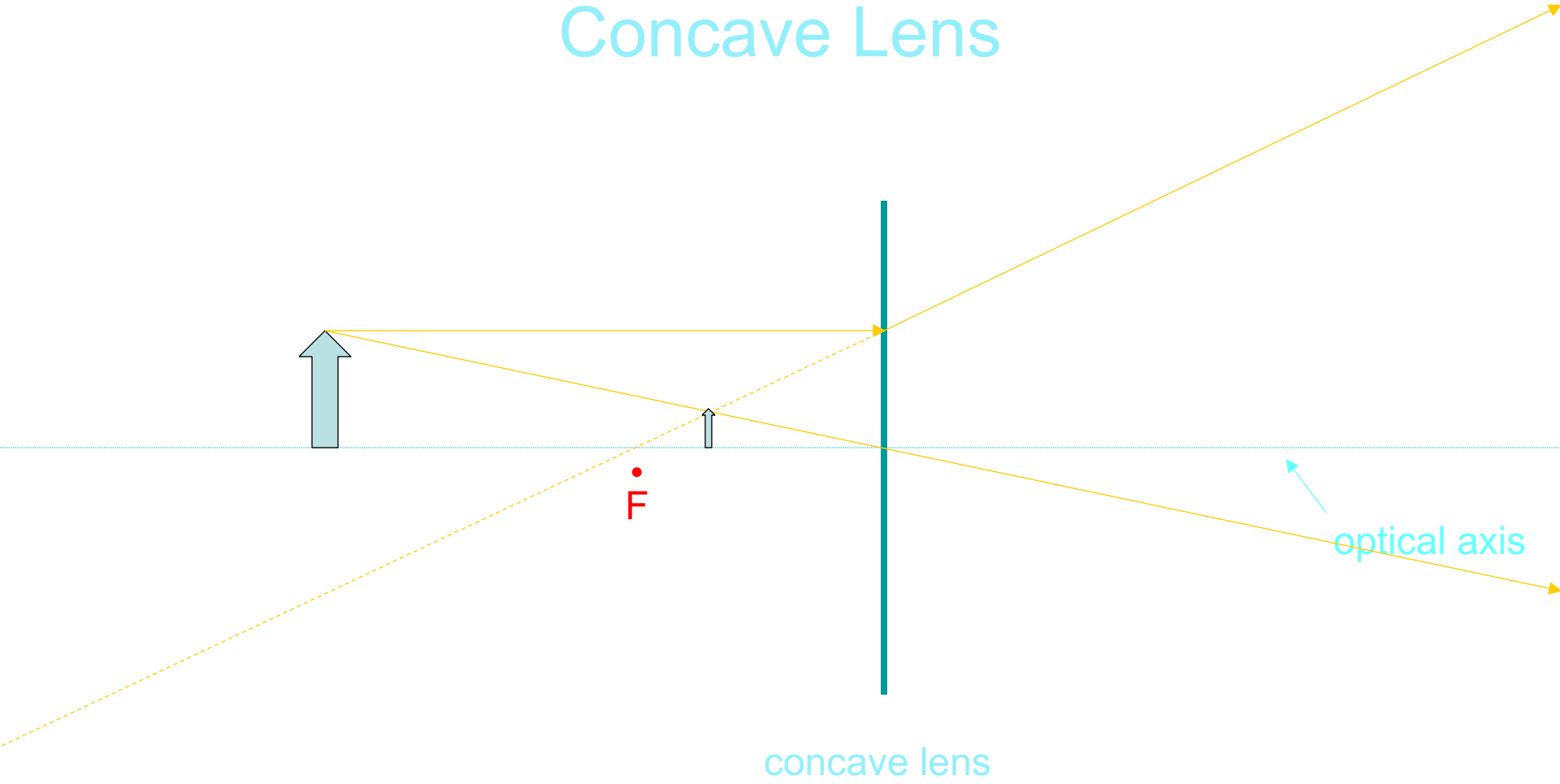
lenses

lens

image

J.M. Gabrielse

Concave Lens



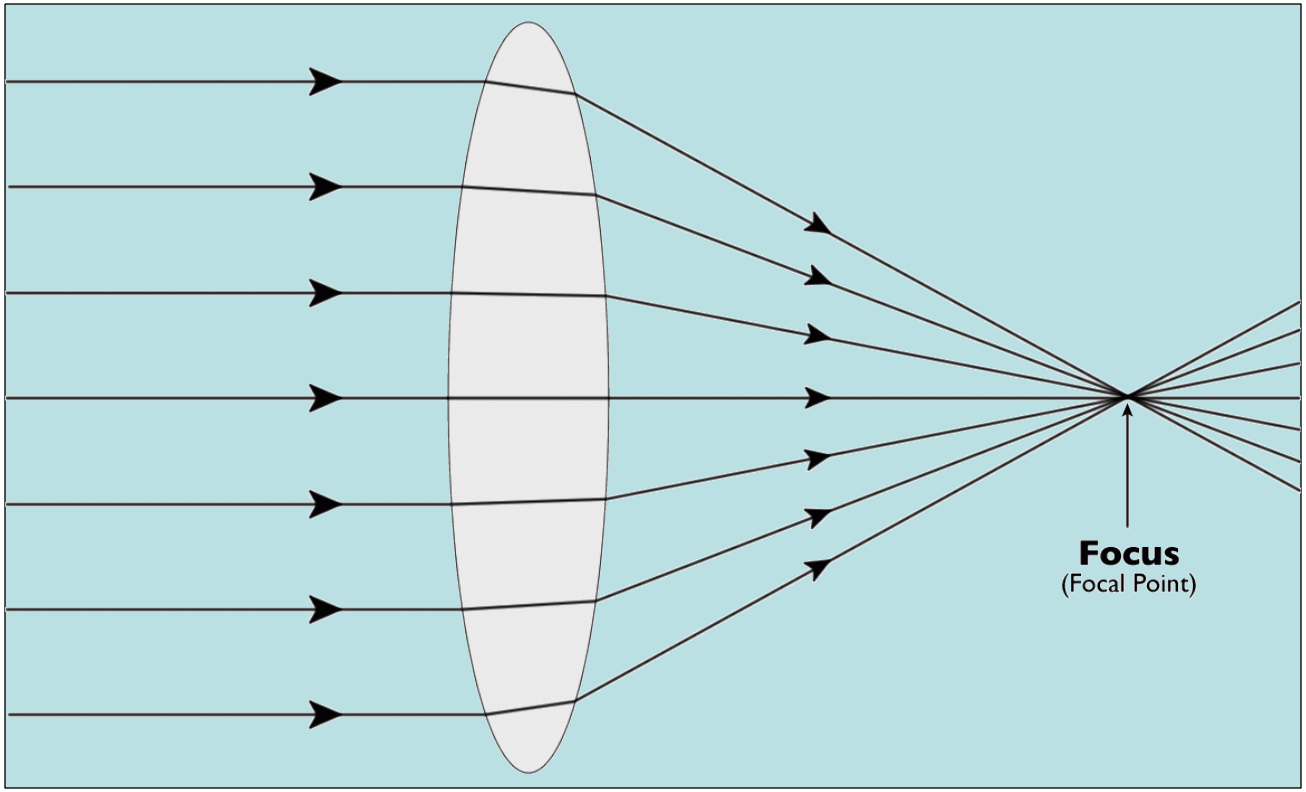
: lenses

lens

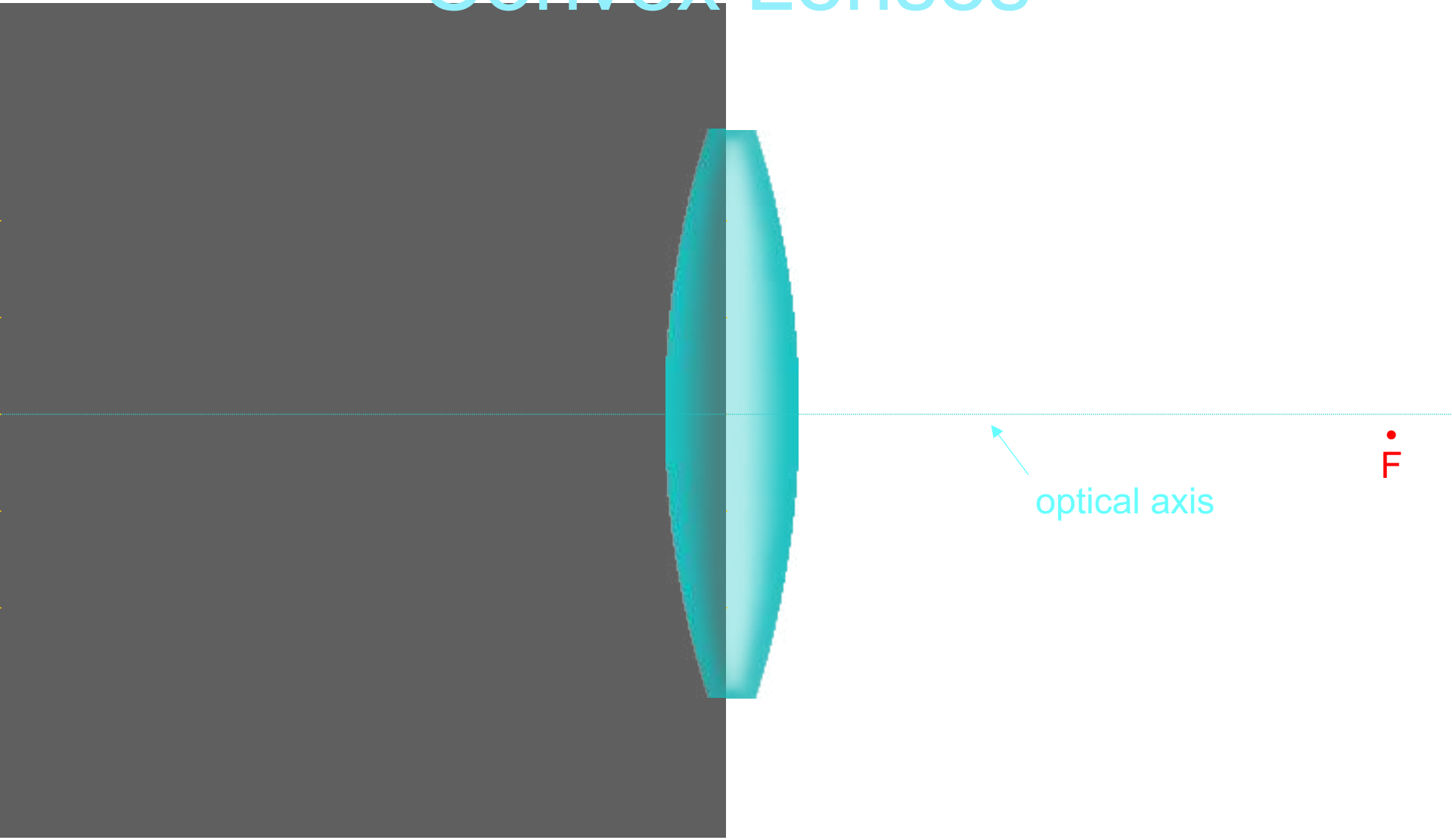
image

J.M. Gabrielse

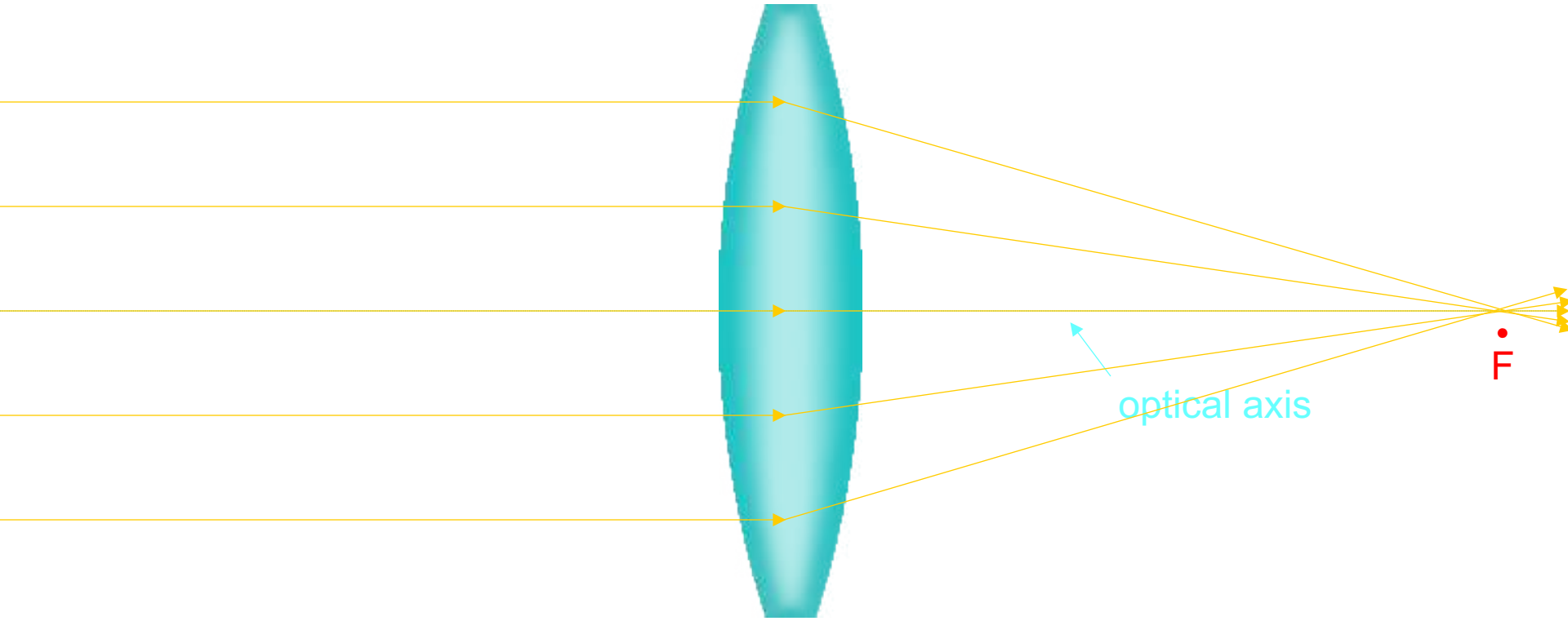
Convex Lenses



Convex Lenses



Convex Lenses



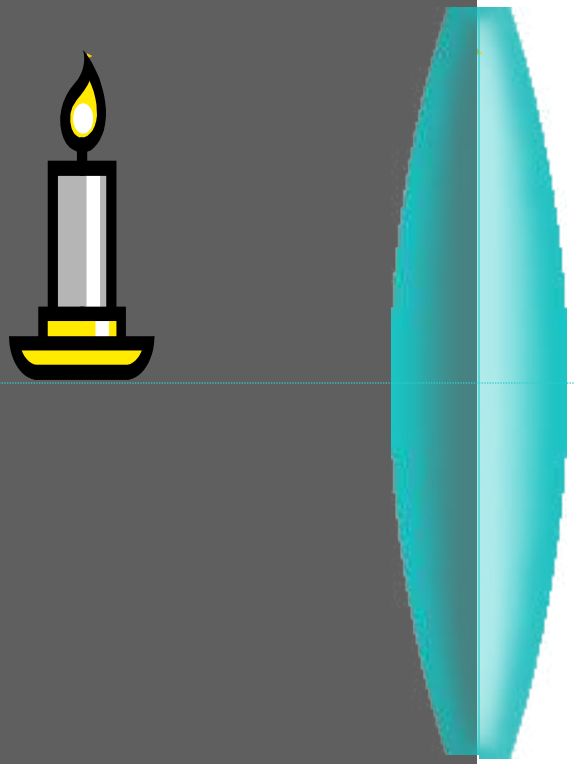
Light rays

optical axis

focal point

Convex Lens

(exar



optical axis

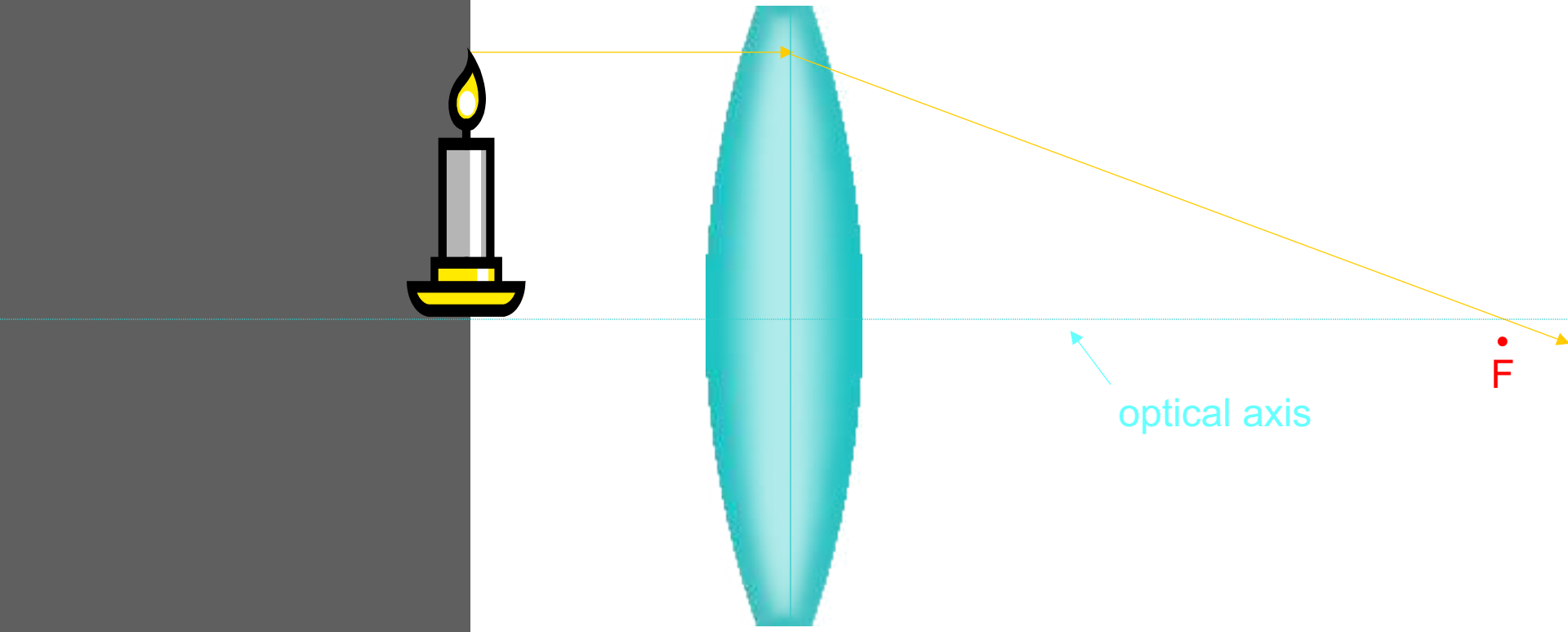
F

The first ray comes in parallel to the optical axis

focal point

J.M. Gabrielse

Convex Lens

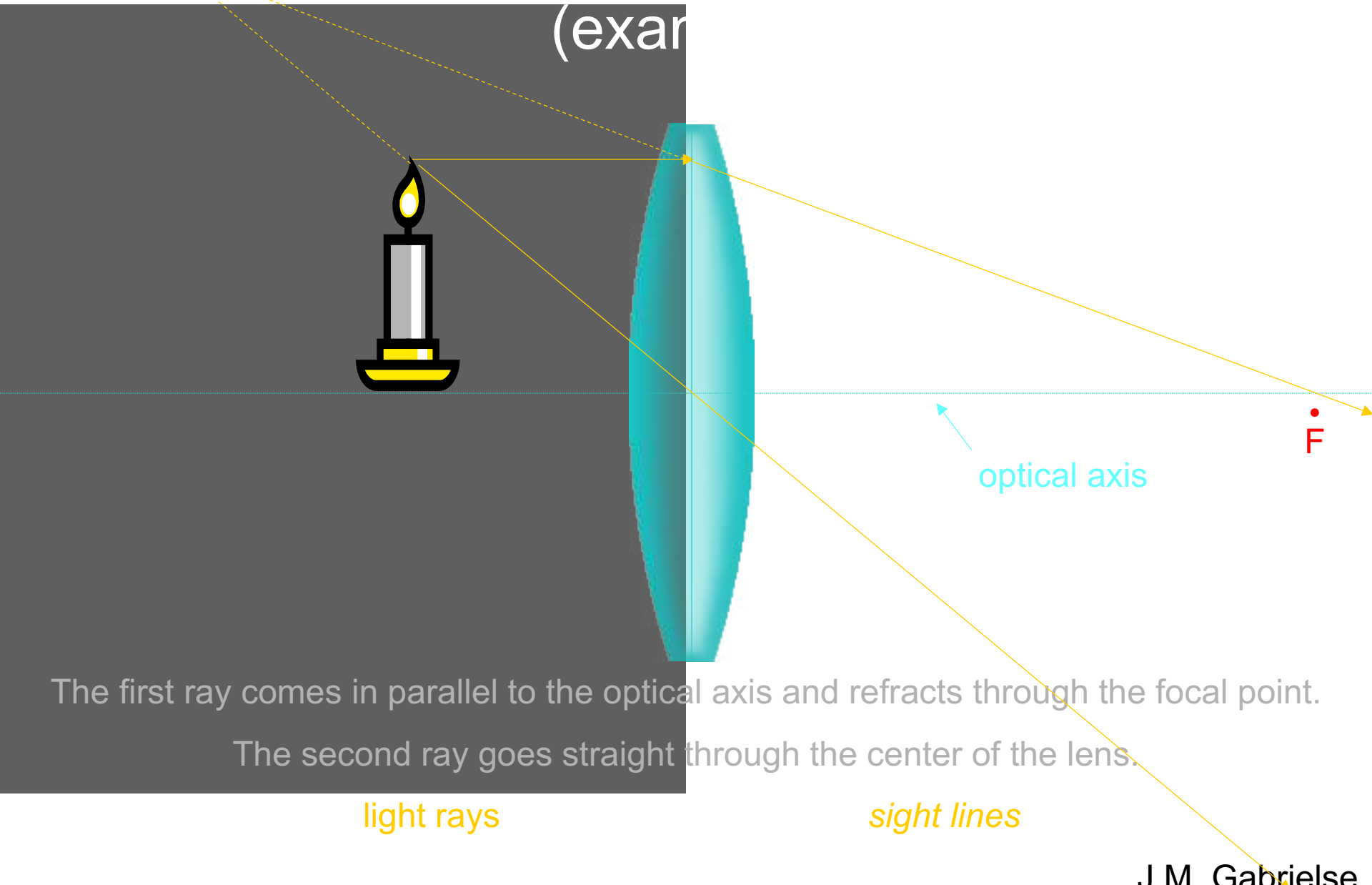


The first ray comes in parallel to the optical axis and refracts through the focal point.

The second ray lens

Convex Lens

(exar



The first ray comes in parallel to the optical axis and refracts through the focal point.

The second ray goes straight through the center of the lens.

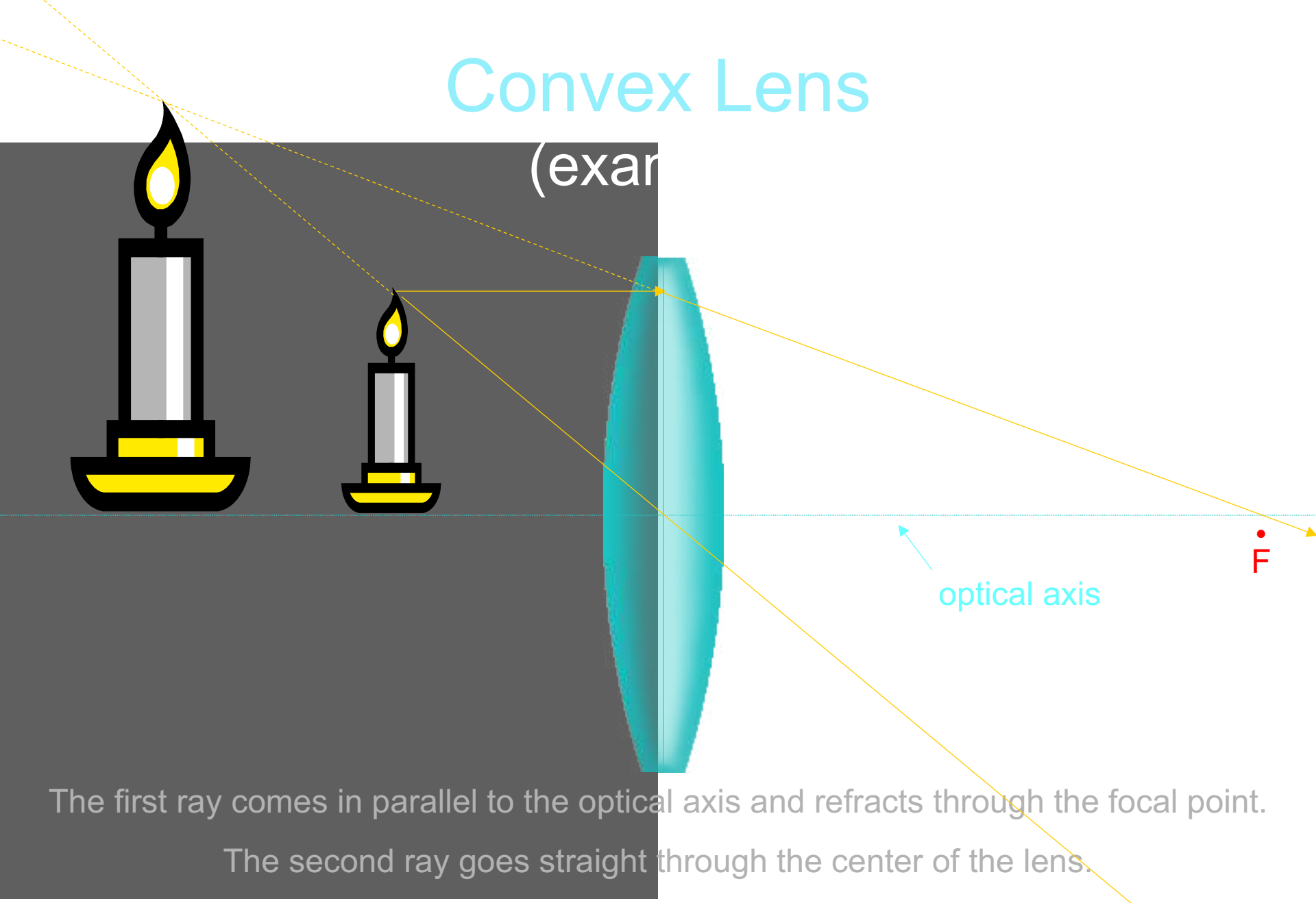
light rays

sight lines

J.M. Gabrielse

Convex Lens

(exar



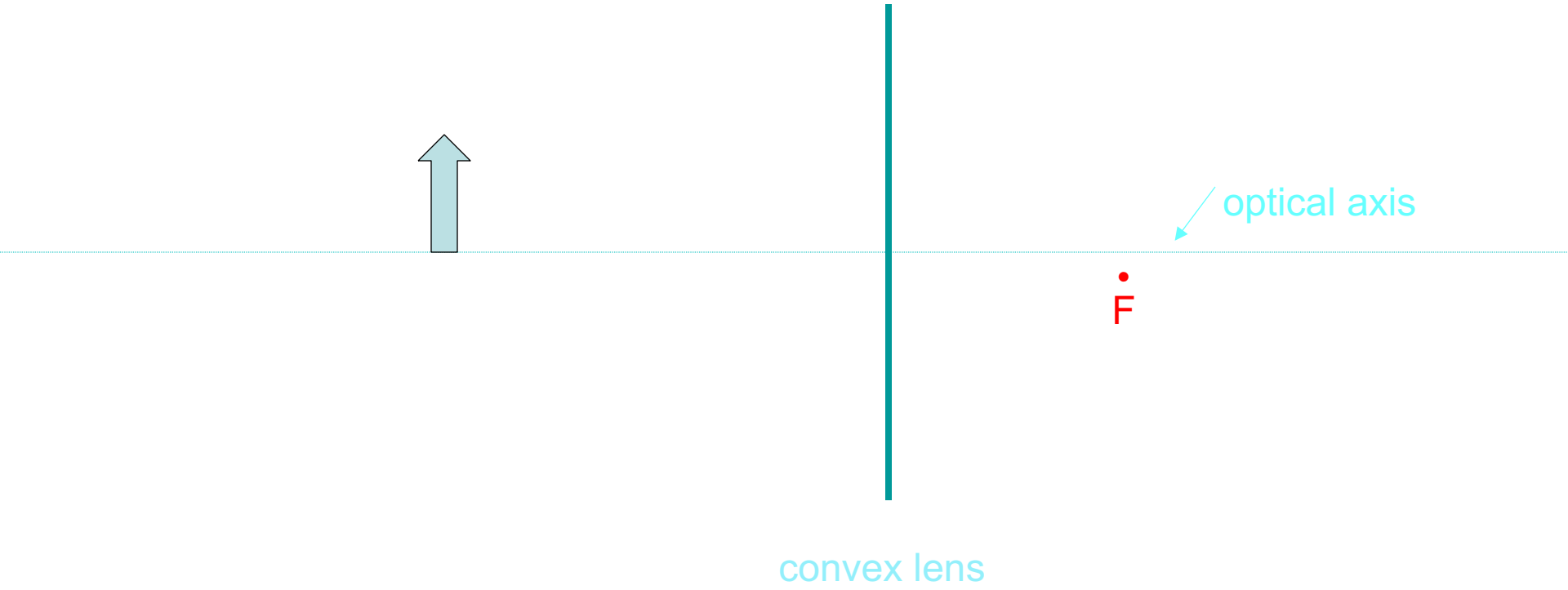
The first ray comes in parallel to the optical axis and refracts through the focal point.

The second ray goes straight through the center of the lens.

The light rays don't converge, but the *sight lines* do.

virtual image *sight lines* J.M. Gabrielse

Convex Lens



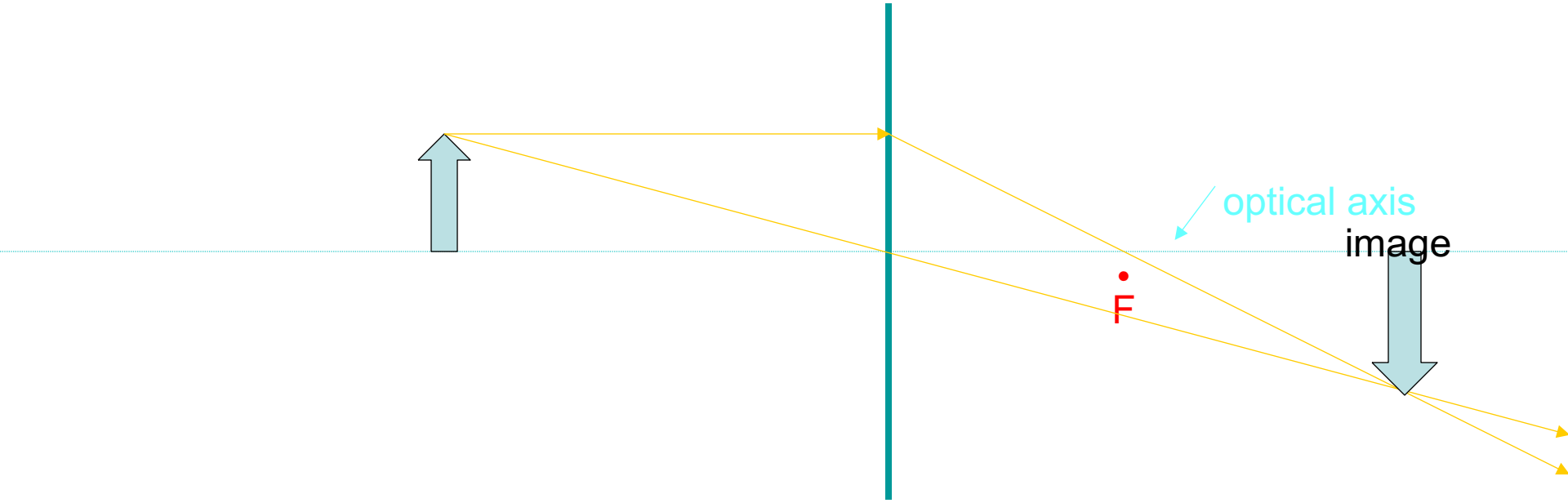
lenses

lens

image

J.M. Gabrielse

Convex Lens



image

- Faulkes Telescope Project: Light & Optics
- Fundamentals of Optics: An Introduction for Beginners
- PHET Geometric Optics (Flash Simulator)
- Thin Lens & Mirror (Java Simulator)