Purdue University Department of Physics

Physics 21900

General Physics II

Electricity, Magnetism and Optics

Lecture 18 – Chapter 22.1-3

Mirrors

Fall 2015 Semester

Prof. Matthew Jones

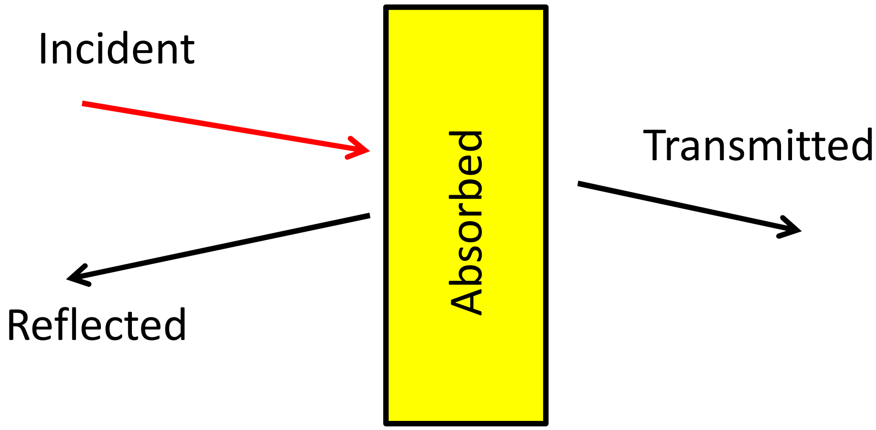
Announcement

Exam #2 will be on November 5^{th} in Phys 112 at 8:00 pm

Electric current, DC circuits, Kirchhoff's Rules
Magnetic Fields, Lorentz Force, Forces on Currents
Ampere's Law, Magnetic Induction, Lenz's Law
Induced EMF, AC Voltage, Transformers

To keep the number of questions reasonable, some will require that you combine knowledge from multiple areas. For example, you might need to know Kirchhoff's rules and how to analyze series and parallel resistors in the same problem.

Interaction of Light with Matter



Electromagnetic radiation (ie, light) travels slower in a material:

$$n = \frac{c}{v}$$

c = speed of light in vacuum (or air)
v = speed of light in the material

$$I\ (W/m^2) = R + T + A$$

(Energy conservation)

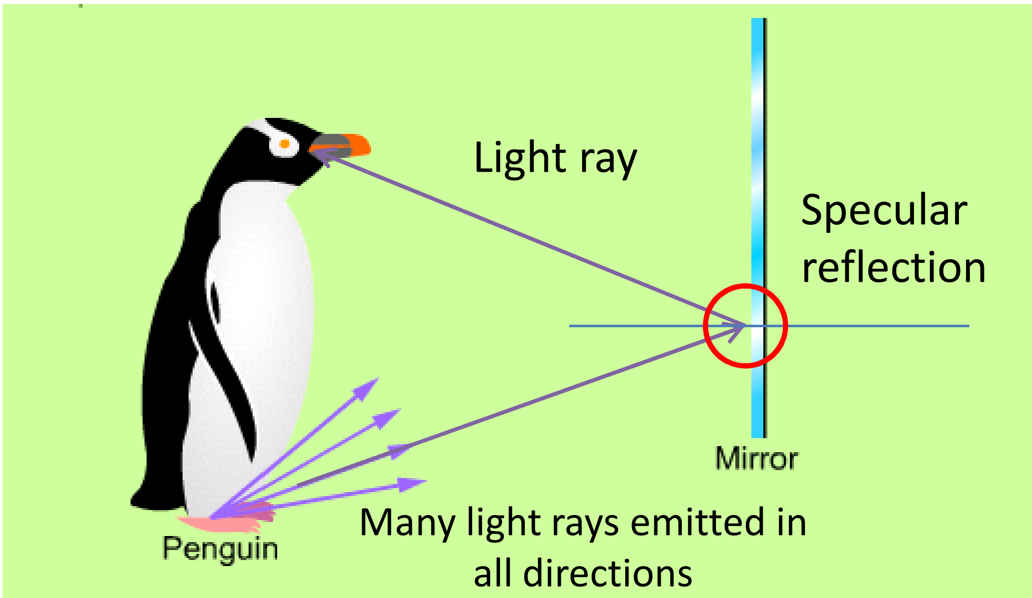
Material	n
Glass	1.5
Water	1.33
Diamond	2.4

Three situations:

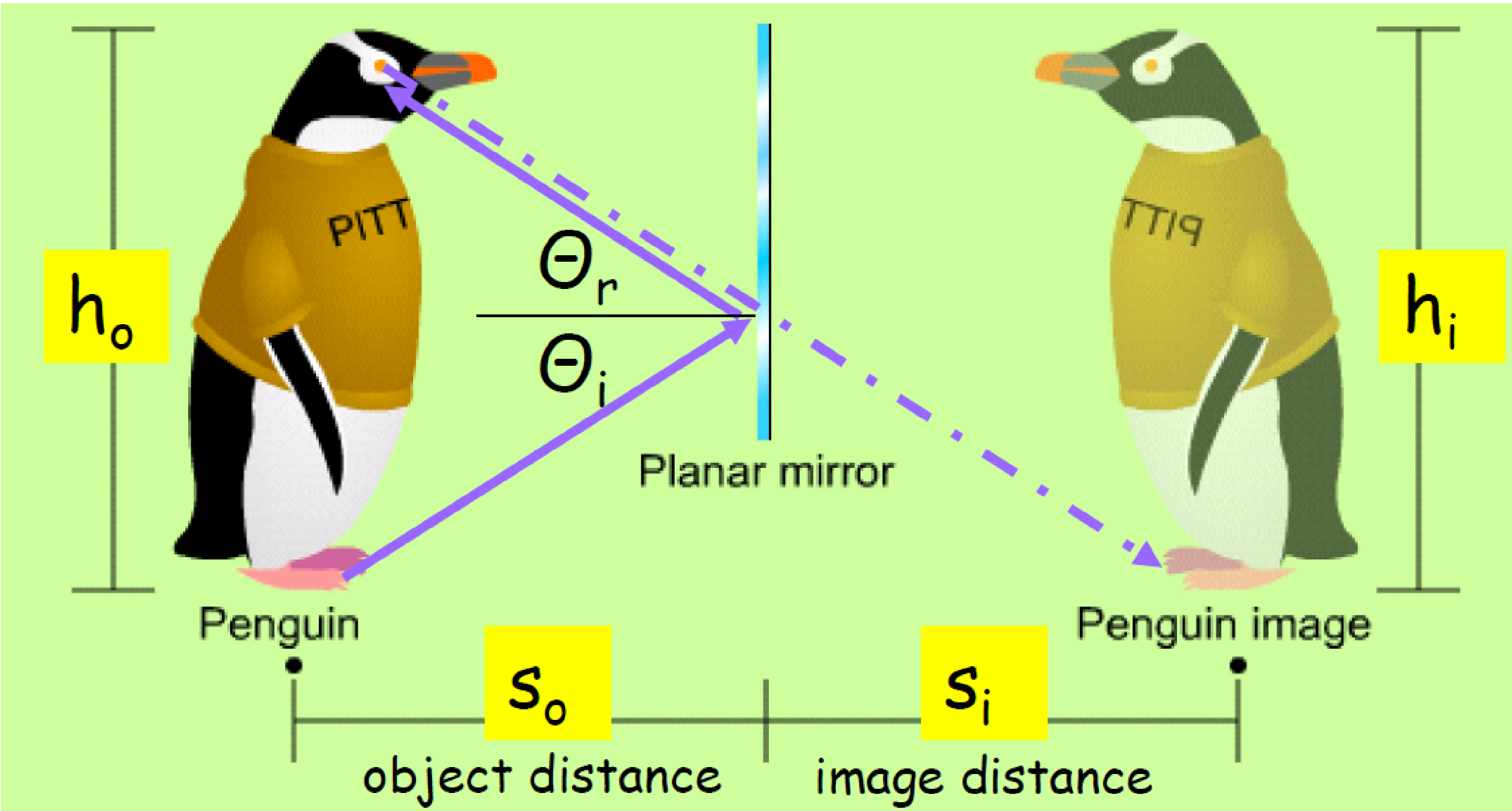
- If $R \approx I$, then it's a mirror
- If $A \approx I$, then it's a filter or absorber
- If $T \approx I$, then it's a lens

The Physics of Plane Mirrors

- How can we describe the images formed by plane mirrors?
- We will only use the law of reflection.

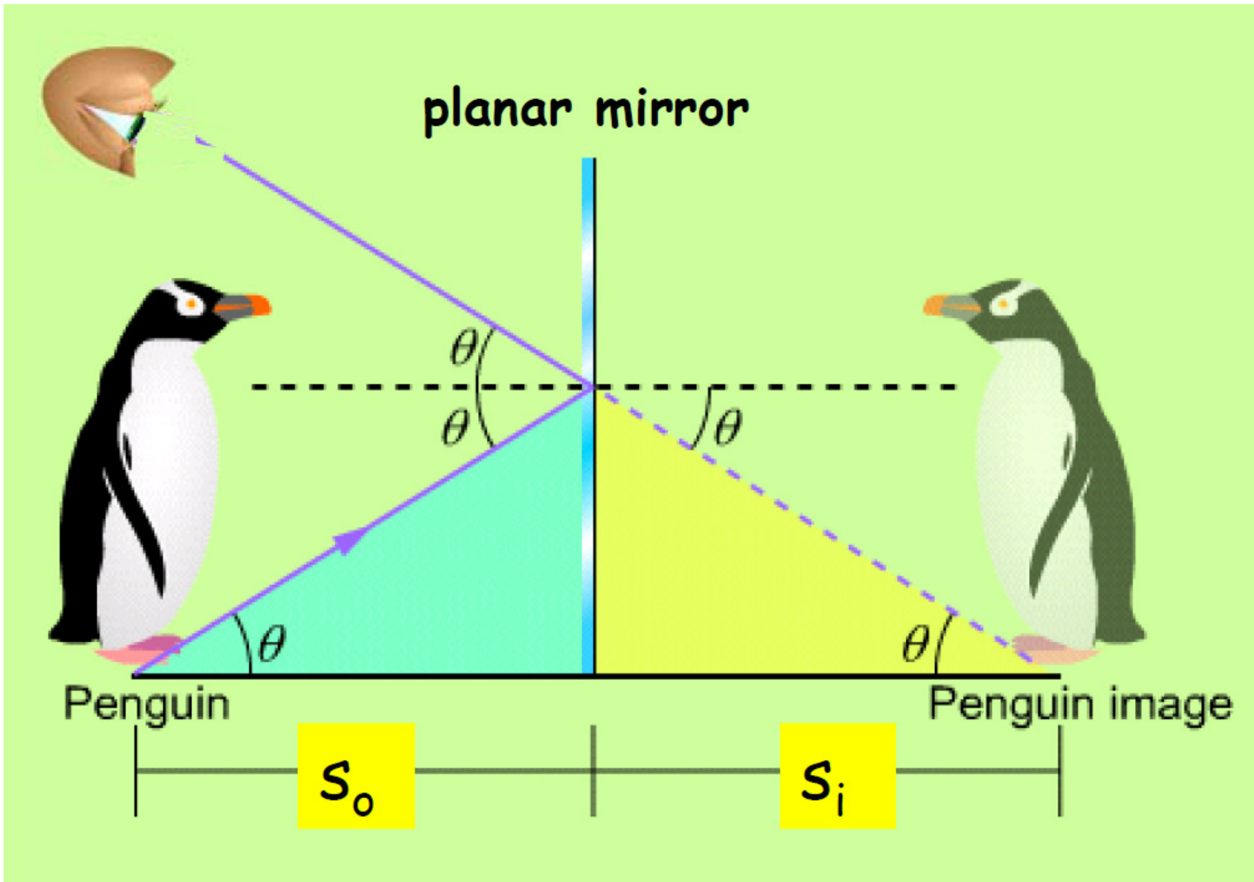


What does the penguin “see”?



- The penguin “sees” a *virtual image*.
- How are s_o, s_i, h_o and h_i related?

For plane mirrors, the image distance equals the object distance.



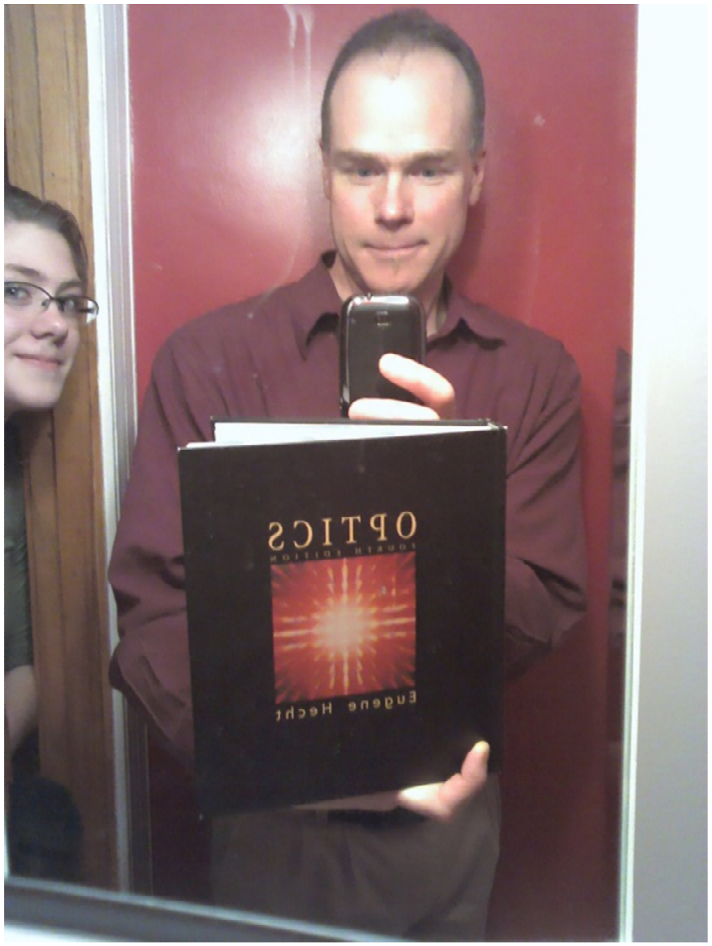
Real object, virtual image.

Aside…

Awareness that the image is a representation of the oneself is non-trivial.

See, for example:
Prior, Schwarz and Güntürkün, **”Mirror-Induced Behavior in the Magpie (Pica pica): Evidence of Self-Recognition”,** PLoS Biology, 2008; 6 (8) e202.
DOI: 10.1371/journal.pbio.0060202

Left to Right Reversal in Plane Mirrors?



- Normally, to read something, we have the text facing us.
- To see the image of the text in the mirror, we turn it away from us.
- The reflected image appears reversed.

Plane Mirror Summary

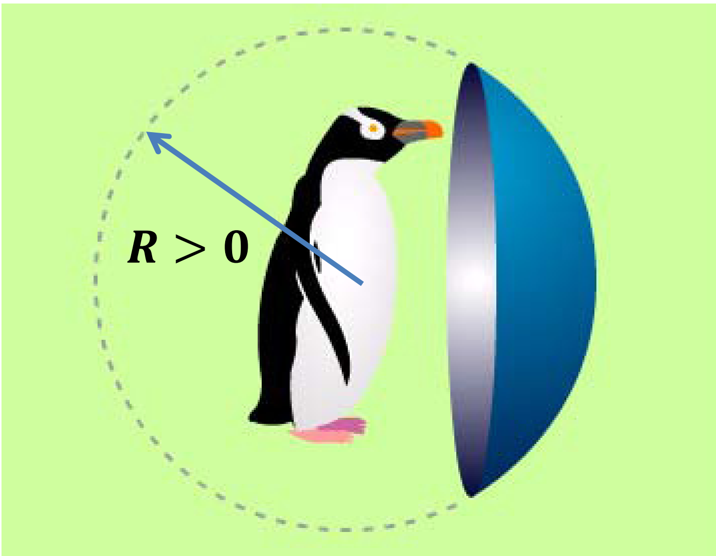
- The image of the real object seen in a plane mirror is located where light reflected from the mirror to the eye of the observer seems to originate.
  - This perceived image is behind the mirror and not at the surface of the mirror.
- Using ray diagrams, the is exactly the same distance behind the plane mirror as the object is in front of it.

Plane mirror virtual image A plane mirror produces a virtual image that is the same distance behind the mirror as the object is in front of it. The reflected light seems to diverge from the image behind the mirror. But no light actually leaves that image—you see light reflected from the mirror.

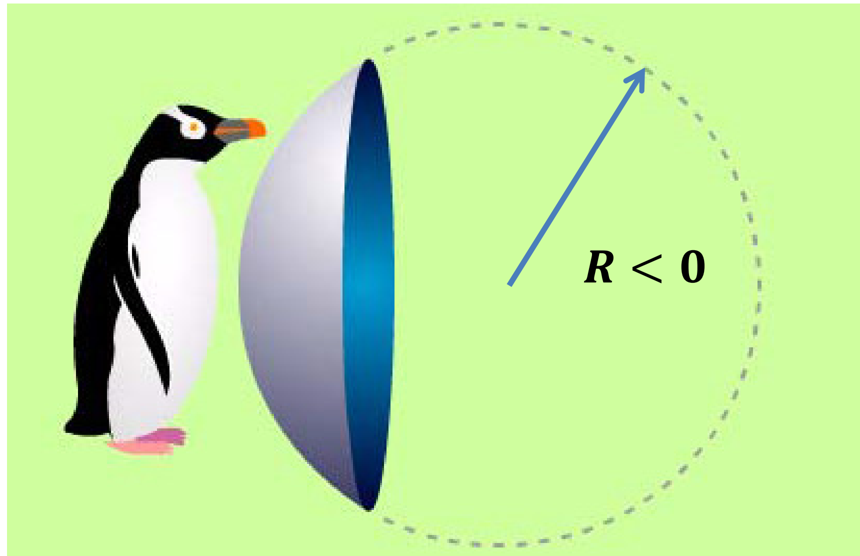
- A virtual image is one from which light rays appear to originate, but they don’t actually pass through the image.

Mirrors made from Curved Surfaces

Concave mirror



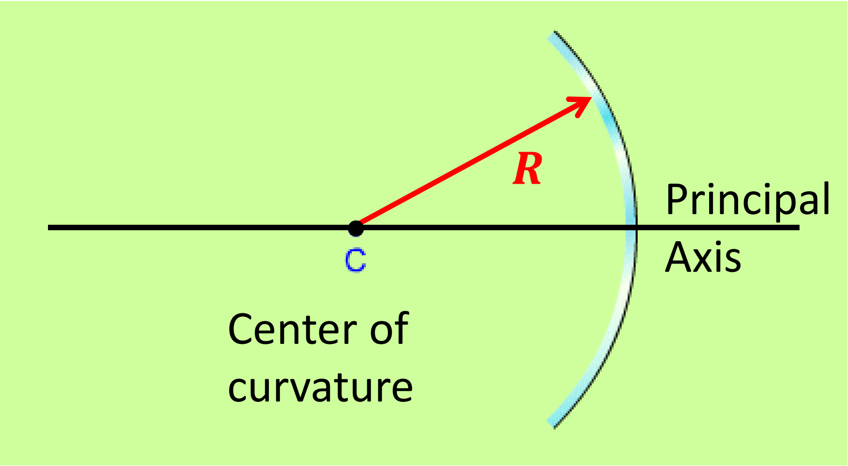
Convex mirror

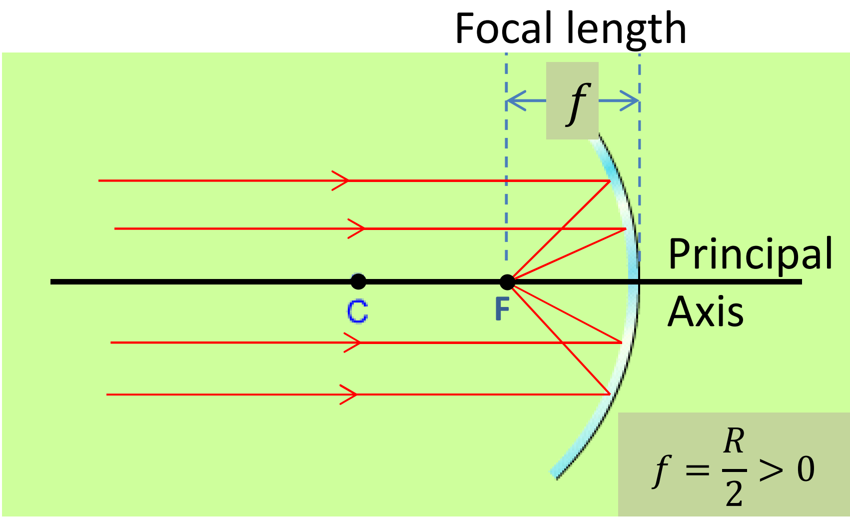


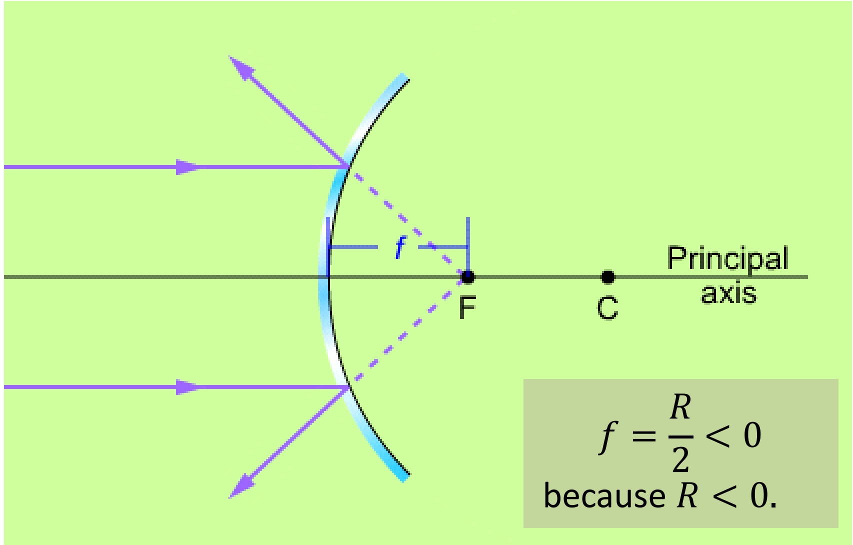
Examples of convex mirrors

Definitions of Terms

- Two special points:
  - Center of curvature, C
  - Focal point, F
- One special length:
  - Focal length, $f = R/2$
  - Remember that $R > 0$ for concave and $R < 0$ for convex mirrors.





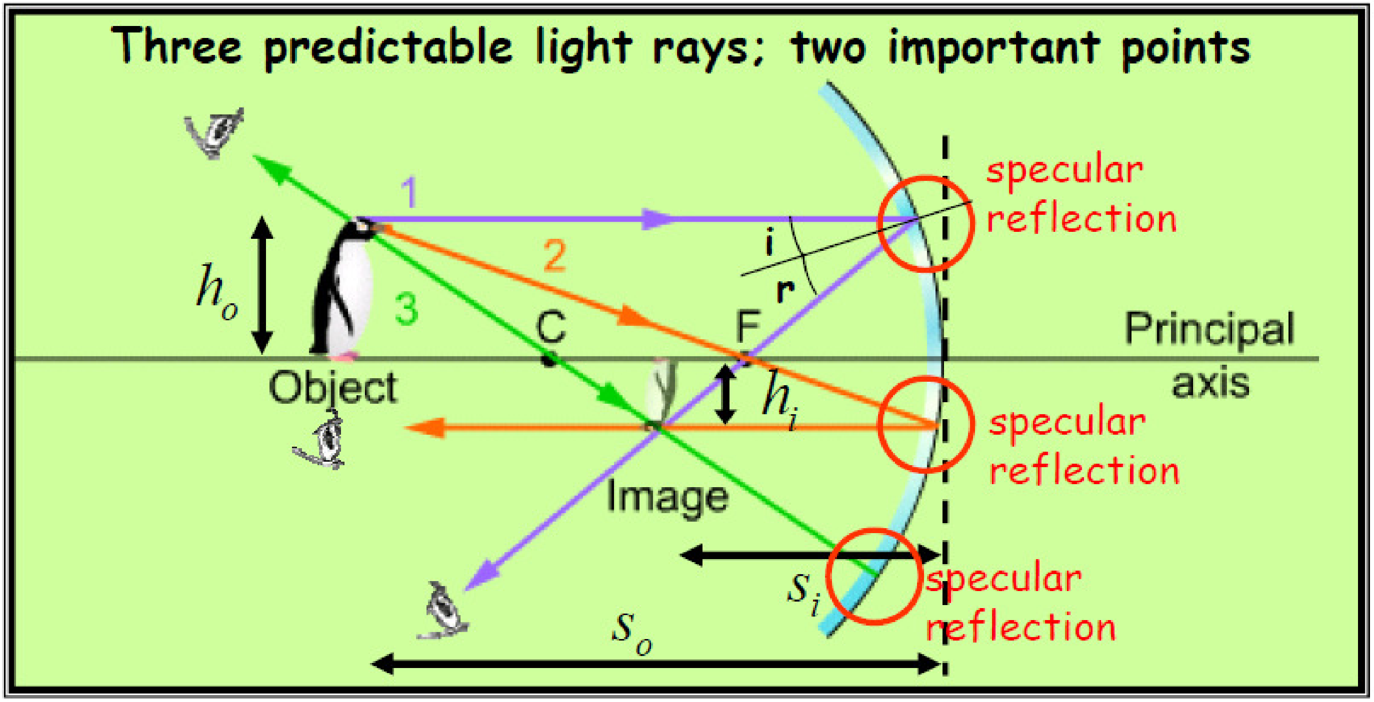


Where is the Image Located?

three predictable rays:

1. parallel to Principal Axis
2. thru F
3. thru C

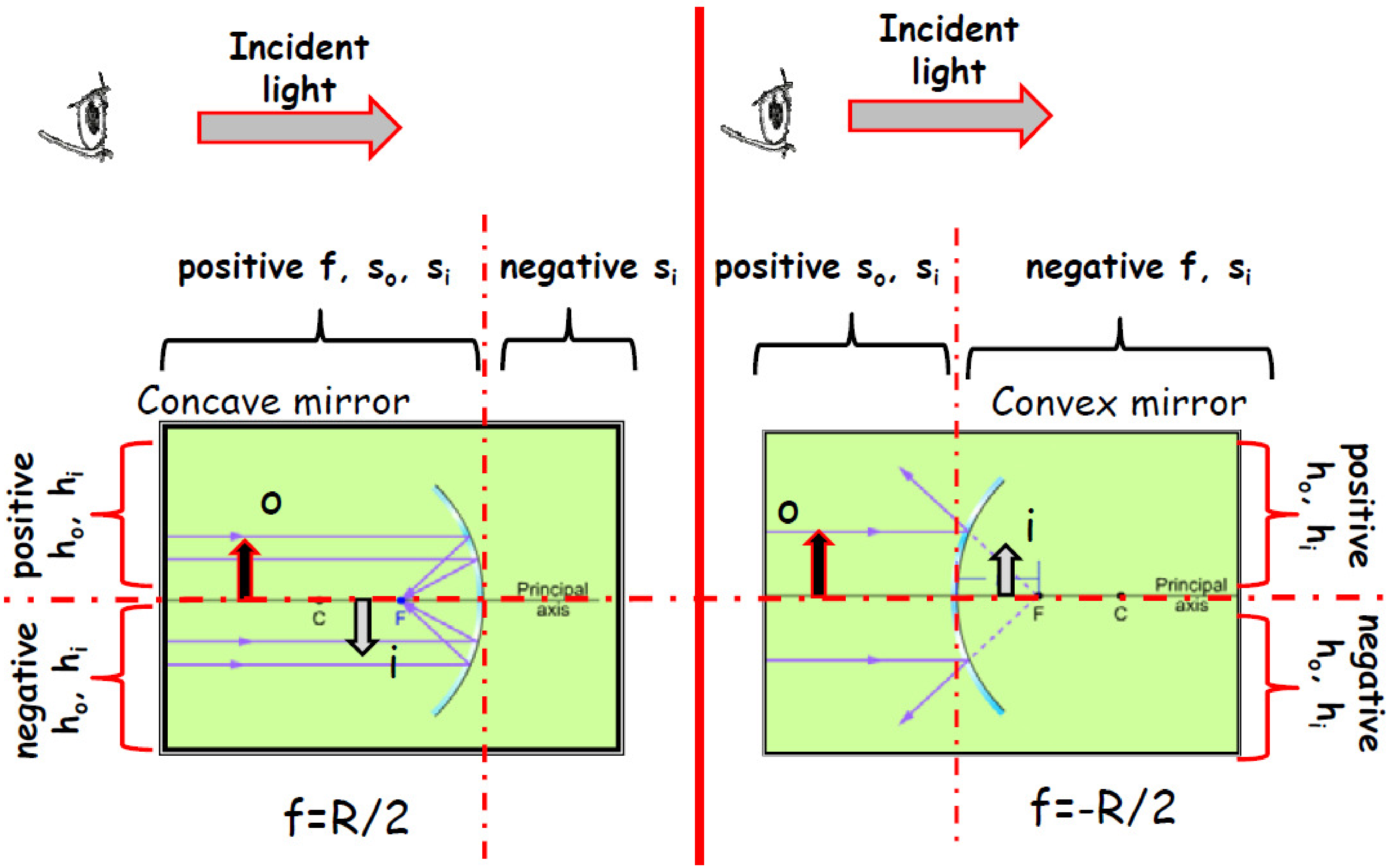
How can the entire image of an object be deduced once a **single point** on the image has been determined?



$$\frac{1}{f} = \frac{1}{s_i} + \frac{1}{s_o} \qquad m = \frac{h_i}{h_o} = -\frac{s_i}{s_o}$$

magnification

Sign Conventions



Sign Conventions are Important

(Different text books may use different sign conventions)

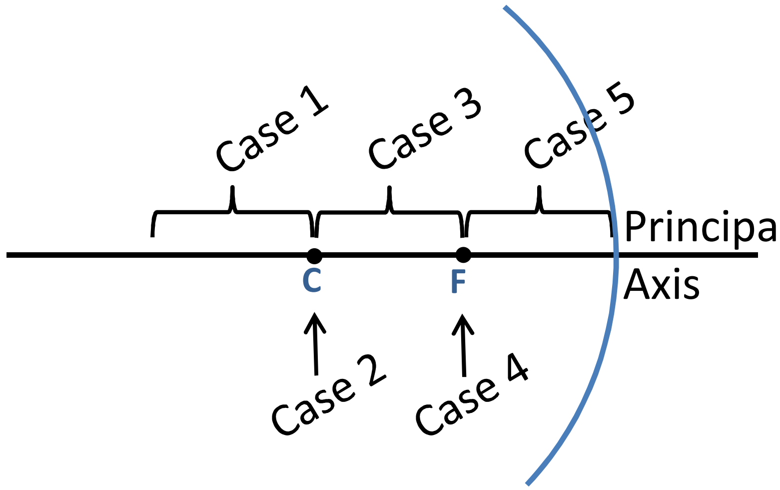
Quantity	Symbol	Positive sign means	Negative sign means
Radius of curvature	R	Concave mirror	Convex mirror
Focal length	$f = R/2$	"	"
Image distance	s_i	In front of mirror (real)	Behind mirror (virtual)
Object distance	s_o	In front of mirror (real)	[redacted]
Magnification	m	Upright image	Inverted image
Image height	h_i	"	"

Be able to distinguish real and virtual images. Remember the definition from page 9?

Each symbol can be assigned a positive or negative value.

A negative or positive sign in front of a numerical value is used to represent information about direction.

Concave Mirror: all possible cases



Case 1: The object is located *beyond* the center of curvature (C)

Case 2: The object is located *at* the center of curvature (C)

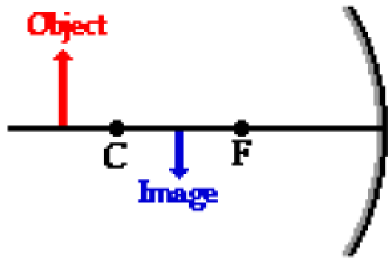
Case 3: The object is located *between* the center of curvature and the focal point (F)

Case 4: The object is located *at* the focal point (F)

Case 5: The object is located *between* the focal point and the mirror

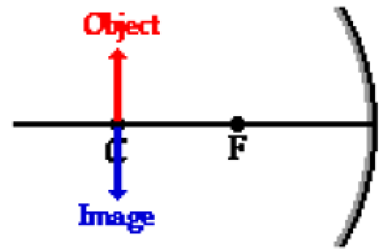
Concave Mirror: all possible cases

Case 1



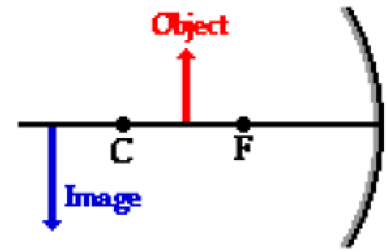
object located *beyond* center of curvature (C)

Case 2



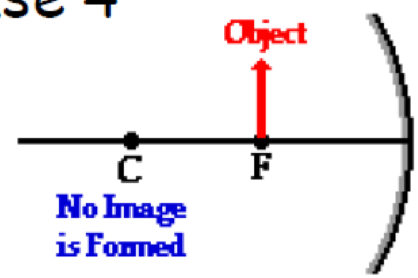
object located at center of curvature (C)

Case 3



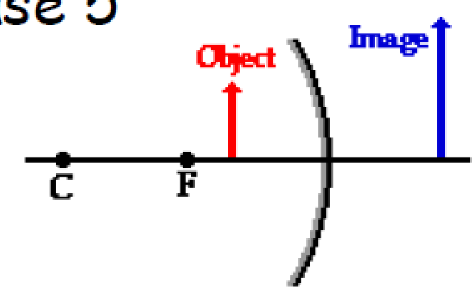
object located between center of curvature (C) and the focal point (F)

Case 4



object located at focal point (F)

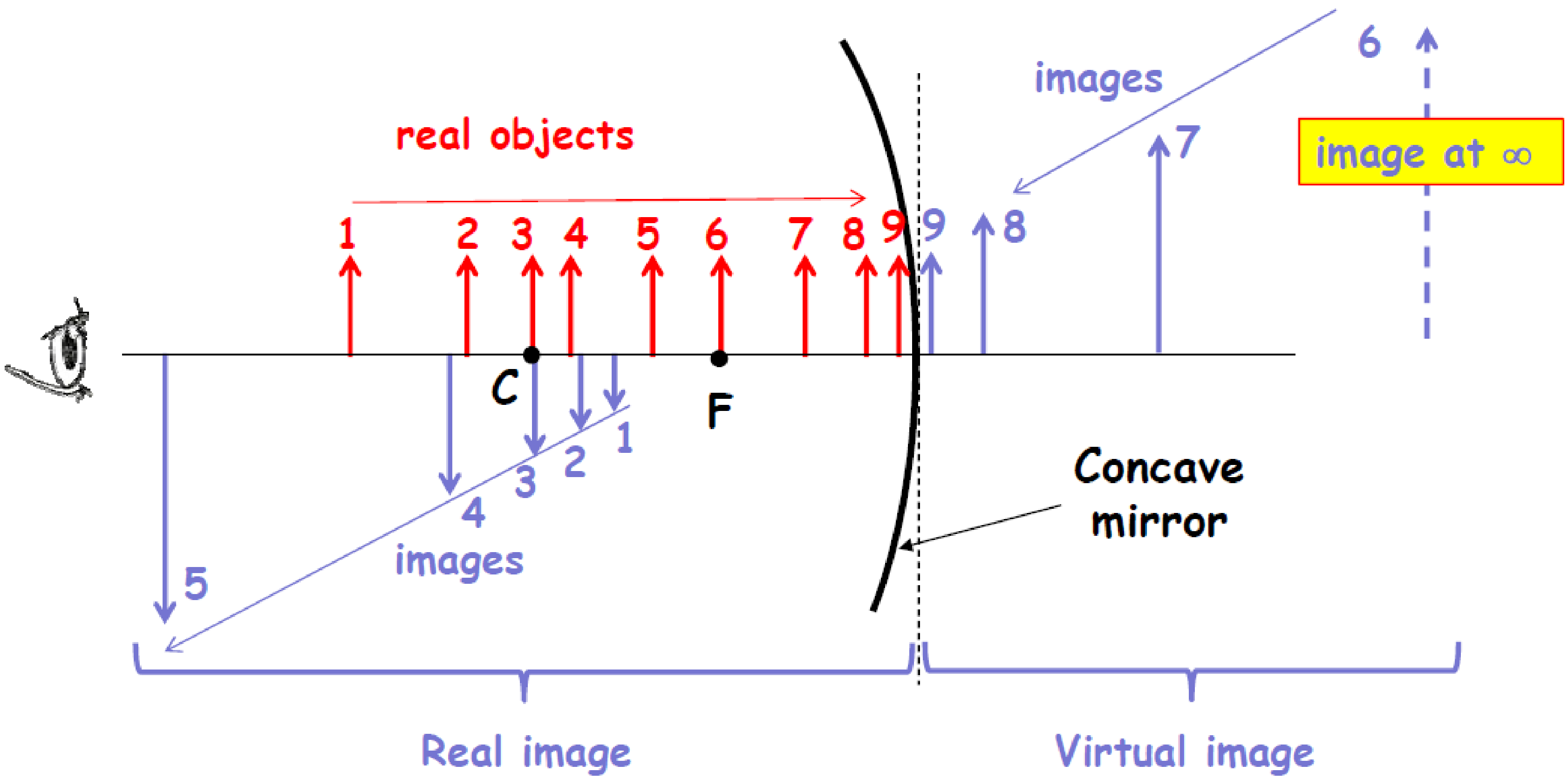
Case 5



object located between focal point (F) and surface of mirror

Object-Image locations for a concave mirror

Different object locations are drawn in red and labeled with a number; the corresponding image locations are drawn in blue and labeled with the identical number.



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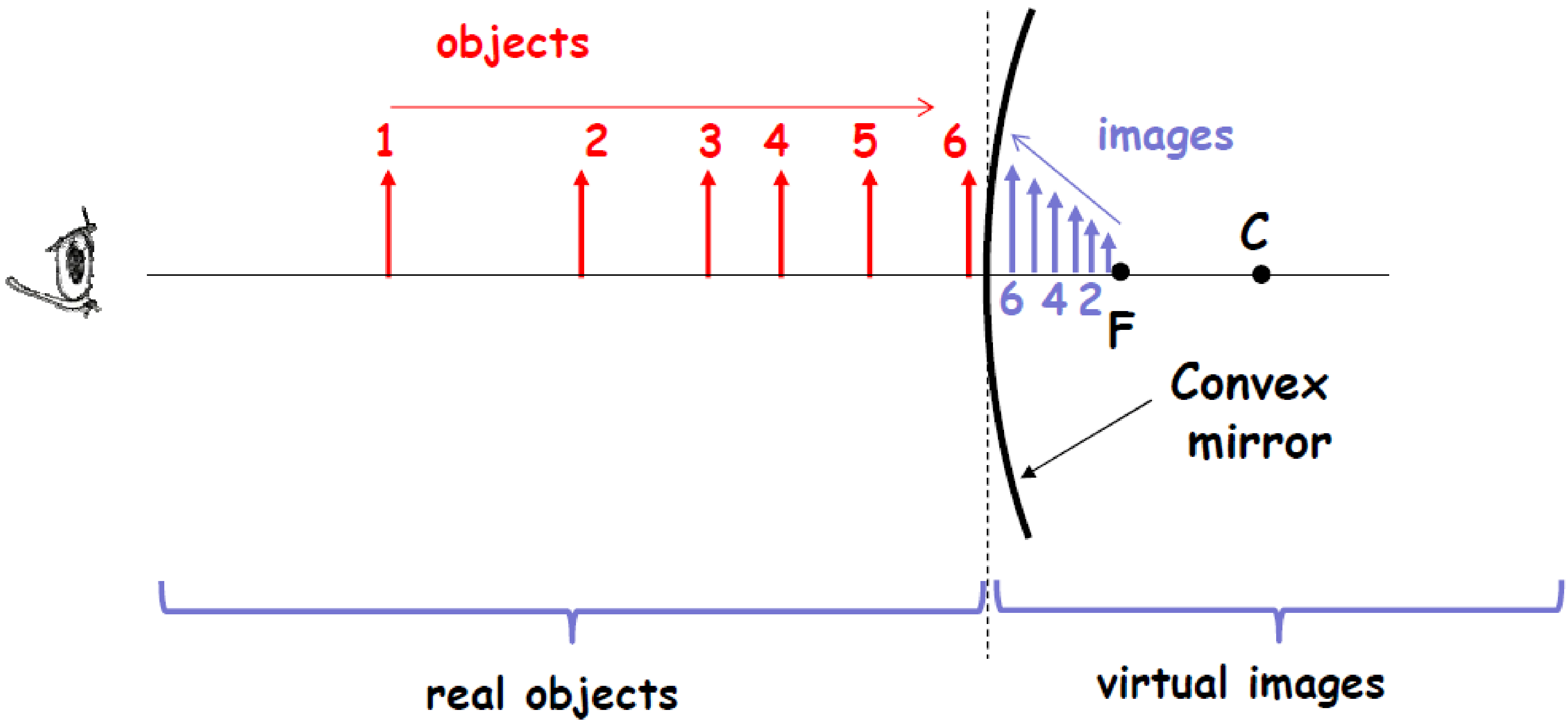
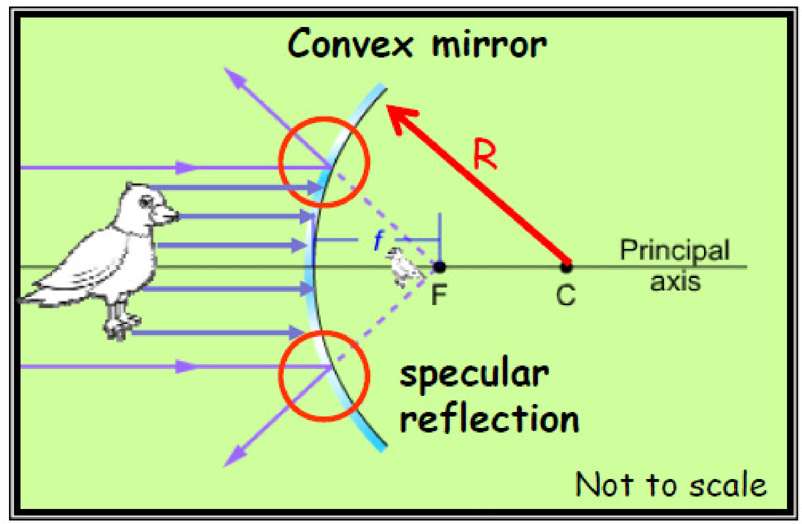


Example: Convex mirror globe

A gazing globe has a diameter of 12 inches. If a bird that is 6 inches tall stands 36 inches in front of the globe, what will the bird see?



diameter = 12 in

$$f = -\frac{R}{2} = -3 \text{ in}$$

$$\frac{1}{f} = \frac{1}{s_i} + \frac{1}{s_o}$$

$$\frac{1}{s_i} = \frac{1}{f} - \frac{1}{s_o} = \frac{1}{(-3)} - \frac{1}{36} = -\frac{12}{36} - \frac{1}{36} = -\frac{13}{36}$$

$s_i = -2.77$ in (virtual image, behind mirror)

$$m = \frac{h_i}{h_o} = -\frac{s_i}{s_o} = -\frac{(-2.77)}{12} = +0.23 \quad \text{(upright image)}$$

$$0.23 = \frac{h_i}{h_o} \Rightarrow h_i = 0.23\,h_o = 0.23(6 \text{ in}) = 1.38 \text{ in}$$