

# Warm-Up

## Mirrors

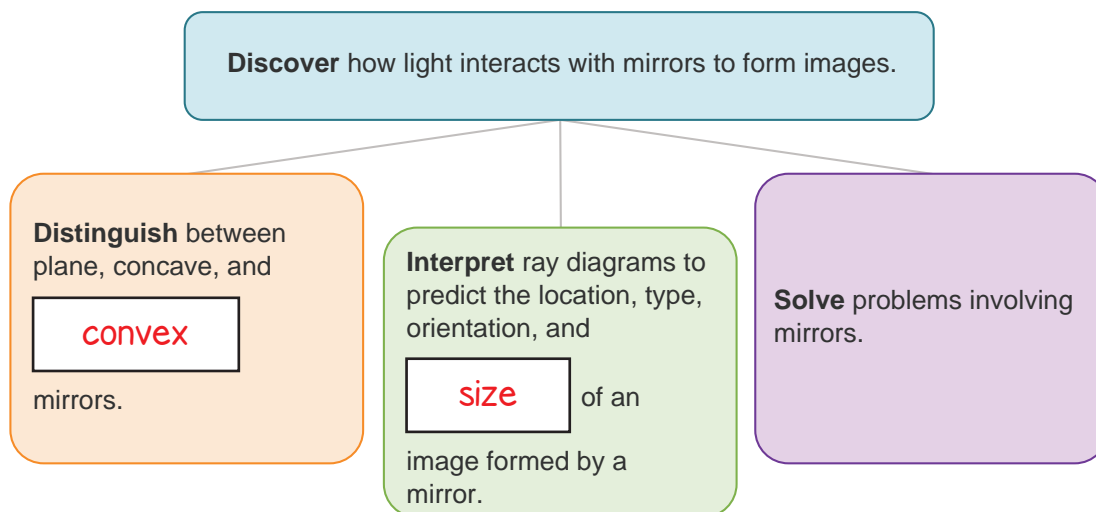


### Lesson Question

How does light interact with mirrors to form images?



### Lesson Goals



### Words to Know

Fill in this table as you work through the lesson. You may also use the glossary to help you.

<b>virtual image</b>	an image formed by diverging light rays that cannot be displayed on a screen
<b>convex</b>	curves outward
<b>real image</b>	an image formed by converging light rays that can be displayed on a screen
<b>diverge</b>	to move away from a common point
<b>concave</b>	curves inward
<b>converge</b>	to move toward a common point

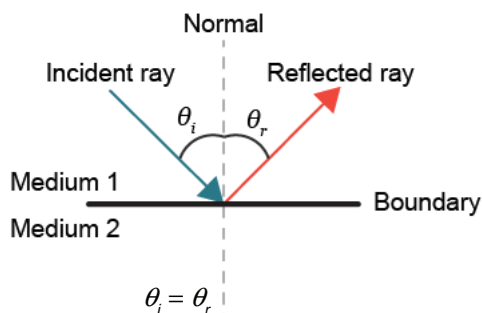


### Words to Know

<b>focal length</b>	the distance from the center of a mirror or lens to a focal point
<b>principal axis</b>	the line that runs through the center of curvature to the midpoint of a lens or mirror
<b>radius of curvature</b>	the distance between the center of curvature to the vertex
<b>center of curvature</b>	the center of the sphere from which a curved mirror was cut
<b>vertex</b>	the point where the principal axis and mirror meet
<b>focal point</b>	the point on a mirror's or lens's axis where reflected or refracted light converges or appears to diverge

### Reflection

- Reflection is the bouncing of a wave off of a boundary.
  - The reflected ray goes back into the original **medium**.
  - The **direction** of the reflected ray is determined using the law of reflection.
    - The angle of incidence is equal to the angle of reflection.



## Instruction

## Mirrors

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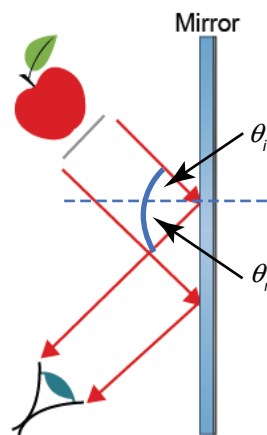
2

**Plane Mirrors**

On plane mirrors, the surface that light interact with is **flat**.

**Image Formation**

- Light strikes an object and is reflected off the object to the **mirror**.
- Light strikes the mirror and is reflected off the mirror.
- Reflected light strikes the observer's eyes.
- The observer sees an **image** that seems to come from behind the mirror.



- Light strikes an object and is reflected off the **object** to the mirror.
- Light strikes the mirror and is reflected off the mirror.
- Reflected light strikes the observer's eyes.
- The observer sees an image that seems to come from **behind** the mirror.

# Instruction | Mirrors

Slide

4

## Image Characteristics

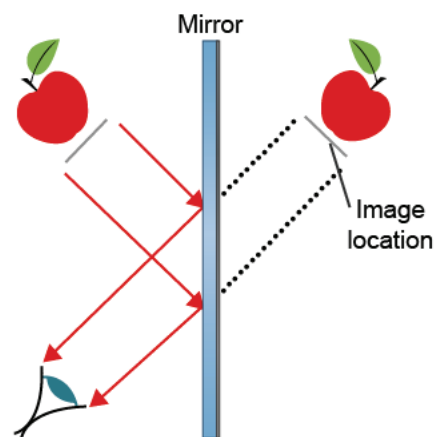
- Image location is the point behind or in front of the mirror where light seems to

**converge** or **diverge** to form an image.

- The image may be **real** or **virtual**.

- A real image is formed by converging light rays that can be displayed on a screen.

- A virtual image is formed by diverging light rays that cannot be displayed on a **screen**.



- Image orientation may be upright or **inverted**.

- Image orientation may also be left-right reversed.

- Image size may be the same, **smaller**, or bigger than the object's actual size.

7

## Concave Mirrors

- Light interacts with the surface that curves **inward** on a **concave** mirror.

## Instruction

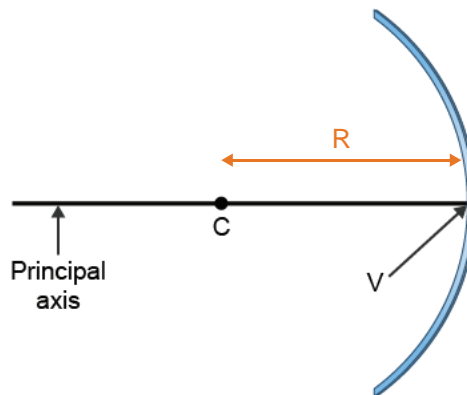
## Mirrors

Slide

7

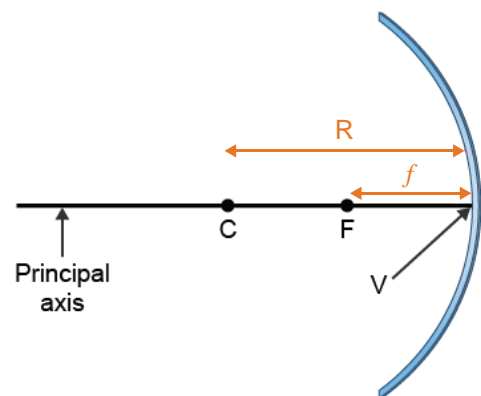
## Features of Concave Mirrors

- The **center of curvature** (C) is the center of the **sphere** from which a curved mirror was cut.
- The **principal axis** is the line that runs through the center of curvature to the center of a mirror.
- The **vertex** (V) is the point where the **principal axis** and mirror meet.
- The **radius of curvature** (R) is the distance between the center of curvature and the **vertex**.



## Features of Concave Mirrors

- The **focal point** (F) is the point on a mirror's axis where reflected light **converges** or appears to diverge.
- **Focal length** ( $f$ ) is the **distance** from the center of a mirror to the focal point.

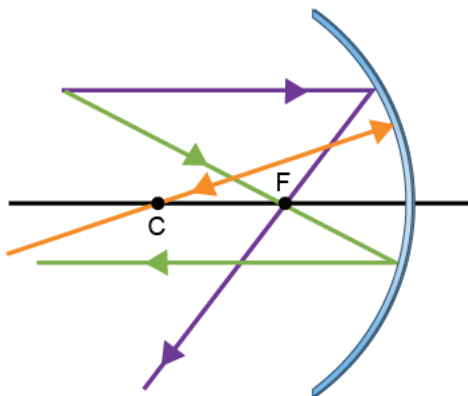


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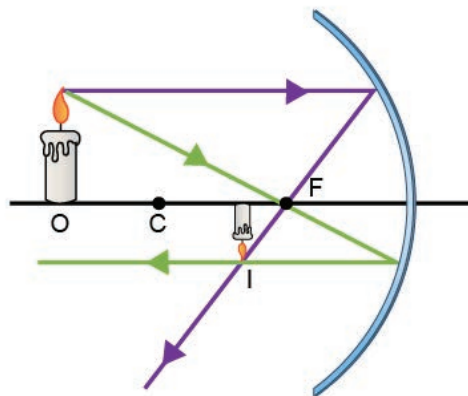
9

**Rule of Thumb for Concave Mirrors**

- Incident rays that travel parallel to the principal axis are reflected through the focal point. back
- Incident rays that pass through the focal point are reflected back to the principal axis. parallel
- Incident rays that pass through the center of curvature are reflected back through the center of curvature.

**Use of Ray Diagrams to Predict Image Characteristics**

- The image characteristics of an object in front of the center of curvature are:
  - in front of mirror.
  - real.
  - inverted.
  - smaller.



Slide

9

### Use of Ray Diagrams to Predict Image Characteristics

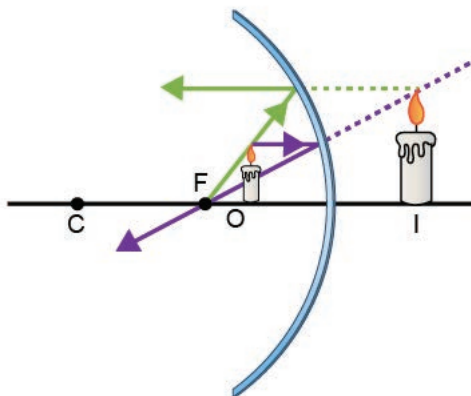
- The image characteristics of an object in between the focal point and the vertex are:

- **behind** the mirror.

- virtual.

- upright.

- **larger**.



11

### Mirror Formula for Curved Mirrors

- The mirror formula is used to determine **focal length** and distances.

- $f$  = focal length

- $d_o$  = distance of object from **mirror**

- $d_i$  = distance of image from mirror

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

Slide

11

**Use of the Mirror Formula to Solve Problems****EXAMPLE**

A 6.0 cm object is 30.0 cm from a concave mirror that has a focal length of 11 cm.

What is the distance of the image from the mirror?

- Given
  - $d_o = 30 \text{ cm}$
  - $f = 11 \text{ cm}$
- Unknown:  $d_i$
- Formula to be used:  $\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$

Solution:

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

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

$$\frac{1}{11 \text{ cm}} - \frac{1}{30 \text{ cm}} = 0.05757 \text{ cm}$$

$$d_i = \frac{1}{0.05757 \text{ cm}} = 17.36 \text{ cm} \approx 17 \text{ cm}$$

Slide

13

**Formula for Magnification**

The formula for magnification can be used to determine magnification,

**heights**, and distances.

- $M$  = magnification
- $h_i$  = height of **image**
- $h_o$  = height of object
- $d_i$  = **distance** of image from mirror
- $d_o$  = distance of object from mirror

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

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

**Use of the Magnification Formula to Solve Mirror Problems****EXAMPLE**

A 6.0 cm object is 30.0 cm from a concave mirror that has a focal length of 11.0 cm. Its image is 17.0 cm in front of the mirror.

What is the height of the image from the mirror?

- Given

- $d_o = \boxed{30.0}$  cm

- $d_i = 17.0$  cm

- $h_o = 6.0$  cm

- Unknown:  $h_i$

- Formula to be used:  $\frac{h_i}{h_o} = -\frac{d_i}{d_o}$

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

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

$$h_i = \boxed{-6.0 \text{ cm}} \left( \frac{17 \text{ cm}}{30 \text{ cm}} \right)$$

$$= -3.4 \text{ cm}$$

Slide

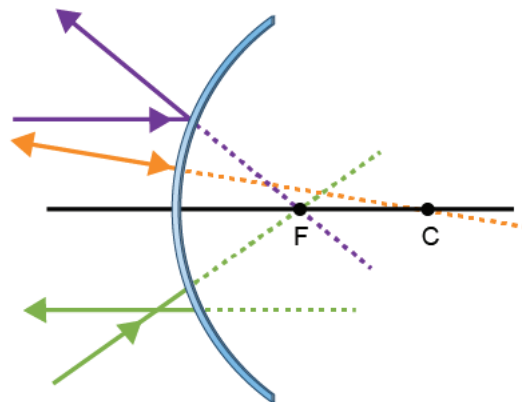
16

### Convex Mirrors

Light interacts with the surface that **curves** outward on a convex mirror.

### Rule of Thumb for Convex Mirrors

- The reflected ray of an incident ray that travels parallel to the principal axis is **extended** to pass through the focal point behind the mirror.
- The reflected ray of the incident ray that appears to pass through the focal point is extended parallel to the principal axis behind the mirror.
- The reflected ray of the incident ray that appears to pass through the center of curvature is extended through the **center of curvature** behind the mirror.

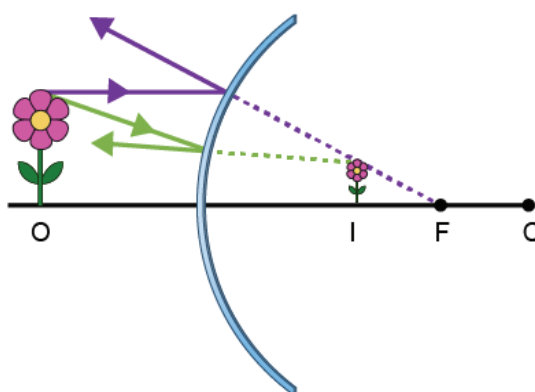


Slide

16

### Use of Ray Diagrams to Predict Image Characteristics

- The image characteristics of an object in between the focal point and the vertex are:
  - behind the mirror.
  - virtual.
  - upright.
  - smaller**.



18

### Mirror Formula and the Formula for Magnification

- The mirror formula is used to determine **focal length** and distances.

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

- The formula for magnification can be used to determine magnification, **heights**, and distances.

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

## Summary

## Mirrors

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Lesson  
Question

How does light interact with mirrors to form images?

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## Answer

(Sample answer) Light interacts with mirrors following the law of reflection. This interaction results in images with a specific location, type, orientation, and size depending on the type of mirror the light interacts with.

Slide

2

## Review: Key concepts

- Plane mirrors are **flat**.
- The images formed by plane mirrors are:
  - located behind the mirror.
  - **virtual**.
  - upright.
  - the same size as the object.
  - the same distance from the mirror as the **object** is from the mirror.

# Summary | Mirrors

Slide

2

- Concave mirrors are curved inward.
- The characteristics of images formed by concave mirrors depend on where the object is located.

Location of Object	Image Characteristics
In front of the center of curvature	In front of mirror, real, inverted, and <span style="border: 1px solid black; padding: 2px;">smaller</span>
Between the focal point and the vertex	<span style="border: 1px solid black; padding: 2px;">Behind</span> the mirror, virtual, upright, and bigger than the object
Between the center of curvature and the focal point	Behind the mirror, <span style="border: 1px solid black; padding: 2px;">real</span> , inverted, and bigger than the object
On the center of curvature	Behind the mirror, real, inverted, and the <span style="border: 1px solid black; padding: 2px;">same</span> size as the object

- Convex mirrors are curved outward.
- Images formed by convex mirrors are:
  - located behind the mirror.
  - virtual.
  - upright.
  - smaller than the object.



# Summary

## Mirrors

*Use this space to write any questions or thoughts about this lesson.*