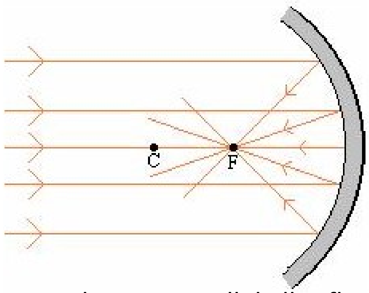
Curved Mirrors

There are two types of curved mirrors:

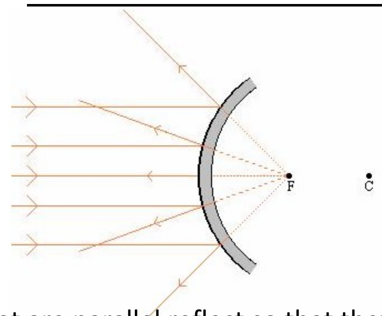
1. ________________________



Incoming rays that are parallel all reflect through the ______________________________.

This is also called a __________________mirror

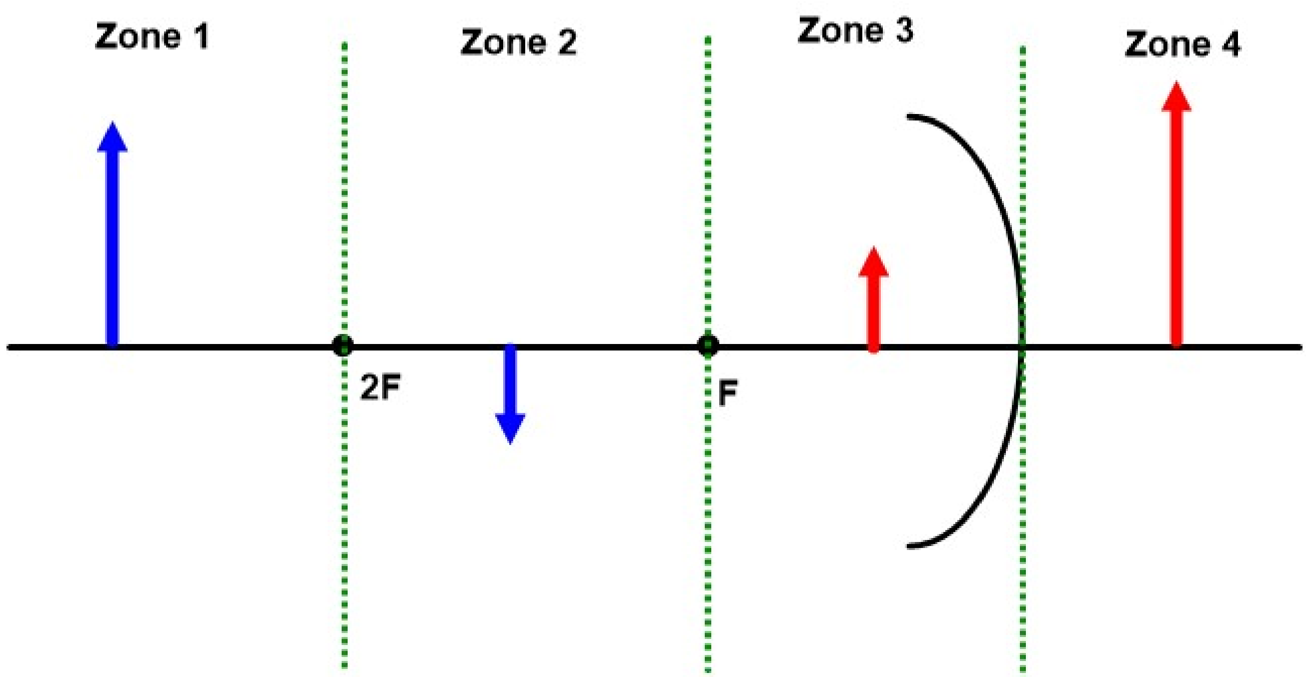
2. _________________________



Incoming rays that are parallel reflect so that they are ___________________________ and will never cross.

This is also called a _____________________ mirror

Predictor Chart for curved mirrors



Locating Images in Concave Mirrors

Write down the rules for locating images formed by concave mirrors and illustrate these rules on the diagram below.

1.	RAY 1:
2.	RAY 2a: *or* RAY 2b:
3.	

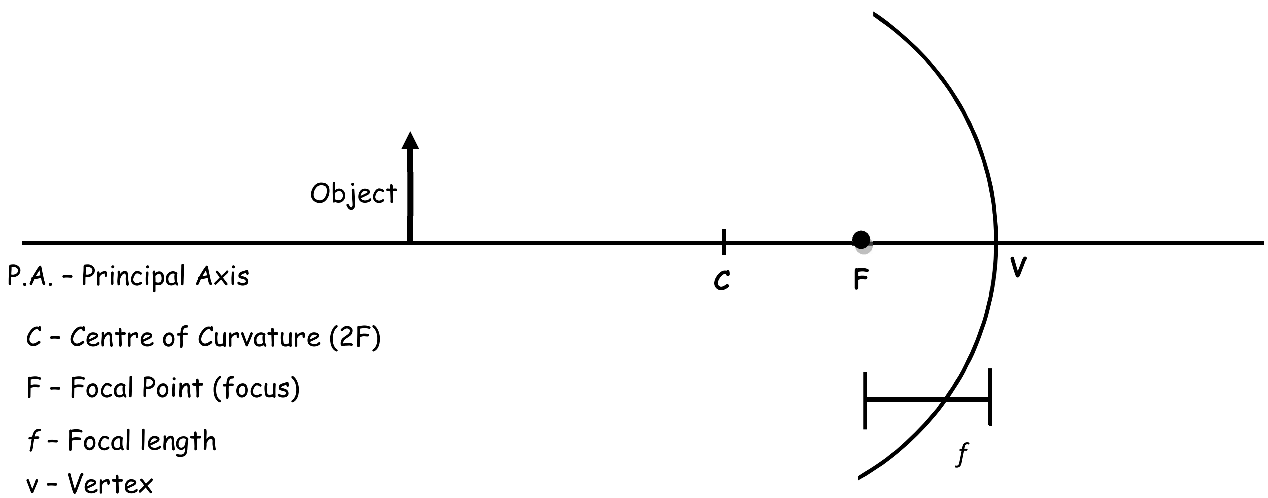


Image Characteristics for Mirrors:

Characteristic **(SALT)** (compared to object)	Descriptions
S – size	smaller, larger, or same
A – attitude	Same or Inverted
L – location	behind or in front of mirror -- relative to V,F and C (ex. between C & F) could be given as a ZONE
T – type	Virtual or real

Summary of Characteristics of Images in Mirrors

Plane Mirrors (flat)

Size	
Attitude	
Location	
Type	

Concave Mirrors

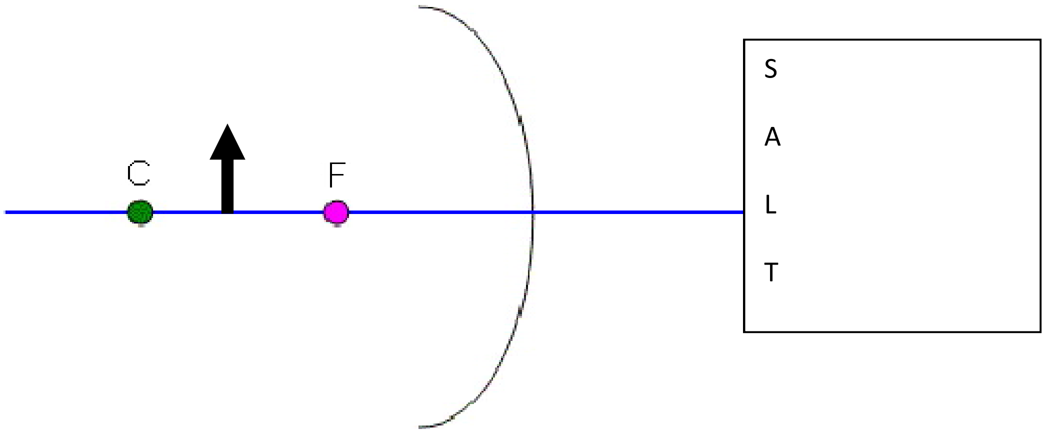
Images formed in concave (converging light) mirrors have different characteristics depending on the location of the object. *Examples on handout from class*

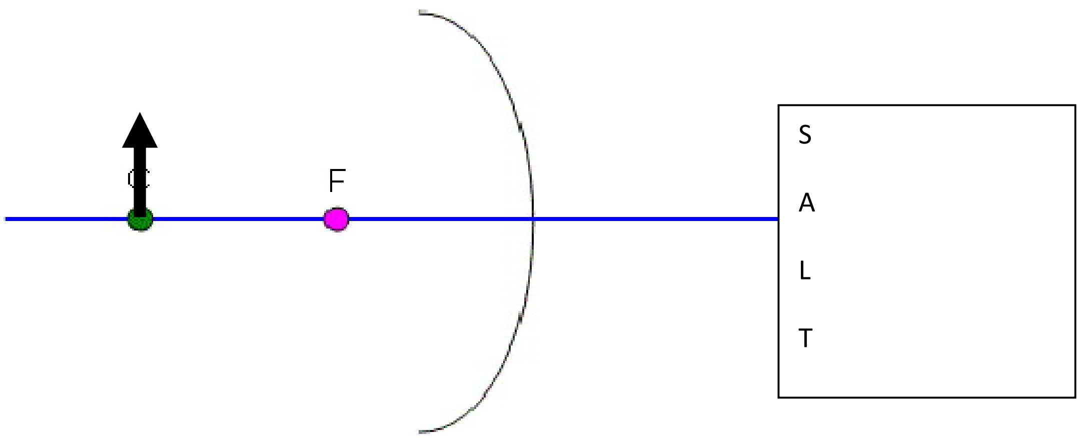
	Image Characteristics			
Location of object	**Size**	**Attitude**	**Location**	**Type**
beyond 'C' (2F) *Zone 1*				
at 'C' (2F)				
between 'C' (2F) and 'F' – *Zone 2*				
at 'F'				
between 'F' and 'V' *Zone 3*				

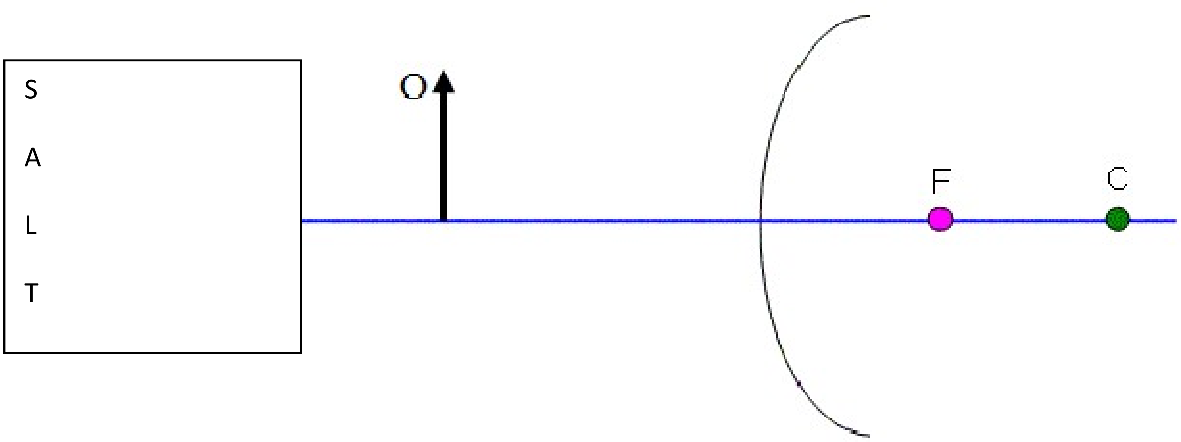
Convex Mirrors

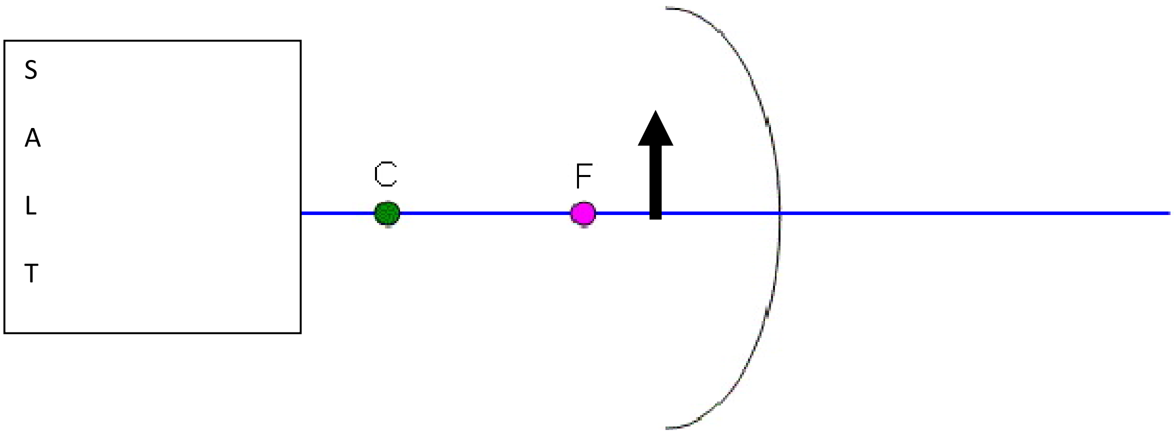
Size	
Attitude	
Location	
Type	

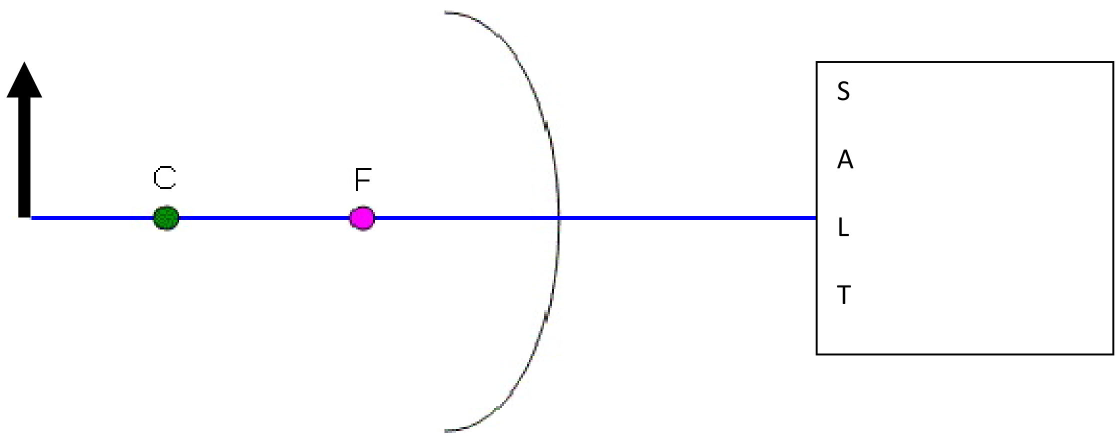
Curved Mirror Ray Diagrams (Homework)

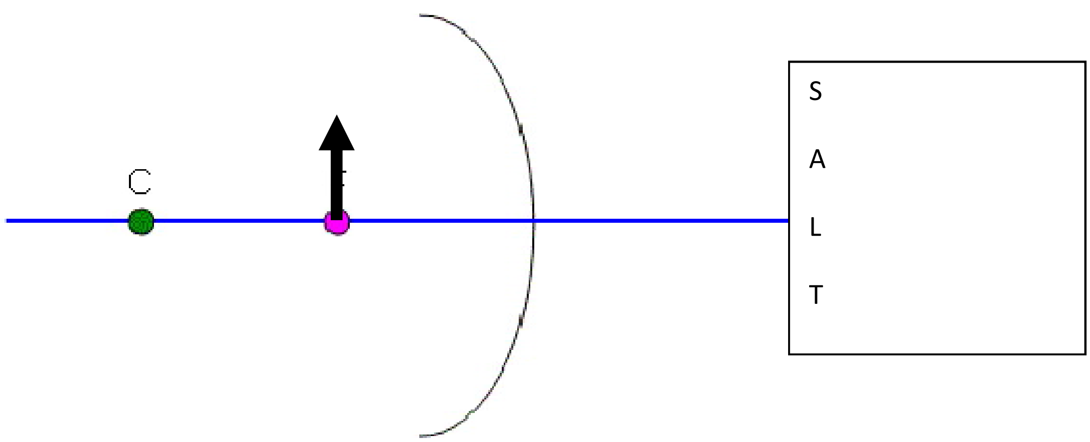







S
A
L
T
C
F


C
F
S
A
L
T


C
S
A
L
T

Uses for Concave Mirrors

- used when concentrating light to a _______________________ is required, also be used to create a beam of ______________________ rays
-

Device	Use of Mirror

Uses for diverging mirrors

-> can see ______________ than a plane mirror ("more amount of stuff")
-> _________________________reasons

Examples:

Magnification

-curved mirrors can be used to ______________________ objects by increasing or decreasing their size
-magnification of an image can be calculated two ways

$$\text{magnification} = \frac{\text{image height}}{\text{object height}} \qquad M =$$

$$\text{magnification} = \frac{\text{image distance}}{\text{object distance}} \qquad M =$$

Example 1: An object is placed 4 cm away from a mirror, and the image reflected in a concave mirror is 7.3 cm away from the mirror. What is the magnification of the object?

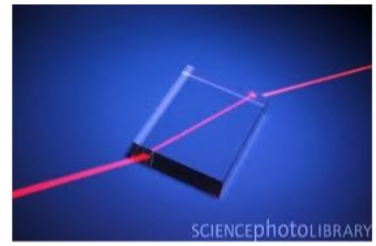
Example 2: A 16 cm tall squirrel runs across the front lawn. Penny sees its reflection in a mirror that is magnified by 0.43X. How tall is the squirrel's reflection?

Example 3: A slide projector has a magnification of 60X. How tall is the slide if the image on the screen is 97 cm tall?

Homework: Complete all practice problems on pg. 424 and 425 (12 of them!)

Refraction

Refraction is the _____________ of light as it travels from one medium into another (with a different _______________)



Light is _____________________ (compared to the speed of light in a vacuum) by optically dense mediums.

The refraction only happens at the ________________________________ between the two mediums.

Index of Refraction (n)
- is a measure of how much light is _________________
-the larger the refractive index, the ________________ light travels

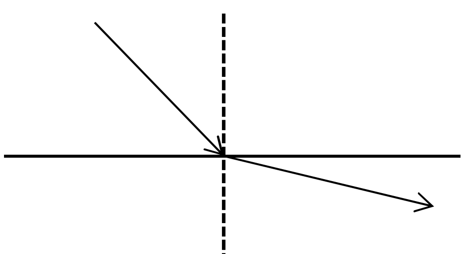
speed of light in a vacuum: c = ______________________________

Example 1. The speed of light through an unknown medium is 1.75×10^8 m/s. What is the index of refraction?

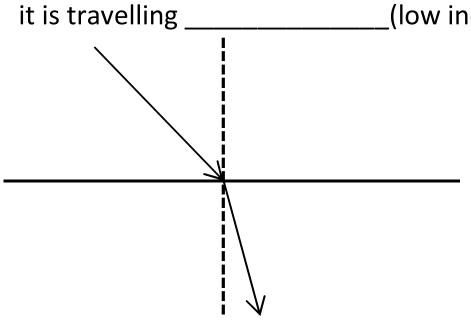
Example 2. What is the speed of light in table salt (n=1.51)?

Homework: Complete the practice problems on page 438 (6 of them)

Predicting the direction that light will refract:



If a light ray goes from a medium where light is travelling _____________ (high index of refraction) to a medium where it is travelling ______________(low index of refraction), it bends ___________ from the normal



If a light ray goes from a medium where light is travelling _____________ (low index of refraction) to a medium where it is travelling _________________ (high index of refraction), it bends ___________________________ the normal

Dispersion is a special kind of refraction where white light is refracted into __________________ so a _______________ _____________________ is seen.

Snell's Law

We already know:
As light slows down, it bends _________________ the normal
As light speeds up, it bends __________________ the normal

$\theta i \neq \theta r$

HOW MUCH the light bends can be calculated using Snell's Law:

n values are ____________________________________
θ values are _______________

Ex 1. When light passes from air into water at an angle of 60° from the normal, what is the angle of refraction?

Ex 2. In an experiment, a block of cubic zirconia is placed in water. A laser beam is pased from the water through the cubic zirconia. The angle of incidence is 50°, and the angle of refraction is 27°. What is the index of refraction of cubic zirconia?

Homework: Complete the practice problems on pages 441-442 (6 of them)

Scenarios where light does NOT refract

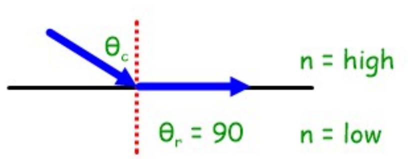
1. Both mediums have the same ____.

2. The light enters along the ___________________ (θ_i = 0).

3. ______________________________________ occurs

- light is "trapped" in the ________________medium because it refracts at an angle of refraction greater than 90°
- light must be travelling from a __________ index of refraction to a ______ index of refraction (speeding up... bending ______________ from the normal)

The _______________ angle (θc) is the angle of incidence at which total internal reflection first happens (when θr = 90°)



At an any θ_i ___________________ than the critical angle, total internal reflection happens

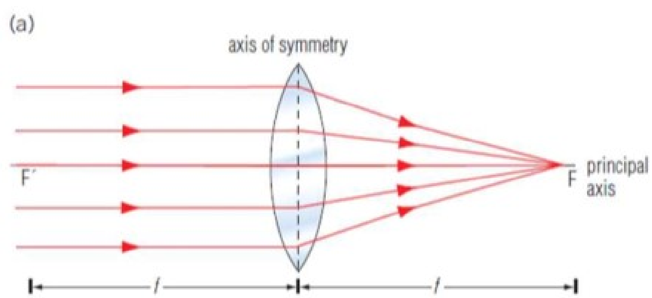
We can calculate the critical angle using Snell's Law (with θ_r = ______°)
Ex. What is the critical angle of light travelling from water into air?

A ________________ is formed when light from a distant object refracts through different temperatures of air before it gets to our eyes.

Lenses

A lens is a ____________ transparent material with a regular shape that refracts light in a ____________________ way.
Most lenses are made of __________________________________ or _______________.
By shaping a lens, it is possible to make light rays _________________ (come together) or _____________ (spread out).
Lenses can produce images of all ____.

Converging Lenses:



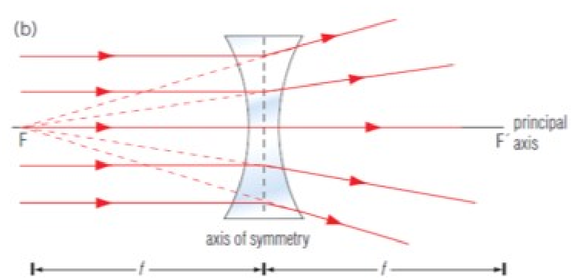
A **converging lens** is _______________ at the centre than at the edges.

As light travels through a converging lens, they are refracted _______________ the principal axis.

This causes the rays to move toward each other. The light rays cross at _____________________________________.

The primary focus is on the __________________________ side of the lens as the object.

Diverging Lenses:



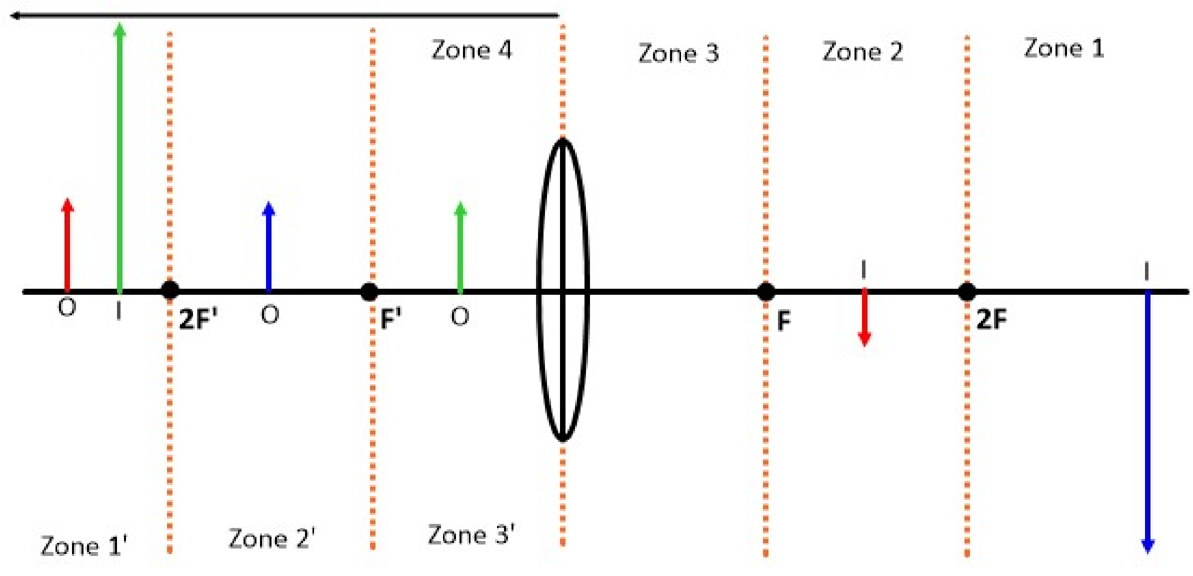
A **diverging lens** is _______________________ in the centre than at the edges.

As light rays pass through a diverging lens, they are refracted_____________________________ the principal axis.

This means the light rays diverge and they will ___________________________ on the other side of the lens.

The primary focus is on the __________________________ of the lens as the object

Predictor Chart for Converging Lenses:



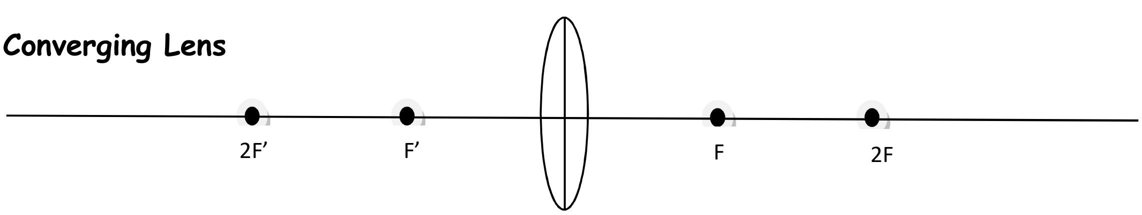
Summary of Characteristics of Images in Lenses

Rules for drawing ray diagrams for Lenses:

In your ray diagrams, assume you are working with a thin lens. All refraction happens at the axis of symmetry

1.	
2.	
3.	

Converging Lens

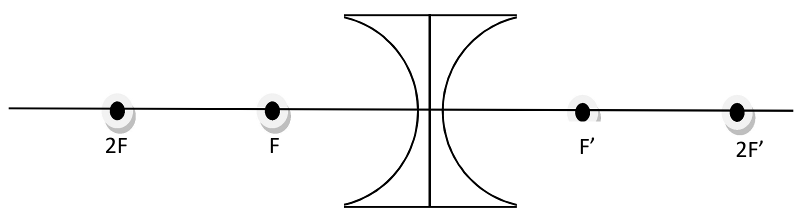


Images formed in converging lenses have different characteristics depending on the location of the object.

	Image Characteristics			
Location of object	**Size**	**Attitude**	**Location**	**Type**
beyond 2F' (Zone 1')				
at 2F'				
between 2F' and F' (Zone 2')				
at F'				
between F' and lens (Zone 3')				

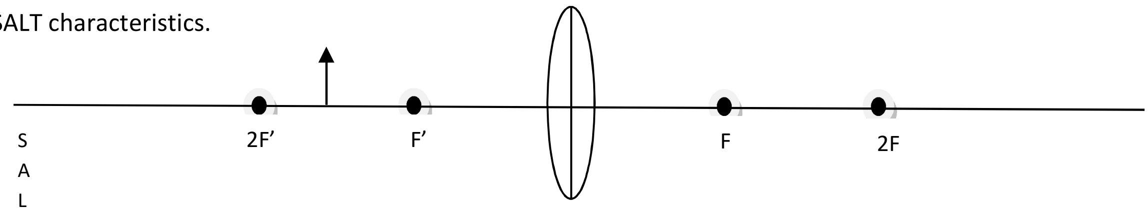
Diverging Lens

Size	
Attitude	
Location	
Type	

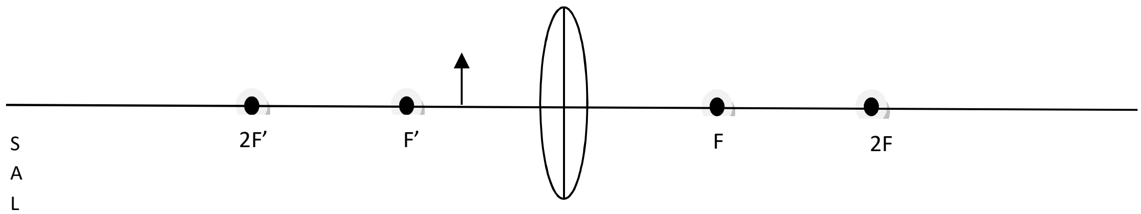


Locating Images in Lenses

For each of the following Lenses, Locate the image and draw it as an arrow from the Principal Axis. Describe the image using the SALT characteristics.



S
A
L
T



S
A
L
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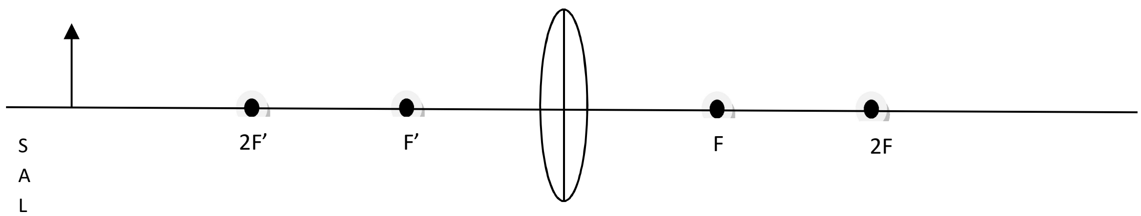

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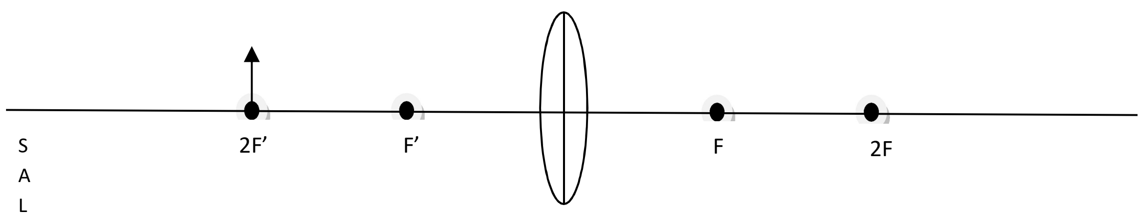
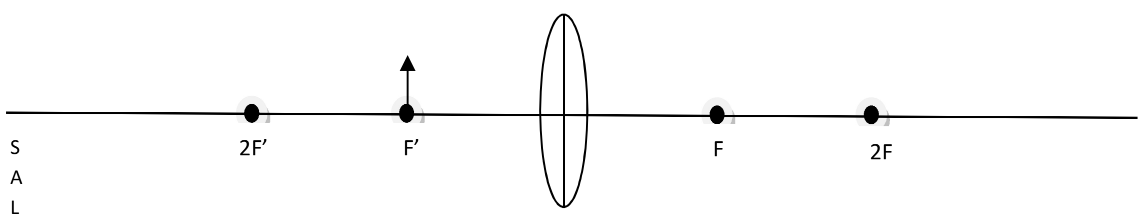
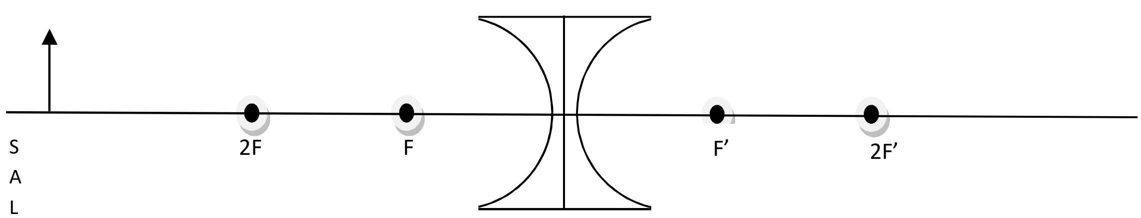


S
A
L
T



S
A
L
T



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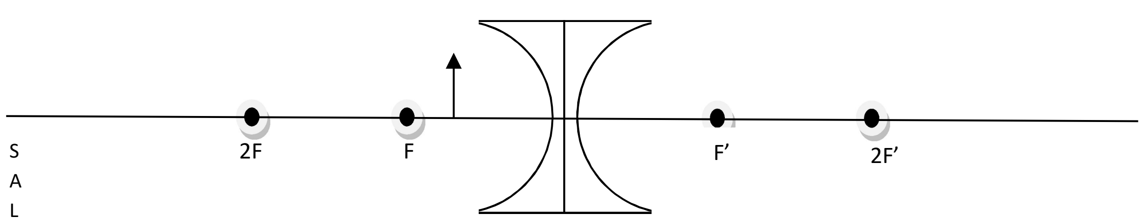


S
A
L
T

Uses for Lenses:

Converging Lenses are useful because they can be used to create a ________________________________ on a screen.

Distance from object to lens	Type of image formed	Uses
Beyond 2F' (zone 1') - converging		
Between F' and 2F' (zone 2') - converging		
Between F' and the converging lens		
Diverging lenses - All distances		

Thin Lens Equation:

To use this equation you must be very careful about the sign (+ or -) that you assign to each value.

FOCAL LENGTH

The focal length for a **converging lens** is ALWAYS ________________________

The focal length for a **diverging lens** is ALWAYS __________________________

OBJECT DISTANCE

The OBJECT DISTANCE is always ________________________

IMAGE DISTANCE – Virtual vs. Real

If the image is **REAL** the distance is always _______________________________

If the image is **VIRTUAL** the distance is always ____________________________

Ex 1. A converging lens of a magnifying glass is held 2.00 cm above a page to magnify the print. If the image produced by the lens is 3.60 cm away and virtual, what is the focal length of the magnifying glass?

Ex 2. A converging lens has a focal length of 60.0 cm. A candle is placed 50 cm from the lens. What type of image is formed, and how far is the image from the lens?

Ex 3. A camera with a 200-mm lens makes a real image of a bird on film. The film is located 201 mm behind the lens. Determine the distance from the lens to the bird.

Homework: Practice problems 1-3 on pages 455-457 (9 of them)
Read section 12.2 (Pg 482-492)

OPTICS LAB 2: THIN LENSES

PURPOSE

You will observe the location of images produced by thin convex (positive, converging) lenses, and verify the thin lens equation for several different object positions.

APPARATUS

Metre stick and supports (x2), object/source light (candle and mount), screen (and mount), converging lens (and mount).

PROCEDURE:

1. Determine the focal length, f, of a convex lens in air using a distant object or light source. (Distant means at least 10 meters away – if possible, the farther the better). You will use this value for f to set up the apparatus as outlined in step 2. This will be done as a class. f =
2. Set up the apparatus listed above (with instructions from your teacher) and measure i) the distance of the object (d_o), ii) the height of the object – candle flame – (h_o), iii) the image distance (d_i) and iv) the image height (h_i) for each of the cases below. Place your data in the chart below. Also determine whether the images in these cases are real or virtual; upright or inverted.

OBSERVATIONS:

TITLE:

Case	d_o (cm)	h_o (cm)	d_i (cm)	h_i (cm)	real/virtual	upright/inverted
1. $d_o = 3f$						
2. $d_o = 2f$						
3. $d_o = 1.5f$						
4. $d_o = 1.0f$						
5. $d_o = 0.5f$						

ANALYSIS: *Answer these questions in the space provided.*

1. For a converging lens, where does the object have to be placed (in relation to ***f***) to create an image that is:
   a) smaller and real ___________________________
   b) larger and virtual ___________________________
   c) same size and real ___________________________
   d) larger and real ___________________________

2. Using the thin lens equation, and your measured distances for the object (d_o) and the image (d_i), calculate an experimental value for the focal length (***f***) in each of the cases. Show your calculations below for each case (3 calculations for *f*).

3*f*: **2*f*:** **1.5*f*:**

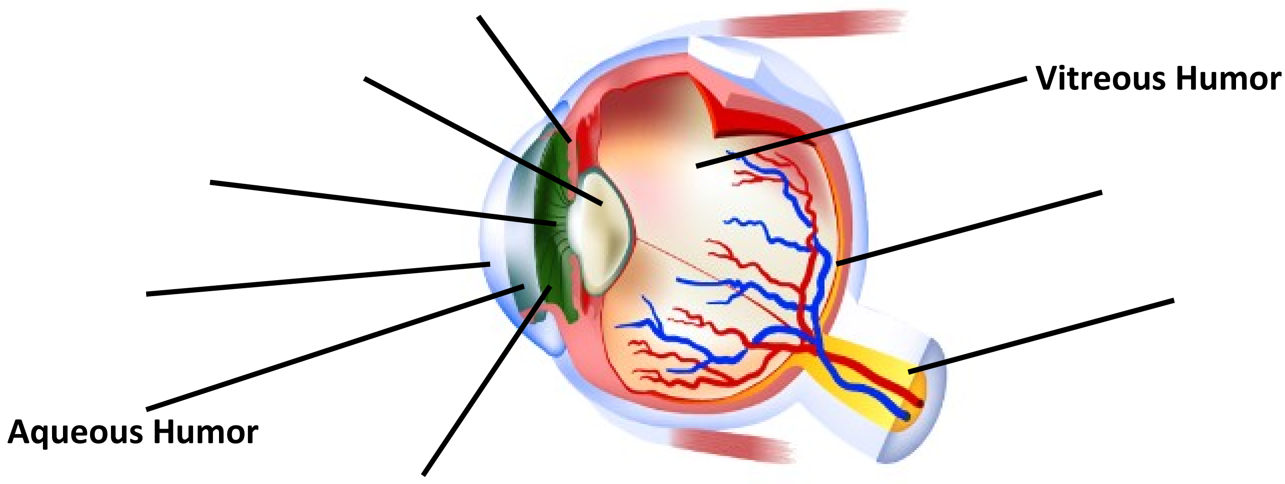
3. How did your calculated value for ***f*** compare with the focal length you got using a 'distant' object?

4. Using the equation for magnification given above, compare calculated values of magnification (**M**) based on i) your measured d_i and d_o with ii) your results for h_i and h_o. Use a table like the one below.

Case	M_d ($d_i \div d_o$)	M_h ($h_i \div h_o$)	Percent difference (M_d - M_h) ÷ M_d x 100
1			
2			
3			
4			
5			

5. Describe two sources of error that would create discrepancies in focal length and magnification (from the true value).

The Human Eye (pg. 468-477)



Part of the eye	Function
Iris	
Pupil	
Lens	
Cornea	
Retina	
Rods	
Cones	
Optic nerve	

Correcting Vision

In good eyesight, images are focussed on the ____________ at the back of the eye. Light is refracted through the _____________ and the ________________ so that the light rays converge on the retina. __________________ contract and relax to reshape the lens which focuses the image onto the retina. When you are seeing nearby objects, the lens is __________________. When you are seeing far away objects, the lens is __________________.

The blind spot is ____.

A person who is **far-sighted** can see objects that are ____________ clearly but cannot see _______________ objects. The image is focussed ____________________________. A __________________ lens can be used to correct vision.

Draw a picture to illustrate far-sightedness and how it is corrected:

A person who is **near-sighted** can see objects that are ____________ clearly but cannot see _______________ objects. The image is focussed ____________________________. A __________________ lens can be used to correct vision.

Draw a picture to illustrate near-sightedness and how it is corrected:

An _________________ is caused by an irregularly shaped cornea. Vision is blurry and can cause ____________ and _____________.

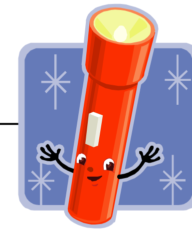
Laser eye surgery corrects vision by ____.

Compare the positives and negatives of laser eye surgery (Hint: read pg. 480)

Positives	Negatives

HW: Pg 481 Q. 4-10,

Light & Optics Review



1. Define the law of reflection. Using diagrams, explain how diffuse reflection is different from regular reflection.

2. Explain the difference between transparent, translucent and opaque objects.

3. Light can be produced many different ways – explain incandescence, chemiluminescence, and fluorescence.

4. Light has a wavelength of 580 nm and travels at the speed of light. What is the frequency?

5. Draw a ray diagram to find the image of an object that is 2.0 cm from a **concave mirror**. The center of curvature is 3 cm. Be sure to include at least 2 light rays, and describe the image using SALT (yes you should be drawing this with a ruler).

6. Draw a ray diagram to find the image of an object that is 4.0 cm from a **convex mirror**. The center of curvature is 5 cm. Be sure to include at least 2 light rays, and describe the image using SALT.

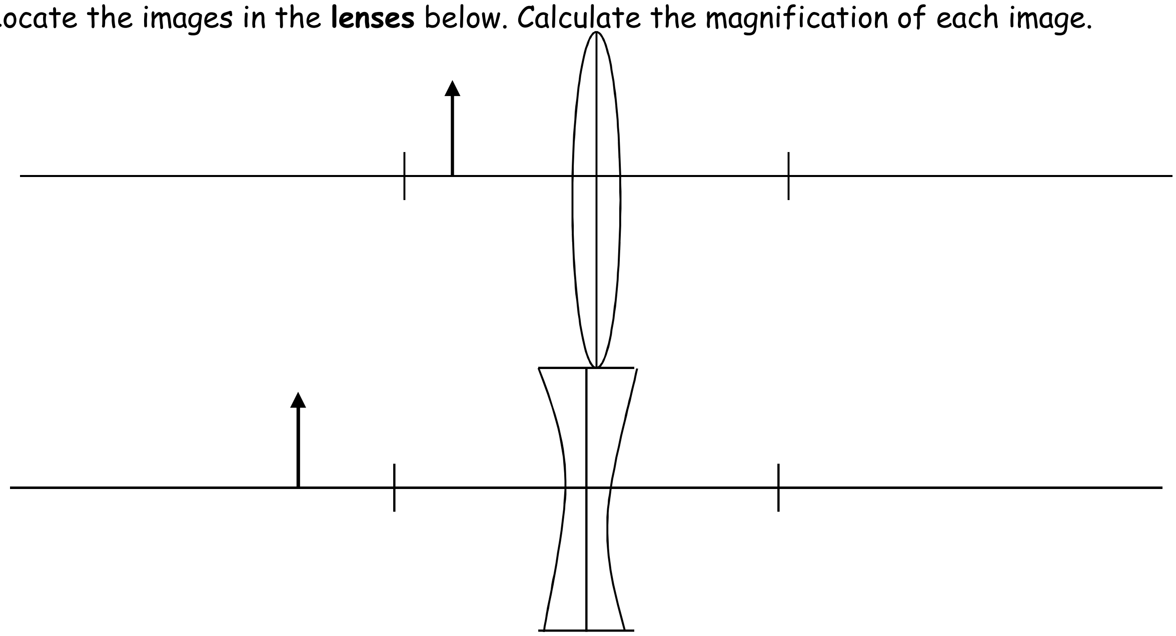
7. If water has an index of refraction of 1.33, how fast does light travel through it?

8. As light travels from water to salt, it bends towards the normal. If the incoming rays are at 52^0 from the normal, what is the angle of the refracted rays? (n_{water}=1.33, n_{salt}=1.54)

9. Light refracts at 52° to the normal as it **exits** a glass of milk. What is the angle of incidence of the incoming rays? (n_{air}=1.0003, n_{milk}=1.35)

10. A 4.5 cm object is placed 19 cm in front of a concave mirror and a real image that is 1.5 cm tall is produced. Determine the distance from the mirror to the image. (Hint: this is a magnification question)

11. Locate the images in the **lenses** below. Calculate the magnification of each image.



12. A magnifying glass of focal length 12 cm is used to magnify print. Where is the image seen if the lens is held 15 cm above the paper?

13. An object is in front of a diverging lens that has a focal length of 12 cm. How far in front of the lens should the object be placed so that the image is 4 cm from the lens? If the image is 3 cm tall, how tall is the object? (tough question!)

14. A 19-cm tall object is placed 21 cm from a converging lens that has a focal length of 14 cm. How far from the lens will the image be formed? How tall is the image? Describe the characteristics of the image. (tough question!)

15. Determine the critical angle for sapphire (use air as the second medium). What does this mean?

Other topics that we have covered this unit and will be on the test:

- ✓ Properties of the Wave (Diagram)
- ✓ Electromagnetic Spectrum
- ✓ Sources of Light
- ✓ Transparent, Translucent, Opaque Objects
- ✓ The ray model of light
- ✓ Shadows
- ✓ Universal Wave Equation Problems
- ✓ Law of Reflection
- ✓ Locating Images in Plane Mirrors
- ✓ Curved mirror terminology (concave, convex, focal point, focal length, centre of curvature, principal axis, object, image…)
- ✓ Locating Images in Concave and Convex Mirrors
  - Describe these using SALT
  - know which side of the mirror F is on
- ✓ Uses of Mirrors
- ✓ Calculating Magnification
- ✓ Refraction
- ✓ Calculating Refractive Index
- ✓ Snell's Law
- ✓ Total Internal Reflection
- ✓ Solving for Critical Angle
- ✓ Locating Images in Converging and Diverging Lenses
  - Describe these using SALT
- ✓ Thin Lens Equation
- ✓ Human Eye

More review questions from the textbook: p 504-507 # 3, 5-7, 11-15, 17, 18-21, 23-32, 36-38