What is scientific notation?

- a way of… ____

The number 154,000,000,000 is written in scientific notation as

The first number (1.54) is called the _____________________________. It must be greater than or equal to 1 and less than 10.

The second number (10) is called the ___________ It will **always** be **_______**.

The third number (11) is called the _____________. It is also referred to as the power of ten.

Write this number in scientific notation by following the steps below. 785 000

Step 1: Write the ______________ by putting the decimal after the first non-zero digit.

Step 2: Write the _____________ (x 10).

Step 3: Find the __________________ by counting the number of places the decimal must move.

Ex. Write the following numbers in scientific notation:

195 000 000 000 =

675 000 000 =

56 000 000 =

72 000 =

What about really small numbers?

Numbers that are less than 1 have a _______________ exponent.

A millionth of a second would look like this: 0.000001 = ________________________.

Ex. Write the following numbers in scientific notation**.** Remember that the coefficient only has one number before the decimal place.

0.00000007 =

0.0000743 =

0.00056 =

0.092 =

When do you write a negative exponent when converting to scientific notation?	When do you write a positive exponent when converting to scientific notation?

Using Calculators in scientific notation

Multiply these two numbers together by following using the Exp or EE button on your calculator

$$(2.1 \times 10^{8}) \times (3.2 \times 10^{4}) = 6.72 \times 10^{12}$$

Type EXACTLY into your calculator:

$(6.3 \times 10^{12}) \times (5 \times 10^{4}) =$

$(3 \times 10^{6}) \div (4.2 \times 10^{-3}) =$

Homework: <u>Scientific Notation/Conversions Practice</u>

1. Express each of the following in scientific notation:

a) 978 000 000 000 = ________________

b) 0.000 000 3001 = _________________

c) 457.1 = _________________________

d) 8 920 000 = _____________________

e) 1000 = _______________________

f) 0.035 000 = ___________________

g) 36 400 = ______________________

h) 0.000 000 0198 = _______________

2. Write the following in standard form:

a) 3.34×10^{4} = _____________________

b) 9.8765×10^{3} = ___________________

c) 5.55×10^{-2} = _____________________

d) 9.98×10^{-5} = _____________________

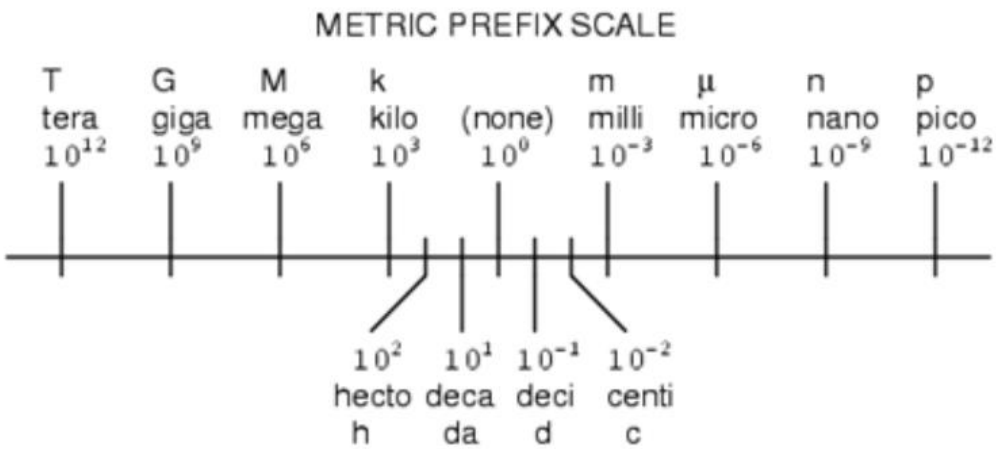
e) 1.8×10^{6} = ______________________

f) 2.8404×10^{-3} = __________________

g) 3×10^{8} = _______________________

h) 9.99×10^{4} = ___________________

<u>Metric Conversions</u>



Use the metric prefix scale to convert between units.

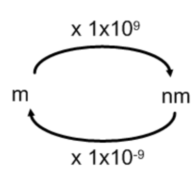
900 mm = ___ m 3 GL = ____ kL 500 cm = ____ nm 265 mm = ____ cm

Converting with nanometres!

One nanometre is _________________ metres.

Convert the following values.

1. 600nm = ___________________ m
2. 20 nm = ____________________ m
3. 4550 nm = __________________ m
4. 175 nm = ___________________ m



5. 6 m = _________________________ nm
6. 2.99×10^{-10} m = ________________ nm
7. 7.5×10^{-9} m = __________________ nm
8. 9.87×10^{-7} m = ________________ nm

Homework: **Convert between the following metric units.**

a) 75m = _________________ km

b) 538 nm = _________________ m

c) 0.0036m = _________________mm

d) 0.000 000 179 m = _________________ nm

e) 50.6 L = _________________ mL

f) 90.25 kV = _________________mV

g) 3.75×10^{-7} m = _________________ nm

h) 2 GV = _________________ V

i) 3.78 nm = _________________ m

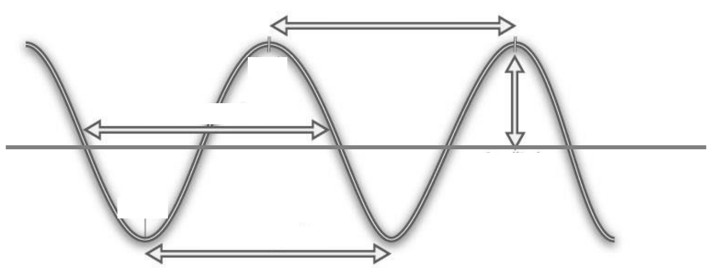
j) 2.5 hours = ___________________ seconds

k) 3 days = _________________ hours

l) 1 000 000 seconds = ___________ days

What is Light?

We now know that light is a form of ________________. This energy travels in ______________, which together with visible light are called electromagnetic radiation.



Properties of Waves	Definition
Crest	
Trough	
Wavelength	
Amplitude	
Frequency	It can also be found using the equation: f =

The energy transferred by a wave often depends on the _________ of the wave **and** its ___________.

The higher the frequency, the _________ energy the wave passes along.

The **wave equation** tells us the relationship between frequency, speed, and wavelength:

Ex 1. Red light has a wavelength of 700 nm. If its frequency is 4.2827×10^{14} Hz, what is the SPEED OF LIGHT?

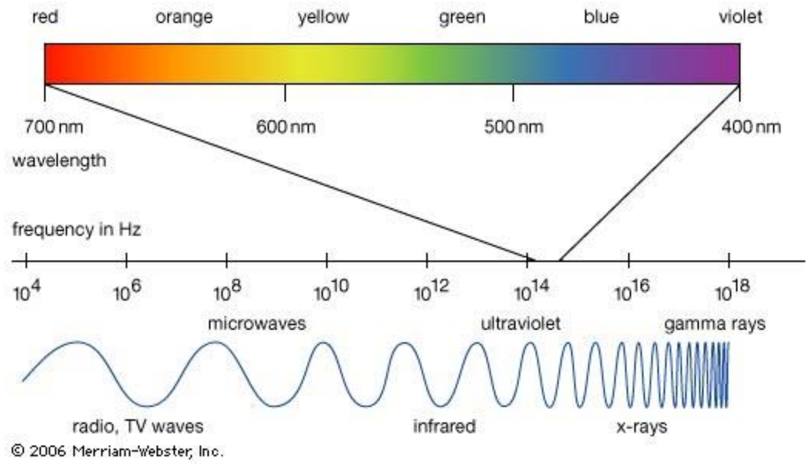
Ex 2. Knowing that the speed of light is 3.0×10^{8} m/s and that some X-rays have a wavelength of 5.25 nm , what is the frequency of the X-rays?

Using the Wave Equation Practice

All final answers should be rounded to 2 decimal places

1. A pendulum goes through 100 cycles in 2.5 minutes. Determine its frequency.
2. While sitting on a dock, a boat passes by you and produces a wave. You estimate the distance from the first crest to the fifth crest is 12 m.
a) Use a diagram to determine the number of cycles and the wavelength of the wave.
b) You measure that it takes 3.4 s for 6 waves to pass your dock. Determine the frequency of the wave.
c) Using your answers from part a) and b) determine the speed of the wave.
3. What is the speed of a wave with a wavelength of 1.75 m and a frequency of 800Hz?
4. A light wave passes through a transparent wall. It has a wavelength of 0.3m and travels at 2000m/s. What is its frequency?
5. A red light has a wavelength of 680 nm. What is its frequency?
6. Radiation from a distant galaxy has a frequency of 3.2×10^{22} Hz. What is the wavelength of the light? What type of ray is it?
7. A light ray from a laser has a frequency of 6.7×10^{14} Hz. What is the wavelength of the light? What colour is the light?

The Electromagnetic Spectrum represents:



We can only see a tiny portion called visible light.

What we see is a ___________________of colours

The difference between colours of light is:

	Radio	Microwaves	Infrared	Visible	Ultraviolet	X-rays	Gamma
Uses							
Wavelength Range	**> 0.3**	**0.001-0.3**	**$7.6x10^{-7}$ - 0.001**	**$3.8x10^{-7}$ - $7.6x10^{-7}$**	**$8x10^{-9}$ - $3.8x10^{-7}$**	**$6x10^{-12}$ - $8x10^{-9}$**	**< $6x10^{-12}$**

Big ________________ Big ____________

Small ________________ Small __________

We can also think about light as a ___________________.It is made of _____________(massless particles that travel in a wave-like pattern at the speed of light). Photons contain a specific amount (bundle) of energy. How much energy the photons contain tells us where the radiation is on the _________________________________
This gives us a *"wave-particle duality"*

The Ray Model of Light

Light can be represented in many different ways; each explanation giving validity to a specific aspect of light. Wave theories help to explain _________________________________, particles explain light at an atomic level, but neither explains ____. This is shown through the ____.

The ray model of light, light is represented by using ___________________________ that show the direction that the light travels. Light rays travel away from the source in ____________________, and in completely _________________________________. Ray diagrams are drawings that show the _________________________ as it radiates out. Each ray has an ___________________________ to indicate which direction the light is travelling in.

Light rays diagrams are useful when explaining what happens to light when it hits an object. Once light strikes an object one of three things will occur:

· Light is transmitted freely through the material · e.g. Clear glass or plastic	
· Some light is transmitted through, some is reflected · e.g. Frosted Glass	
· No light is transmitted through the material, all light is reflected · e.g. Wood door	

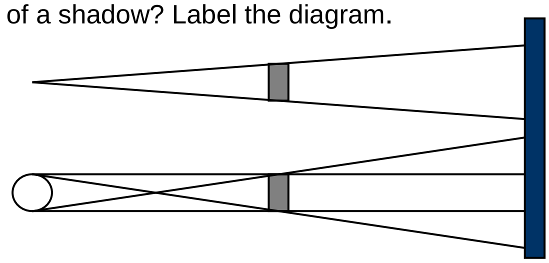
Light Reflection

You can see objects around you because ____ and has returned to your eyes. Incoming rays _______________________________ to one another and in regular reflection (_____________________________________), outgoing rays _____________________________________, travelling parallel as well. In regular reflection, all of the light rays are the same both incoming and outgoing. When this happens you can see a __________________ _______________ on the smooth surface. However, not all objects are smooth; some are composed of many rough edges. The _____________________ causes the parallel incoming light rays to be ____________________________in many different directions, resulting in _______________________________. Diffuse reflection allows you to see the object rather than a reflected image.

Shadows

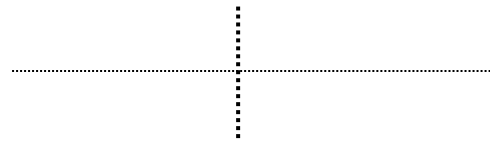
1. How does a shadow form?

2. What is the difference between the umbra and the penumbra of a shadow? Label the diagram.



3. Using a diagram, explain how shadows can change size even though the object remains constant

The Law of Reflection



When light reflects off a surface, the angle of incidence

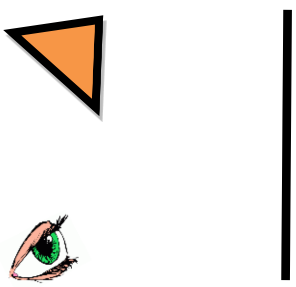
is ________________ to the angle of reflection.

The law of reflection can be written using mathematical symbols. Theta, ______, is used as the symbol for an angle. Subscripts identify the angle. The law says that _________________________.

The angle of incidence and the angle of reflection are always measured from the normal and not from the surface of the object.

Any mirror that has a flat reflective surface is called a ____________________ mirror. When using a ________ mirror it's not possible to make an image you can capture on paper (placed behind mirror), since no light from the object ________________________. This means the image in a plane mirror is a _____________ image, an image formed by rays that do not actually pass through the location of the image. (This is an exact reflection of the real object).

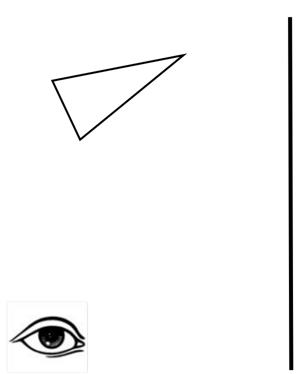
How to Draw a Ray Diagram on a Plane Mirror

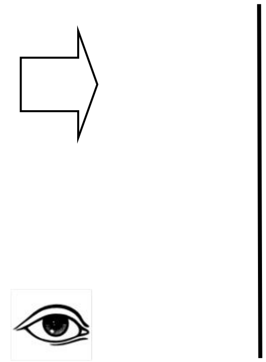


Reflection of Plane Mirrors

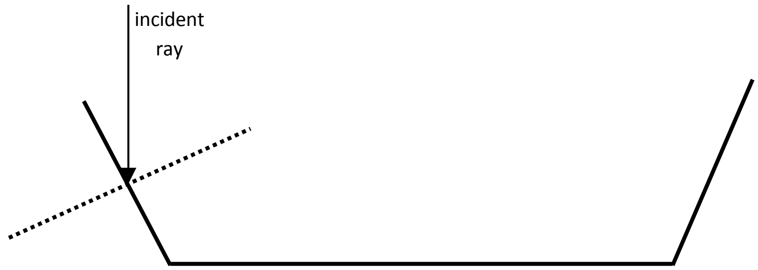
1. Aim the ray box so that the light passes over top of the first dot. Use two mirrors to reflect the light through the second dot. Use a pencil to trace over the pathway of light.

2. Draw ray diagrams to show the image and the rays that extend to the eye.





3. Trace the incident ray as it reflects from the mirrored surface until it leaves the area (draw in the normals first to show that that law of reflection is being followed... the first normal is drawn for you)



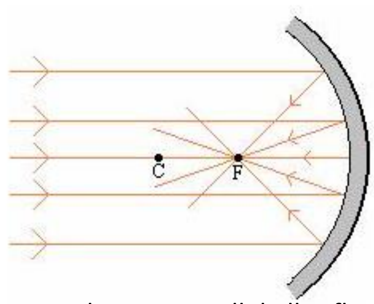
4. Why are letters on an ambulance written in reverse and backward? (Hint: Look at it in the mirror)

5. Come up with a word that does not change appearance in a mirror. (Use the flat mirror to check!)

Curved Mirrors

There are two types of curved mirrors:

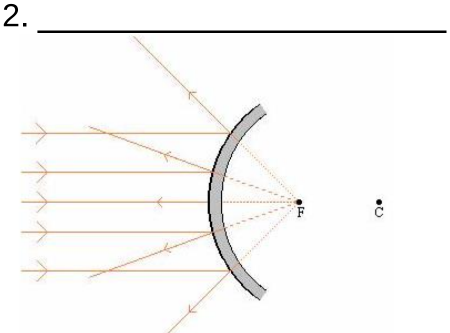
1. ______________________________



Incoming rays that are parallel all reflect through the ________________________________.

This is also called a ____________________mirror

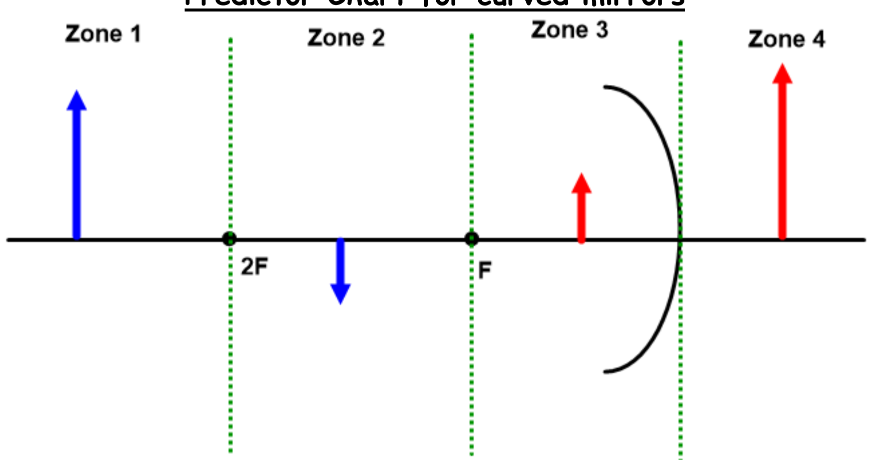
2. _______________________________



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.	

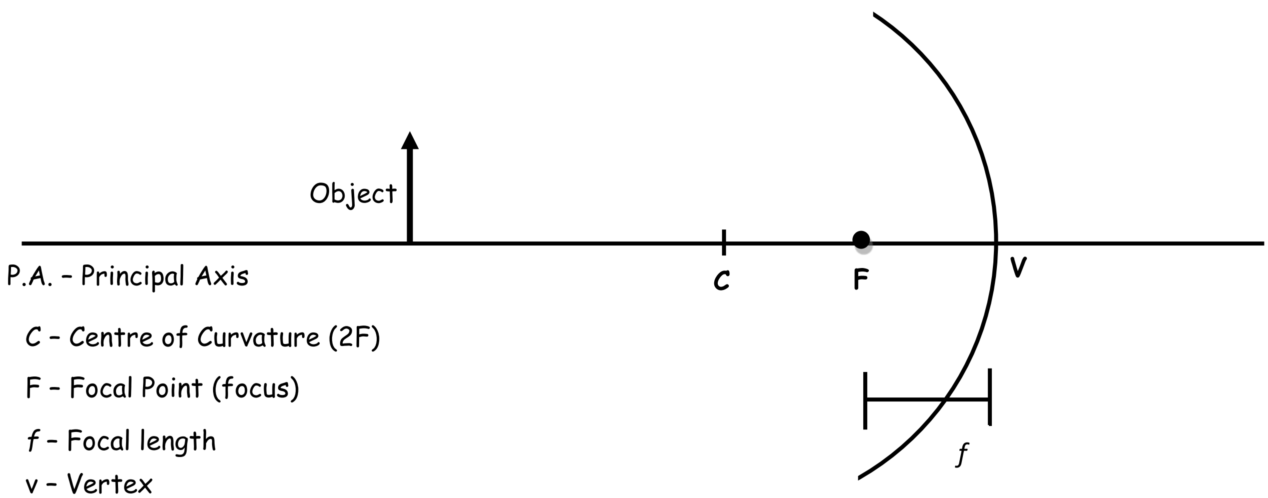


Image Characteristics for Mirrors:

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

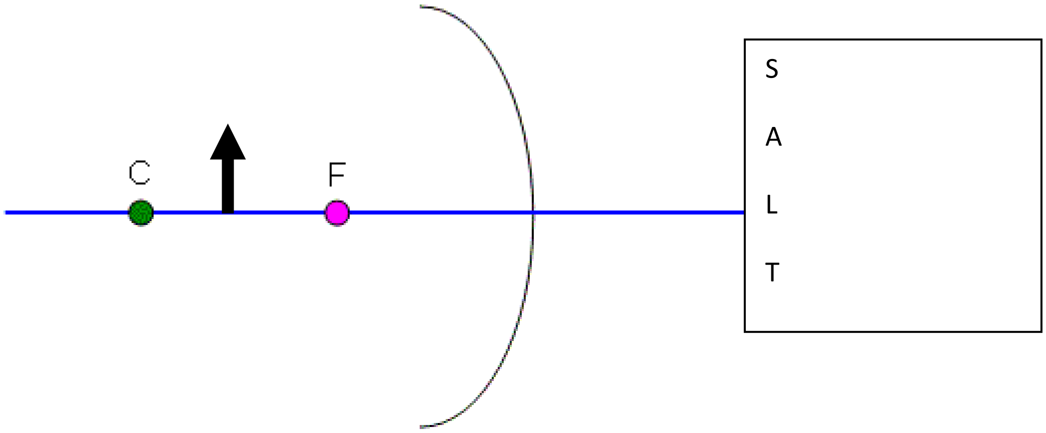
Images formed in concave (converging light) mirrors have different characteristics depending on the location of the object.

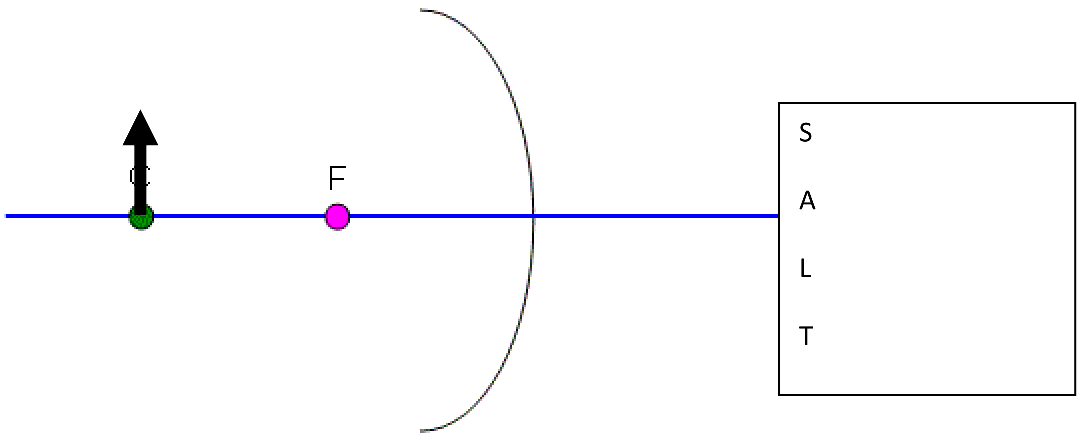
	Image Characteristics			
Location of object	**Size**	**Attitude**	**Location**	**Type**
beyond ‘C’ (2F) *Zone 1*				
at ‘C’ (2F)				
between ‘C’ (2F) and ‘F’ – *Zone 2*				
at ‘F’				
between ‘F’ and ‘V’ *Zone 3*				

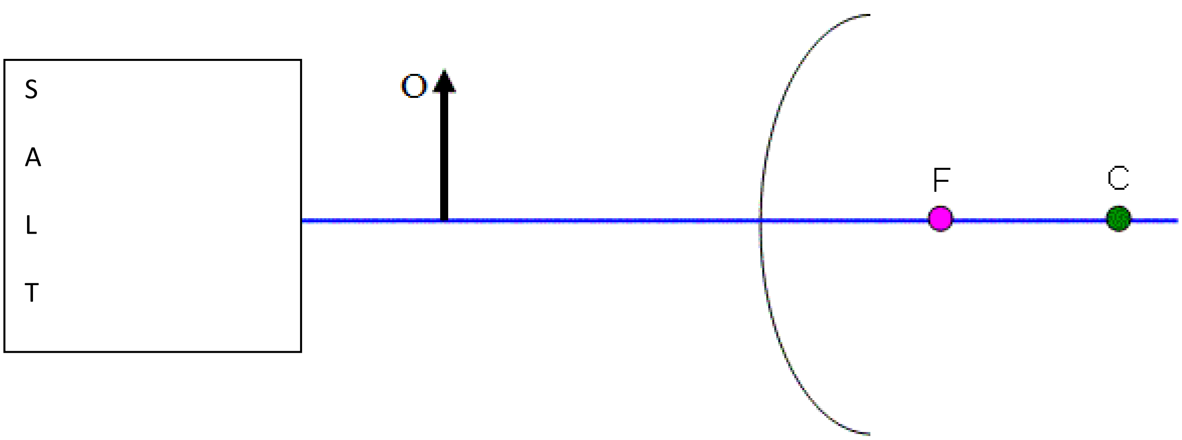
Convex Mirrors

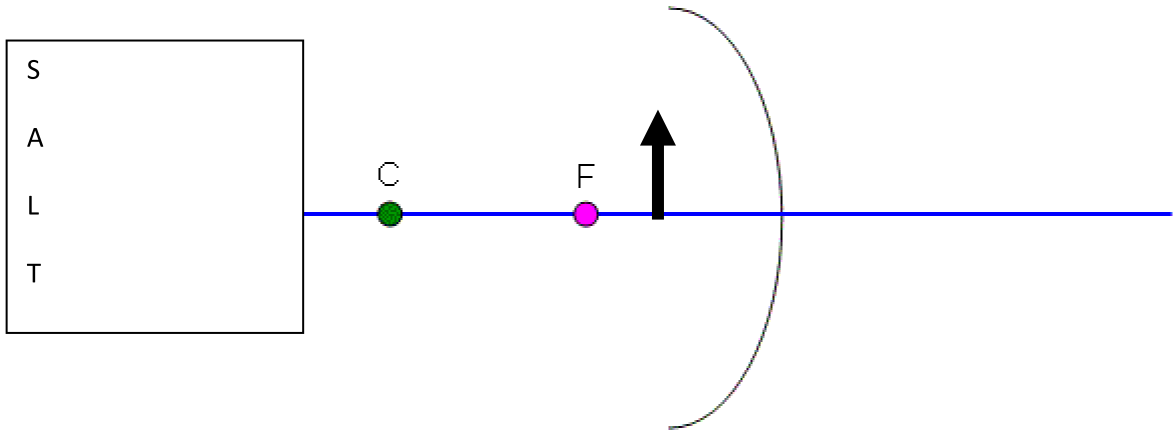
Size	
Attitude	
Location	
Type	

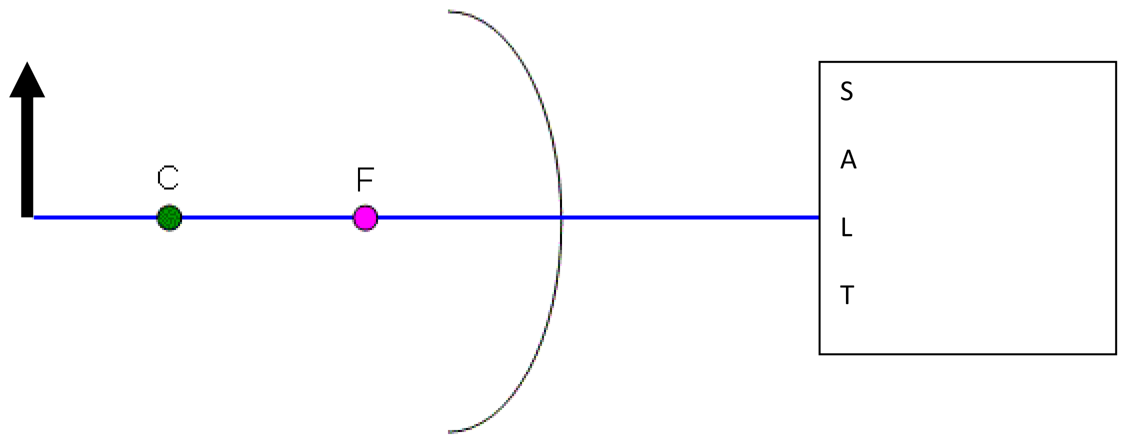
Curved Mirror Ray Diagrams (Homework)

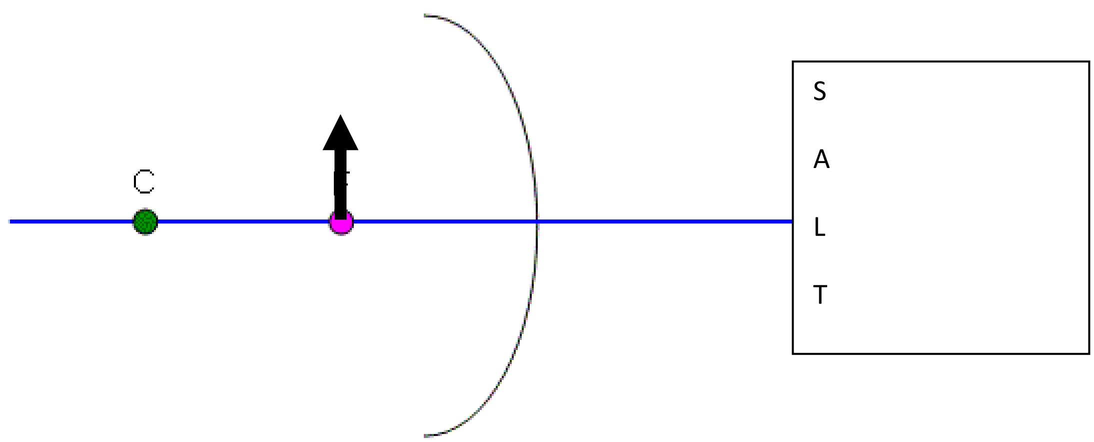







S
A
L
T
C
F


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

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

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

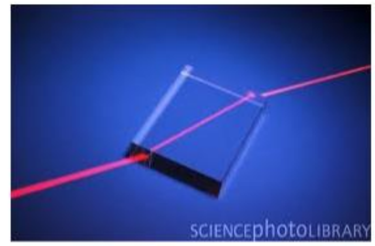
Example 1: An object is placed 4 cm away from a mirror, and the image reflected in a concave mirror is 7.3 cm away from the mirror. What is the magnification of the object?

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

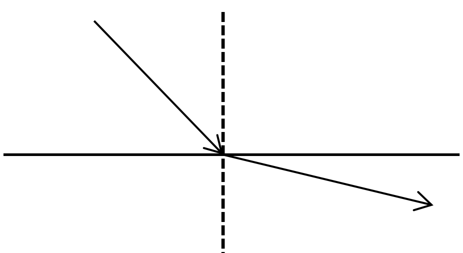
speed of light in a vacuum: c = ______________________________

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

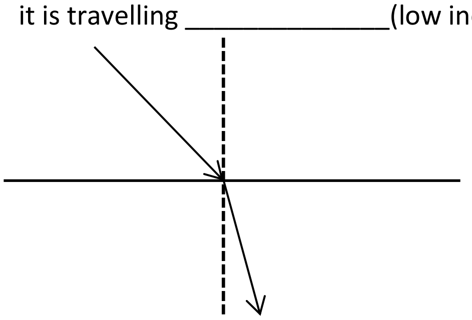
Example 2. What is the speed of light in table salt (n=1.51)?

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

θi≠θr

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

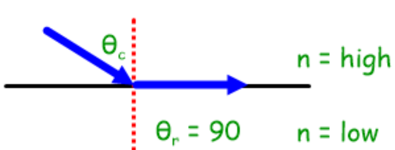
1. Both mediums have the same ____.

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

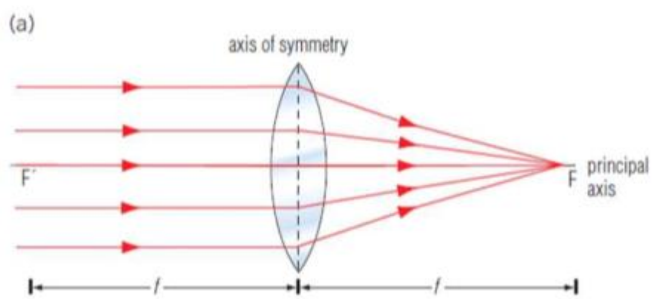
We can calculate the critical angle using Snell's Law (with θ_r = ______°)
Ex. What is the critical angle of light travelling from water into air?

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:



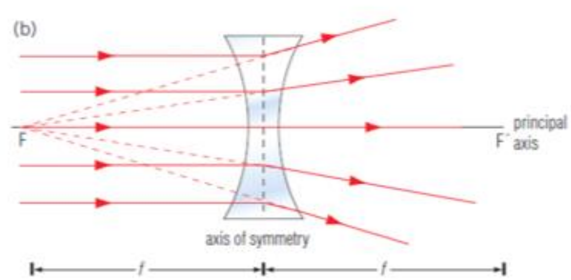
A **converging lens** is _______________ at the centre than at the edges.

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:



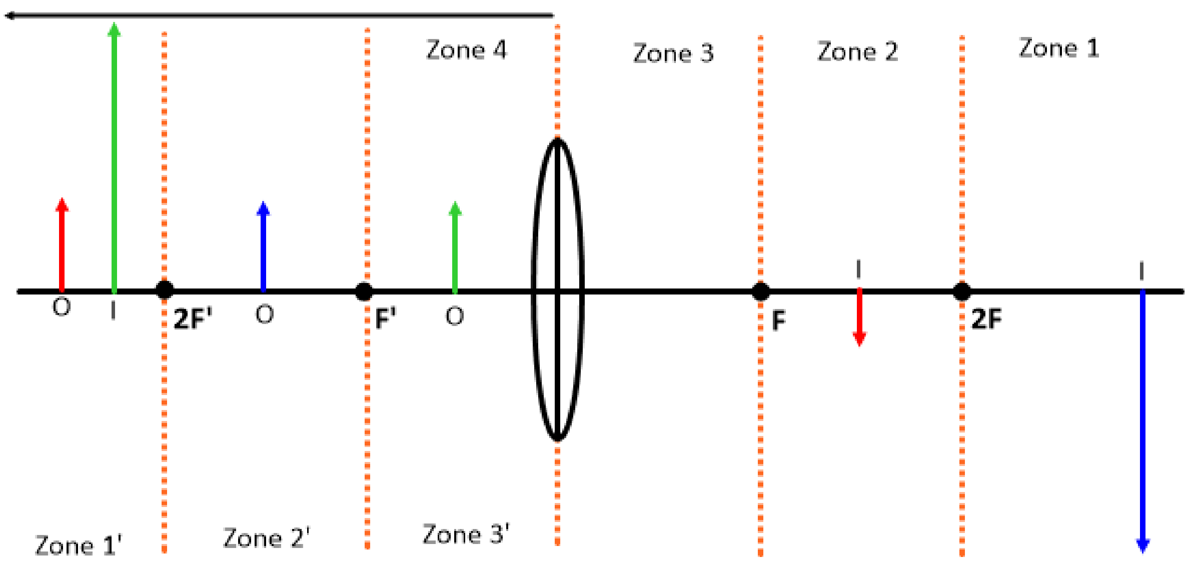
A **diverging lens** is _______________________ in the centre than at the edges.

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:



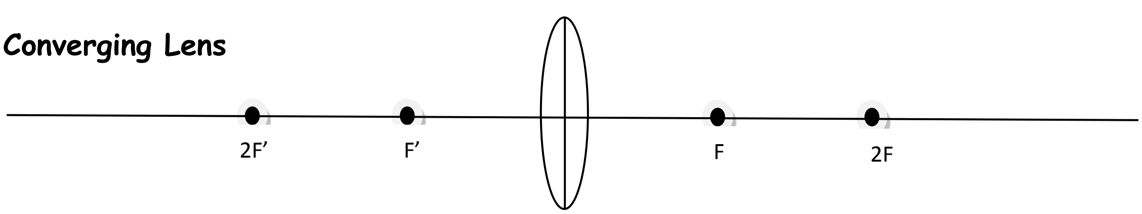
Summary of Characteristics of Images in Lenses

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

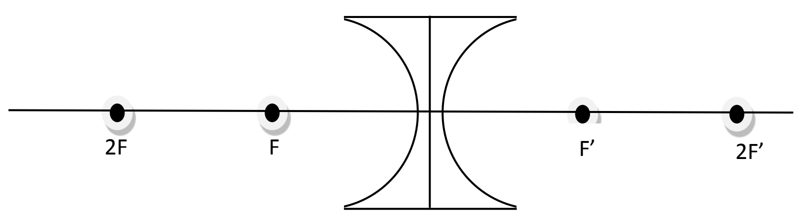


Images formed in converging lenses have different characteristics depending on the location of the object.

	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')				

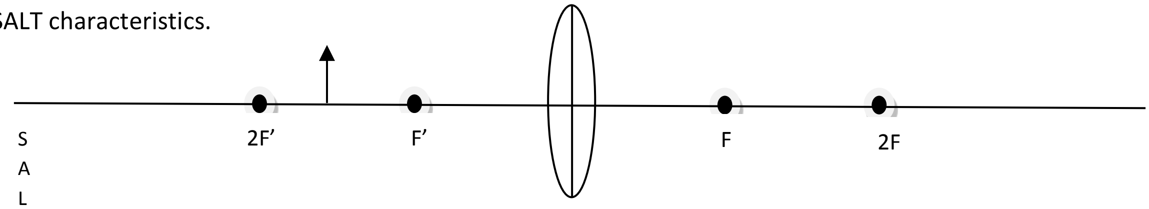
Diverging Lens

Size	
Attitude	
Location	
Type	

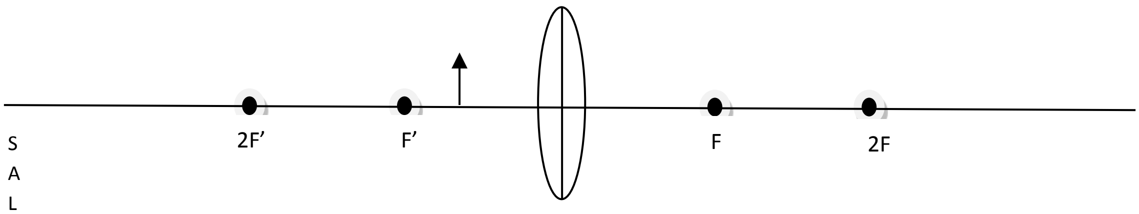


Locating Images in Lenses

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



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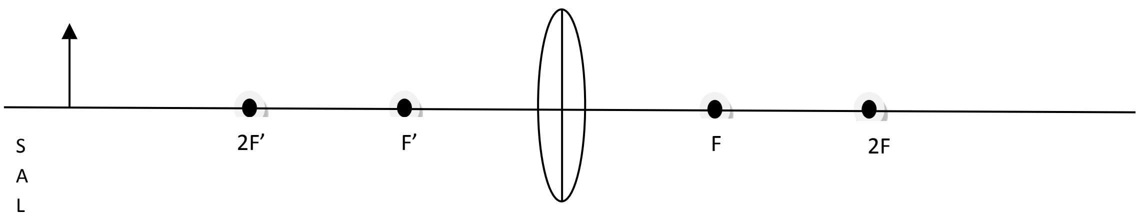

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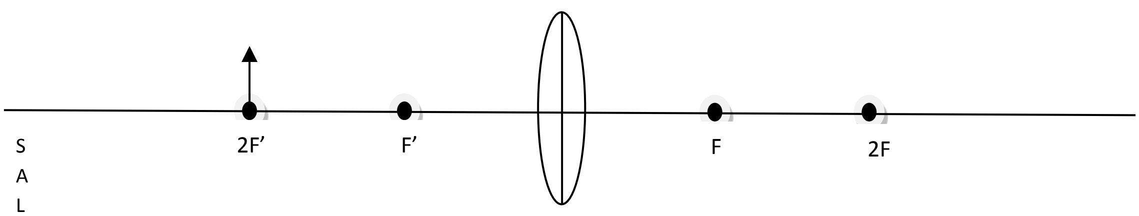

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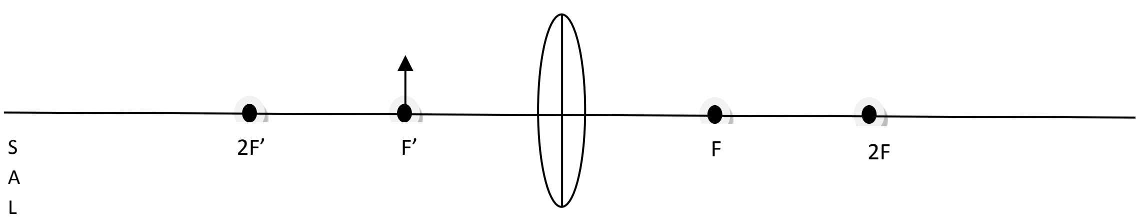

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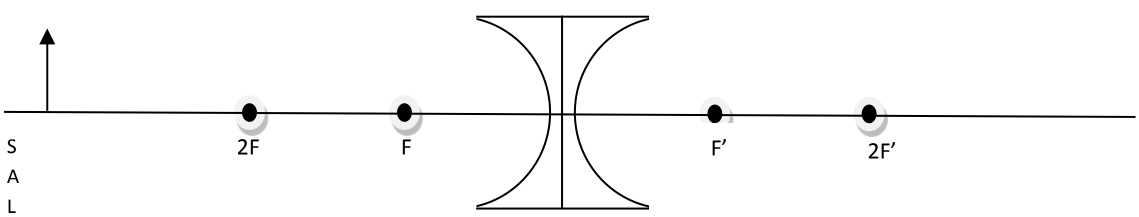

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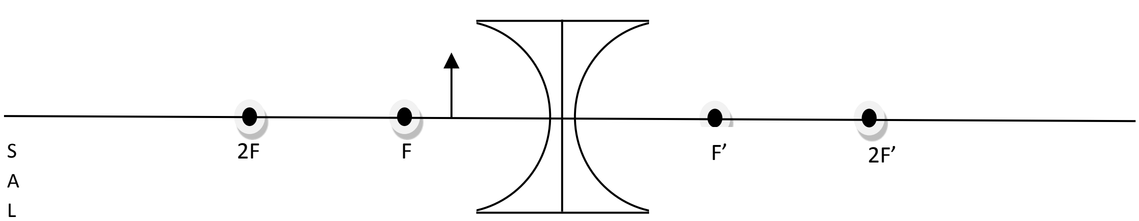

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Uses for Lenses:

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 $(M_d - M_h) \div M_d \times 100$
1			
2			
3			
4			
5			

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