LIGHT BOX & OPTICAL SET

ESR23

Experiment Guide

ACTIVITIES INCLUDED:

Diffraction
Angle of Reflection Using a Plane Mirror
Refraction of Different Shaped Prisms
Refraction (Snell's Law)
Index of Refraction
Dispersion of Light (Rainbows)
Dispersion of Infrared Light
Mixing Colours
Blocking Colours in a Prism Using Filters
Detecting Colours in Monochromatic Light
Study of Concave Mirrors
Study of Convex Mirrors
Spherical Aberration
Study of Convex Lenses (Ray Diagrams)
Study of Concave Lenses (Ray Diagrams)
How the Eye Works
How Glasses Work in Far-sighted Vision
How Glasses Work in Near-sighted Vision

REQUIRED COMPONENTS (INCLUDED)

Name of Part	***Quantity***
Light Box	1
Lamp holder	1
Bulb 12V 20W	2 (one in lamp holder and one spare)
4mm banana plug leads	2
Plane mirror on stand	1
Slit former plates	2 (1 slit/2 slit and wide slit/3 slit)
Coloured slides	8 (tri colour, red, green, blue, magenta, cyan, yellow, violet)
Coloured Cards	8 (red, magenta, orange, yellow, green, cyan, blue, violet)
Rectangular prism	1
45, 45, 90 triangular prism	1
Equilateral triangular prism	1
30, 60, 90 triangular prism	1
Semi-circular prism	1
Bi-concave lens	1
Bi-convex lens	2
Parabolic mirror	1
Semi-circular mirror	1
Instruction manual	1
Semi-circular dish	1

REQUIRED COMPONENTS (NOT INCLUDED)

Name of Part	***Quantity***
Power supply (12V-2amp)	1
Ruler/straight edge	1
Protractor	1
Computer paper	6 sheets

RECOMMENDED COMPONENTS (NOT INCLUDED)

Name of Part	***Quantity***
Cheap camera that has no infrared filter	1
Red pencil	1
Blue pencil	1
Small box	1
Box knife	1
Tape	
1” tall glass equilateral prism	1

SAFE HANDLING OF APPARATUS:

WARNING: The lamp casing gets extremely hot when in use. Do not touch the lamp until it has completely cooled. Do not leave the lamp on for any longer than necessary to complete the experiment. Turn the lamp off while not looking at the apparatus.

BREAKABLE WARNING: The slides in this kit should be handled with care. Do not touch or scratch the surface of these lenses.

The Light Box is made of special plastic that will not warp or melt under the heat of the lamp. However, care should be taken to ensure that the colour filters do not remain in position for long periods of time. Otherwise radiant heat from the lamp may affect them. The slides are *very sensitive* to heat and will warp and discolour if left near the lamp for more than a few seconds at a time.

Ventilate the light box appropriately especially when using three colour filters at the same time to avoid damage of the filters. Make sure the ray end of the box is uncovered and the underside of the box should be open to allow air to pass underneath it.

Use only a 12V DC power source with the lamp in this kit. Higher voltages may blow the bulb.

INITIAL SET-UP OF APPARATUS:

Set up the ray box as shown in diagram 1 below.

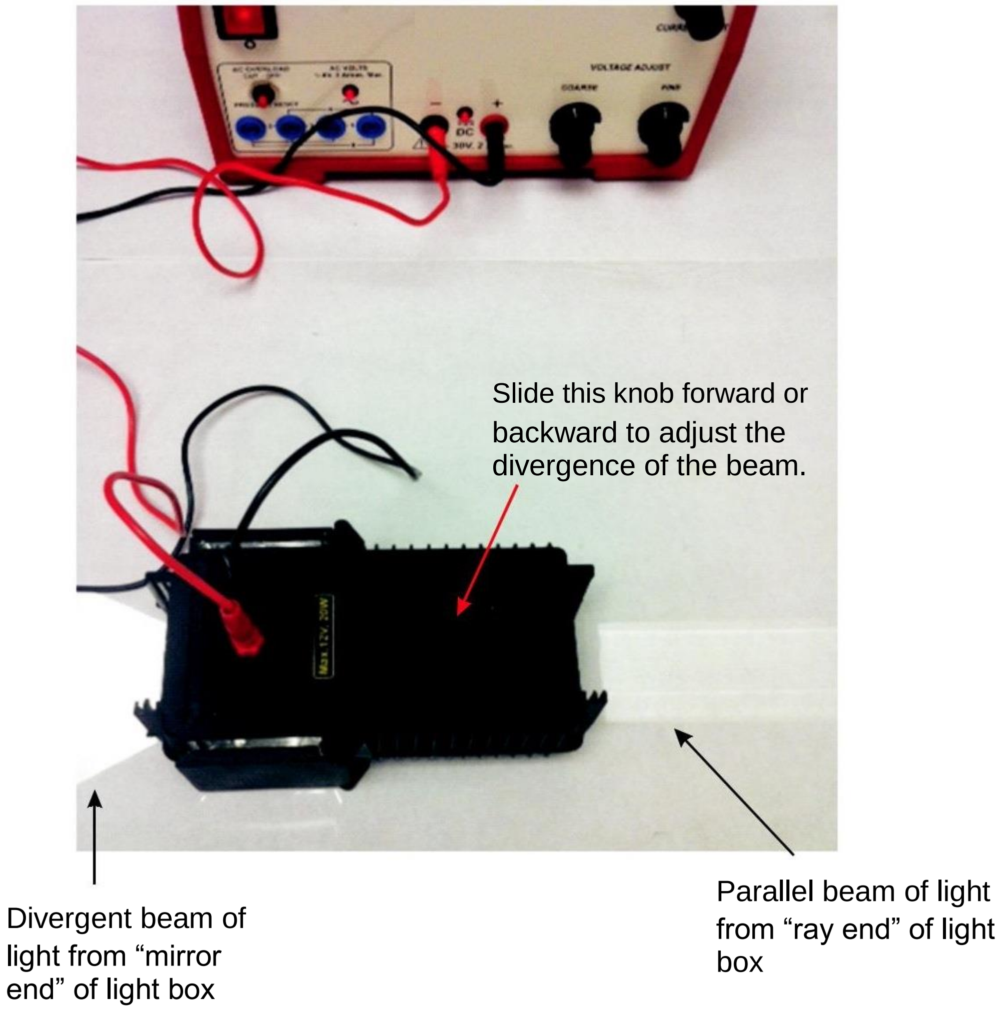

Diagram 1

1. Take the lamp holder out of the case and insert the two plastic knobs through the notches and then twist 90^{o} to lock the lamp into place. This is shown in diagram 2.

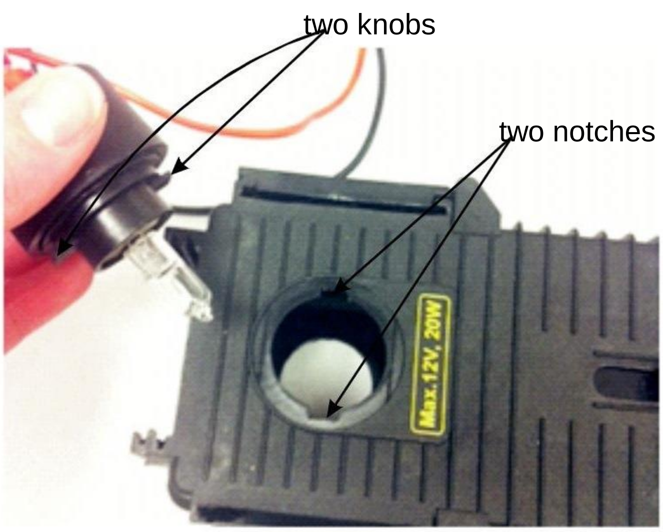

Diagram 2

DIFFRACTION

Diffraction is a wave property where a wave moves around a barrier and spreads out. Diffraction can be seen with sound waves, water (physical) waves, and it also occurs with light. In light waves is difficult to see the light bending around a barrier, however, the fuzzy edges of a shadow when a beam of light is incident on an object show that some interference has taken place. The classic penny and a laser demonstration which shows the “Fresnel bright spot”, sometimes called the “Poisson Spot”, is proof that light waves do indeed bend around a barrier.

EQUIPMENT NEEDED:

REQUIRED COMPONENTS (INCLUDED)

Name of Part	***Quantity***
Light box	1
Box of filters	1
Banana plug leads	2

REQUIRED COMPONENTS (NOT INCLUDED)

Name of Part	***Quantity***
Power supply	1
Ruler	1

To demonstrate diffraction set up the light box as shown in diagram 1. Place a box of slides in the path of the “ray end” of the light box as shown in diagram 3.

Diagram 3

1. Set up your apparatus as shown in diagram 1. Draw what you think the shadow of a small box placed in the beam of light would look like once the light box is turned on. This is shown in diagram 3.
   Any answer is acceptable here. You may want to ask students to share some of their thoughts/ideas.

2. What happens to the shadow's edge as it moves farther away from the box?
   The shadow gets fuzzy. It is harder to tell exactly where the shadow starts and stops.

3. The name we give for waves bending around a barrier is called ___*diffraction*_______.

Name:____ Date:_______________

DIFFRACTION

Diffraction is a wave property where a wave moves around a barrier and spreads out. Diffraction can be seen with sound waves, water (physical) waves, and it also occurs with light.

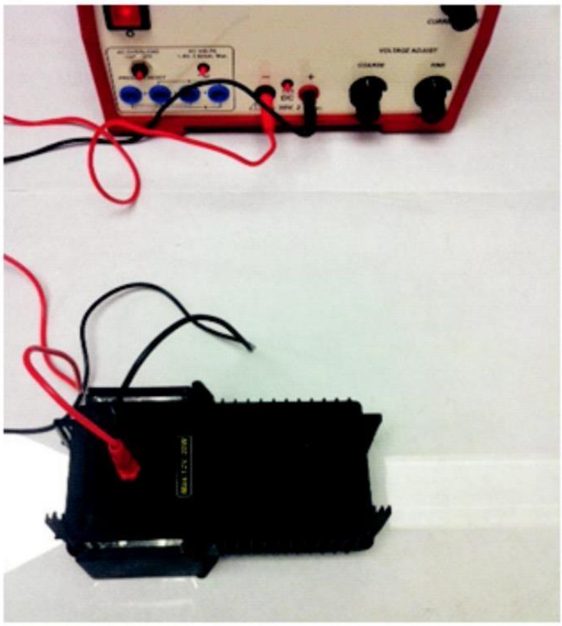

Diagram 1

1. Set up your apparatus as shown in diagram 1. Draw what you think the shadow of a small box placed in the beam of light would look like once the light box is turned on.

2. What happens to the shadow's edge as it moves farther away from the box?

____

____

____

3. The name we give for waves bending around a barrier is called ______________________.

ANGLE OF REFLECTION USING A PLANE MIRROR

The angle of incidence is the angle that the a beam of light going toward a reflecting surface or medium makes with the normal line on the surface of that medium. The angle of reflection is the angle that the beam reflecting off of that surface makes with the normal line. A normal line is a line perpendicular to the surface of the mirror or medium. For students it would seem natural to measure the angle between the surface of the plane mirror and the incident ray. However, when the surface of reflection is curved, it is not possible to do this. The normal to a curved surface as well as a flat surface can easily be found and therefore we measure our angles to the normal line.

EQUIPMENT NEEDED:

REQUIRED COMPONENTS (INCLUDED)

Name of Part	***Quantity***
Light box	1
4mm banana plug leads	2
Plane mirror	1
Single slit slide	1

REQUIRED COMPONENTS (NOT INCLUDED)

Name of Part	***Quantity***
Power supply	1
Ruler	1

PRE-LAB QUESTION:

1. What is the angle of incidence and the angle of refraction in the diagram below? 65^o for both

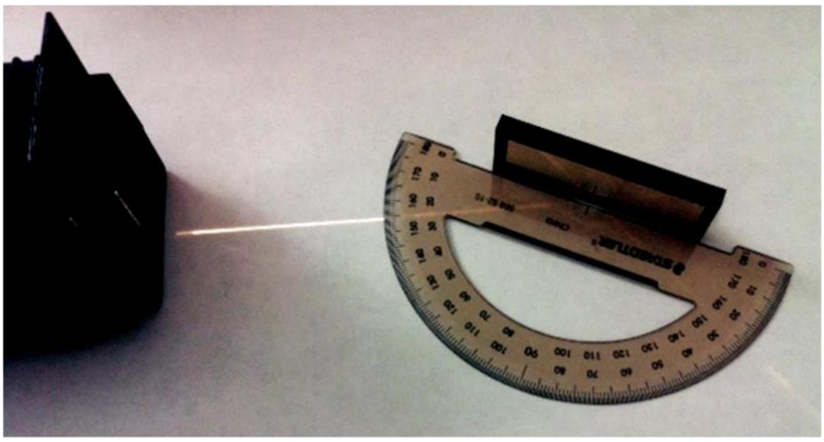

Diagram 4

PROCEDURE:

1. Set up apparatus as shown in diagram 4.
2. Use the single slit and adjust the width of the beam so that the width is parallel.
3. Put the plane mirror against the edge of the protractor and aim the beam of light directly towards the centre of the protractor.

4. In the data table record your angle of incidence and angle of reflection. (Note that the 90^o line is zero, so the number you should record is how many degrees the incident and reflected ray are from the 90^o line. This imaginary line 90^o from the surface of your plane mirror is called the ___*normal line*_____.
5. Rotate the table so that the angle of incidence is 10^o, then measure and record your angle of reflection.
6. Continue increasing the angle of incidence by 10^o increments until you reach 80^o, and continue to record both your angle of incidence and reflection.

DATA TABLE:

Angle of Incidence (degrees)	***Angle of Reflection (degrees)***
0	0
10	10
25	25
30	30
40	40
50	48
60	60
70	68
80	82

CONCLUSION:

Make a rule that describes how the angle of incidence affects the angle of reflection:
The angle of incidence is always equal to the angle of reflection.

Name:____ Date:______________

ANGLE OF REFLECTION USING A PLANE MIRROR

The *angle of incidence* is the angle that the a beam of light going toward a reflecting surface or medium makes with the normal line on the surface of that medium. The *angle of reflection* is the angle that the beam reflecting off of that surface makes with the normal line. A *normal line* is a line perpendicular to the surface of the mirror or medium. For students it would seem natural to measure the angle between the surface of the plane mirror and the incident ray. However, when the surface of reflection is curved, it is not possible to do this. The normal to a curved surface as well as a flat surface can easily be found and therefore we measure our angles to the normal line.

PRE-LAB QUESTION:

1. What is the angle of incidence and the angle of refraction in the diagram below?

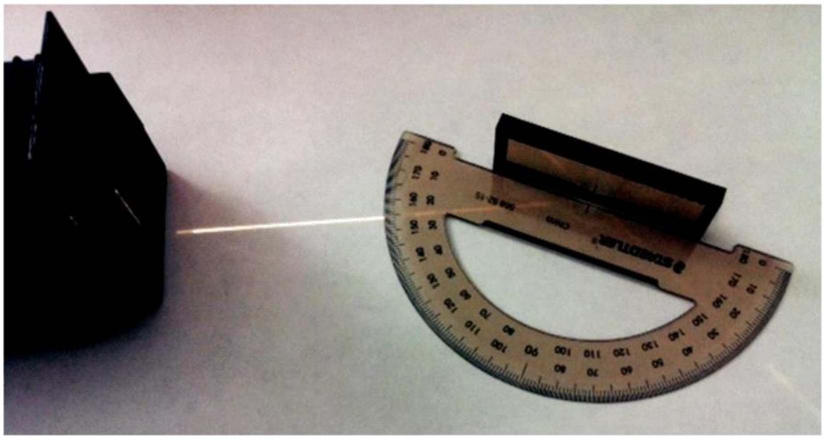

Diagram 4

PROCEDURE:

1. Set up apparatus as shown in diagram 4.
2. Use the single slit and adjust the width of the beam so that the width is parallel.
3. Put the plane mirror against the edge of the protractor and aim the beam of light directly towards the centre of the protractor.
4. In the data table record your angle of incidence and angle of reflection. (Note that the 90^o line is zero, so the number you should record is how many degrees the incident and reflected ray are from the 90^o line. This imaginary line 90^o from the surface of your plane mirror is called the ____________________________.
5. Rotate the table so that the angle of incidence is 10^o, then measure and record your angle of reflection.
6. Continue increasing the angle of incidence by 10^o increments until you reach 80^o, and continue to record both your angle of incidence and reflection.

DATA TABLE:

Angle of Incidence (degrees)	***Angle of Reflection (degrees)***

CONCLUSION:

Make a rule that describes how the angle of incidence affects the angle of reflection:

____

____

____

____

REFRACTION OF DIFFERENT SHAPED PRISMS

BACKGROUND:

What happens to light beam when it travels through a medium instead of around it or being reflected off of it? As a beam of light travels from one medium to another it speeds up or slows down. As this happens, the direction the wave is traveling also changes. This bending of the wave and speed change is called refraction. Trace each of the six prisms on blank piece of paper for your students. Then use the three parallel slit slide to trace three beams of light going towards the prism at any angle you think will be interesting for the students as shown in diagram 5. Photocopy this sheet with enough for each student plus a few extra in case some students want to redo their diagrams.

EQUIPMENT NEEDED:

REQUIRED COMPONENTS (INCLUDED)

Name of Part	*Quantity*
Light box	1
4mm banana plug leads	2
Slide with three slits	1
Different shaped prisms	6

REQUIRED COMPONENTS (NOT INCLUDED)

Name of Part	*Quantity*
White paper	1
Red pencil	1
Blue pencil	1
Straight edge	1
12 V power supply	1

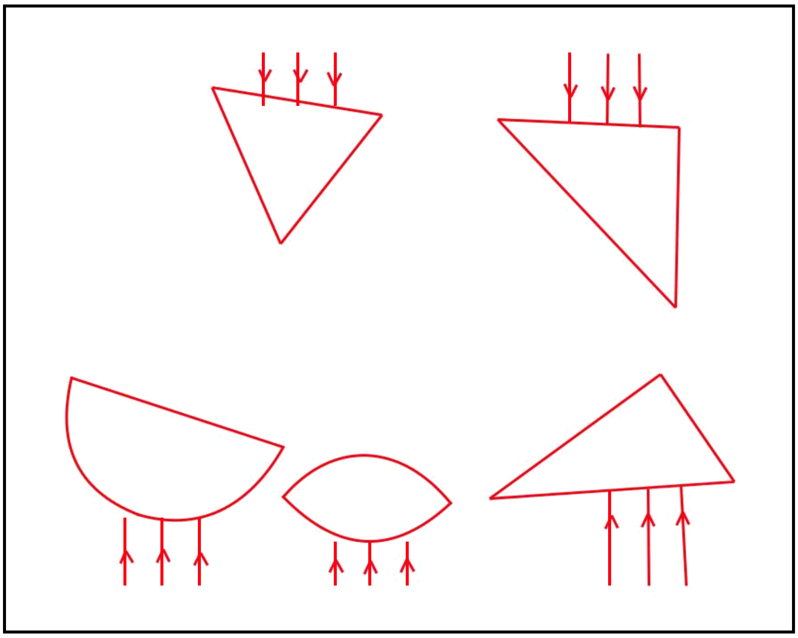

Diagram 5

PROCEDURE:

1. Insert the slide with three slits into the ray end of the light box.
2. Adjust the condenser lens until the beams are parallel. Using a ruler to measure the distance between the centres of the two outside beams close to the light box and then further away from the light box will help make sure the beams are completely parallel.

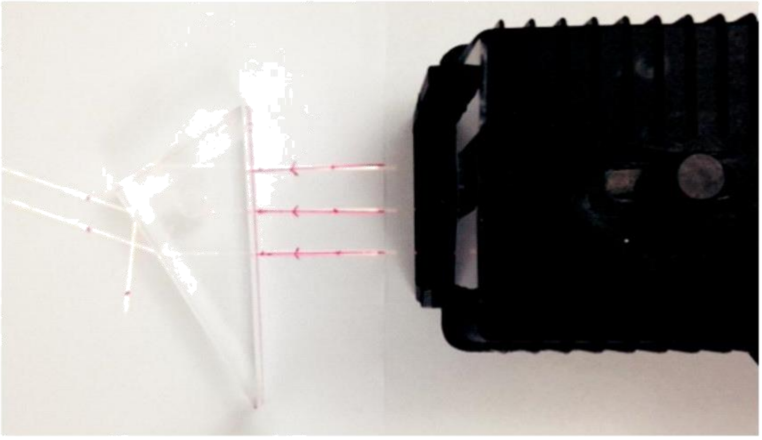

Diagram 6a

3. Predict what a beam of parallel rays will look like as they travel through the prisms by drawing their predicted rays with a blue pencil and ruler.
4. Then set up the light box as shown in diagram 6 and record the position of the actual rays by placing a dot where each of the five rays leave the prism and another dot about one inch away from the prisms' surface along the refracted rays.
5. Students can then use a straight e d g e a n d t h e i r p e n c i l t o reconstruct where the rays were both inside the prism and the direction they took as they left the prism. As shown with the triangular prism in diagram 6.

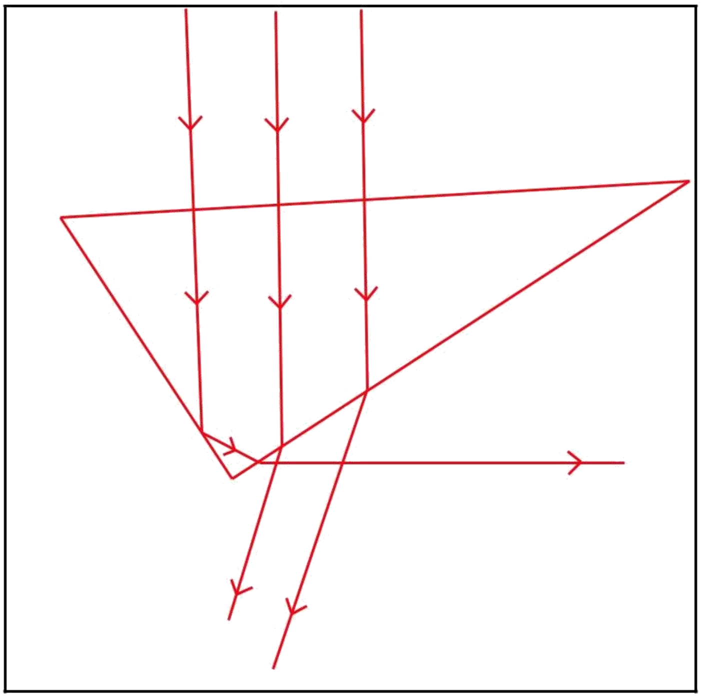

Diagram 6b

FOLLOW UP QUESTIONS:

1. What happened to the beams as they travelled from air into the prism? *The beams changed direction.*
2. Does rotating the prism change if the light bends towards or away from the normal? *It changes the direction of the final beam, but it does not change whether the angle bends towards or away from the normal.*
3. Does the light bend only when entering the prism, only when exiting or both? *Both*
4. Does the light bend towards or away from the normal when entering the prism? *Towards*
5. Does the light bend towards or away from the normal when exiting the prism? *Away*

Name:____ Date:____________

REFRACTION OF DIFFERENT SHAPED PRISMS

BACKGROUND:

What happens to light beam when it travels through a medium instead of around it or being reflected off of it? As a beam of light travels from one medium to another it speeds up or slows down. As this happens, the direction the wave is traveling also changes. This bending of the wave and speed change is called refraction.

PROCEDURE:

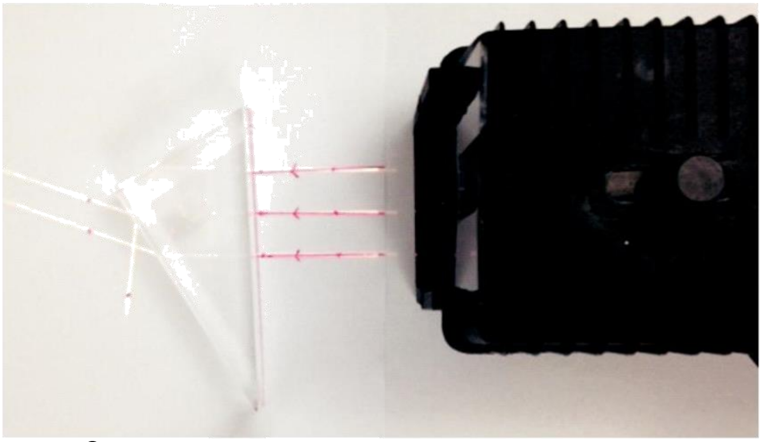

Diagram 6a

1. Insert the slide with three slits into the ray end of the light box.
2. Adjust the condenser lens until the beams are parallel. Using a ruler to measure the distance between the centres of the two outside beams close to the light box and then further away from the light box will help make sure the beams are completely parallel.
3. Predict what a beam of parallel rays will look like as they travel through the prisms by drawing your predicted rays with a blue pencil and ruler.
4. Set up the light box as shown in diagram 6 and record the position of the actual rays by placing a dot where each of the three rays leave the prism and another dot about one inch away from the prisms' surface along the refracted rays.

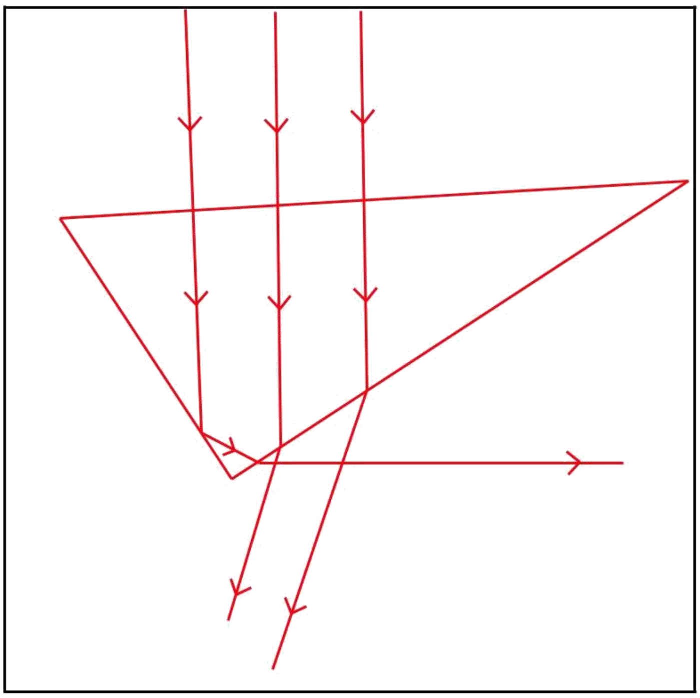

Diagram 6b

5. Use a straight edge and pencil to reconstruct where the rays were both inside the prism and the direction they took as they left the prism as shown with the triangular prism in diagram 6.

FOLLOW UP QUESTIONS:

1. What happened to the beams as they travelled from air into the prism?

____

____

____

2. Does rotating the prism change if the light bends towards or away from the normal?

____

____

____

3. Does the light bend only when entering the prism, only when exiting or both?

____

4. Does the light bend towards or away from the normal when entering the prism?

____

5. Does the light bend towards or away from the normal when exiting the prism?

____

REFRACTION (SNELL'S LAW)

BACKGROUND:

Traveling through different mediums causes a light ray to bend to different angles. Each transparent medium will speed up or slow down a light wave a different amount. Snell's Law states that the index of refraction of the first medium (n_1) times the sine of the incident angle (q_1) is equal to the index of refraction of the second medium (n_2) times the sine of the refracted angle (q_2):

Snell's Law:

$$n_1 \sin q_1 = n_2 \sin q_2$$

EQUIPMENT NEEDED:

REQUIRED COMPONENTS (INCLUDED)

Name of Part	***Quantity***
Red and black leads	1
Single slit slide	1
Light box	1
Rectangular prism	1

REQUIRED COMPONENTS (NOT INCLUDED)

Name of Part	***Quantity***
White paper	1
Straight edge	1
12 V power supply	1
Protractor	1

1. Use the rectangular shaped block and set up the light box as shown in the diagram 7.

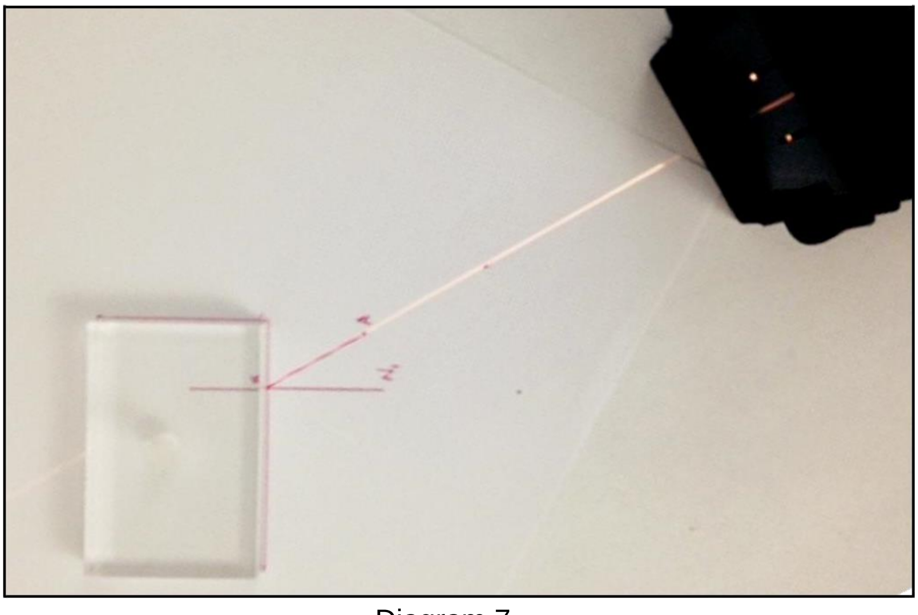

Diagram 7

2. Place the rectangular prism in the centre of the paper and trace along all four sides.
3. Remove the block and draw a normal line to one of the long sides of the rectangular prism and label this line N1. Label the point where the block and the normal line intersect B.
4. Draw a line at a 30 degree angle from N1 to point B and label this starting point A.
5. Rotate the paper and prism until the light shines directly on top of the line AB as shown in diagram 7.
6. Place one dot where the light ray leaves the block on the other side and a second dot somewhere on top of the ray about 1" from where the ray leaves the prism on the other side.
7. Remove your prism from the paper and label the point where the light ray emerged from the prism as point C and label the second point where the light ray was 1" from where it emerged at point D.
8. At point C draw a second normal line to the surface of the prism and label this N2.
9. With a straight edge connect dots B and C.
10. Your final picture should look like diagram 8.

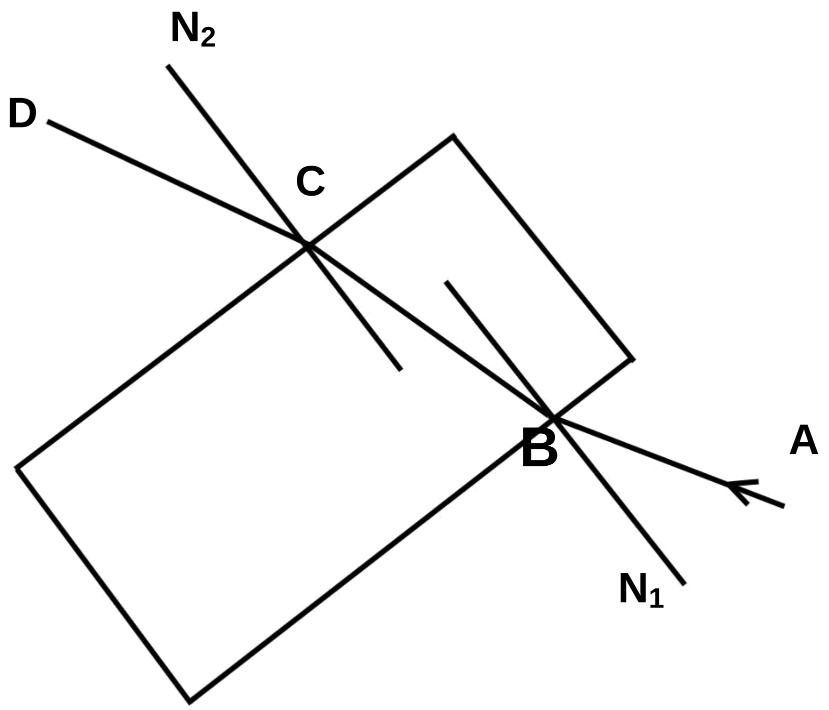

Diagram 8

11. Measure the angles ABN1, CBN1, BCN2, and DCN2 and write those values on the space provided below.

ABN1___30°____ CBN1___16°_____ BCN2__16°______ DCN2__30°______

12. Use Snell's Law to calculate the index of refraction of the prism.

$$N_1 \sin q_1 = n_2 \sin q_2$$

$$(1.00)(\sin 30^o) = n_2 \sin(16^o)$$

n_2=1.8 (this is a typical student response, answers may vary +/- .2 depending on how students measure)

FOLLOW UP QUESTIONS:

1. What was the index of refraction of your prism?*1.8*
2. How did the measured angle ABN1 compare to the angle DCN2? Why do you think you got this result?
   The angles have the same measure because the index of refraction of air is the same on both sides of the prism.
3. When traveling from air into plastic, did the ray bend toward or away from the normal? *towards*
4. When traveling from plastic into air, did the ray bend towards or away from the normal? *away*

Name:____ Date:____________

REFRACTION (SNELL'S LAW)

BACKGROUND:

Traveling through different mediums causes a light ray to bend to different angles. Each transparent medium will speed up or slow down a light wave a different amount. Snell's Law states that the index of refraction of the first medium (n_1) times the sine of the incident angle (q_1) is equal to the index of refraction of the second medium (n_2) times the sine of the refracted angle (q_2):

Snell's Law:

$$n_1 \sin q_1 = n_2 \sin q_2$$

1. Use the rectangular shaped block and set up the light box as shown in the diagram 7.

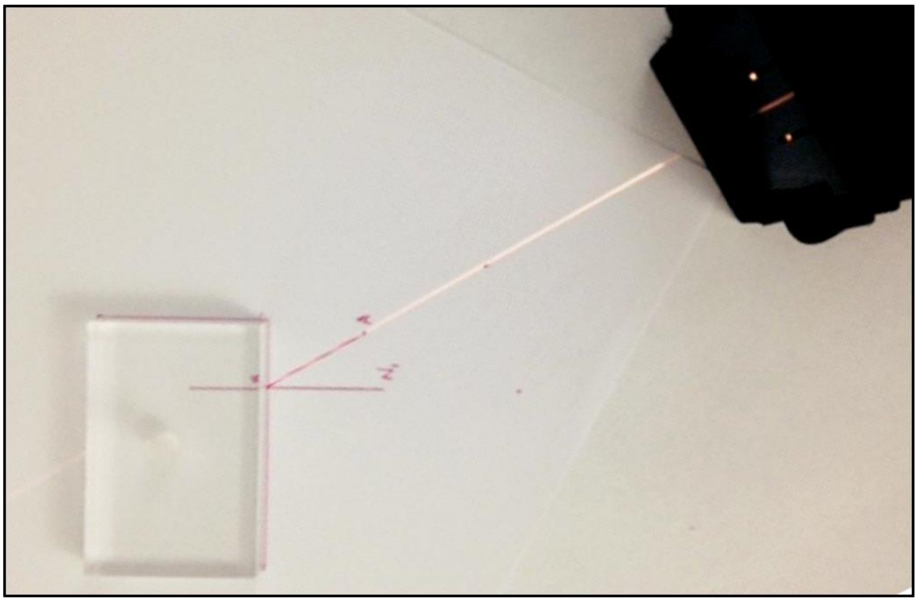

Diagram 7

2. Place the rectangular prism in the centre of the paper and trace along all four sides.
3. Remove the block and draw a normal line to one of the long sides of the rectangular prism and label this line N1. Label the point where the block and the normal line intersect B.
4. Draw a line at a 30 degree angle from N1 to point B and label this starting point A.
5. Rotate the paper and prism until the light shines directly on top of the line AB as shown in diagram 7.
6. Place one dot where the light ray leaves the block on the other side and a second dot somewhere on top of the ray about 1” from where the ray leaves the prism on the other side.
7. Remove your prism from the paper and label the point where the light ray emerged from the prism as point C and label the second point where the light ray was 1” from where it emerged at point D.
8. At point C draw a second normal line to the surface of the prism and label this N2.
9. With a straight edge connect dots B and C.

10. Measure the angles ABN1, CBN1, BCN2, and DCN2 and write those values on the space provided below.

ABN1___________ CBN1___________ BCN2 ___________ DCN2 ___________

11. Use Snell's Law to calculate the index of refraction of the prism.

FOLLOW UP QUESTIONS:

1. What was the index of refraction of your prism?

____

2. How did the measured angle ABN1 compare to the angle DCN2? Why do you think you got this result?

____

____

____

3. When traveling from air into plastic, did the ray bend toward or away from the normal?

____

4. When traveling from plastic into air, did the ray bend towards or away from the normal?

____

INDEX OF REFRACTION

BACKGROUND:

As a light ray travels from one medium to another it speeds up or slows down. As the light speeds up or slows down it changes direction (bends). How far the light bends is a property of the medium in which it travels. The ratio of the speed of the object in that medium to the speed of light in a vacuum is called the index of refraction, or the refractive index. This number has no units and is commonly represented by “n” in formulas and equations. In this experiment students can study the index of refraction of certain liquids. As an extension, a teacher can also give the index of refraction of certain medium and have the students identify the medium using a reference table. The following fluids work well for this experiment:

water – 1.33, corn oil – 1.47, ethyl alcohol – 1.36, glycerol- 1.47

A teacher may disguise the colour of the liquids without changing the index of refraction too much by adding food colouring to the liquids. If using ethyl alcohol, glycerol, or other chemicals, make sure that all proper safety procedures are followed such as wearing safety goggles and working in a well-ventilated area.

A 360^{o} protractor is needed for this experiment. A paper protractor has the advantage of being flat and can easily be printed from the internet.

EQUIPMENT NEEDED:

REQUIRED COMPONENTS (INCLUDED)

Name of Part	***Quantity***
Slide with single slit	1
Semi-circular Dish	1
Light box	1
Banana plug leads	2

REQUIRED COMPONENTS (NOT INCLUDED)

Name of Part	***Quantity***
Corn Oil	Enough to fill the dish
12 V power supply	1
Glycerol	Enough to fill the dish
Water	Enough to fill the dish
Ethyl Alcohol	Enough to fill the dish
360^{o} Protractor	1
Food colouring	Few drops

Make a prediction: Before you are three liquids, as light passes through these liquids, the light will bend based on the index of refraction. In the space provided below, make a hypothesis and list the liquids in order from highest index of refraction to lowest index of refraction. Justify your reasoning.

HYPOTHESIS:

Anything is acceptable here. Allow students to pour some of the liquids out, the glycerol is very thick, while the ethyl alcohol is thin and runny. You may want to do several different liquids and give each group of students a different liquid to report back to the class on or you may want to have each group test three different liquids on their own.

PROCEDURE:

1. Set up your apparatus as shown in diagram 9. Place your semi-circular dish so the flat edge is exactly lined up and centred on the 90^o line as shown in the diagram.

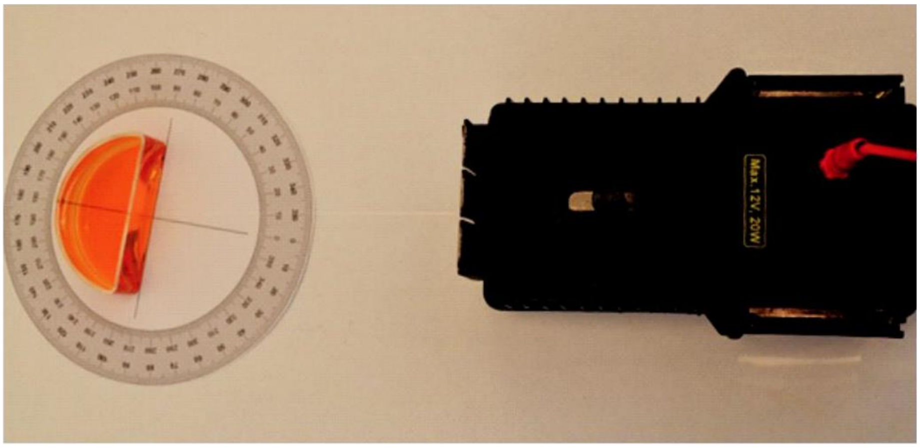

Diagram 9a

2. Add your given liquid to the semi-circle dish and record its name on the data table. Fill to about 1/4” from the top of the dish.

3. Start with the beam of light lined up exactly on the 0^o line.

4. Record your angle of incidence (in this case 0^o) and your angle of refraction (also 0^o) in the data table provided.

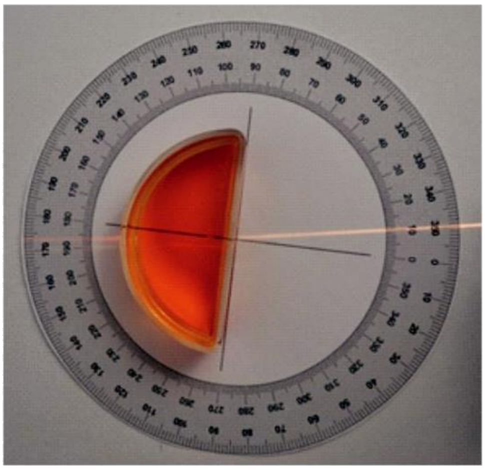

Diagram 9b

5. Rotate the light box so that the incident ray is exactly on top of the 10^o mark and record the value of the refracted ray. Continue to increase the angle of incidence until you have at least 6 good data points spaced out between 0^o and 60^o. Two refracted rays may appear. This is because the top of the dish does not contain liquid, you can get rid of the second ray by taking a sheet of paper or your hand and slowly covering the top of the slit until one of the rays disappears.

DATA TABLE:

Liquid: Corn oil

Angle of Incidence (degrees)	*Angle of Reflection (degrees)*
0	0
10	10
25	25
30	30
40	40
50	48
60	60
70	68
80	82

DATA ANALYSIS:

1. Use Snell's Law to find the index of refraction for corn oil for each of your angles. Show one sample calculation below showing all work including formula and substitution with units.

$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$

$$(1.00)(\sin 30^o) = n_2 \sin(20^o)$$

n_2=1.46 (this is a typical student response, answers may vary +/- .05 depending on how students measure)

2. What is your average index of refraction?

Angle of incidence (degrees)	Angle of refraction (degrees)	Sin (angle of incidence)	Sin (angle of refraction)	incident in radians	refracted in radians	n2=Sin I / Sin R
0	0	0	0	0	0	#DIV/0!
5	3.5	0.08715574	0.0610485	0.087266	0.061087	1.427647
15	10	0.25881905	0.1736482	0.261799	0.174533	1.490479
25	17	0.42261826	0.2923717	0.436332	0.296706	1.445483
30	20	0.5	0.3420201	0.523599	0.349066	1.461902
40	27	0.64278761	0.4539905	0.698132	0.471239	1.415861
50	31	0.76604444	0.5150381	0.872665	0.541052	1.487355

3. What are the values of the index of refraction for the other substances that were tested? Use these values to put the substances in order from highest index of refraction to lowest. *Teachers may want students to answer this question using their own data and the data of their classmates before the accepted values are given to the students. A typical response for this question would be … Glycerol and corn oil were too close to be determined which was higher since one group found glycerol to be 1.45, and one found glycerol to be 1.50, another group found corn oil to be 1.40 and 1.52, however water had a lower index of refraction at 1.28.*

4. What is the given value for the index of refraction for your substance? What is your percent error?
   The given value for the index of refraction of corn oil is 1.47, and the percent error is 1.4%

5. In the previous “Snell's Law” experiment, the rectangular prism refracts light as the light beam enters the prism and again the light is refracted when it leaves the prism. Why is the light not refracted when it leaves the semi-circular dish?
   Light speeds up as it leaves the dish, however, since the outside of the dish is a semi-circle, the light always leaves the semi-circle at an angle of 0o to the normal, so the light ray does not bend.

Name:____ Date:____________

INDEX OF REFRACTION

BACKGROUND:

As a light ray travels from one medium to another it speeds up or slows down. As the light speeds up or slows down it changes direction (bends). How far the light bends is a property of the medium in which it travels. The ratio of the speed of the object in that medium to the speed of light in a vacuum is called the index of refraction, or the refractive index. This number has no units and is commonly represented by "n" in formulas and equations. In this experiment students can study the index of refraction of certain liquids. As an extension, a teacher can also give the index of refraction of certain medium and have the students identify the medium using a reference table. The following fluids work well for this experiment:

water – 1.33, corn oil – 1.47, ethyl alcohol – 1.36, glycerol- 1.47

HYPOTHESIS:

Before you are three liquids, as light passes through these liquids, the light will bend based on the index of refraction. In the space provided below, make a hypothesis and list the liquids in order from highest index of refraction to lowest index of refraction. Justify your reasoning.

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PROCEDURE:

1. Set up your apparatus as shown in diagram 9. Place your semi-circular dish so the flat edge is exactly lined up and centred on the 90^{o} line as shown in the diagram.

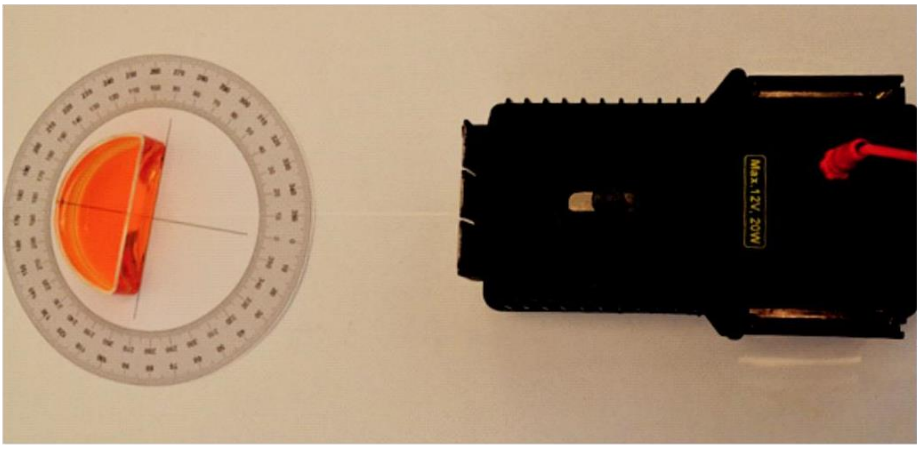

Diagram 9

2. Add your given liquid to the semi-circle dish and record its name on the data table. Fill to about 1/4" from the top of the dish.

3. Record your angle of incidence (in this case 0^o) and your angle of refraction (also 0^o) in the data table provided.

4. Rotate the light box so that the incident ray is exactly on top of the 10^o mark and record the value of the refracted ray. Continue to increase the angle of incidence until you have at least 6 good data points spaced out between 0^o and 60^o. Two refracted rays may appear. This is because the top of the dish does not contain liquid, you can get rid of the second ray by taking a sheet of paper or your hand and slowly covering the top of the slit until one of the rays disappears.

DATA TABLE:

Liquid: ________________________

Angle of Incidence (degrees)	***Angle of Reflection (degrees)***

DATA ANALYSIS:

1. Use Snell's Law to find the index of refraction for corn oil for each of your angles. Show one sample calculation below showing all work including formula and substitution with units.

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2. What is your average index of refraction?

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3. What are the values of the index of refraction for the other substances that were tested? Use these values to put the substances in order from highest index of refraction to lowest.

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4. What is the given value for the index of refraction for your substance? What is your percent error?

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5. In the previous "Snell's Law" experiment, the rectangular prism refracts light as the light beam enters the prism and again the light is refracted when it leaves the prism. Why is the light not refracted when it leaves the semi-circular dish?

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DISPERSION OF LIGHT (RAINBOWS)

The separation of visible light into its component colours by means of a prism, usually a triangular prism, is called dispersion. Visible light, also known as white light, is really a mix of many different colours. Each colour has a slightly different index of refraction which means that some colours bend or change direction more than others when traveling from one medium to another. Light with a red wavelength (electromagnetic waves that have a wavelength of about 700nm) do not bend as much as light with a violet wavelength (electromagnetic waves that have a wavelength of about 400 nm). White light separated by a prism always separates the colours in the following order from least bent to most bent: red, orange, yellow, green, blue, and violet.

EQUIPMENT NEEDED:

REQUIRED COMPONENTS (INCLUDED)

Name of Part	***Quantity***
Equilateral triangular prism	1
Slide with single slit	1
Light box	1
Leads	2

REQUIRED COMPONENTS (NOT INCLUDED)

Name of Part	***Quantity***
White paper	1
Power supply 12V	1

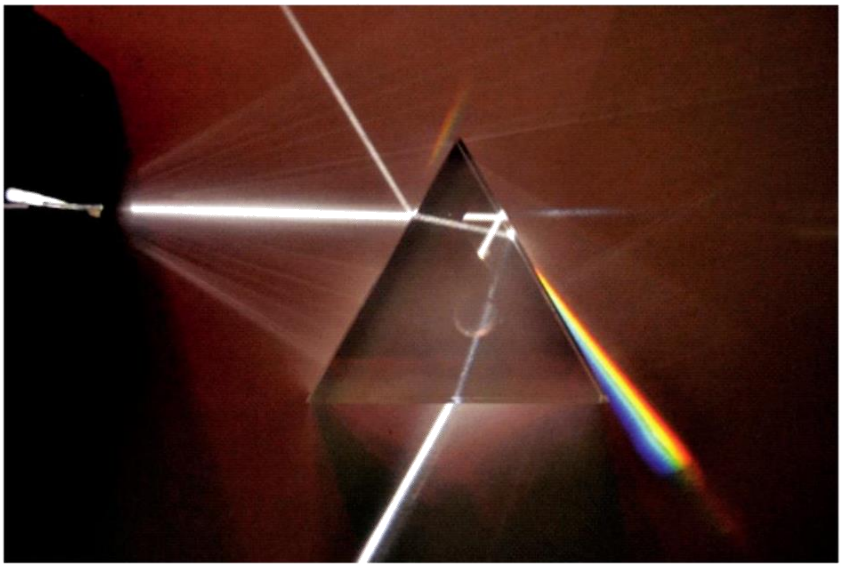


Diagram 10

To see the dispersion of light, set up the light box as shown in diagram 10. Slowly turning the prism clockwise or counter-clockwise will help produce a wider and more clear rainbow.

DISPERSION OF INFRARED LIGHT

EQUIPMENT NEEDED:

REQUIRED COMPONENTS (INCLUDED)

Name of Part	***Quantity***
Equilateral triangular prism	1
Slide with single slit	1
Light box	1
Leads	2
Flat condenser	1

REQUIRED COMPONENTS (NOT INCLUDED)

Name of Part	***Quantity***
Piece of paper	1
Power supply	1
Camera with no infrared filter	1

Set up your apparatus as shown in diagram 10. Rotate the prism so the rainbow is as wide as possible and mark with a pencil the exact spot where you can no longer see the red of the rainbow with your eyes. Then look at the rainbow though a camera that has no infrared filter on it. Most cheap cameras, including cell phone cameras, do not have a filter. As you look through the camera look at the line that shows the edge of the red colour. You will notice that the camera picks up some red colour past this mark. The camera picks up some infrared radiation, which is also refracted by the prism and converts it to visible light for the camera screen.

MIXING COLOURS

When using paint, the primary colours of paint are yellow, magenta, and cyan. Primary colours are used to make just about every possible colour of paint. However when mixing light, the primary colours used are red, green, and blue light. Mixing all three together will make white light. Students typically have experience mixing paint, but not mixing light. It is often surprising to them how the colours combine.

WARNING:

The Light Box is made of special plastic that will not warp or melt under the heat of the lamp. However, care should be taken to ensure that the colour filters do not remain in position for long periods of time. Otherwise radiant heat from the lamp may affect them. The slides are *very sensitive* to heat and will warp and discolour if left near the lamp for more than a few seconds at a time.

EQUIPMENT NEEDED:

REQUIRED COMPONENTS (INCLUDED)

Name of Part	*Quantity*
Light box	1
Red and black leads	1 each
Red colour slide	1
Blue colour slide	1
Green colour slide	1

REQUIRED COMPONENTS (NOT INCLUDED)

Name of Part	*Quantity*
Power supply	1
White paper	1

Set up the apparatus as shown in diagram 11. Have students predict which colours will appear by mixing the two colours of light, and then have students record their actual observations.

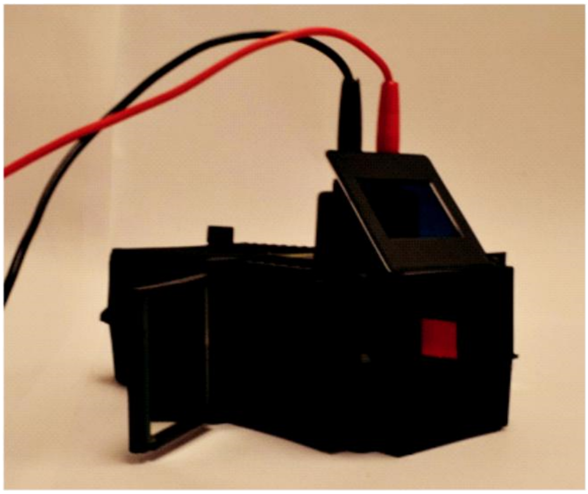
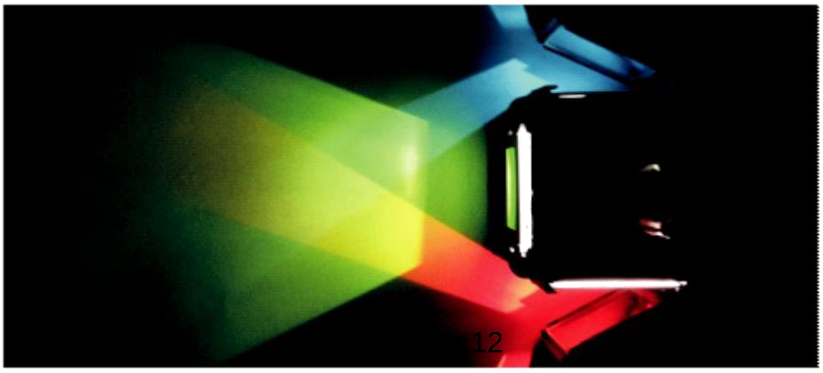


Diagram 11

Colours mixed	Predicted Colour	Colour Made
Red and Blue	*Purple (typical response)*	*magenta*
Red and Green	*Brown (typical response)*	*yellow*
Green and Blue	*Cyan (typical response)*	*cyan*
Red Green & Blue	*Black (typical response)*	*white*


12

As shown in diagram 12, the mirrors on the sides of the light box can rotate so that blue and red light can be focused into the green beam's path. Notice the diamond of white coloured light in the middle that is a result of all three primary colours being mixed together. Because the intensity of the light from the red and blue slides is more intense, it works best to mix the colours with the green slide in the middle.

Also, rotating one mirror and then the other away from the light box allows you to mix two colours at a time if need be.

EXTENSIONS:

1. Other ways to make white light. Since mixing any two of the primary colours of light (red, green, and blue) will yield one of the primary colours of paint (magenta, cyan, and yellow), There are three other ways that a student can make white light by mixing only two colour slides. Encourage students to find these colour combinations and hypothesize on why these colour combinations yield white light.
   The colour combinations are cyan and red, green and magenta, and blue and yellow (as shown in diagram 13) . This is because each of the secondary colours (magenta, cyan, and yellow) are really a combination of two colours already. If the third primary colour is added to the light mixture, white light is produced.

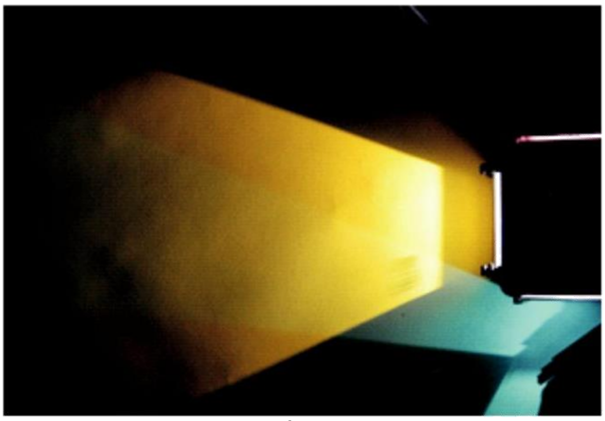


Diagram 13

2. **Making rainbow shadows:**
   Shadows are fun to play with, even if they are black or grey, but using the light box, shadows can be rainbow coloured. Place some small object in the path of all three primary colours where they mix and form white light. You will see red, green, and blue shadows. Mix the colours of the slides on the light box to form new patterns.

BLOCKING COLOURS IN A PRISM USING FILTERS

BACKGROUND:

When light hits a surface, three things can happen: the light can be reflected, absorbed, or transmitted. A combination of reflection and absorption happens on most opaque surfaces. When a piece of paper looks “red” to our eyes, is it creating red light? No, it's absorbing everything but the red colour. The red colour that is reflected is what our eyes detect and see, therefore the paper looks red. The paper only looks red when light containing the colour red is shining on it. If very little light is shining, the paper looks black.

EQUIPMENT NEEDED:

REQUIRED COMPONENTS (INCLUDED)

Name of Part	***Quantity***
Light box	1
Leads	2
Red colour slide	1
Blue colour slide	1
Green colour slide	1
Equilateral prism	1
Slide with single slit	1

REQUIRED COMPONENTS (NOT INCLUDED)

Name of Part	***Quantity***
Power supply	1
White sheet of paper	1
1” tall equilateral prism*	1

* The prism included in the kit can be used as well, but a taller prism is easier to work with.

A white surface reflects all colours. Use a white piece of paper and the equilateral prism to create a rainbow on the white paper. Set up the apparatus as shown in diagram 14. Introduce the appropriate slides in the middle of the rainbow.

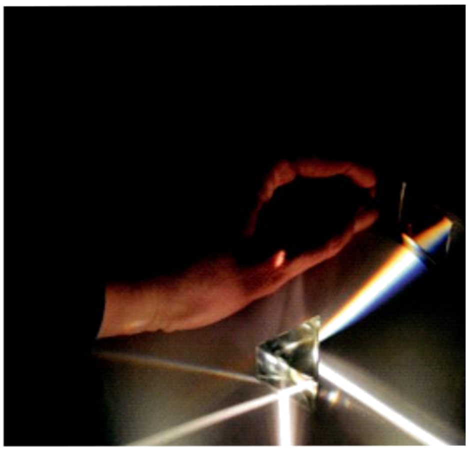


Diagram 14

Have student predict what will happen to the rainbow if a filter is used to allow only a certain frequency of colour though.

1. If a red filter is used to allow only red light into the prism, what will the rainbow look like? *Students may think that the whole rainbow will turn red, or that the red part of the rainbow will disappear. Have students write down their thoughts and then share them with the class.*

   Observations with red filter:
   The red, orange and yellow part of the rainbow will stay but the colours will look to have different intensities of red.

2. If a blue filter is used to allow only blue light into the prism, what will the rainbow look like? *Again have students write down their thoughts and discuss.*

   Observations with the blue filter:
   Approximately the yellow through violet portion of the rainbow appears, although the yellow now appears blue. Since only blue light is allowed through, only colours that have some blue light in them will appear on the spectrum.

3. If a green filter is used to allow only green light into the prism, what will the rainbow look like? *Again have students write down their thoughts and discuss.*

   Observations with the green filter:
   Approximately the orange through blue portion of the rainbow appears, although the green is most prominent. Since only green light is allowed through, only colours that have some green light in them will appear on the spectrum.

4. If all three filters are used to allow light into the prism, what will the rainbow look like? *Again have students write down their thoughts and discuss.*

   Observations with all three filters:
   No light is shown through since all of the colours of white light are filtered out.

Name:____ Date:________________

BLOCKING COLOURS IN A PRISM USING FILTERS

BACKGROUND:

When light hits a surface, three things can happen: the light can be reflected, absorbed or transmitted. A combination of reflection and absorption happens on most opaque surfaces. When a piece of paper looks "red" to our eyes, is it creating red light? No, it's absorbing everything but the red colour. The red colour that is reflected is what our eyes detect and see, therefore the paper looks red. The paper only looks red when light containing the colour red is shining on it. If very little light is shining, the paper looks black, or you may not even see the paper depending on how little light there is.

PROCEDURE:

1. A white surface reflects all colours. Use the white paper and the equilateral prism to create a rainbow on the white paper as shown in diagram 14.

2. Introduce the appropriate slides in the middle of the rainbow.

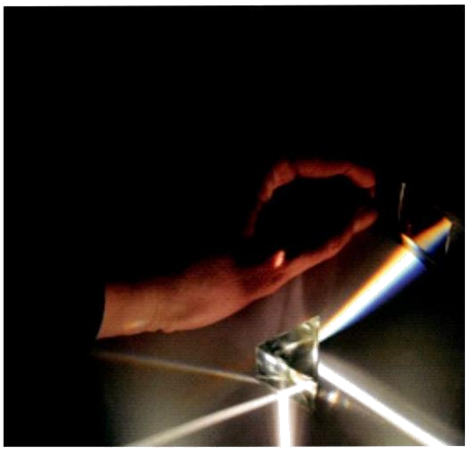


Diagram 14

3. Predict what will happen to the rainbow if a filter is used to allow only a certain frequency of colour though.

Hypothesis 1:

If a red filter is used to allow only red light into the prism, what will the rainbow look like?

____

____

Observations with red filter:

____

____

____

____

Hypothesis 2:
If a blue filter is used to allow only blue light into the prism, what will the rainbow look like?

Observations with the blue filter:

Hypothesis 3:
If a green filter is used to allow only green light into the prism, what will the rainbow look like?

Observations with the green filter:

Hypothesis 4:
If all three filters are used to allow light into the prism, what will the rainbow look like?

Observations with all three filters:

DETECTING COLOURS IN MONOCHROMATIC LIGHT

BACKGROUND:

When light hits a surface three things can happen. Light is reflected, transmitted, or absorbed. Some surfaces absorb only certain frequencies of light while reflecting other frequencies. An object that appears red is really reflecting only red light and absorbing all other frequencies. Different types of light make objects appear slightly different colours. For example a person's makeup might look different in florescent light then it does outside in bright sunlight (or natural light).

The colours that humans perceive are a result of the way our brain and eyes work together. Other animals see colour completely differently than humans do. The retina of a human eye has two types of receptors called cones and rods that pick up colour and send those signals back to the brain. The rods detect how bright or dark the light coming into the eye is and the cones detect colour. There are three types of cones that detect the frequencies of red, green, and blue light. This is why the primary colours for light are red, green, and blue. Our eyes discern all other colours by using those three frequencies of light.

A person who is colour blind does not have one or more of the three types of cones, or the cone(s) do not work properly. Most colour blindness is genetic. A person who is born colour blind cannot gain that vision back. Most people who are colour blind can see colours just not as many colours as people with normal vision.

A student who is colour blind will not have the same answers as a student who has normal vision in this lab. It is important to be aware and sensitive of students who may be colour blind while doing this lab.

These instructions are for the teacher to make the different colour viewing boxes. There are eight coloured slides included in the kit, magenta, cyan, red, orange, yellow, green, blue, and violet. A box can be made for each colour and students can share the boxes or test only one box and share the results. Alternately, all eight colour cards can be taped to a flat surface and colour filtered light can be shown on the slides separately as shown in diagram 20, however, this method works only when a room can be completely darkened. Once the students know what colour the cards are, it is harder for their brain to detect the true colours of the light reflected off the cards.

TO MAKE YOUR COLOUR VIEWING BOXES:

1. Take a coloured filter and place it in the slide holder at the front of the light box as shown in diagram 15.
2. Then take a small box and place it up tight against the slide.
3. Use a pencil or pen to mark the height of the top of the slide.

Diagram 15

4. Remove the slide from the holder and place it on the end of the box so that the top of the slide is aligned with the mark you drew in step 3.
5. Place a small dot where the edge of the filter is on all four sides of the slides as shown in diagram 16.

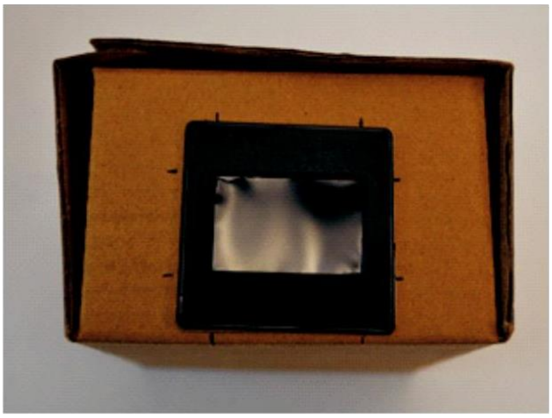


Diagram 16

6. Remove the slide from the box and use a straight edge to connect the dots so the exact location of just the colour filter portion of the slide is outlined as shown in diagram 17.

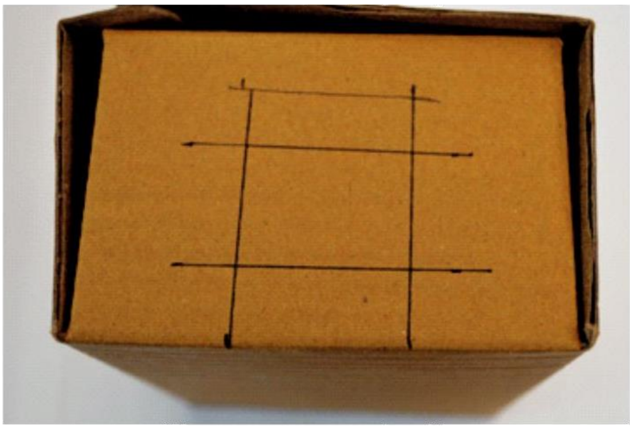


Diagram 17

7. Use a box knife to cut a hole the exact size of the filter in the end of your box.
8. Tape one of the coloured papers on the bottom of the box.
9. Place a small viewing hole in the box directly above the filter as shown in diagram 18.

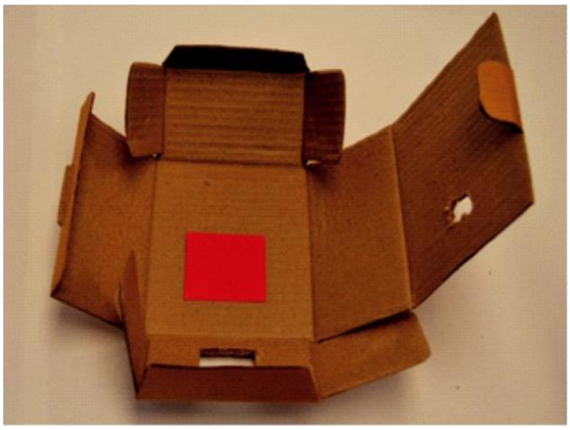


Diagram 18

10. Tape the box back up and seal the edges so no light can get into the box except where the viewing hole is and where the filter is.

PROCEDURE:

1. Put either a red, green, or blue coloured filter into the light box.
2. Place the colour viewing box as close as possible to the slide so that the open rectangle on the side of the box is completely covered by the coloured filter of the slide as shown in diagram 19.
3. Record the coloured slide you are using.
4. Turn the light on for only a few seconds. Make sure that the light box is properly ventilated. Leaving the light on for more than a few seconds will cause the filter to warp and discolour, permanently damaging the slide.
5. Look through the viewing hole on the top of the box and record the colour of the square paper you see at the bottom of the box. Make sure that no other light except the light from the light box is illuminating the colour paper inside the colour viewing box.

Diagram 19

6. Record the colour the paper on the bottom of the box appears to be in your data table. If you are unsure of the colour, record if the paper appears light or dark coloured.
7. Replace the coloured filter with another filter and repeat steps 1-6 until you have viewed the coloured paper on the bottom of the box with all of the slides.
8. Predict what colour the paper at the bottom of the box is.
9. Look through the large rectangular hole where the light shines in the box and record the actual colour of the paper.
10. Test at least three different colour viewing boxes and be prepared to share your results with the class.

DATA:

Diagram 20 All eight colours of paper shown. The top row shows white light on the paper, the second row shows red light on the paper, the third row shows green light on the papers and the last row shows blue light on the papers. The actual colours of the paper in order from left to right are magenta, cyan, violet, blue, green, yellow, orange, red.

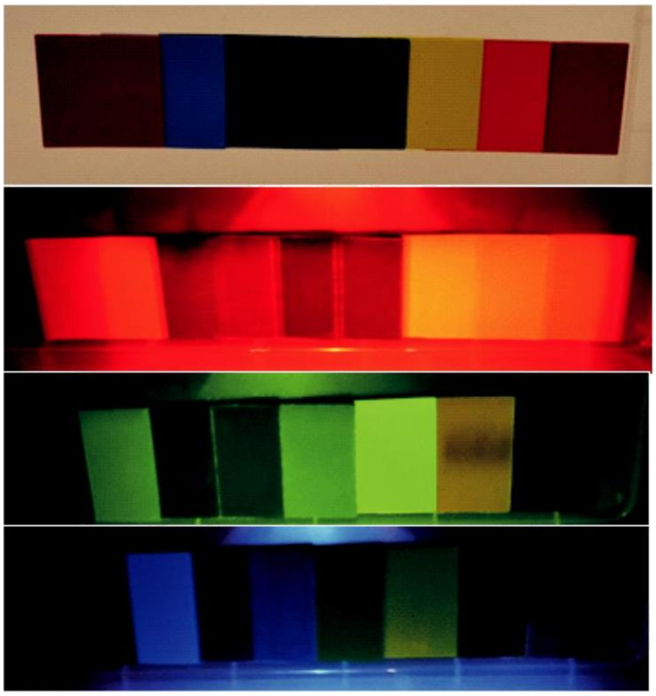


Diagram 20

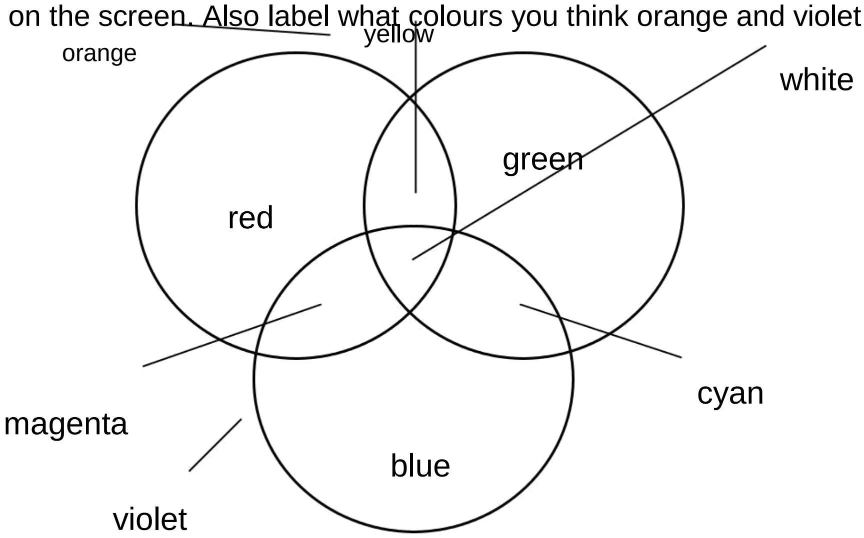
CLASS DATA:

1. What colours appeared to be red or light coloured when red light is shown on them? *Magenta, yellow, red, orange*
2. What colours appeared to be dark or black when red light is shown on them? *Violet, blue, green, cyan*
3. What colours appear to be green or light coloured when green light is shown on them? *Cyan, green, yellow, orange*
4. What colours appear to be black or dark when green light is shown on them? *Magenta, violet, blue, red*
5. What colours appear to be blue or light coloured when blue light is shown on them? *Cyan, violet, blue, yellow, orange*
6. What colours appear to be dark or black when blue light is shown on them? *Magenta, red, green*

Note: The blue filter must have let a little bit of green light in as shown by the results from this experiment.

QUESTIONS:

1. The following chart shows the three primary colours of light incident on a white screen, where the circles of light overlap, the colours overlap as well. Label the colours that show when the light mixes on the screen. Also label what colours you think orange and violet are composed of.



2. When a light is reflected by monochromatic light it appears to be either white or the colour of the light that is incident on it. Which colours did the cyan paper reflect? *Green and blue*

3. Which colours did the magenta paper reflect? *Blue and red*

4. Which colours did the yellow paper reflect? *Red and green*

5. Look at the diagram in question one. What two colours make up the colour cyan? If more than one colour of light is reflected by a surface, what happens to the colour or colours reflected? Do the colours appear separately or do they mix together to form a new colour? Give evidence from your experiment to support your claim.
   The colours mix together to form a new single colour. For example cyan is made up of the colours green and blue, so cyan reflects only green and blue light. Instead of seeing the colours green and blue reflected separately, we see a paper that is cyan in colour when white light is shown on it. Pure green light and pure blue light are reflected off of a cyan card because the blue and green are the two colours that make up cyan. The cyan card looks dark or black in red light because it absorbs red light.

6. Predict what colour the following papers would appear to be if the cyan filter was shown on the paper.
   Red-*black*
   Yellow-*green*
   Green- *green*
   Blue- *blue*
   Magenta-*blue*
   Cyan- *cyan/white*

7. Test your predictions in question six, where you correct? Explain what colour the papers appeared to be in cyan light using the ideas of reflection and absorption of colour to explain your results.
   I was correct. A cyan filter means that no red light is allowed through the filter, only blue and green light. Therefore the red paper would appear black or dark in colour since cyan has no red light in it. The colour yellow is made up of red and green light. Since the cyan filter blocks all the red light, no red light would be reflected. The only colour reflected by the yellow paper would be green, so the yellow paper would look green. The green paper would also look green because green paper only reflects green light and cyan filter allows green light through. The blue paper would appear blue because blue paper only reflects blue light and blue light is let through by the cyan filter. The magenta paper reflects equal parts of red and blue light, but since the cyan filter blocks the red light, the magenta paper would only reflect the blue light and would therefore look blue. And the cyan paper would reflect all the light shown on it. Our eyes might interpret this as the paper being white in colour, but the colour reflected would be cyan.

Name:____ Date:________________

DETECTING COLOURS IN MONOCHROMATIC LIGHT

BACKGROUND:

When light hits a surface three things can happen. Light is reflected, transmitted, or absorbed. Some surfaces absorb only certain frequencies of light while reflecting other frequencies. An object that appears red is really reflecting only red light and absorbing all other frequencies. Different types of light make objects appear slightly different colours. For example a person's makeup might look different in florescent light then it does outside in bright sunlight (or natural light).

The colours that humans perceive are a result of the way our brain and eyes work together. Other animals see colour completely differently than humans do. The retina of a human eye has two types of receptors called cones and rods that pick up colour and send those signals back to the brain. The rods detect how bright or dark the light coming into the eye is and the cones detect colour. There are three types of cones that detect the frequencies of red, green, and blue light. This is why the primary colours for light are red, green, and blue. Our eyes discern all other colours by using those three frequencies of light.

A person who is colour blind does not have one or more of the three types of cones, or the cone(s) do not work properly. Most colour blindness is genetic. A person who is born colour blind cannot gain that vision back. Most people who are colour blind can see colours just not as many colours as people with normal vision.

PROCEDURE:

1. Put either a red, green, or blue coloured filter into the light box.
2. Place the colour viewing box as close as possible to the slide so that the open rectangle on the side of the box is completely covered by the coloured filter of the slide as shown in diagram 19.

Diagram 19

3. Record the coloured slide you are using.
4. Turn the light on for only a few seconds. Make sure that the light box is properly ventilated. Leaving the light on for more than a few seconds will cause the filter to warp and discolour, permanently damaging the slide.
5. Look through the viewing hole on the top of the box and record the colour of the square paper you see at the bottom of the box. Make sure that no other light except the light from the light box is illuminating the colour paper inside the colour viewing box.
6. Record the colour the paper on the bottom of the box appears to be in your data table. If you are unsure of the colour, record if the paper appears light or dark coloured.
7. Replace the coloured filter with another filter and repeat steps 1-6 until you have viewed the coloured paper on the bottom of the box with all of the slides.
8. Predict what colour the paper at the bottom of the box is.
9. Look through the large rectangular hole where the light shines in the box and record the actual colour of the paper.
10. Test at least three different colour viewing boxes and be prepared to share your results with the class.

DATA:

Colour of the Slide	Colour the Paper Appears

Colour I think the paper is:________________________________

Actual colour of the paper:________________________________

Colour of the Slide	Colour the Paper Appears

Colour I think the paper is:________________________________

Actual colour of the paper:________________________________

Colour of the Slide	Colour the Paper Appears

Colour I think the paper is:________________________________

Actual colour of the paper:________________________________

CLASS DATA:

1. What colours appeared to be red or light coloured when red light is shown on them?

____

2. What colours appeared to be dark or black when red light is shown on them?

____

3. What colours appear to be green or light coloured when green light is shown on them?

____

4. What colours appear to be black or dark when green light is shown on them?

____

5. What colours appear to be blue or light coloured when blue light is shown on them?

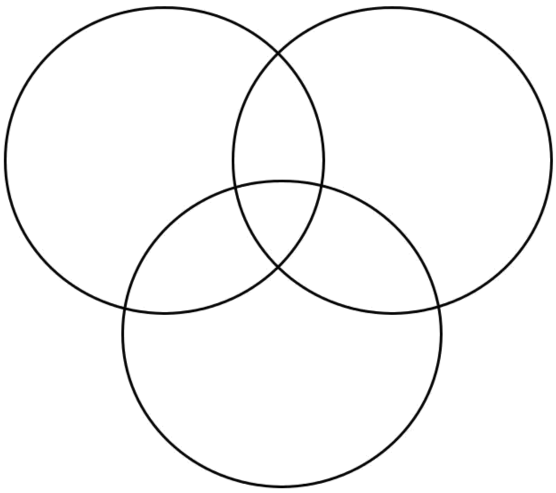
____

6. What colours appear to be dark or black when blue light is shown on them?

____

QUESTIONS:

1. The following chart shows the three primary colours of light incident on a white screen, where the circles of light overlap, the colours overlap as well. Label the colours that show when the light mixes on the screen. Also label what colours you think orange and violet are composed of.



2. When a light is reflected by monochromatic light it appears to be either white or the colour of the light that is incident on it. Which colours did the cyan paper reflect?

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3. Which colours did the magenta paper reflect?

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4. Which colours did the yellow paper reflect?

____

5. Look at the diagram in question one. What two colours make up the colour cyan? If more than one colour of light is reflected by a surface, what happens to the colour or colours reflected? Do the colours appear separately or do they mix together to form a new colour? Give evidence from your experiment to support your claim.

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6. Predict what colour the following papers would appear to be if the cyan filter was shown on the paper.
Red –
Yellow -
Green –
Blue -
Magenta -
Cyan -

7. Test your predictions in question six, where you correct? Explain what colour the papers appeared to be in cyan light using the ideas of reflection and absorption of colour to explain your results.

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STUDY OF CONCAVE MIRRORS

BACKGROUND:

A concave mirror is shaped like a cave in that the middle of the mirror is farther away from the light source than the outside of the mirror. A concave mirror has a smooth reflective surface that bows inwards in an arc shape. It focuses parallel beams of light into one specific and unique point known as the focal point. Since the beams of light do indeed cross at this middle point, a real image is formed. Real images are always inverted, or upside down from the object that originally made the image. Concave mirrors can also form a virtual image.

REQUIRED COMPONENTS (INCLUDED)

Name of Part	***Quantity***
Red and black leads	2
Light box	1
Concave/convex mirror	1
Slide with single slit	1
Slide with three slits	1

REQUIRED COMPONENTS (NOT INCLUDED)

Name of Part	***Quantity***
Power supply	2
White paper	1
Ruler	1

PROCEDURE:

1. Set up the apparatus as shown in diagram 21 with the three slit slide in place. Adjust the condenser by sliding the knob on top of the light box forward or backward until the light coming out of the light box is parallel.

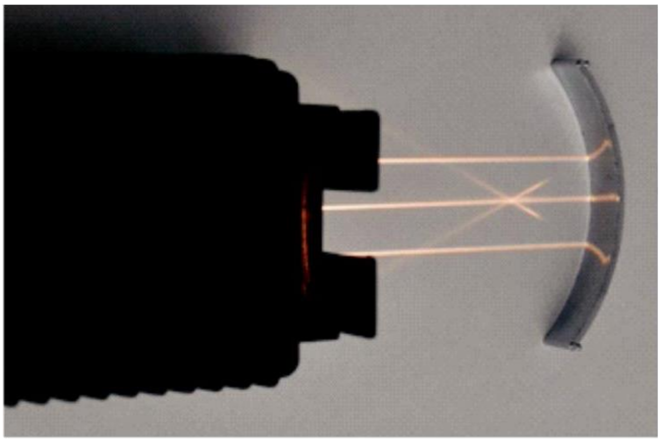

Diagram 21

2. Notice that all the parallel beams are reflected through the same point. This point is called the *focal point*. It is a given distance from your mirror. This distance from the mirror to the spot where all the beams cross is called the *focal length*.

3. On your paper trace the outside surface of the mirror and then mark the focal point with a dot and label this dot 'f'.

4. The focal length is ______2.75cm_________ for this mirror.

5. Write a rule for predicting where a beam of light parallel to the normal will reflect for a concave mirror and write this rule below:
A parallel beam of light will be reflected through the focal point of a concave mirror.

6. Next replace the parallel beams of light with a single beam by using the single slit slide. The spot where the normal line crosses the surface of the mirror is called the *vertex*. This means at 0^o the beam will be reflected directly back on top of itself.

7. Rotate the light box so that the incident ray hits the vertex at every possible angle as shown in diagram 22.

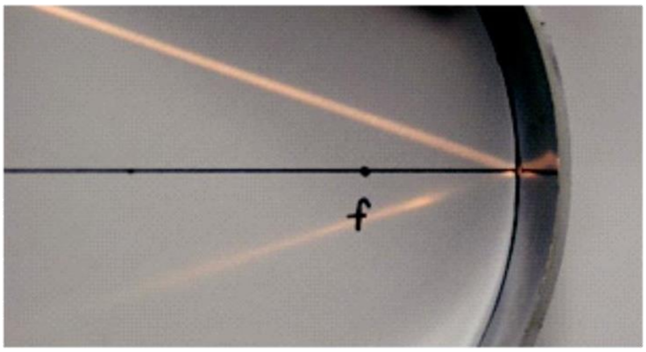

Diagram 22

8. Write a rule that describes how the incident ray and the reflected ray behave in terms of angle of incidence and angle of reflection.
The angle of incidence is always equal to the angle of reflection for any incidence ray that hits the mirror at the vertex.

9. Twice the focal length is called the *centre of curvature*. The mirror is shaped like an arc, which is a small segment of a circle. The centre of curvature is the place that is equidistance from every point on the surface of the mirror. Double the focal length to find the centre of curvature and place a dot on your centre of curvature labeled 'c'.

10. Set up your light box as shown in diagram 23 so that the incident ray travels through the centre of curvature and hits the mirror. You can move your incident ray to several different positions to check your results.

11. Write a rule in the space below that describes how the reflected ray behaves when the incident ray travels through the centre of curvature on its way to the mirror.
The reflected ray is reflected back through the centre of curvature.

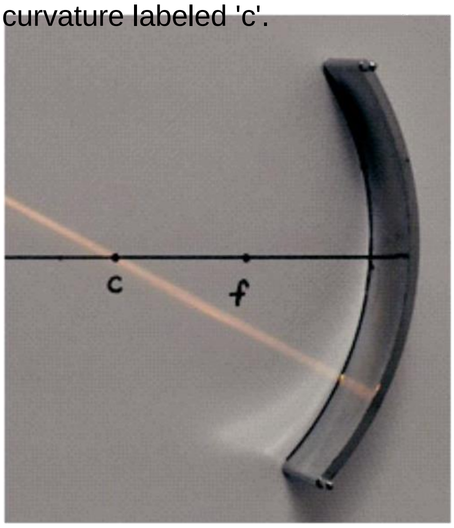

Diagram 23

12. Now rotate your optics table so that the incident ray passes through the focal point on its way to the mirror as shown in diagram 24. Try several different incident angles to check your results.

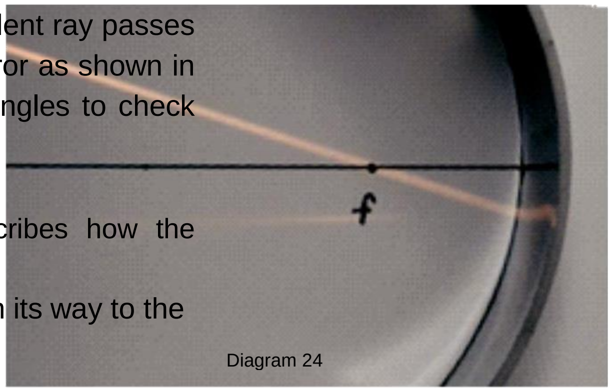

Diagram 24

13. Write a rule in the space below that describes how the reflected ray behaves when the incident ray travels through the focal point on its way to the mirror.
The reflected ray travels parallel to the normal line if it passes through the focal point on its way to the mirror.

Students can use this knowledge to draw optics diagrams that predict the size, orientation, location and type of image an object will produce.

A sample of ray diagrams of the concave mirrors is shown below:

Concave Mirrors

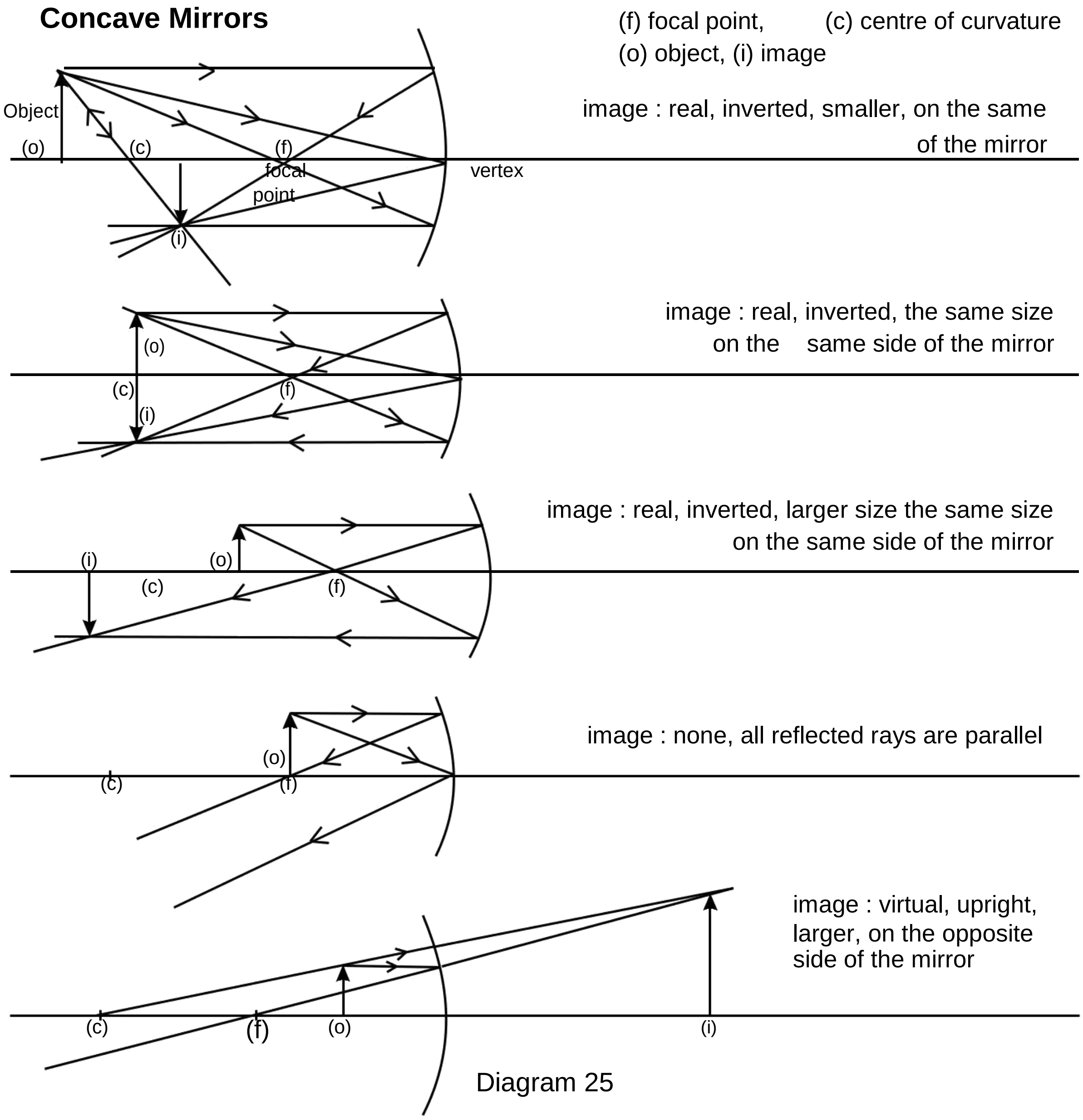

Diagram 25

Name:____ Date:__________

STUDY OF CONCAVE MIRRORS

BACKGROUND:

A concave mirror is shaped like a cave in that the middle of the mirror is farther away from the light source than the outside of the mirror. A concave mirror has a smooth reflective surface that bows inwards in an arc shape. It focuses parallel beams of light into one specific and unique point known as the focal point. Since the beams of light do indeed cross at this middle point, a real image is formed. Real images are always inverted, or upside down from the object that originally made the image. Concave mirrors can also form a virtual image.

PROCEDURE:

1. Set up the apparatus as shown in diagram 21 with the three slit slide in place. Adjust the condenser by sliding the knob on top of the light box forward or backward until the light coming out of the light box is parallel.

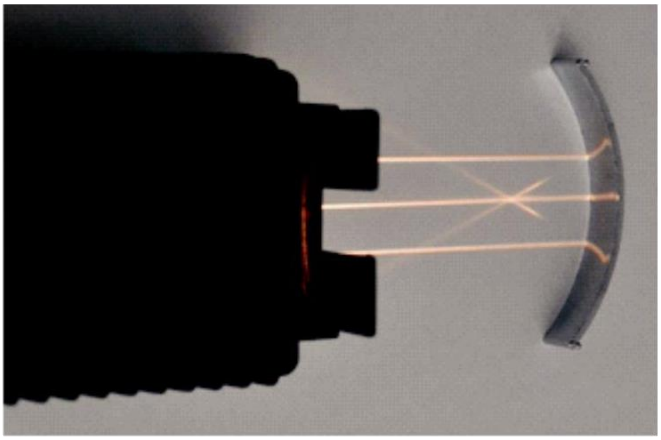

Diagram 21

2. Notice that all the parallel beams are reflected through the same point. This point is called the __________________________. It is a given distance from your mirror. This distance from the mirror to the spot where all the beams cross is called the _________________________.

3. On your paper trace the outside surface of the mirror and then mark the focal point with a dot and label this dot 'f'.

4. The focal length is _______________ for this mirror.

5. Write a rule for predicting where a beam of light parallel to the normal will reflect for a concave mirror and write this rule below:

____

____

6. Next replace the parallel beams of light with a single beam by using the single slit slide. The spot where the normal line crosses the surface of the mirror is called the ________________. This means at 0^o the beam will be reflected directly back on top of itself.

7. Rotate the light box so that the incident ray hits the vertex at every possible angle.

8. Write a rule that describes how the incident ray and the reflected ray behave in terms of angle of incidence and angle of reflection.

____

____

9. Twice the focal length is called the ___________________________________. The mirror is shaped like an arc, which is a small segment of a circle. The centre of curvature is the place that is equidistance from every point on the surface of the mirror. Double the focal length to find the centre of curvature and place a dot on your centre of curvature labelled 'c'.

10. Set up your light box so that the incident ray travels through the centre of curvature and hits the mirror. You can move your incident ray to several different positions to check your results.

11. Write a rule in the space below that describes how the reflected ray behaves when the incident ray travels through the centre of curvature on its way to the mirror.

____

____

12. Now rotate your optics table so that the incident ray passes through the focal point on its way to the mirror. Try several different incident angles to check your results.

13. Write a rule in the space below that describes how the reflected ray behaves when the incident ray travels through the focal point on its way to the mirror.

____

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STUDY OF CONVEX MIRRORS

BACKGROUND:

A convex mirror is shaped so that the centre of the mirror is closer to the object that is being reflected than the outside edges of the mirror, which are further away. These mirrors are often used at convenience stores to see down aisles or used as a passenger side mirror in automobiles because they can take larger area and reflect it to appear in a smaller space. Convex mirrors also have a focal point and a centre of curvature but these points reside behind the mirror. Since the beams never cross but get radiated away from the surface of the mirror, this mirror can only form virtual (imaginary) images. Virtual images are always right side up (erect) and are smaller than the object. The images appear on the opposite side (or in) the mirror. Unlike concave mirrors, a convex mirror's image type does not depend on the position from the focal point to the surface of the mirror that the object is placed.

REQUIRED COMPONENTS (INCLUDED)

Name of Part	***Quantity***
Red and black leads	2
Light box	1
Concave/convex mirror	1
Slide with single slit	1
Slide with three slits	1

REQUIRED COMPONENTS (NOT INCLUDED)

Name of Part	***Quantity***
Power supply	2
White paper	1
Ruler	1

PROCEDURE:

1. Set up the apparatus as shown in diagram 26 so that the three parallel slits are incident on the mirror and the middle beam reflects back on itself. Adjust the condenser by sliding the knob on top of the light box forward or backward until the light coming out of the light box is parallel.

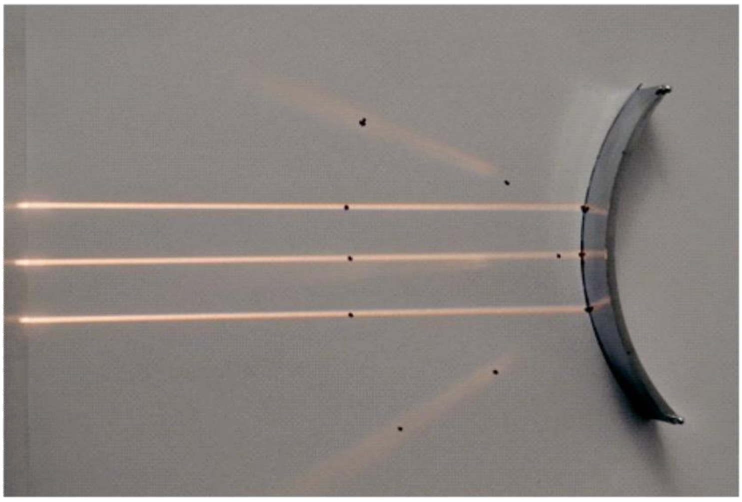

Diagram 26

2. Notice that all the parallel beams are dispersed. Put a piece of white paper under the mirror and trace the surface of the mirror. Then place one dot where each of beams is incident on the mirror and a second dot on each reflected ray one inch from the mirror as shown in diagram 26.

3. Remove the paper and place on a flat surface to draw the incident rays and reflected rays by connecting the dots with a straight edge.

4. Then use your straight edge to trace the reflected rays back through the surface of the mirror to where they would appear to come from as shown in diagram 27. The lines should all cross at one point. This point is called the *focal point*. It is a given distance from your mirror. This distance from the mirror to the spot where all the beams cross is called the *focal length*. Mark the focal point with a 'f' on the paper.

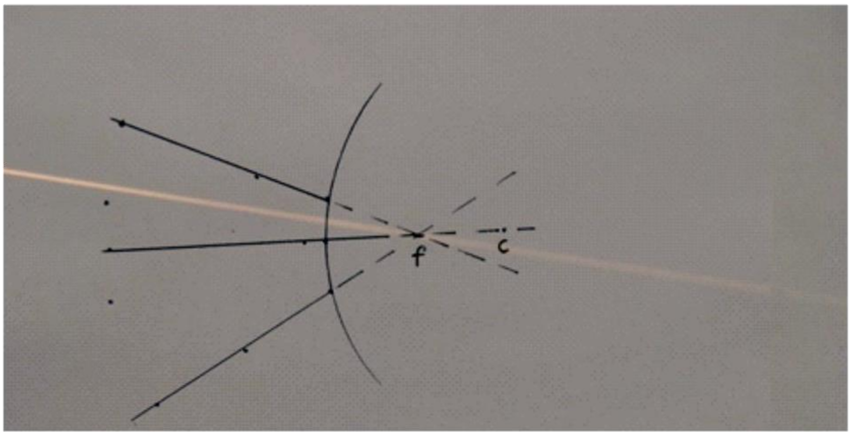

Diagram 27

5. The focal length is ____2.75cm___________ for this mirror.

6. Write a rule for predicting where a beam of light parallel to the normal will reflect for a convex mirror and write this rule below:
A parallel beam of light will be reflected as though it appears to come from the focal point of a convex mirror.

7. Next replace the parallel beams of light with a single beam by using the single slit slide. The spot where the normal line touches the surface of the mirror is called the *vertex*. This means at 0^{o} the beam will be reflected directly back on top of itself.

8. Move the light box so that the incident ray hits the vertex at every possible angle.

9. Write a rule that describes how the incident ray and the reflected ray behave in terms of angle of incidence and angle of reflection.
The angle of incidence is always equal to the angle of reflection for any incidence ray that hits the mirror at the vertex. Drawing a straight line behind the mirror in the opposite direction as the reflected ray will show where the ray appears to have come from.

10. Twice the focal length is called the *centre of curvature*. The centre of curvature is the place that is equidistance from every point on the surface of the mirror. Double the focal length to find the centre of curvature and label that point with a letter 'c' as shown in diagram 27.

11. Rotate your light box so that the incident ray is aimed directly towards the centre of curvature and hits the mirror. You can move your incident ray to several different positions to check your results.

12. Write a rule in the space below that describes how the reflected ray behaves when the incident ray travels towards the centre of curvature on its way to the mirror.
The reflected ray is reflected back through the same path it originated from. The reflected ray will appear to come from behind the mirror as though it travelled straight through the mirror from the centre of curvature.

13. Now rotate your light box so that the incident ray is aimed directly at the focal point as shown in diagram 27 and replace the mirror. Do this for several different incident angles.

14. Write a rule in the space below that describes how the reflected ray behaves when the incident ray travels directly towards the focal point.
The reflected ray always travels parallel to the normal line and looks as though it came from behind the mirror, parallel to the normal line as shown in diagram 28.

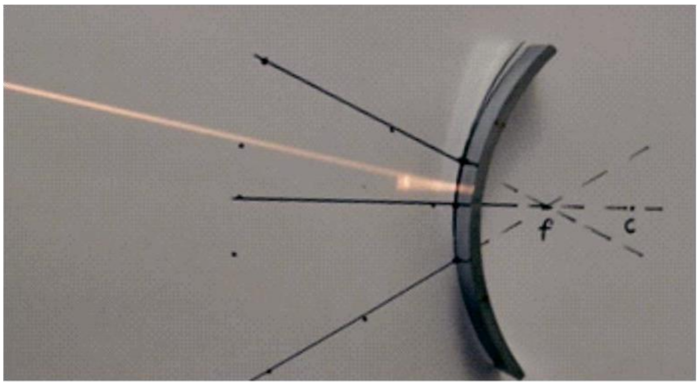

Diagram 28

Students can use this knowledge to draw optics diagrams that predict the size, orientation, location and type of image an object will produce.

A sample of ray diagrams of the concave mirrors is shown below:

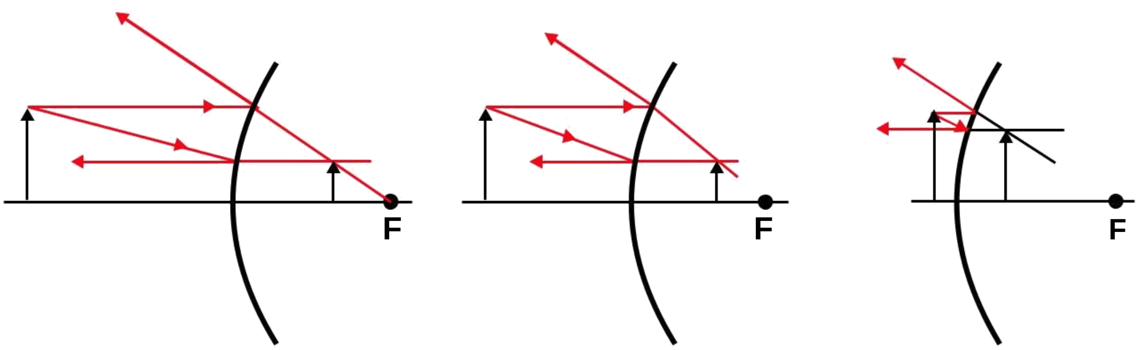

Diagram 29

Name:____ Date:____________

STUDY OF CONVEX MIRRORS

BACKGROUND:

A convex mirror is shaped so that the centre of the mirror is closer to the object that is being reflected than the outside edges of the mirror, which are further away. These mirrors are often used at convenience stores to see down aisles or used as a passenger side mirror in automobiles because they can take larger area and reflect it to appear in a smaller space. Convex mirrors also have a focal point and a centre of curvature but these points reside behind the mirror. Since the beams never cross but get radiated away from the surface of the mirror, this mirror can only form virtual (imaginary) images. Virtual images are always right side up (erect) and are smaller than the object. The images appear on the opposite side (or in) the mirror. Unlike concave mirrors, a convex mirror's image type does not depend on the position from the focal point to the surface of the mirror that the object is placed.

PROCEDURE:

1. Set up the apparatus as shown in diagram 26 so that the three parallel slits are incident on the mirror and the middle beam reflects back on itself. Adjust the condenser by sliding the knob on top of the light box forward or backward until the light coming out of the light box is parallel.

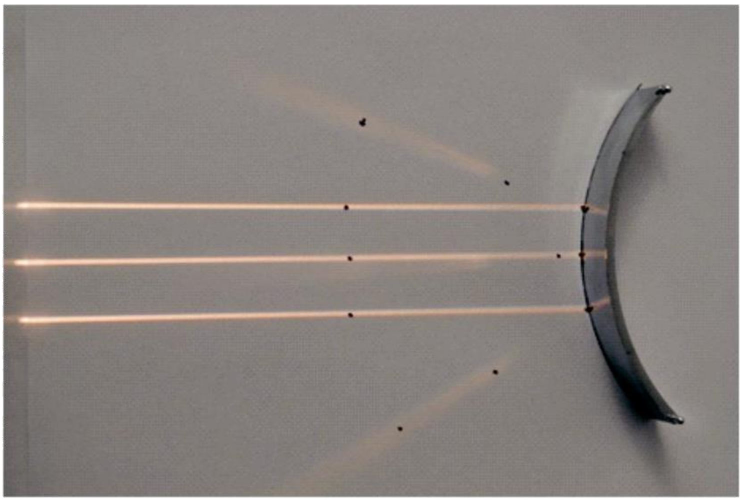

Diagram 26

2. Notice that all the parallel beams are dispersed. Put a piece of white paper under the mirror and trace the surface of the mirror. Then place one dot where each of beams is incident on the mirror and a second dot on each reflected ray one inch from the mirror as shown in diagram 20.
3. Remove the paper and place on a flat surface to draw the incident rays and reflected rays by connecting the dots with a straight edge.
4. Then use your straight edge to trace the reflected rays back through the surface of the mirror to where they would appear to come from. The lines should all cross at one point. This point is called the _________________________. It is a given distance from your mirror. This distance from the mirror to the spot where all the beams cross is called the _________________________. Mark the focal point with a 'f' on the paper.
5. The focal length is _________________ for this mirror.

6. Write a rule for predicting where a beam of light parallel to the normal will reflect for a convex mirror and write this rule below:

____

____

7. Next replace the parallel beams of light with a single beam by using the single slit slide. The spot where the normal line touches crosses the surface of the mirror is called the ____________________. This means at 0^o the beam will be reflected directly back on top of itself.

8. Move the light box so that the incident ray hits the vertex at every possible angle.

9. Write a rule that describes how the incident ray and the reflected ray behave in terms of angle of incidence and angle of reflection.

____

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10. Twice the focal length is called the ______________________________. The centre of curvature is the place that is equidistance from every point on the surface of the mirror. Double the focal length to find the centre of curvature and label that point with a letter 'c'.

11. Rotate your light box so that the incident ray is aimed directly towards the centre of curvature and hits the mirror. You can move your incident ray to several different positions to check your results.

12. Write a rule in the space below that describes how the reflected ray behaves when the incident ray travels towards the centre of curvature on its way to the mirror.

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13. Now rotate your light box so that the incident ray is aimed directly at the focal point on its way to the mirror and replace the mirror. Do this for several different incident angles.

14. Write a rule in the space below that describes how the reflected ray behaves when the incident ray travels directly towards the focal point on its way to the mirror.

SPHERICAL ABERRATION

BACKGROUND

Aberration - a departure from the expected or proper course. (Webster's Dictionary)

Spherical shaped mirrors have images that are blurry as a result of a property of spherical mirrors called spherical aberration. The shape of a spherical mirror does not allow all the parallel rays of light to focus on the same focal point. The rays that are incident on the outside of the mirror do not focus on the same point that the rays striking nearer to the vertex focus.

Diagram 30 illustrates spherical aberration. There are six parallel rays incident on the mirror. The reflected rays are also shown. Notice that not all the reflected rays pass through the focal point.

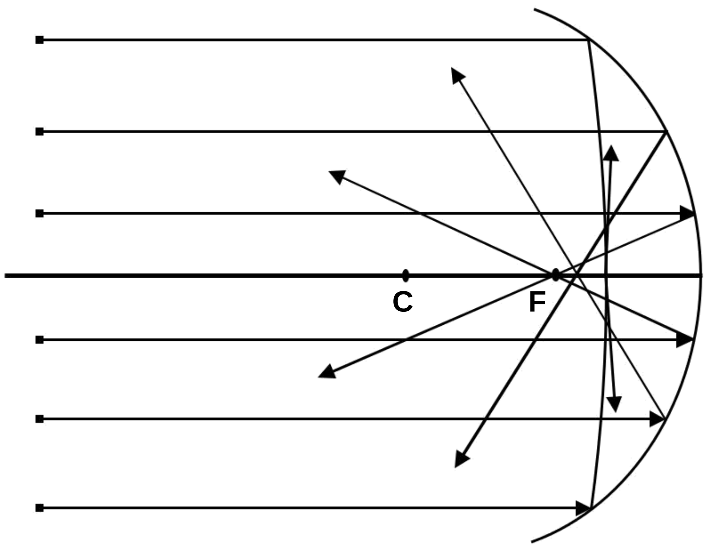


Diagram 30

Many stores that sell magic supplies and novelties have a mirrored device where people can try to touch a real object and put their hands right through it. It is often called a “desktop mirage hologram device”, even though it is not a mirage or a hologram. However, the apparatus is a series of two spherical convex mirrors placed facing each other with a small hole cut in the top. An object can be placed inside the mirrors and the real image of the object will appear as though it is floating in air above the mirrors. The reason two mirrors are used is because the image looks more realistic and clearer if the outside rays of the mirror are blocked by the second mirror, decreasing the spherical aberration and producing a sharper image.

REQUIRED COMPONENTS (INCLUDED)

Name of Part	***Quantity***
Red and black leads	2
Light box	1
Semi-circular mirror	1
Parabolic mirror	1

REQUIRED COMPONENTS (NOT INCLUDED)

Name of Part	***Quantity***
Power supply	2
White paper	1

Students can witness spherical aberration by focusing a parallel beam of light at the semi-circular mirror. Compare the shape of the bright spot (the focal point) on the spherical semi-circular mirror to the more well-defined and smaller bright spot produced by the parabolic concave mirror shown in diagram 31.

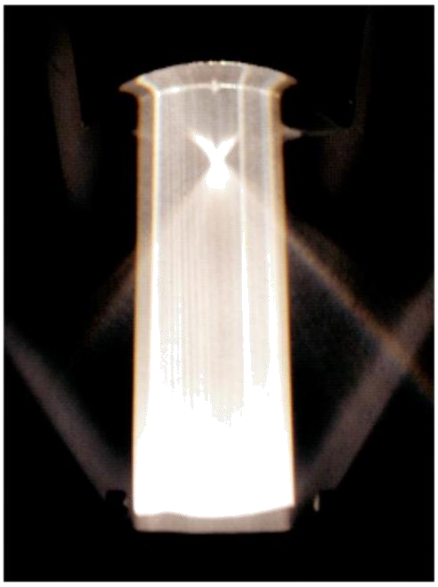


Diagram 31

STUDY OF CONVEX LENSES (RAY DIAGRAMS)

BACKGROUND

A convex lens has one or two spherical surfaces on it. The middle of the lens is the thickest point and the edges of the lens are the thinnest point of the lens. Convex lenses focus parallel beams of light into one specific and unique point known as the focal point. Since the beams of light do indeed cross at this middle point, a real image is formed. Real images are always inverted, or upside down from the object that originally made the image. Convex lenses can also form a virtual image.

REQUIRED COMPONENTS (INCLUDED)

Name of Part	*Quantity*
Red and black leads	2
Light box	1
Convex lens shaped prism	1
Slide with single slit	1
Slide with three slits	1

REQUIRED COMPONENTS (NOT INCLUDED)

Name of Part	*Quantity*
Power supply	2
White paper	1
Ruler	1

PROCEDURE:

To begin the study of convex lenses it is easier to study the lenses in two dimensions before studying three dimensions.

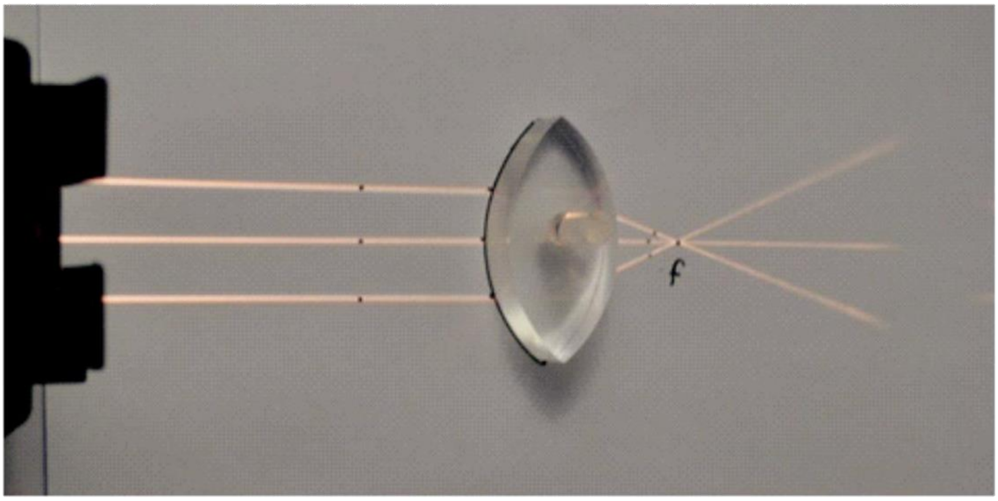


Diagram 32

1. Set up the apparatus as shown in diagram 32. Use the triple slit slide and align the slide so that all three beams are parallel using the condensing lens and the knob at the top of the light box to adjust its position.

2. Notice that all the parallel beams are refracted through the same point. This point is called the focal point. It is a given distance from the centre of your two-dimensional lens. This distance from the mirror to the spot where all the beams cross is called the focal length. Mark the focal point with a 'f' as shown in diagram 32.

3. Then measure this same distance on the opposite side of the lens and mark the focal point on that side of the lens.

4. The focal length is _______________ for this lens.

5. Write a rule for predicting where a beam of light parallel to the normal will refract for a concave mirror and write this rule below:
   A parallel beam of light will be refracted through the focal point on the opposite side of the incident rays of a convex lens.

6. Replace the triple slit slide with a single slit slide in the light box.

7. Now rotate your light box so that the incident ray passes through the focal point on its way to the lens as shown in diagram 33.

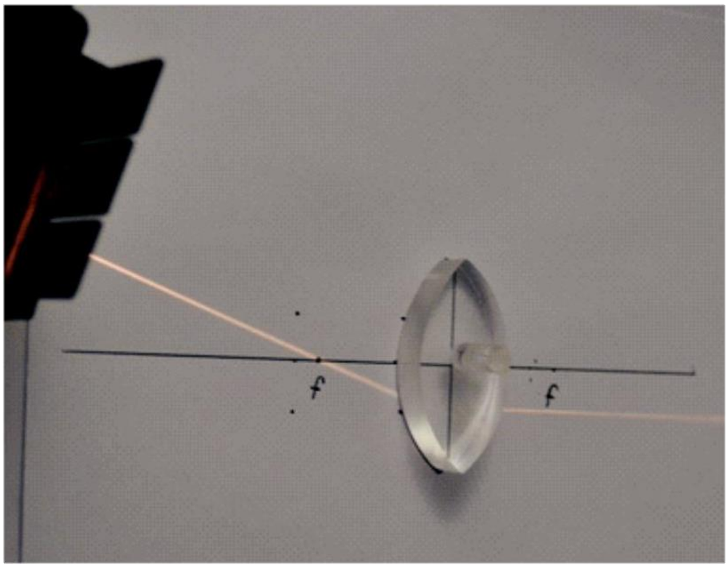


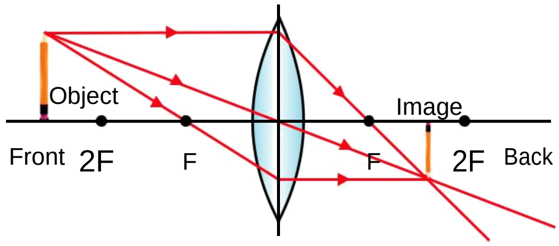
Diagram 33

8. Write a rule in the space below that describes how the refracted ray behaves when the incident ray travels through the focal point on its way to the lens.
   The refracted ray travels parallel to the normal line on the opposite side of the lens if it passes through the focal point on its way to the lens.

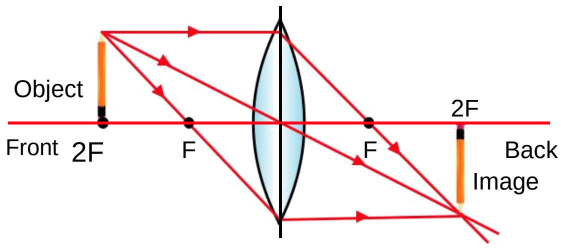
   Students can use this knowledge to draw optics diagrams that predict the size, orientation, location and type of image an object will produce.

A sample of ray diagrams of the concave mirrors is shown below:

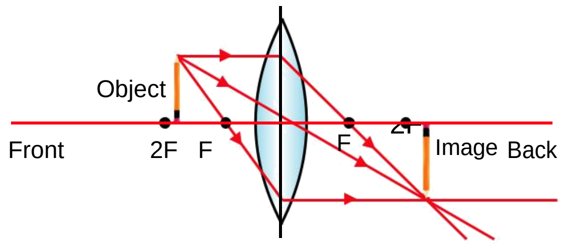
Ray Diagrams



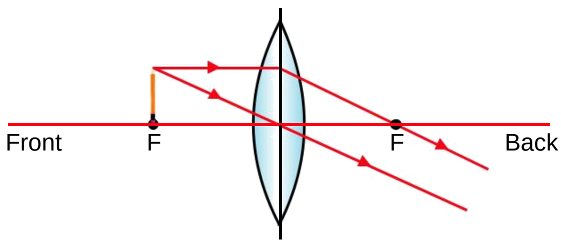
Configuration : object outside 2F, real smaller image between F and 2F



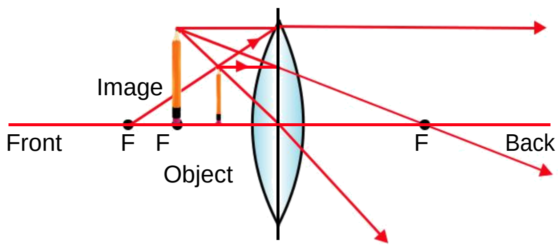
Configuration : object at 2F, real image at 2F same size object



Configuration : object between F and 2F, magnified real image outside 2F



Configuration : object at F, image at infinity



Configuration : object inside F, magnified virtual Image on the same side of the lens as the object

Diagram 34

Name:____ Date:____________

STUDY OF CONVEX LENSES (RAY DIAGRAMS)

BACKGROUND

A convex lens has one or two spherical surfaces on it. The middle of the lens is the thickest point and the edges of the lens are the thinnest point of the lens. Convex lenses focus parallel beams of light into one specific and unique point known as the focal point. Since the beams of light do indeed cross at this middle point, a real image is formed. Real images are always inverted, or upside down from the object that originally made the image. Convex lenses can also form a virtual image.

PROCEDURE:

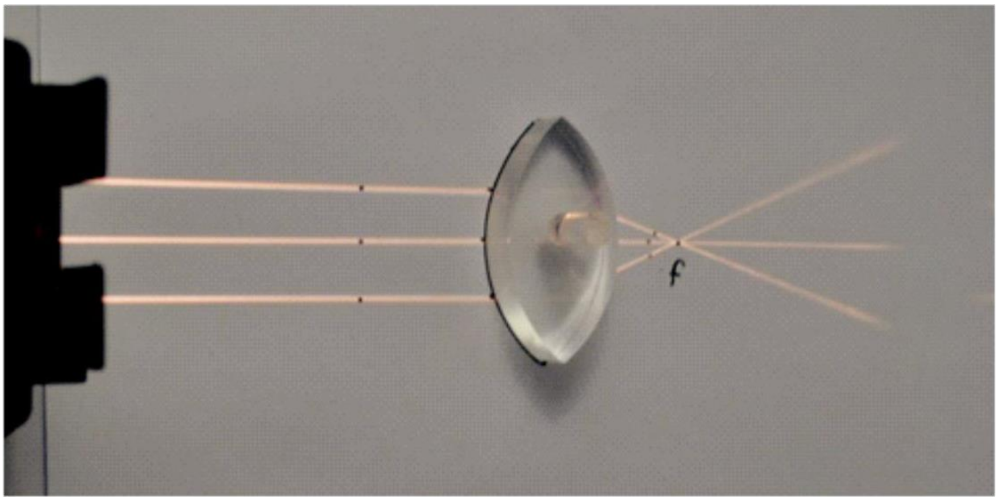


Diagram 32

1. Set up the apparatus as shown in diagram 32. Use the triple slit slide and align the slide so that all three beams are parallel using the condensing lens and the knob at the top of the light box to adjust its position.

2. Notice that all the parallel beams are refracted through the same point. This point is called the ____________________. It is a given distance from the centre of your two-dimensional lens. This distance from the mirror to the spot where all the beams cross is called the ________________________. Mark the focal point with a 'f' as shown in diagram 32.

3. Then measure this same distance on the opposite side of the lens and mark the focal point on that side of the lens.

4. The focal length is ________________ for this lens.

5. Write a rule for predicting where a beam of light parallel to the normal will refract for a concave mirror and write this rule below:

____

____

6. Replace the triple slit slide with the single slit slide in the light box.

7. Now rotate your light box so that the incident ray passes through the focal point on its way to the lens.

8. Write a rule in the space below that describes how the refracted ray behaves when the incident ray travels through the focal point on its way to the lens.

STUDY OF CONCAVE LENSES (RAY DIAGRAMS)

BACKGROUND:

A concave lens is shaped so that the centre of the lens is thinner than the outside end of the lenses. Since the beams never cross but get refracted away from the surface of the lens, this lens can only form virtual (imaginary) images. Virtual images are always right side up (erect) and smaller than the object. The images appear between the focal point and the lens. Unlike convex lenses, a concave lenses' image type does not depend on the position from the focal point to the surface of the mirror that the object is placed.

REQUIRED COMPONENTS (INCLUDED)

Name of Part	***Quantity***
Red and black leads	2
Light box	1
Concave lens shaped prism	1
Slide with single slit	1
Slide with three slits	1

REQUIRED COMPONENTS (NOT INCLUDED)

Name of Part	***Quantity***
Power supply	2
White paper	1
Ruler	1

PROCEDURE:

1. To begin the study of concave lenses, set up your light box as shown in diagram 35. Align the three beams so they are parallel to each other by sliding the knob at the top of light box.

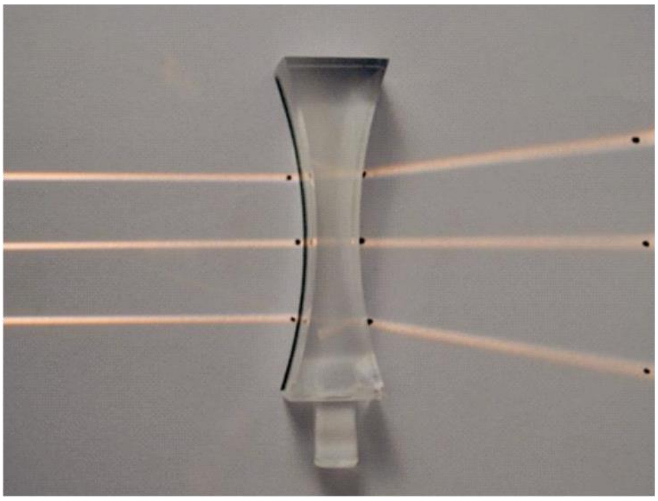


Diagram 35

2. Notice that all the parallel beams are dispersed. Put a piece of white paper under the lens and trace the surface of the lens. Then place one dot on each beam as it travels towards the mirror. Place a second dot where each beam is incident on the lens and a third dot on each refracted ray where it leaves the lens. Place a fourth dot on each ray one inch from where it left the lens as shown in diagram 35.

3. Remove the paper and place on a flat surface to draw the incident rays and refracted rays by connecting the dots with a straight edge.

4. Then use your straight edge to trace the refracted rays back through the surface of the lens to where they would appear to come from. The lines should all cross at one point. This point is called the _*focal point*____. It is a given distance from your mirror. This distance from the mirror to the spot where all the beams cross is called the __*focal length*__. Label the focal point with an 'f' as shown in diagram 36.

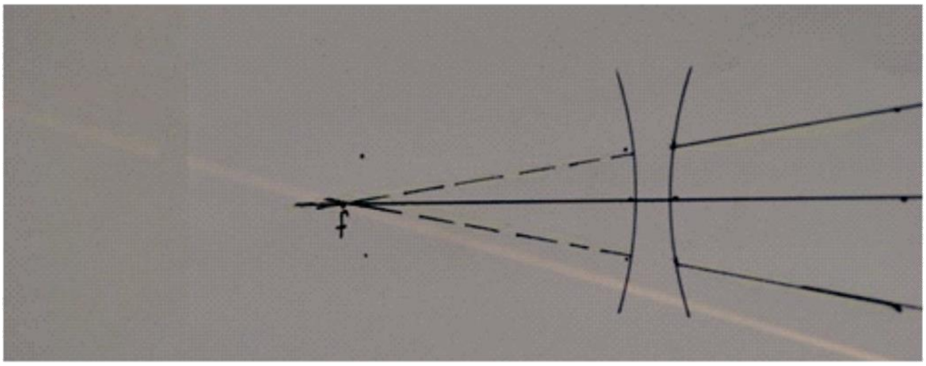


Diagram 36

5. The focal length is _______________ for this lens.

6. Write a rule for predicting where a beam of light parallel to the normal will refract for a concave lens and write this rule below:
   A parallel beam of light will be refracted as though it appears to come through the focal point on the same side of the concave lens that the original beams travelled through.

7. Replace the three parallel slit slide with a single slit slide. Aim the incident ray directly towards the focal point on the other side of the lens as shown in diagram 36. You can move your incident beam to several different positions to check your results.

8. Write a rule in the space below that describes how the refracted ray behaves when the incident ray travels through the focal point on its way to the lens.
   The refracted ray always travels parallel to the normal line and looks as though it came from behind the lens, parallel to the normal line, as shown in diagram 37.

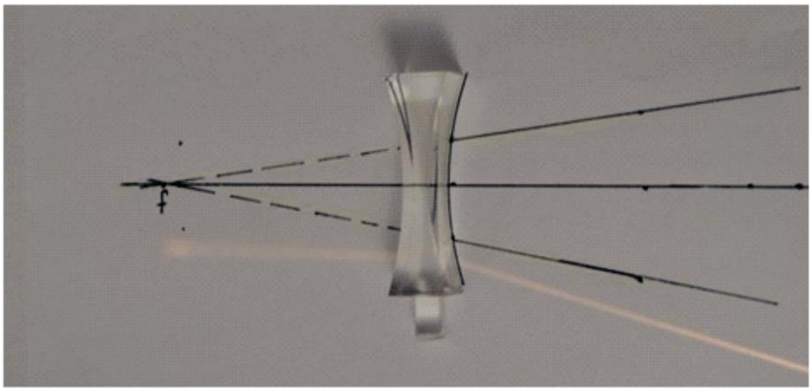


Diagram 37

Students can use this knowledge to draw optics diagrams that predict the size, orientation, location and type of image an object will produce.

A sample of ray diagrams of the concave lenses is shown below:

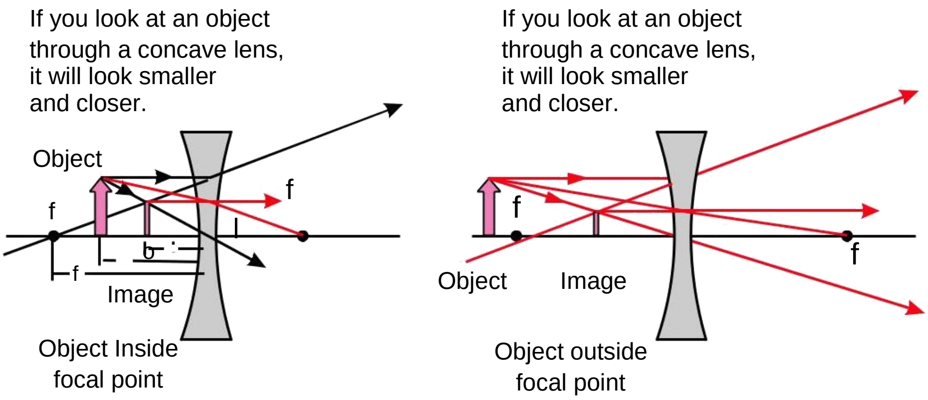


Diagram 38

Name:____ Date:___________

STUDY OF CONCAVE LENSES (RAY DIAGRAMS)

BACKGROUND:

A concave lens is shaped so that the centre of the lens is thinner than the outside end of the lenses. Since the beams never cross but get refracted away from the surface of the lens, this lens can only form virtual (imaginary) images. Virtual images are always right side up (erect) and smaller than the object. The images appear between the focal point and the lens. Unlike convex lenses, a concave lenses' image type does not depend on the position from the focal point to the surface of the mirror that the object is placed.

PROCEDURE:

1. To begin the study of concave lenses, set up your light box as shown in diagram 35. Align the three beams so they are parallel to each other by sliding the knob at the top of light box.

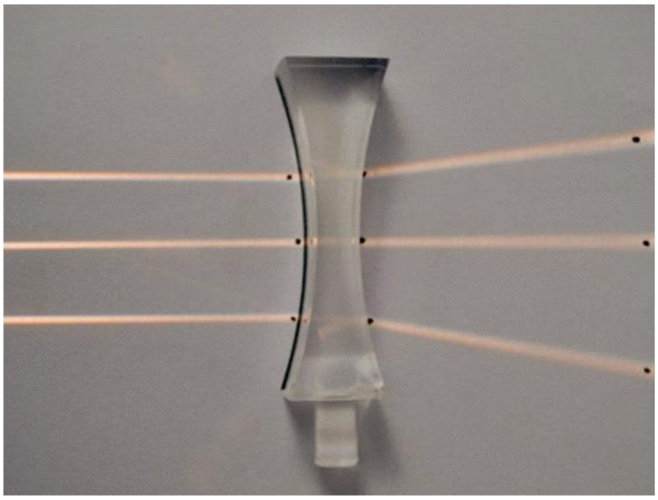


Diagram 35

2. Notice that all the parallel beams are dispersed. Put a piece of white paper under the lens and trace the surface of the lens. Then place one dot on each beam as it travels towards the mirror. Place a second dot where each beam is incident on the lens and a third dot on each refracted ray where it leaves the lens. Place a fourth dot on each ray one inch from where it left the lens as shown in diagram 35.

3. Remove the paper and place on a flat surface to draw the incident rays and refracted rays by connecting the dots with a straight edge.

4. Then use your straight edge to trace the refracted rays back through the surface of the lens to where they would appear to come from. The lines should all cross at one point. This point is called the _______________________. It is a given distance from your mirror. This distance from the mirror to the spot where all the beams cross is called the _____________________. Label the focal point with an 'f'.

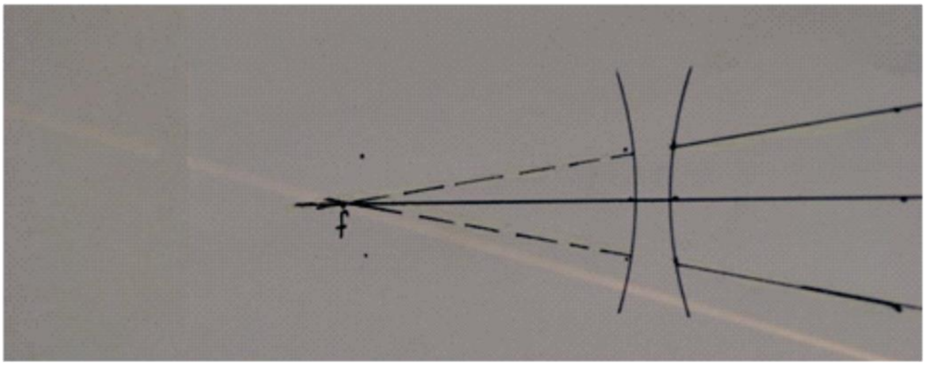


Diagram 36

5. The focal length is _______________ for this lens.

6. Write a rule for predicting where a beam of light parallel to the normal will refract for a concave lens and write this rule below:

____

____

____

____

7. Replace the three parallel slit slide with a single slit slide.

8. Aim the incident ray directly towards the focal point on the other side of the lens. You can move your incident beam to several different positions to check your results.

9. Write a rule in the space below that describes how the refracted ray behaves when the incident ray travels through the focal point on its way to the lens.

____

____

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HOW THE EYE WORKS

BACKGROUND:

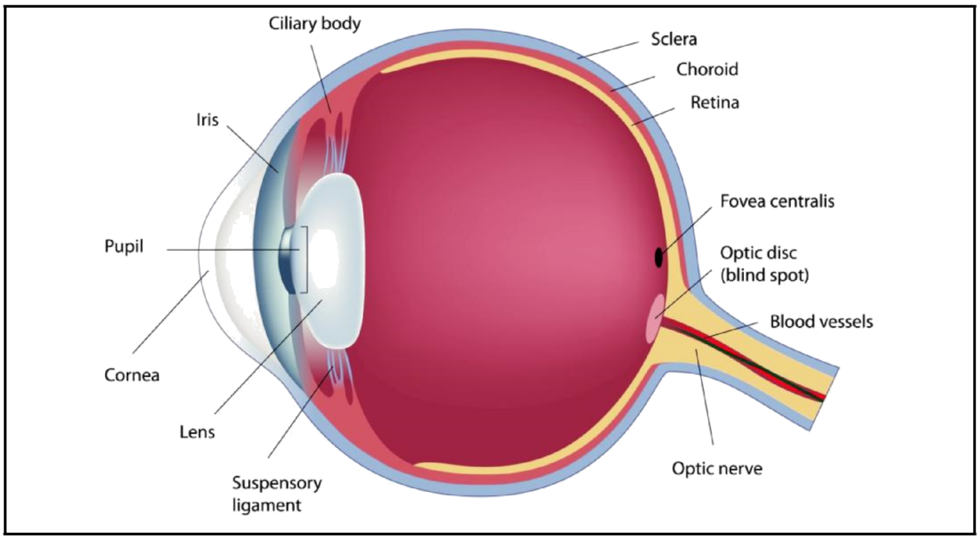

Diagram 39

1. Label the retina, iris, cornea, and lens in the eye diagram 39 above. The iris is the coloured part of your eye. It controls how much light is let into the eye. The retina is a screen in the back of your eye that collects the image the eye sees. The lens and cornea work together to focus the light to make an image. The cornea also protects the eye.

2. Is the lens of your eye a convex or concave lens? Explain your answer.
   My lens is a convex lens. In order to produce an image that can be projected on a screen or on the retina, the image must be real and only convex lenses can produce real images.

REQUIRED COMPONENTS (INCLUDED)

Name of Part	*Quantity*
Red and black leads	2
Light box	1
Semi-circular lens shaped prism	1
Slide with three slits	1

REQUIRED COMPONENTS (NOT INCLUDED)

Name of Part	*Quantity*
Power supply	2
White paper	1
Ruler	1
Small paper labelled “Retina”	1

PROCEDURE:

1. Set up your light box and lens on a white sheet of paper as shown in diagram 40.

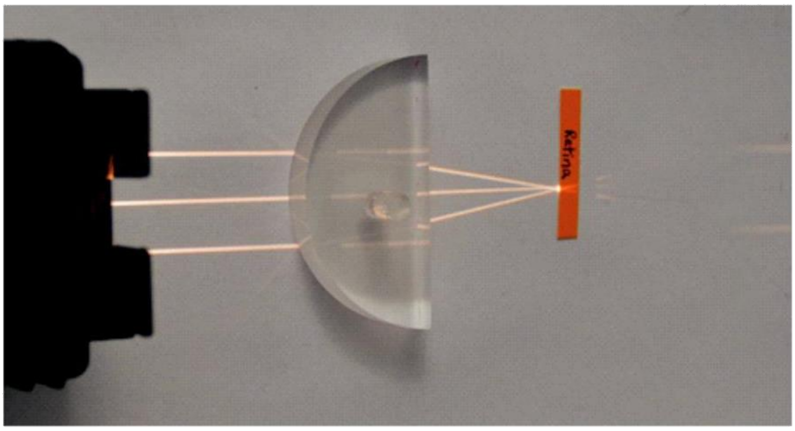

Diagram 40

2. Record the distance that the lens is from the retina where the image is focused.

____

3. The rays of the outside light come into your eye pretty much parallel to each other. How do parallel rays behave when they travel through your lens? Write the rule below.
   Parallel beams of light will be refracted through the focal point, so the image is in focus at the focal point.

Name:____ Date:__________

HOW THE EYE WORKS

BACKGROUND:

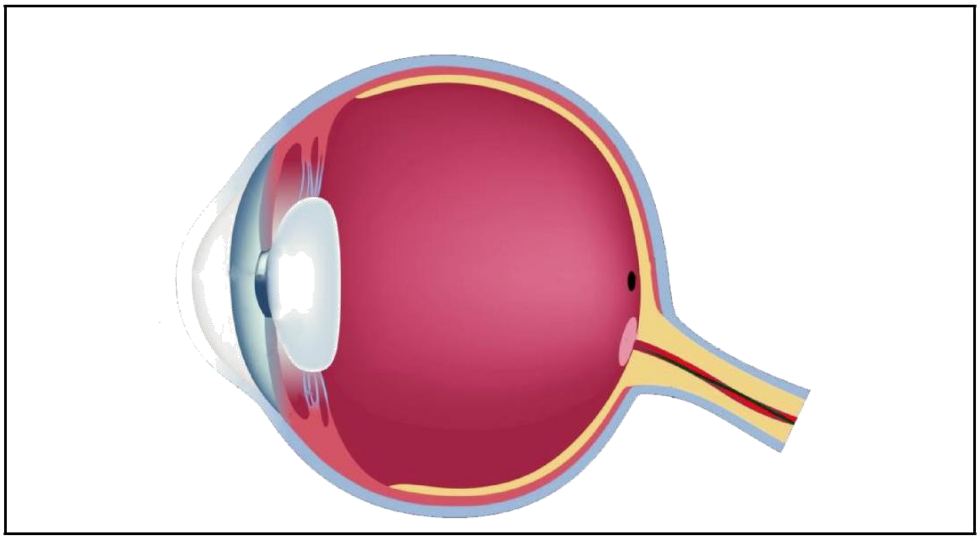

Diagram 41

1. Label the retina, iris, cornea, lens in the eye diagram 41 above. The iris is the coloured part of your eye. It controls how much light is let into the eye. The retina is a screen in the back of your eye that collects the image the eye sees. The lens and cornea work together to focus the light to make an image. The cornea also protects the eye.

2. Is the lens of your eye a convex or concave lens? Explain your answer.

____

____

PROCEDURE:

1. Set up your light box and lens on a white sheet of paper as shown in diagram 40.

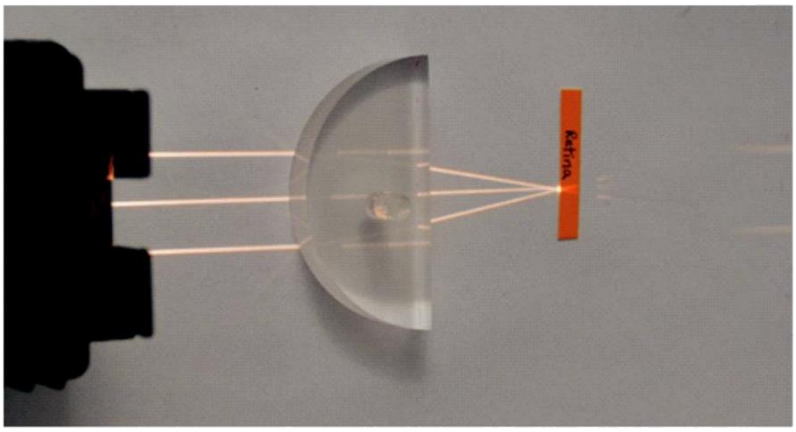

Diagram 40

2. Record the distance that the lens is from the retina where the image is focused.

___

3. The rays of the outside light come into your eye pretty much parallel to each other. How do parallel rays behave when they travel through your lens? Write the rule below.

___

___

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HOW GLASSES WORK IN FARSIGHTED VISION

BACKGROUND:

A person who has farsighted vision (also called hyperopia) means that the light is focused behind the retina instead of on the retina. This can be caused by an eyeball that is too short, a cornea that is not curved enough or a lens that sits too far back in the eye. People with hyperopia can usually see far distances, but up close their vision is blurry and they will need glasses for reading. A convex lens can be used to correct farsighted vision.

REQUIRED COMPONENTS (INCLUDED)

Name of Part	***Quantity***
Red and black leads	2
Light box	1
Semi-circular lens shaped prism	1
Convex lens shaped prism	1
Slide with three slits	1

REQUIRED COMPONENTS (NOT INCLUDED)

Name of Part	***Quantity***
Power supply	2
White paper	1
Ruler	1
Small paper labelled "Retina"	1

PROCEDURE:

1. Move the retina (screen) closer to the lens and predict what happens to the vision of the person. This is a person whose eyeball is too short. Record your observations.
   The closer the screen and image get to one another the less focused the image and the person's vision become.

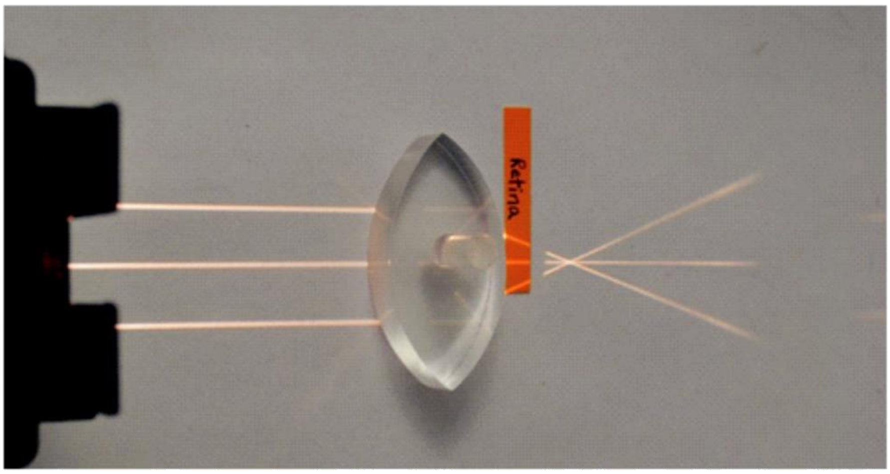

Diagram 42

2. Use the semi-circular prism to add some glasses (another lens) in between the parallel rays and the lens of the eye. Bring the lenses together so that they are touching. Adjust the screen (retina) until the image is clear again and then record the distance between the retina (screen) and the lens (the lens closer to the retina) as shown in diagram 43.

   ____________________.

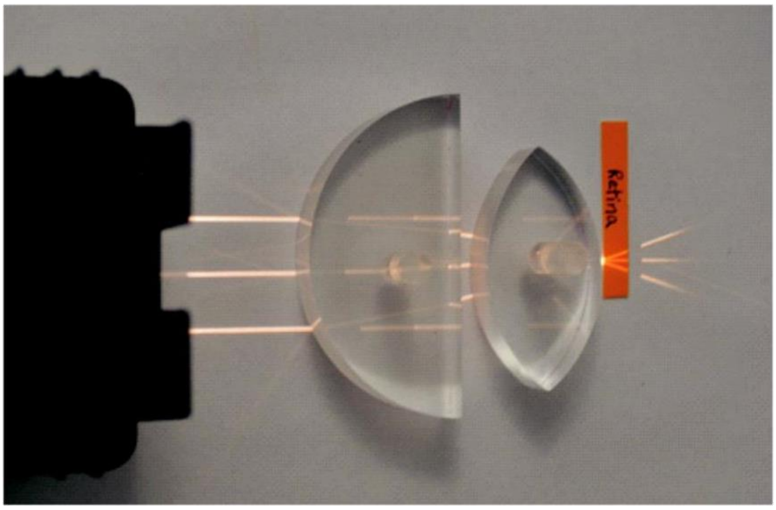

Diagram 43

3. For a person with farsighted vision because their eyeball is too short, was the distance between the lens and the retina less than, greater than or equal to the distance in a person with normal vision?
   The person with normal vision had longer distance between their lens and their retina, the person with the farsighted vision had a smaller distance.

4. What type of lenses would be in the glasses for a person with farsighted vision? *Convex lenses*

5. A person cannot change the distance between their retina and their lens, in order to be able to see clearly, what can an optometrist change?
   An optometrist can change the focal point of the glasses, so that the lenses of the glasses work with the lenses of the eye in order to produce a clear image on the retina. The optometrist can also adjust where the glasses sit on a person's face to correct vision.

Name:____ Date:___________

HOW GLASSES WORK IN FARSIGHTED VISION

BACKGROUND:

A person who has farsighted vision (also called hyperopia) means that the light is focused behind the retina instead of on the retina. This can be caused by an eyeball that is too short, a cornea that is not curved enough or a lens that sits too far back in the eye. People with hyperopia can usually see far distances, but up close their vision is blurry and they will need glasses for reading. A convex lens can be used to correct farsighted vision.

PROCEDURE:

1. Move the retina (screen) closer to the lens and predict what happens to the vision of the person. This is a person whose eyeball is too short. Record your observations.

   ____

   ____

   ____

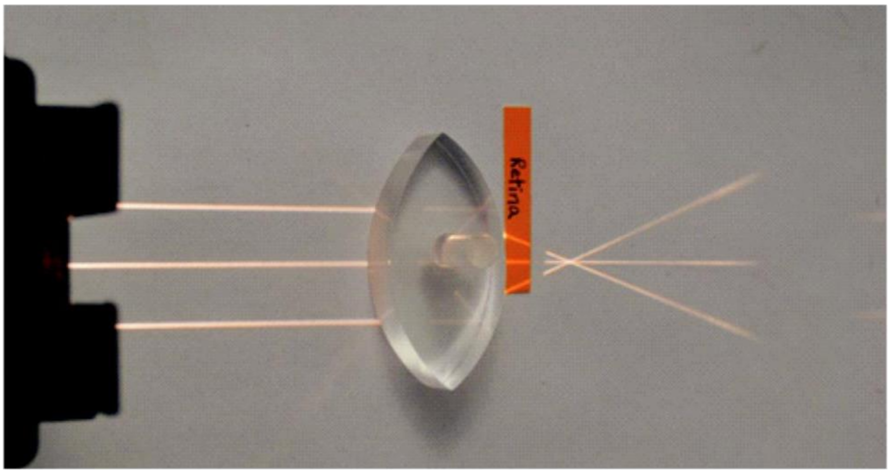

Diagram 42

2. Use the semi-circular prism to add some glasses (another lens) in between the parallel rays and the lens of the eye. Bring the lenses together so that they are touching. Adjust the screen (retina) until the image is clear again and then record the distance between the retina (screen) and the lens (the lens closer to the retina).

   ____________________.

3. For a person with farsighted vision because their eyeball is too short, was the distance between the lens and the retina less than, greater than or equal to the distance in a person with normal vision?

   ____

   ____

   ____

4. What type of lenses would be in the glasses for a person with farsighted vision?

____

5. A person cannot change the distance between their retina and their lens, in order to be able to see clearly, what can an optometrist change?

____

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HOW GLASSES WORK IN NEAR-SIGHTED VISION

BACKGROUND:

A person who has near-sighted vision (also called myopia) has an image that is focused in front of the retina. This can be caused by the distance between their lens and their retina being too large or the cornea being too rounded. People with myopia can usually see close (near) distances, but far away their vision is blurry and they will need glasses for driving.

PROCEDURE:

1. Start with convex shaped prism and the screen (retina) aligned so the lines are focused on the retina.

2. Move the retina (screen) farther from the lens and explain what happens to the vision of the person.
   The further the screen and image get from one another, the more blurry the image and the person's vision become.

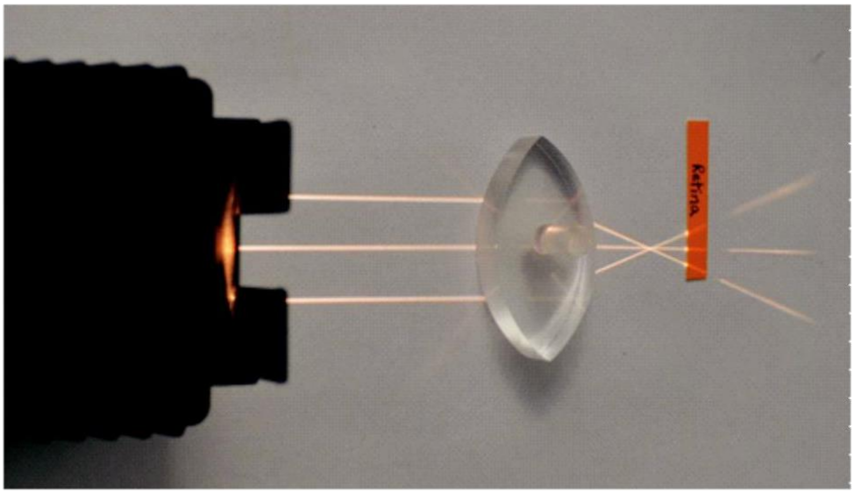

Diagram 44

3. Use the concave lens shaped prism to add some glasses (another lens) in between the light box (representing what the person is looking at) and the convex lens (representing the lens of the eye) as shown in diagram 45 and then bring the lenses together so that they are touching. Adjust the screen (retina) until the image is clear again and then record the distance between the retina (screen) and the lens (the lens closer to the retina).

   ____

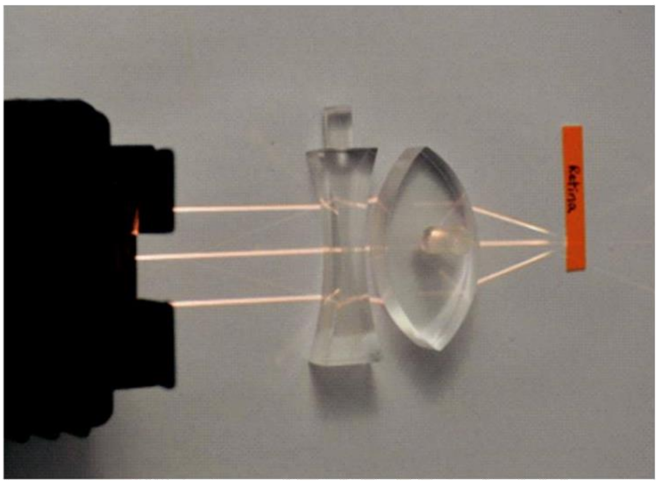

Diagram 45

4. For a person with near-sighted vision, was the distance between the lens and the retina less than, greater than, or equal to the distance in a person with normal vision?
   The person with normal vision had a shorter distance between their lens and their retina, the person with the farsighted vision had a larger distance.

5. What type of lenses would be in the glasses for a person with near-sighted vision? *Concave lenses*

6. A person cannot change the distance between their retina and their lens, in order to be able to see clearly, however some people have Lasik eye surgery. This is where the cornea of the eye is reshaped using a laser. Would a near-sighted person want their cornea flattened or more round?
   A person with near-sighted vision would want the shape of the cornea to be flatter, this would increase the focal point of their cornea allowing the image to be produced further away from their lens and focus on the back of their retina.

Name:____ Date:____________

HOW GLASSES WORK IN NEAR-SIGHTED VISION

BACKGROUND:

A person who has near-sighted vision (also called myopia) has an image that is focused in front of the retina. This can be caused by the distance between their lens and their retina being too large or the cornea being too rounded. People with myopia can usually see close (near) distances, but far away their vision is blurry and they will need glasses for driving.

PROCEDURE:

1. Start with convex shaped prism and the screen (retina) aligned so the lines are focused on the retina.

2. Move the retina (screen) farther from the lens and explain what happens to the vision of the person.

____

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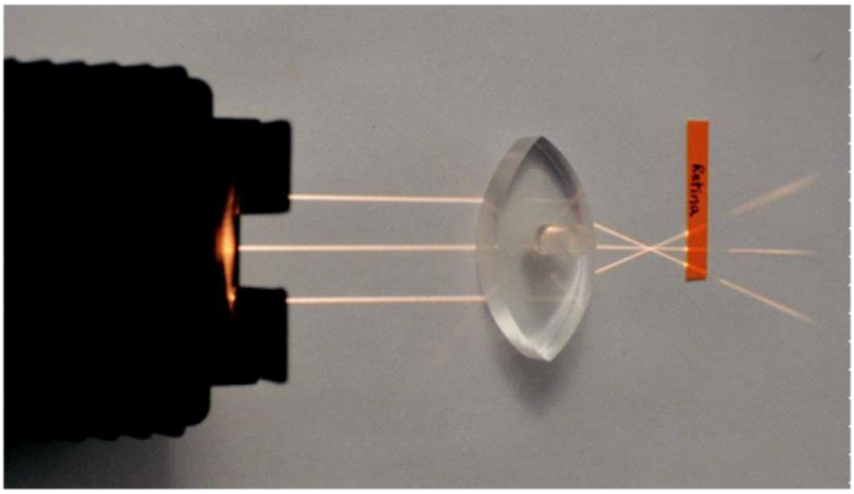

Diagram 44

3. Use the concave lens shaped prism to add some glasses (another lens) in between the light box (representing what the person is looking at) and the convex lens (representing the lens of the eye) and then bring the lenses together so that they are touching. Adjust the screen (retina) until the image is clear again and then record the distance between the retina (screen) and the lens (the lens closer to the retina).

____

4. For a person with near-sighted vision, was the distance between the lens and the retina less than, greater than, or equal to the distance in a person with normal vision?

   ____

5. What type of lenses would be in the glasses for a person with near-sighted vision?

   ____

6. A person cannot change the distance between their retina and their lens, in order to be able to see clearly, however some people have Lasik eye surgery. This is where the cornea of the eye is reshaped using a laser. Would a near-sighted person want their cornea flattened or more round?

   ____

   ____

   ____

   ____