Equipment

Figure one shows all the equipment that is included with your OS-8500 Introductory Optics System. The system also includes a fitted box, with cutouts for each component, and of course, this manual. If you wish to order additional components or replacement parts, please see the information at the end of the manual.

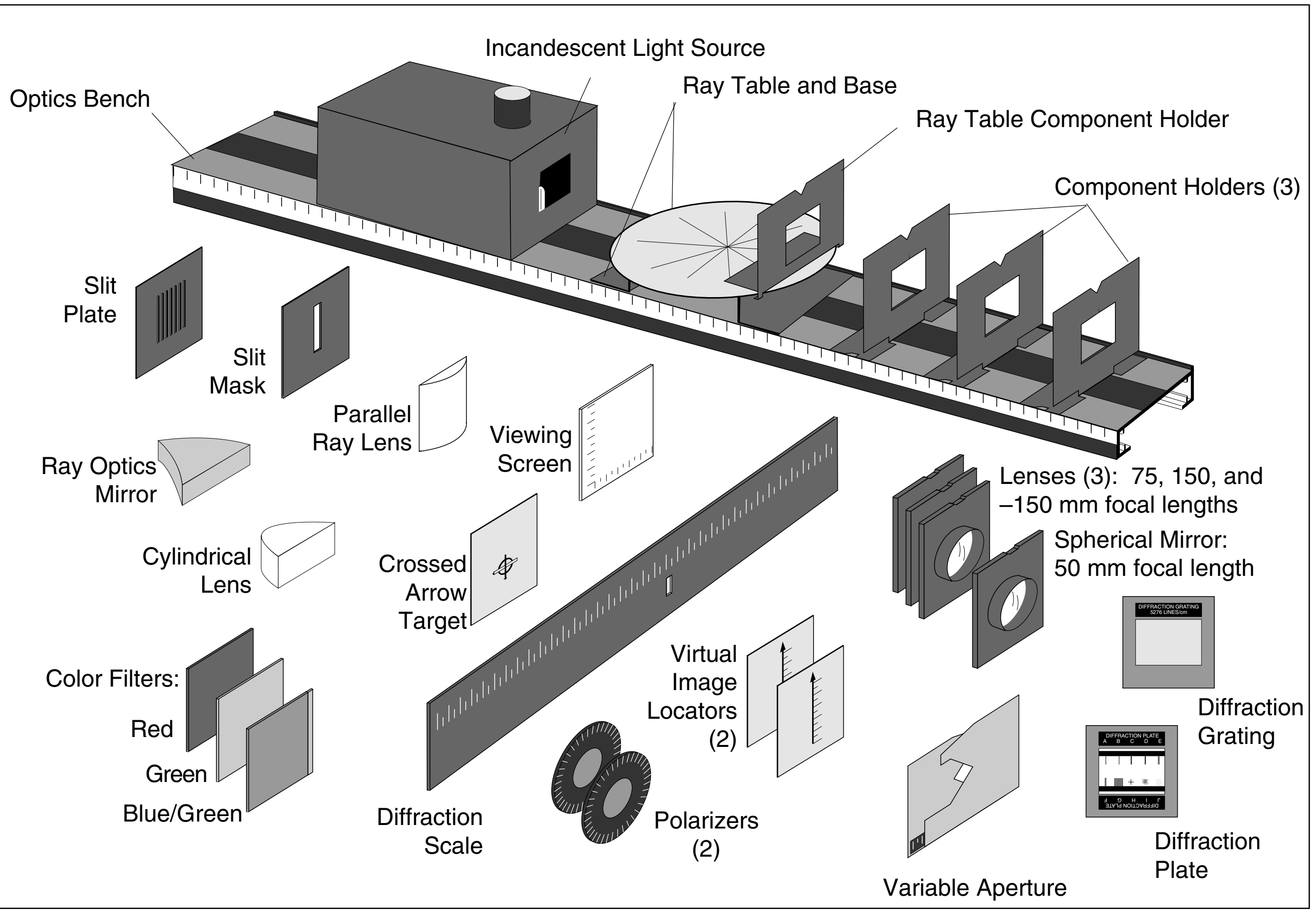


Figure 1: Equipment Included in the OS-8500 Introductory Optics System

Setting Up the Equipment

Optics Bench

The Optics Bench is shown in Figure 2. The Light Source, Component Holders, and Ray Table Base all attach magnetically to the bench as shown. For proper optical alignment, the edge of each of these components should be mounted flush to the alignment rail, which is the raised edge that runs along one side of the bench.

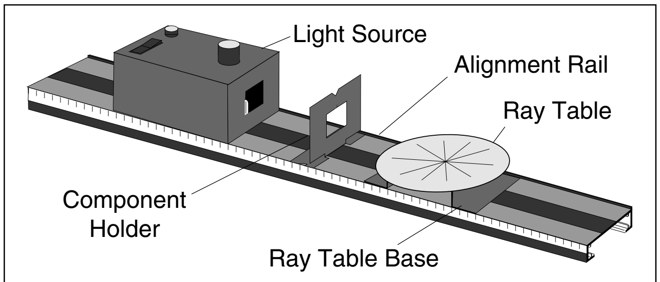


Figure 2: Bench

> **NOTE:** Avoid scratching or otherwise abusing the surface of the magnetic pads. If they get dirty, use only soapy water or rubbing alcohol for cleaning. Other solvents may dissolve the magnetic surface.

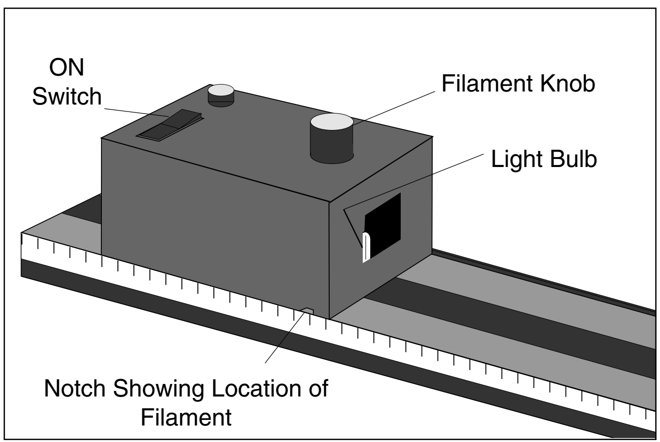


Figure 3: Using the Light Source

Incandescent Light Source

The Light Source is shown in Figure 3. To turn it on, connect the power cord to any grounded 105-125 VAC receptacle, and flip the switch on the top panel to ON. If at any time the light fails to come on, check with your instructor.

The Filament Knob on the top of the unit moves the light bulb from side to side. The notch at the bottom indicates the position of the light bulb filament, so that accurate measurements can be made during experiments.

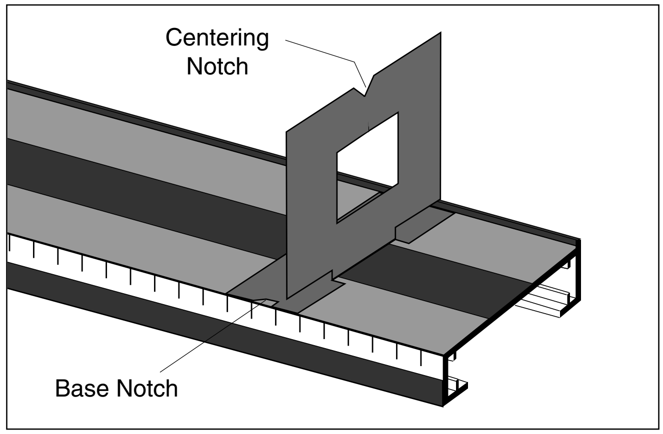


Figure 4: Using the Component Holders

Component Holders and Components

The Optics set comes with three regular Component Holders and one holder designed for use with the Ray Table. The regular Component Holders attach magnetically to the optics bench, as in Figure 4. The notch at the top of each holder is for centering components on the holder. The notches in the base of the holders are for accurate distance measurements on the metric scale of the bench. These base notches—and also the edge of the component holder base—are positioned so that they align with the vertical axis of a mounted lens or mirror. Accurate measurements of component position can be made as shown in Figure 5.

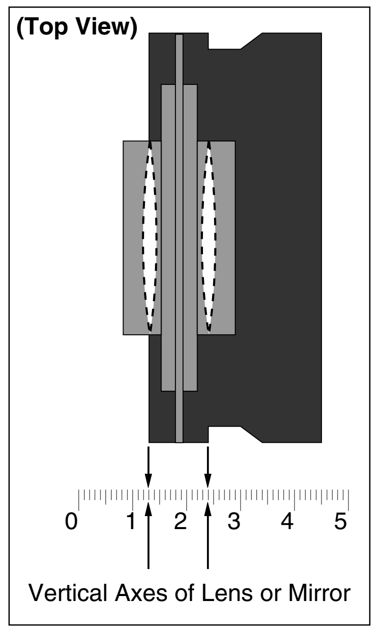


Figure 5: Component Alignment

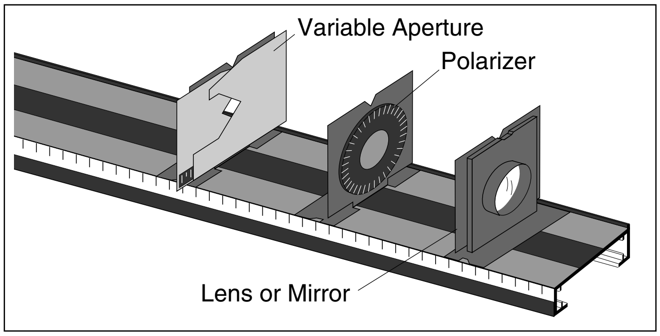


Figure 6: Using the Component Holders

The Variable Aperture, the Polarizers, and the Lenses attach to the component holders as shown in Figure 6. Use the centering notch to align the components along the optical axis of the bench and, in the case of the Polarizers, to measure the angle of polarization.

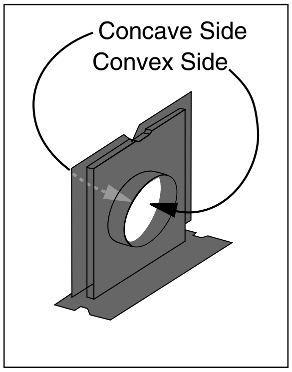
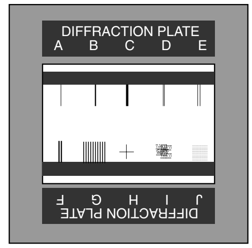


Figure 7: The Spherical Mirror

The Spherical Mirror mounts onto the component holders in the same manner as the Lenses. However, the mirror is silvered on both sides, so that, depending on which side you use, it can be a convex or a concave mirror (see Figure 7).

Diffraction Experiments

Set up diffraction experiments as shown in Figure 8. You can use either the Diffraction Plate, which has ten different apertures, or the Diffraction Grating, which has a line spacing of 600 lines/mm. If you are using the Diffraction Plate, place the Slit Mask on the other side of the component holder and position it so that only a single diffraction aperture is illuminated by the light from the light source.



Pattern	No. Slits	Slit Width (mm)	Slit Spacing center-to-center (mm)
A	1	0.04	
B	1	0.08	
C	1	0.16	
D	2	0.04	0.125
E	2	0.04	0.250
F	2	0.08	0.250
G	10	0.06	0.250
H	2 (crossed)	0.04	
I	225 Random Circular Apertures (.06 mm dia.)		
J	15 x 15 Array of Circular Apertures (.06 mm dia.)		

Figure 9: Diffraction Plate Apertures

When you look through the aperture or grating toward the light source, you will see the diffraction pattern superimposed over the Diffraction Scale. You can use the illuminated scale to accurately measure the geometry of the diffraction pattern. Information about analyzing the measurements is provided in experiments 9, 15, 16, and 17. The dimensions of the apertures in the Diffraction Plate are provided in Figure 9.

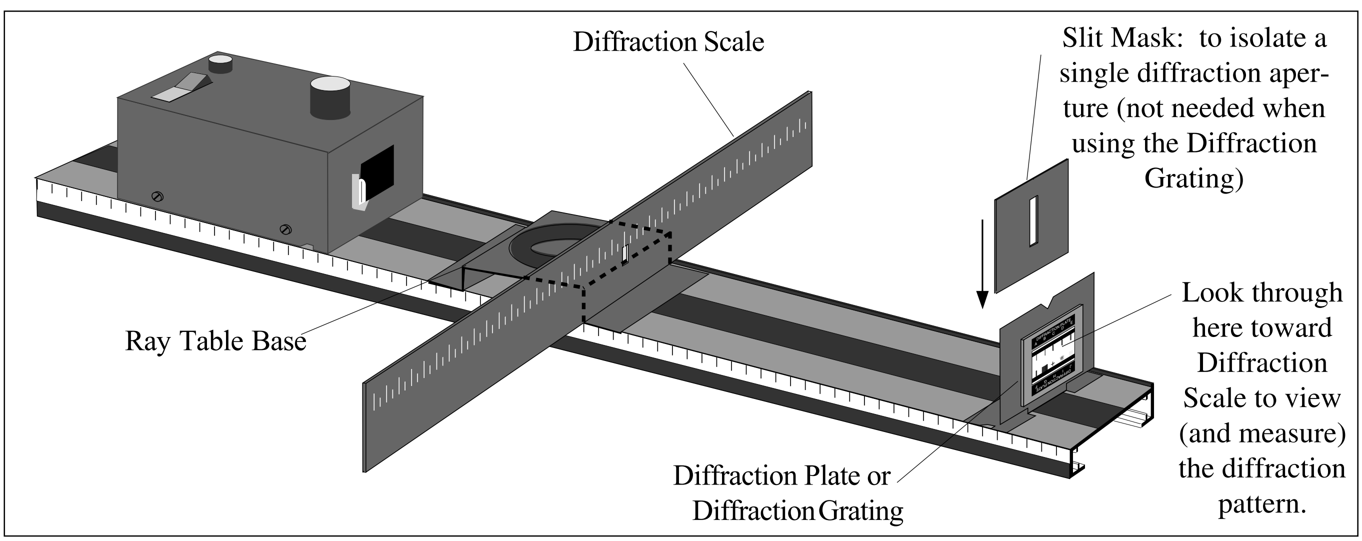


Figure 8: Setting Up a Diffraction Experiment

Basic Ray Optics Setup

The basic setup for Ray Optics is shown in Figure 10. The Ray Table Base should be flush against the alignment rail. The Ray Table fits over the pin on the top of the Base.

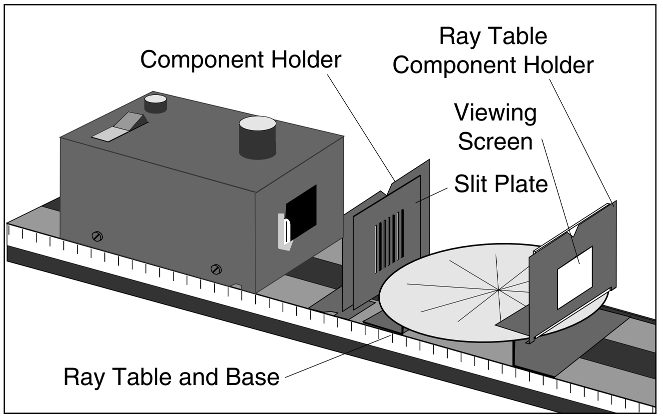


Figure 10: Basic Ray Optics Setup

Notice that the Ray Table Base is slightly slanted. When mounting the base on the Optics Bench, be sure the Ray Table slants down toward the Light Source. This ensures sharp, bright rays. (In all the experiments described in this manual, the error introduced by this tilt is negligible.)

Either side of the Ray Table may be used. One side has a rotational scale, the other has both a rotational scale and a grid that may be used for linear measurements.

The Slit Plate is attached to a component holder between the Light Source and the Ray Table. The positioning shown in the illustration will give clear, sharp rays in a slightly darkened room. However, the quality of the rays is easily varied by adjusting the distance between the Light Source and the Slit Plate. Narrower, less divergent rays may be obtained by sliding the Light Source farther away from the slits, but there is a corresponding loss of brightness.

The Ray Table Component Holder attaches magnetically to the Ray Table as shown. It may be used to mount the Viewing Screen, the Polarizer, or another component.

Single Ray Setup

Most quantitative ray optics experiments are most easily performed using a single ray. This can be obtained by using the Slit Mask, as shown in Figure 11, to block all but the desired ray.

For accurate measurements using the rotational scale, the incident ray must pass directly through the center of the Ray Table. To accomplish this, alternately adjust:

① the lateral position of the Slit Plate on its Component Holder,

② the position of the light source filament with respect to the optical axis, and

③ the rotation of the Ray Table.

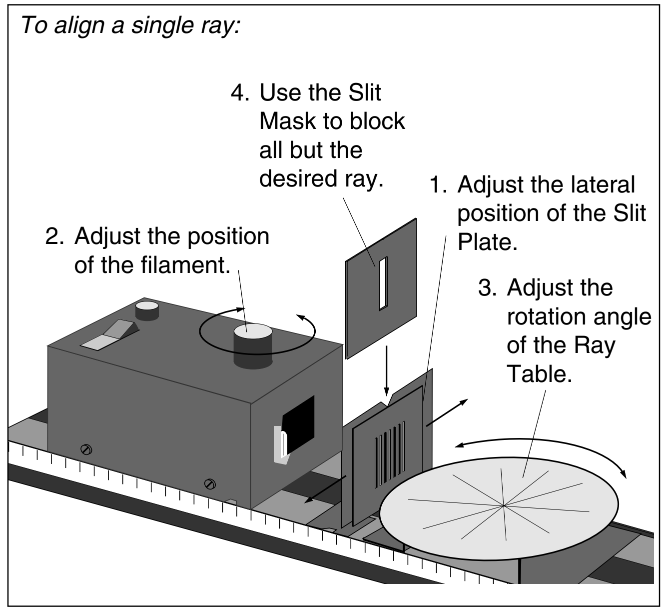


Figure 11: Single Ray Setup

When one of the rays is aligned in this manner, place the Slit Mask on the other side of the Component Holder to block all but the desired ray.

Parallel Ray Setup

Parallel rays are obtained by positioning the Parallel Ray Lens between the Light Source and the slits, as shown in Figure 12. Use the parallel lines of the Ray Table grid as a reference, and adjust the longitudinal position of the lens until the rays are parallel.

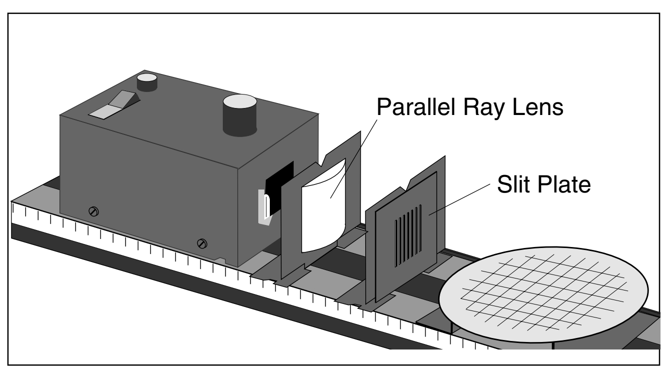


Figure 12: Single Ray Setup

Copy Ready Experiments

The following experiments are written in worksheet form.
Feel free to photocopy them for use in your lab.

➤**NOTE:** The first paragraph in each experiment lists all the equipment needed to perform the experiment. Be sure to read this equipment list first, as the requirements vary with each experiment.

Experiment 1: Introduction to Ray Optics

EQUIPMENT NEEDED:

-Optics Bench,
-Ray Table and Base,
-Slit Plate,
-Viewing Screen.
-Light Source,
-Component Holder,
-Ray Table Component Holder,

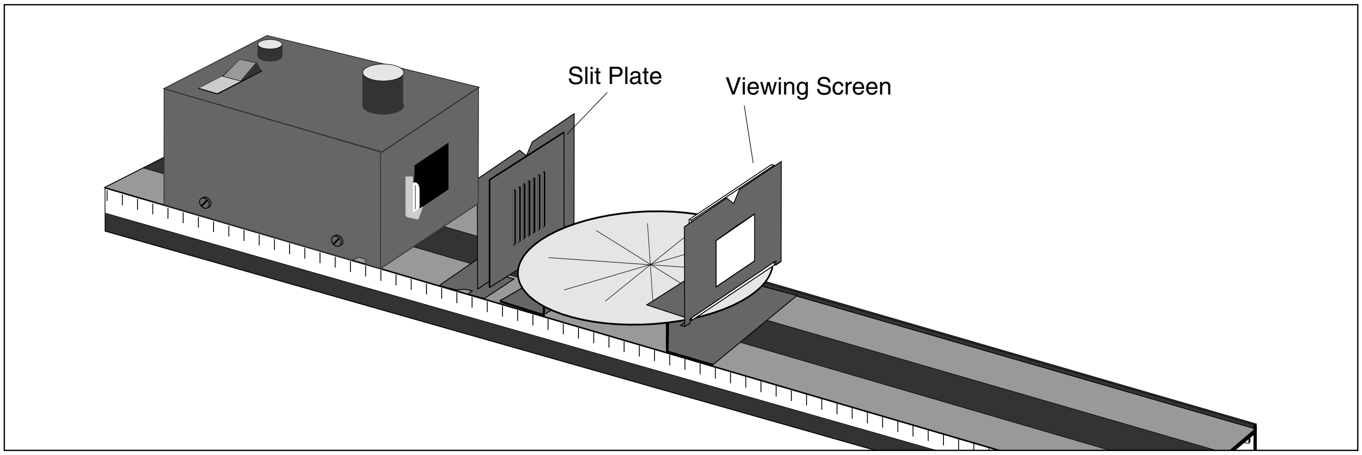


Figure 1.1 Equipment Setup

Purpose

① Observe straight line propagation of light.

② Use Ray Tracing to locate an object.

Procedure

Set up the equipment as shown in Figure 1.1, and turn on the Light Source. Darken the room enough so the light rays on the Ray Table are easily visible.

Straight Line Propagation of Light

Observe the light rays on the Ray Table.

① Are the rays straight? ____.

② How does the width and distinctness of each ray vary with its distance from the Slit Plate?
____.

Set the Viewing Screen and its holder aside for the next step.

③ Lower your head until you can look along one of the "Rays" of light on the Ray Table. Where does the light originate? What path did it take going from there to your eye? Try this for several rays.
____.

Replace the Viewing Screen as shown in Figure 1.1. Rotate the Slit Plate slowly on the component holder until the slits are horizontal. Observe the slit images on the Viewing Screen.

④ How does the width and distinctness of the slit images depend on the angle of the Slit Plate?
____.

⑤ For what angle of the Slit Plate are the images most distinct? For what angle are the images least distinct?____.

⑥ On a separate sheet of paper, explain your observations in terms of the straight line propagation of light. Include a diagram showing how the width of the slit images depends on the orientation of the Light Bulb filament with respect to the Slit Plate.

____.

Ray Tracing: Locating the Filament

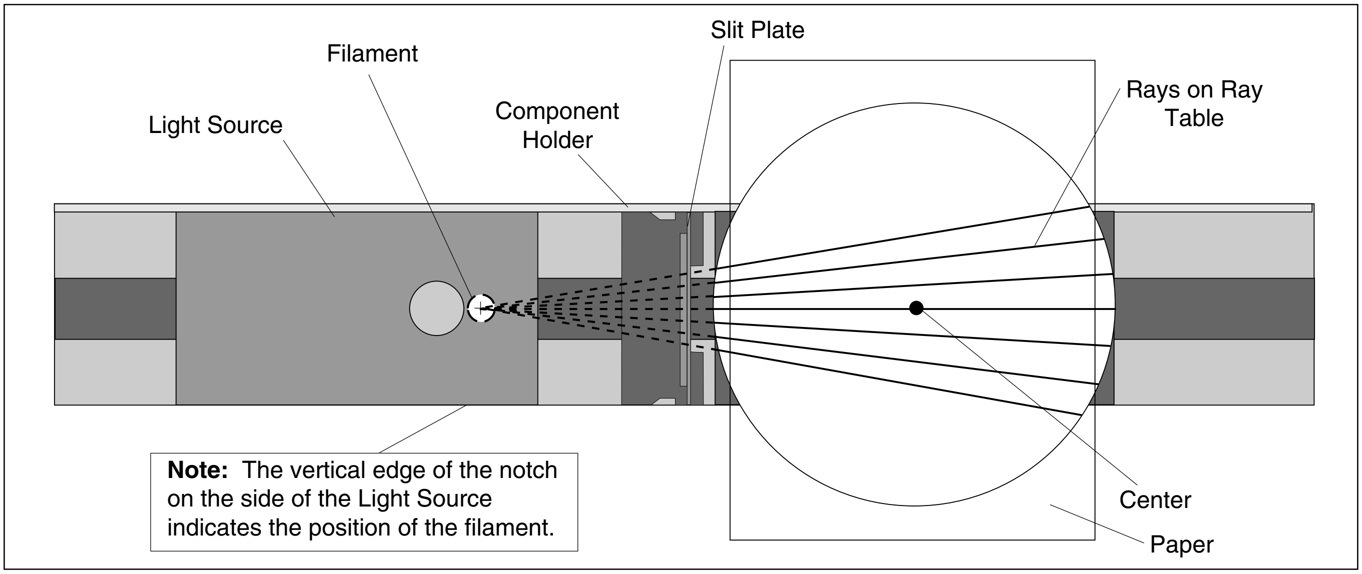


Figure 1.2: Ray Tracing

You can use the fact that light propagates in a straight line to measure the distance between the Light Source filament and the center of the Ray Table. Figure 1.2 shows how. The rays on the Ray Table all originate from the filament of the Light Source. Since light travels in a straight line, you need only extend the rays backward to locate the filament. (See Step 3 in the first part of this experiment.)

Place a piece of blank white paper on top of the Ray Table, holding it there with a piece of tape. Make a reference mark on the paper at the position of the center of the Ray Table. Using a pencil and straight edge, trace the edges of several of the rays onto the paper.

Remove the paper. Use the pencil and straightedge to extend each of the rays. Trace them back to their common point of intersection. (You may need to tape on an additional sheet of paper.) Label the filament and the center of the Ray Table on your diagram.

① Measure the distance between your reference mark and the point of intersection of the rays.

____.

② Use the metric scale on the Optics Bench to measure the distance between the filament and the center of the Ray Table directly (see the note in Figure 1.2).

____.

③ How well do your measurements in Steps 1 and 2 agree? Comment.

____.

One of the key ideas that this experiment illustrates is the ability for us to trace light rays to their origin or apparent origin. This concept will prove most useful in future experiments.

Experiment 2: The Law of Reflection

EQUIPMENT NEEDED:

- -Optics Bench
- -Ray Table and Base
- -Slit Plate
- -Ray Optics Mirror.
- -Light Source
- -Component Holder
- -Slit Mask

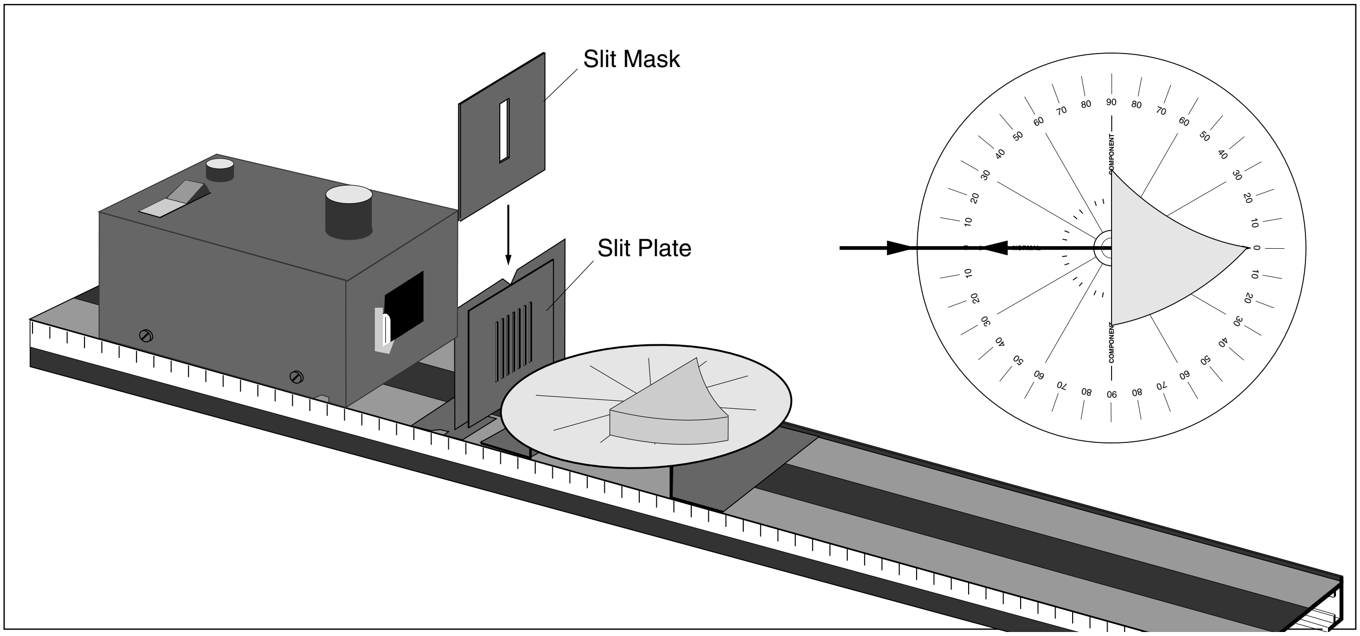


Figure 2.1 Equipment Setup

Introduction

The shape and location of the image created by reflection from a mirror of any shape is determined by just a few simple principles. One of these principles you already know: light propagates in a straight line. You will have an opportunity to learn the remaining principles in this experiment.

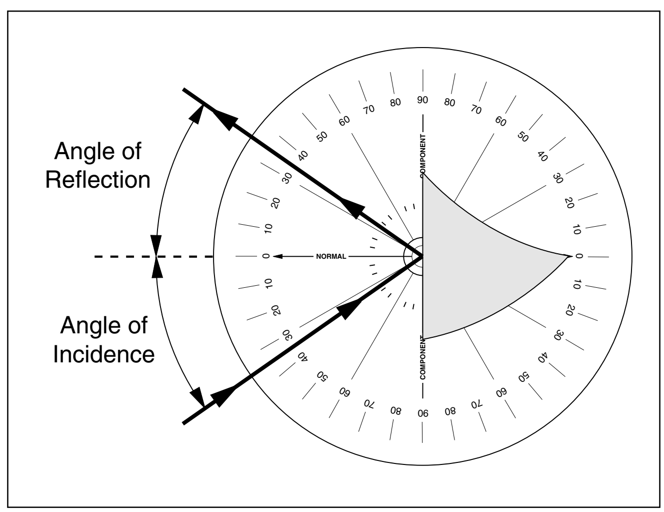


Figure 2.2 Incident and Reflected Rays

To determine the basic principles underlying any phenomenon, it is best to observe that phenomenon in its simplest possible form. In this experiment, you will observe the reflection of a single ray of light from a plane mirror. The principles you discover will be applied, in later experiments, to more complicated examples of reflection.

Procedure

Set up the equipment as shown in Figure 2.1. Adjust the components so a single ray of light is aligned with the bold arrow labeled "Normal" on the Ray Table Degree Scale. Carefully align the flat reflecting surface of the mirror with the bold line labeled "Component" on the Ray Table. With the mirror properly aligned, the bold arrow on the Ray Table is normal (at right angles) to the plane of the reflecting surface.

Rotate the Ray Table and observe the light ray. The angles of incidence and reflection are measured with respect to the normal to the reflecting surface, as shown in Figure 2.2.

By rotating the Ray Table, set the angle of incidence to each of the settings shown in Table 2.1. For each angle of incidence, record the angle of reflection ($Reflection_1$). Repeat your measurements with the incident ray coming from the opposite side of the normal ($Reflection_2$).

① Are the results for the two trials the same? If not, to what do you attribute the differences?

____

② Part of the law of reflection states that the incident ray, the normal and the reflected ray all lie in the same plane. Discuss how this is shown in your experiment

____.

③ What relationship holds between the angle of incidence and the angle of reflection?

____

Additional Questions

① The Law of Reflection has two parts. State both parts.

② You were asked to measure the angle of reflection when the ray was incident on either side of the normal to the surface of the mirror. What advantages does this provide?

③ Physicists expend a great deal of energy in attempts to increase the accuracy with which an exact law can be proven valid. How might you test the Law of Reflection to a higher level of accuracy than in the experiment you just performed?

Table 2.1 Data

Angle of:	**Incidence**	**$Reflection_1$**	**$Reflection_2$**
	0°		
	10°		
	20°		
	30°		
	40°		
	50°		
	60°		
	70°		
	80°		
	90°		

Experiment 3: Image Formation in a Plane Mirror

EQUIPMENT NEEDED:

-Optics Bench
-Ray Table and Base
-Slit Plate
-Light Source
-Component Holder
-Ray Optics Mirror

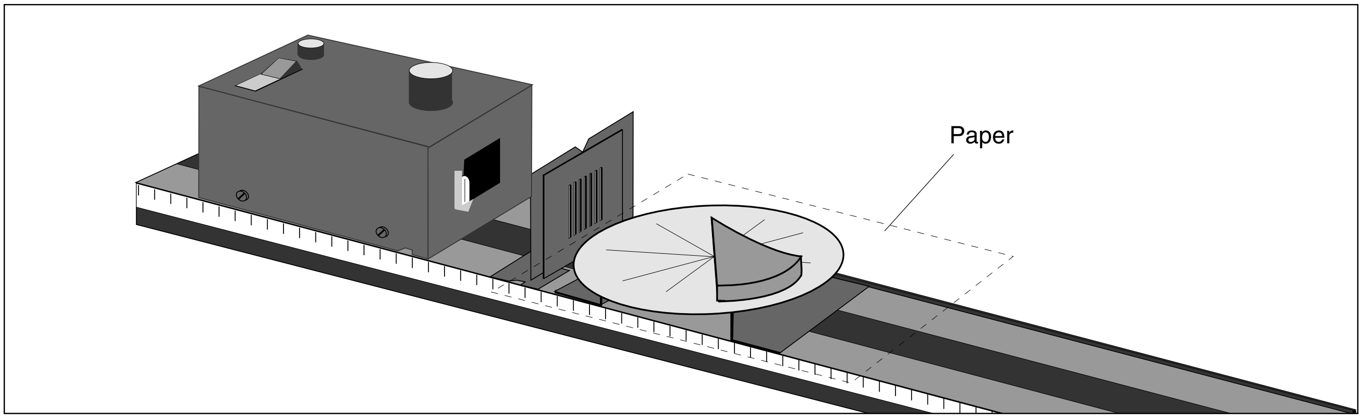


Figure 3.1 Equipment Setup

Introduction

Looking into a mirror and seeing a nearly exact image of yourself hardly seems like the result of simple physical principles. But it is. The nature of the image you see in a mirror is understandable in terms of the principles you have already learned: the Law of Reflection and the straight-line propagation of light.

In this experiment you will investigate how the apparent location of an image reflected from a plane mirror relates to the location of the object, and how this relationship is a direct result of the basic principles you have already studied.

Procedure

Set up the equipment as shown in Figure 3.1. Adjust the Slit Plate and Light Source positions for sharp, easily visible rays.

As shown, place a blank, white sheet of paper on top of the Ray Table, and place the Ray Optics Mirror on top of the paper. Position the mirror so that all of the light rays are reflected from its flat surface. Draw a line on the paper to mark the position of the flat surface of the mirror.

Look into the mirror along the line of the reflected rays so that you can see the image of the Slit Plate and, through the slits, the filament of the Light Source. (Rotate the mirror as needed to do this.)

① Do the rays seem to follow a straight line into the mirror? ________________________________.

With a pencil, mark two points along one edge of each of the incident and reflected rays. Label the points (r_1,r_2, etc.), so you know which points belong to which ray.

Remove the paper and reconstruct the rays as shown on the next page (Figure 3.2), using a pencil and straight-edge. If you need to, tape on additional pieces of paper. Draw dotted lines to extend the incident and reflected rays. (If this ray tracing technique is unfamiliar to you, review ray tracing in Experiment 1: Introduction to Ray Optics.)

On your drawing, label the position of the filament and the apparent position of its reflected image.

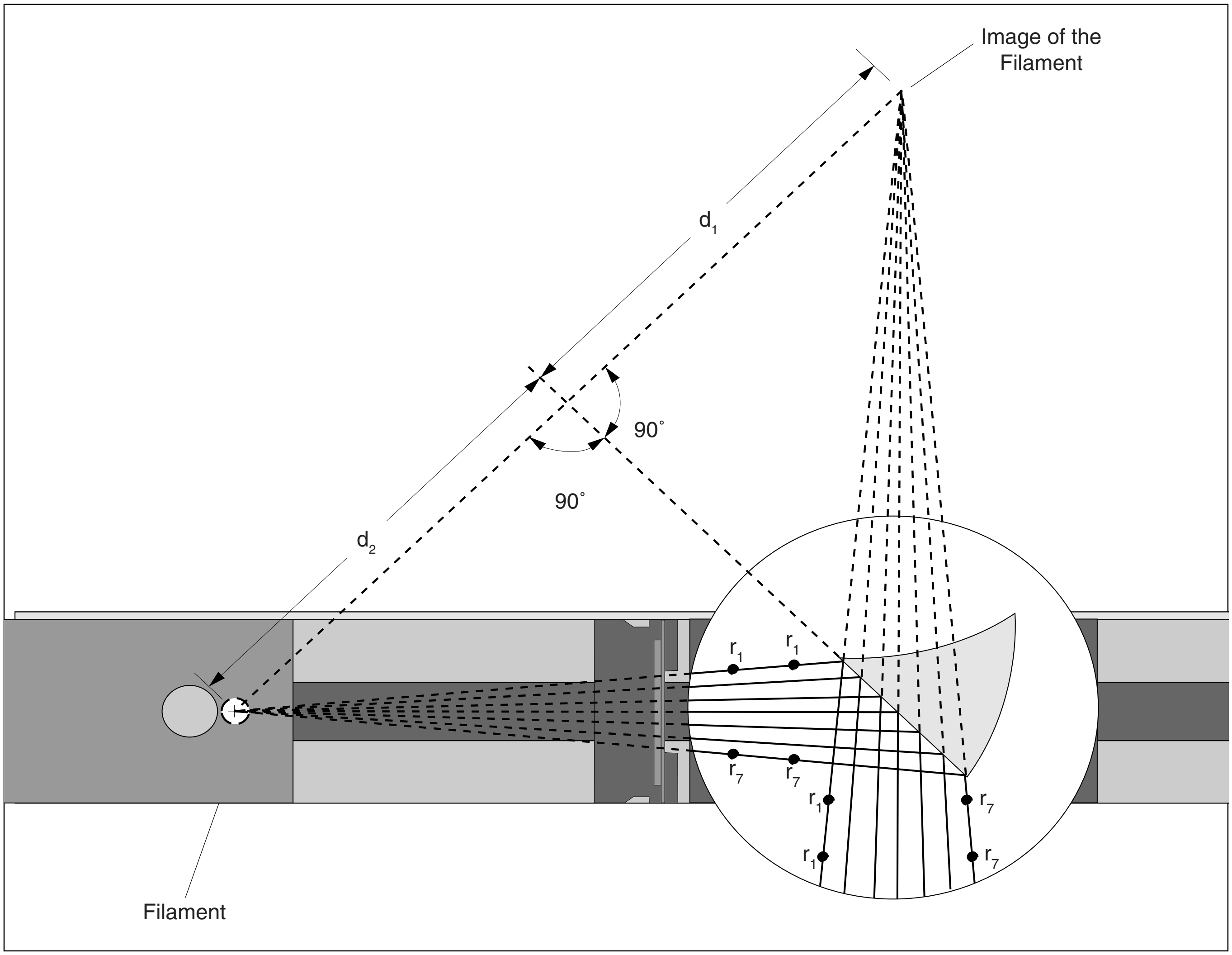


Figure 3.2 Ray Tracing

② What is the perpendicular distance from the filament to the plane of the mirror (distance d_1, as shown in the Figure 3.2)? ____.

③ What is the perpendicular distance from the image of the filament to the plane of the mirror (distance d_2, as shown in the Figure)? ____.

Change the position of the mirror and the Light Source and repeat the experiment.

④ What is the relationship between object and image location for reflection in a plane mirror?

____.

Additional Questions

① If one wall of a room consists of a large, flat mirror, how much larger does the room appear to be than it actually is?

② Make a diagram illustrating why an image of the letter F, reflected from a plane mirror, is inverted. (Treat each corner on the F as a source of light. Locate the image for each source to construct the image of the F.)

③ How does the size of the image reflected from a plane mirror relate to the size of the object?

Experiment 4: The Law of Refraction

EQUIPMENT NEEDED:

- -Optics Bench
- -Ray Table and Base
- -Slit Plate
- -Cylindrical Lens.
- -Light Source
- -Component Holder
- -Slit Mask

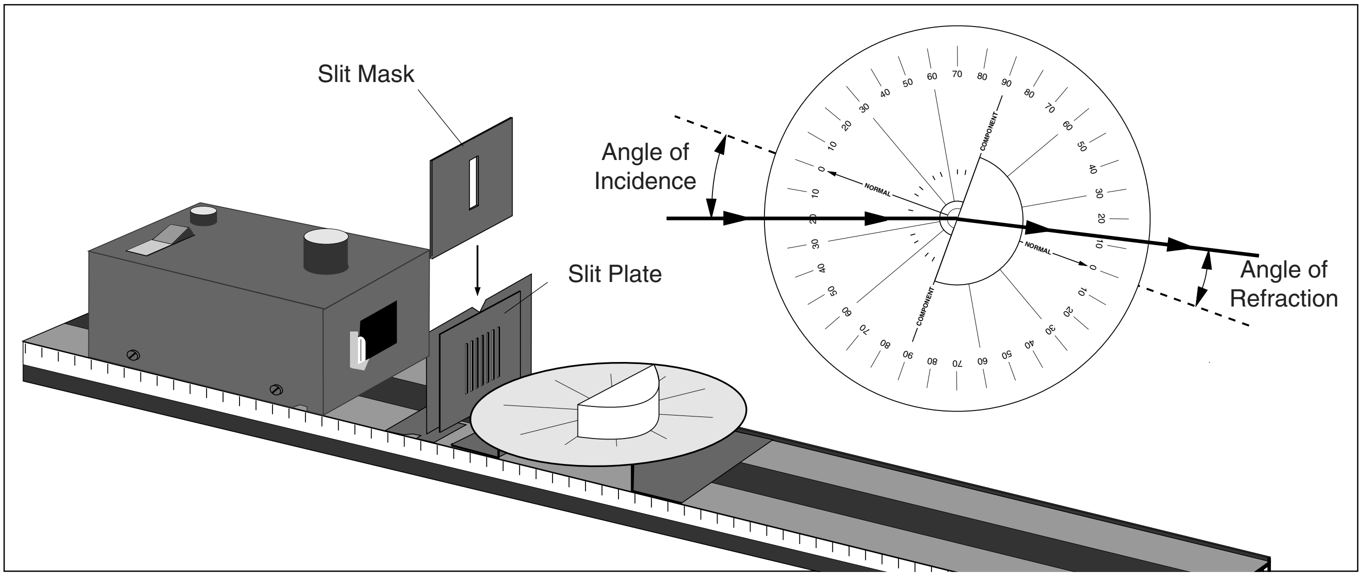


Figure 4.1 Equipment Setup

Introduction

As you have seen, the direction of light propagation changes abruptly when light encounters a reflective surface. The direction also changes abruptly when light passes across a boundary between two different media of propagation, such as between air and acrylic, or between glass and water. In this case, the change of direction is called Refraction.

As for reflection, a simple law characterizes the behavior of a refracted ray of light. According to the Law of Refraction, also known as Snell's Law:

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

The quantities n_1 and n_2 are constants, called indices of refraction, that depend on the two media through which the light is passing. The angles θ_1 and θ_2 are the angles that the ray of light makes with the normal to the boundary between the two media (see the inset in Figure 4.1). In this experiment you will test the validity of this law, and also measure the index of refraction for acrylic.

Procedure

Set up the equipment as shown in Figure 4.1. Adjust the components so a single ray of light passes directly through the center of the Ray Table Degree Scale. Align the flat surface of the Cylindrical Lens with the line labeled "Component". With the lens properly aligned, the radial lines extending from the center of the Degree Scale will all be perpendicular to the circular surface of the lens.

Without disturbing the alignment of the Lens, rotate the Ray Table and observe the refracted ray for various angles of incidence.

① Is the ray bent when it passes into the lens perpendicular to the flat surface of the lens?

____

_______________________________________.

② Is the ray bent when it passes out of the lens perpendicular to the curved surface of the lens?

____

_______________________________________.

By rotating the Ray Table, set the angle of incidence to each of the settings shown in Table 4.1 on the following page. For each angle of incidence, measure the angle of refraction ($Refraction_1$). Repeat the measurement with the incident ray striking from the opposite side of the normal ($Refraction_2$).

Angle of:	**Incidence**	**Refraction$_1$**	**Refraction$_2$**
	0°		
	10°		
	20°		
	30°		
	40°		
	50°		
	60°		
	70°		
	80°		
	90°		

Table 4.1 Data

③ Are your results for the two sets of measurements the same? If not, to what do you attribute the differences?

____

____.

On a separate sheet of paper, construct a graph with sin(angle of refraction) on the x-axis and sin(angle of incidence) on the y-axis. Draw the best fit straight line for each of your two sets of data.

④ Is your graph consistent with the Law of Refraction? Explain.

____.

⑤ Measure the slope of your best fit lines. Take the average of your results to determine the index of refraction for acrylic (assume that the index of refraction for air is equal to 1.0).

n = ____________________________________.

Additional Questions

① In performing the experiment, what difficulties did you encounter in measuring the angle of refraction for large angles of incidence?

② Was all the light of the ray refracted? Was some reflected? How might you have used the Law of Reflection to test the alignment of the Cylindrical Lens?

③ How does averaging the results of measurements taken with the incident ray striking from either side of the normal improve the accuracy of the results?

Experiment 5: Reversibility

Equipment Needed:

- -Optics Bench
- -Ray Table and Base
- -Slit Plate
- -Cylindrical Lens.
- -Light Source
- -Component Holder
- -Slit Mask

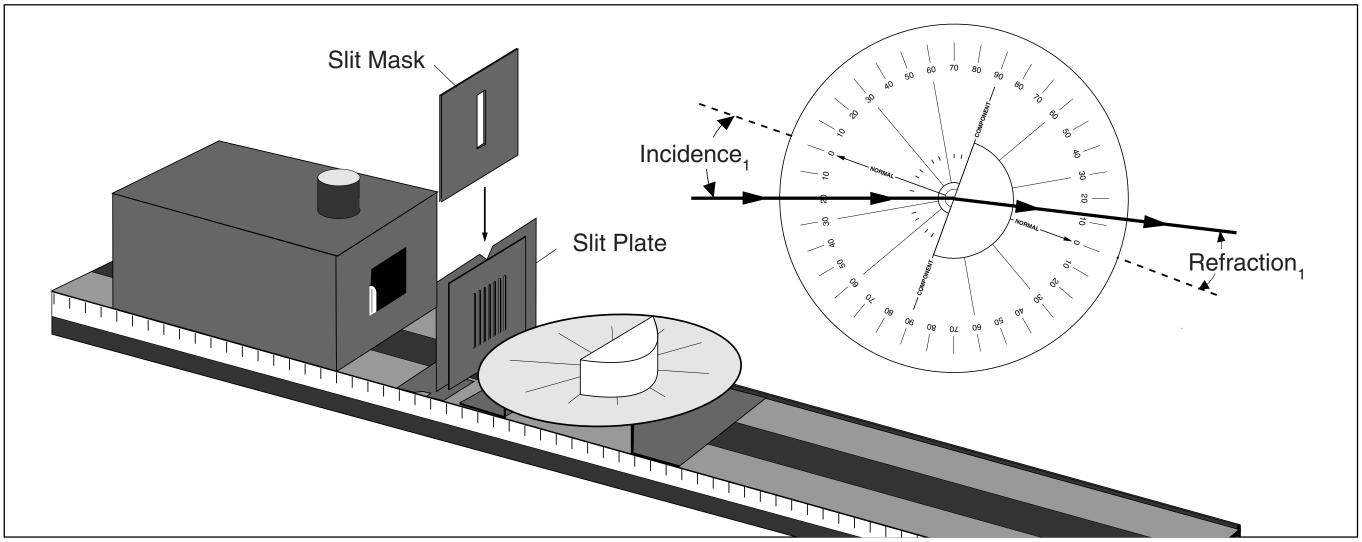


Figure 5.1 Equipment Setup

Introduction

In Experiment 4, you determined the relationship that exists between the angle of incidence and the angle of refraction for light passing from air into a more optically dense medium (the Cylindrical Lens). An important question remains. Does the same relationship hold between the angles of incidence and refraction for light passing out of a more optically dense medium back into air? That is to say, if the light is traveling in the opposite direction, is the law of refraction the same or different? In this experiment, you will find the answer to this question.

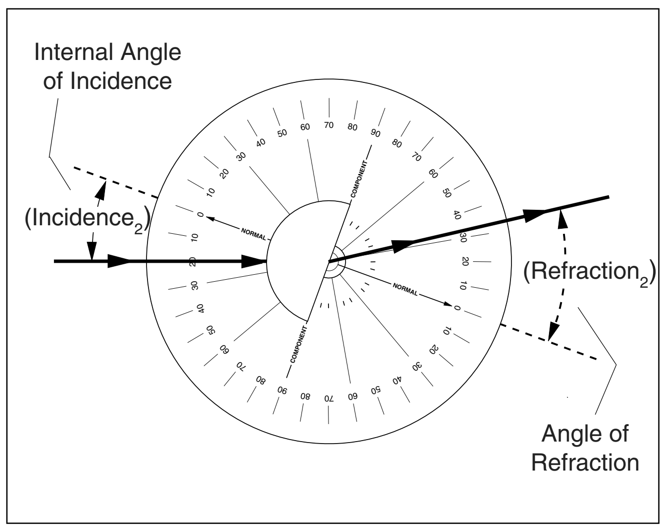


Figure 5.2 Internal Angle of Incidence

Procedure

Set up the equipment as shown in Figure 5.1. Adjust the components so a single ray of light passes directly through the center of the Ray Table Degree Scale. Align the flat surface of the Cylindrical Lens with the line labeled "Component". With the lens properly aligned, the radial lines extending from the center of the Degree Scale will all be perpendicular to the circular surface of the lens.

Without disturbing the alignment of the lens, rotate the Ray Table and set the angle of incidence to the values listed in Table 5.1 on the following page. Enter the corresponding angles of Refraction in the table in two columns: Refraction_1 and Incidence_2. (Let $\text{Incidence}_2 = \text{Refraction}_1$).

Table 5.1 Data

Ray Incident on:	**Flat Surface**		**Curved Surface**	
Angle of:	**Incidence$_1$**	**Refraction$_1$**	**Incidence$_2$**	**Refraction$_2$**
	0°			
	10°			
	20°			
	30°			
	40°			
	50°			
	60°			
	70°			
	80°			
	90°			

Now let the incident ray strike the curved surface of the lens. (Just rotate the Ray Table 180°.) The internal angle of incidence for the flat surface of the Cylindrical Lens is shown in Figure 5.2. Set this angle of incidence to the values you have already listed in the table (Incidence$_2$). Record the corresponding angles of refraction (Refraction$_2$).

① Using your collected values for Incidence$_1$ and Refraction$_1$, determine the index of refraction for the acrylic from which the Cylindrical Lens is made. (As in experiment 4, assume that the index of refraction for air is equal to 1.0.)

n_1 =

____.

② Using your collected values for Incidence$_2$ and Refraction$_2$, redetermine the index of refraction for the acrylic from which the Cylindrical Lens is made.

n_2 =

____.

③ Is the Law of Refraction the same for light rays going in either direction between the two media?

____.

④ On a separate sheet of paper, make a diagram showing a light ray passing into and out of the Cylindrical Lens. Show the correct angles of incidence and refraction at both surfaces traversed by the ray. Use arrow heads to indicate the direction of propagation of the ray. Now reverse the arrows on the light ray. Show that the new angles of incidence and refraction are still consistent with the Law of Refraction. This is the principle of optical reversibility.

⑤ Does the principle of optical reversibility hold for Reflection as well as Refraction? Explain.

____.

Experiment 6: Dispersion and Total Internal Reflection

EQUIPMENT NEEDED:

- -Optics Bench
- -Ray Plate and Base
- -Slit Plate
- -Cylindrical Lens
- -Viewing Screen.
- -Light Source
- -Component Holder
- -Slit Mask
- -Ray Table Component Holder

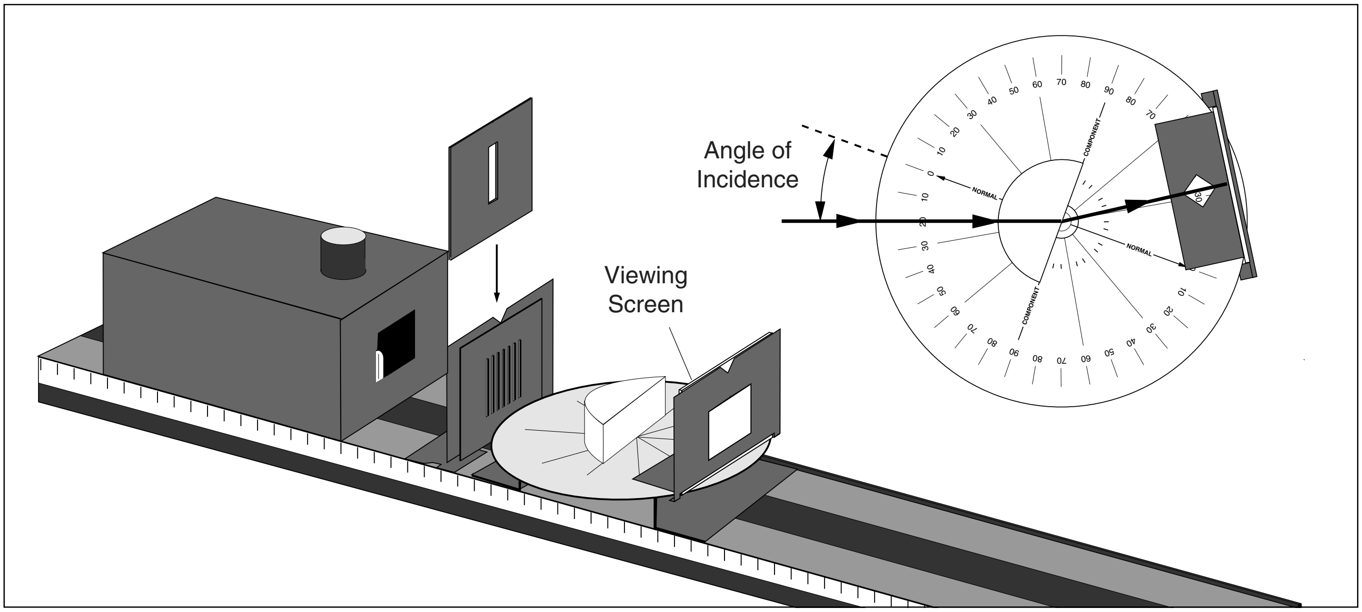


Figure 6.1 Equipment Setup

Introduction

In this experiment you will look at two phenomena related to refraction: Dispersion and Total Internal Reflection. Dispersion introduces a complication to the Law of Refraction, which is that most materials have different indexes of refraction for different colors of light. In Total Internal Reflection, it is found that in certain circumstances, light striking an interface between two transparent media can not pass through the interface.

Procedure

Set up the equipment as shown in Figure 6.1, so a single light ray is incident on the curved surface of the Cylindrical Lens.

Dispersion

Set the Ray Table so the angle of incidence of the ray striking the flat surface of the lens (from inside the lens) is zero-degrees. Adjust the Ray Table Component Holder so the refracted ray is visible on the Viewing Screen.

Slowly increase the angle of incidence. As you do, watch the refracted ray on the Viewing Screen.

① At what angle of refraction do you begin to notice color separation in the refracted ray?

② At what angle of refraction is the color separation a maximum? ____________________

____.

③ What colors are present in the refracted ray? (Write them in the order of minimum to maximum angle of refraction.)

____

____.

④ Measure the index of refraction of acrylic for red and blue light ($n_{acrylic} \sin \theta_{acrylic} = n_{air} \sin \theta_{air}$).

> ➤**NOTE:** In Experiment 4 we said that the index of refraction of a given material is a constant. That statement was almost accurate, but not quite. As you can see, different colors of light refract to slightly different angles, and therefore have slightly different indexes of refraction.

n_{red} = _______________________________________.

n_{blue} = ____.

Total Internal Reflection

Without moving the Ray Table or the Cylindrical Lens, notice that not all of the light in the incident ray is refracted. Part of the light is also reflected.

① From which surface of the lens does reflection primarily occur? ___________________

____.

② Is there a reflected ray for all angles of incidence? (Use the Viewing Screen to detect faint rays.)

____

____.

③ Are the angles for the reflected ray consistent with the Law of Reflection? __________

____.

④ Is there a refracted ray for all angles of incidence?____________________________

____.

⑤ How do the intensity of the reflected and refracted rays vary with the angle of incidence?

____.

⑥ At what angle of refraction is all the light reflected (no refracted ray)? ______________

____.

Experiment 7: Converging Lens – Image and Object Relationships

EQUIPMENT NEEDED:

- -Optics Bench
- -75 mm Focal Length Convex Lens
- -Component Holders (3)
- -Light Source
- -Crossed Arrow Target
- -Viewing Screen.

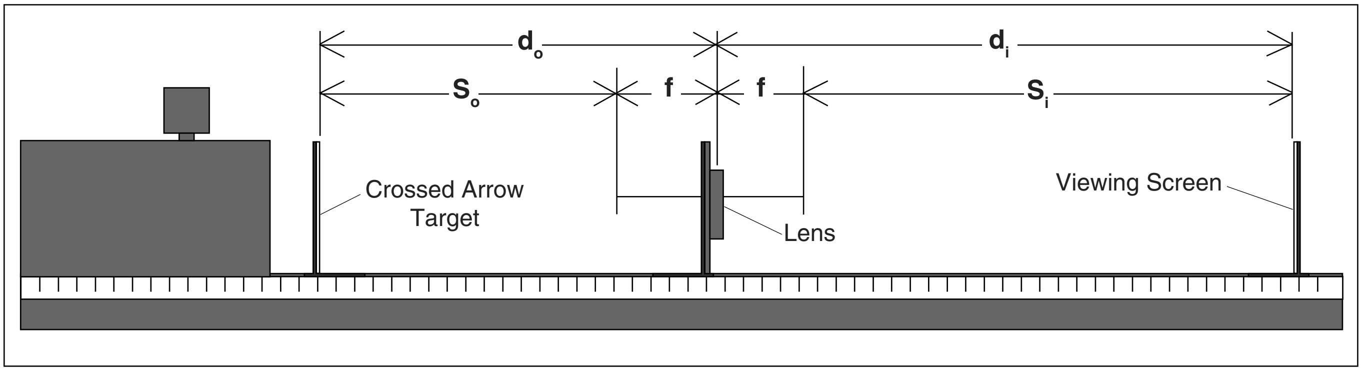


Figure 7.1: Equipment Setup

Introduction

Given a lens of any shape and index of refraction, you could determine the shape and location of the images it forms based only on the Law of Refraction. You need only apply the law along with some of the ray tracing techniques you have already used. However, for spherical lenses (and for spherical mirrors as well), there is a more general equation that can be used to determine the location and magnification of an image. This equation is called the Fundamental Lens equation:

$$1/\mathbf{d_o} + 1/\mathbf{d_i} = 1/\mathbf{f}$$

where **f** is the focal length of the lens, and $\mathbf{d_o}$ and $\mathbf{d_i}$ are the distance from the mirror to the image and object respectively (see Figure 7.1). The magnification of the image is given by the equation:

$$\mathbf{m} = -\mathbf{d_i}/\mathbf{d_o}$$

In this experiment, you will have an opportunity to test and apply these equations.

➤**NOTE:** Instead of the above equation, you may have learned the Fundamental Lens Equation as $\mathbf{S_oS_i} = \mathbf{f}^2$, where $\mathbf{S_o}$ and $\mathbf{S_i}$ are the distances between the principle focus of the lens and the object and image, respectively. If so, notice that $\mathbf{S_o} = \mathbf{d_o} - \mathbf{f}$, and $\mathbf{S_i} = \mathbf{d_i} - \mathbf{f}$ (see Figure 7.1). Using these equalities, convince yourself that $1/\mathbf{d_o} + 1/\mathbf{d_i} = 1/\mathbf{f}$ and $\mathbf{S_oS_i} = \mathbf{f}^2$ are different expressions of the same relationship.

Procedure

Set up the equipment as shown in Figure 7.1. Turn on the Light Source and slide the lens toward or away from the Crossed Arrow Target, as needed to focus the image of the Target onto the Viewing Screen.

① Is the image magnified or reduced? ______________________________.

② Is the image inverted?____________________________________.

③ Based on the Fundamental Lens Equation, what would happen to $\mathbf{d_i}$ if you increased $\mathbf{d_o}$ even further?____.

Table 7.1: Data and Calculations

Data			Calculations			
d_o (mm)	d_i	h_i	$1/d_i + 1/d_o$	1/f	h_i/h_o	$-d_i/d_o$
500						
450						
400						
350						
300						
250						
200						
150						
100						
75						
50						

③ What would happen to $\mathbf{d_i}$ if $\mathbf{d_o}$ were very, very large?
_______________________________.

④ Using your answer to question 4, measure the focal length of the lens.

Focal Length = ____.

Now set $\mathbf{d_o}$ to the values (in millimeters) listed in the table above. At each setting, locate the image and measure $\mathbf{d_i}$. Also measure $\mathbf{h_i}$, the height of the image. ($\mathbf{h_o}$ is the height of the arrow on the crossed arrow target.)

Using the data you have collected, perform the calculations shown in the table.

⑤ Are your results in complete agreement with the Fundamental Lens Equation? If not, to what do you attribute the discrepancies?
____.

⑥ For what values of $\mathbf{d_o}$ were you unable to focus an image onto the screen? Use the Fundamental Lens Equation to explain why.
____.

Additional Questions

① For a lens of focal length f, what value of d_o would give an image with a magnification of one?

② Is it possible to obtain a non-inverted image with a converging spherical lens? Explain.

③ For a converging lens of focal length f, where would you place the object to obtain an image as far away from the lens as possible? How large would the image be?

Experiment 8: Light and Color

EQUIPMENT NEEDED:

- -Optics Bench
- -Component Holder
- -Slit Plate
- -Cylindrical Lens
- -Colored Filters (3)
- -Ray Table and Base
- -Ray Table Component Holder
- -Slit Mask
- -Viewing Screen

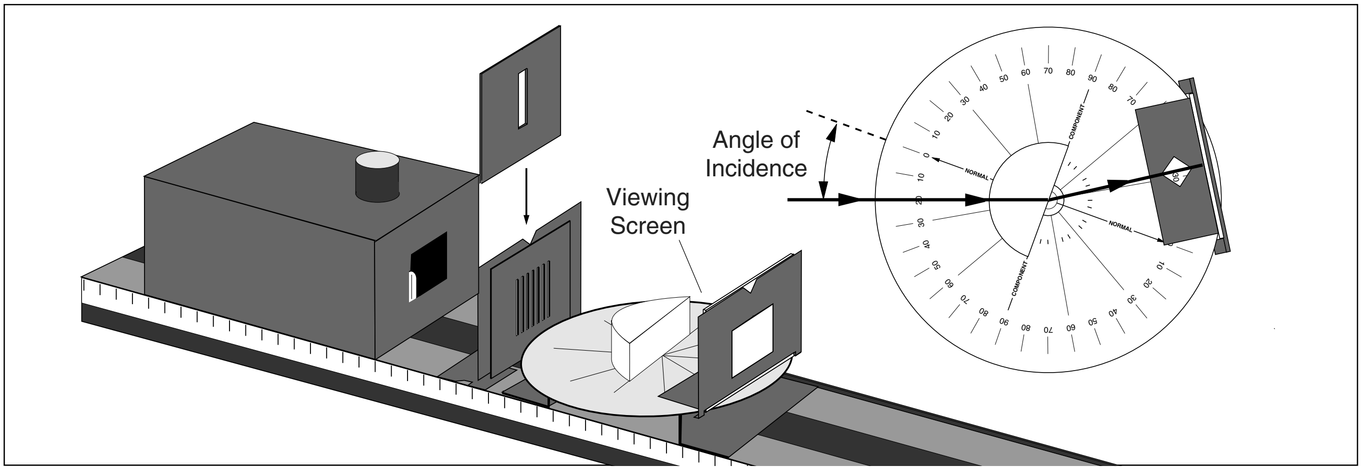


Figure 8.1 Equipment Setup

Introduction

Early investigators assumed that light, in its purest, simplest form is white; and that refractive materials alter the characteristics of the white light to create the various colors. Sir Isaac Newton was the first to show that light, in its simplest form, is colored; and that refractive materials merely separate the various colors which are the natural constituents of white light. He used this idea to help explain the colors of objects.

The Colors of Light

Set up the equipment as shown in Figure 8.1, so that a single ray of light passes through the center of the Ray Table. Slowly rotate the Ray Table to increase the angle of incidence of the light ray. Examine the refracted ray on the Viewing Screen. Notice the color separation at large angles of refraction.

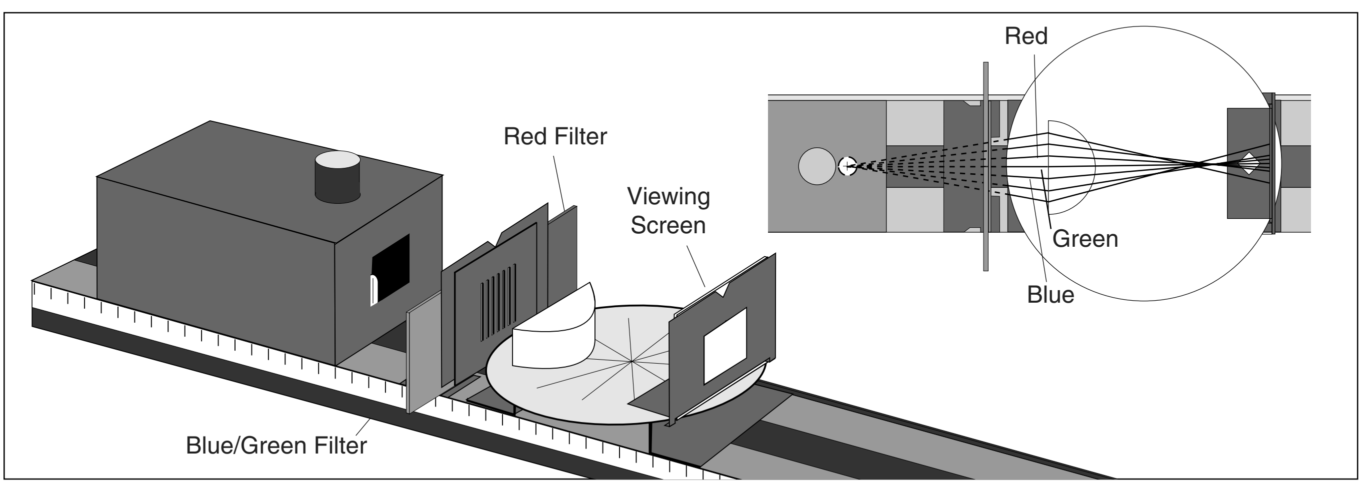


Figure 8.2 Mixing Colored Light

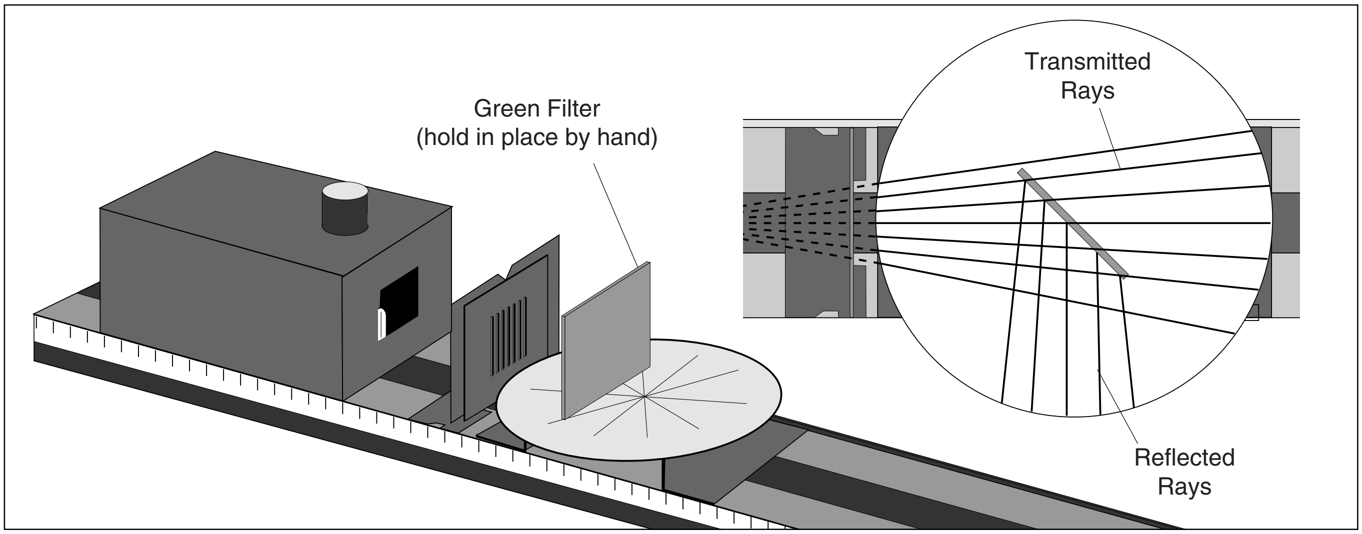


Figure 8.3 Equipment Setup

① Do your observations support Newton's theory? Explain. ______________________________

____.

To investigate further, setup the equipment as shown in Figure 8.2. Arrange the Cylindrical Lens so that the three central light rays (one red, one green, and one blue) intersect at precisely the same point on the Ray Table. Slowly move the Viewing Screen toward this point of intersection (you'll have to remove it from its component holder).

② What color of light results when red, green, and blue light are mixed? How does this support Newton's theory? ____

____.

The Colors of Objects

Set up the equipment as shown in Figure 8.3. Observe the light rays that are transmitted and reflected from the Green Filter.

① What color are the transmitted rays? What color are the reflected rays?

____.

Place the Red Filter behind the Green Filter (so the light passes first through the Green Filter and then through the Red Filter). Look into the Green Filter.

② What color are the reflected rays now? Which rays are reflected from the front surface of the Green Filter, and which are reflected from the front surface of the Red Filter?

____.

Place the Blue Filter over the Light Source aperture so the incident rays are blue. Let these rays pass through the Green Filter only.

③ What colors are the reflected rays now?

____.

④ Based on your observations, what makes the Green Filter appear green?

____.