Lab 13 – Image Formation – Individual

Introduction

Rays of light are generally straight lines, except when the light is refracted or reflected. Real objects emit light from every point. To make things easier, we usually consider one point at a time, so that the rays we trace are those from a point source called "the Object".

To form an image, the rays from the object reflect or refract and afterward they can be interpreted as passing (or appearing to pass) through a common source point. This common point shared by all of the rays after reflection or refraction is called "the Image".

Individual rays obey the reflection equation or Snell's Law:

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

where θ_1 is the angle of an incident (incoming) ray, θ_1' is the angle of a reflected ray, and θ_2 is the angle of a refracted ray. When dealing with reflection and refraction, angles are measured ***from the normal.***

Trough Reflection and Refraction, Mirrors and Lenses form an image of an object. The position and nature of the image depends on the focal length of the mirror/lens and the position of the object. Position of the object or image is described by the distance between the object/image and the mirror/lens. Thin-Lens/Mirror Equation states that $\mathbf{f^{-1} = d_o^{-1} + d_i^{-1}}$, where **f** is a focal length of a lens, $\mathbf{d_o}$ is the distance to an object or **p**, and $\mathbf{d_i}$ is the distance to an image or **q**. An object is always considered to be real, therefore $\mathbf{d_o}$ is always positive; however, an image could be real (appears on a screen) or virtual (does not appear on a screen). Negative sign of $\mathbf{d_i}$ indicates virtual nature of an image. A ***real image*** is formed by actual reflected/refracted rays and ***is inverted***; a ***virtual image*** is formed by the extensions of the actual rays and ***is upright***.

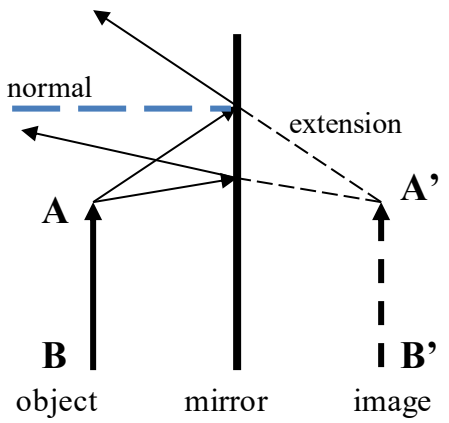


Figure 1. Image formation by a flat mirror

The laws of reflection of light enable us to find the image formed by any mirror, plane or curved.

If the light from an object falls on a **smooth surface**, such as a mirror, the reflection of that light from the mirror appears to rise from the "image" of the object. The effects of such a reflection from a plane mirror are shown in Figure 1 where **AB** is an object, in the shape of an arrow. The figure shows two rays of light from the point A striking the mirror and reflected. Point **A'**, behind the mirror, is where the extensions of reflected rays meet.

So, *any ray from **A** striking the mirror, after reflection appears to come from **A'***. For this reason, **A'** is called the image of **A** in the mirror. To the eye the points **A** and **A'** look similar.

Since the arrow **AB** is a collection of points, the mirror forms an image of every one of the points of the arrow, and the image of the arrow has the shape of an arrow. **A'B'** is referred to as the image of the object **AB** formed by the plane mirror.

Part #1. Image Formed by a Flat Mirror

If you cannot print Sheet A from the end of the instructions, use a blank sheet of paper draw a dot labeled A and a thick line as shown. Trace rays to locate the image of point **A**, which is a source of light, formed by the plane mirror.

ATT: ***Use a ruler for your geometric construction***.

1) Draw two rays towards the mirror starting from **A** where one of rays must strike the mirror head on (perpendicular), with an incident angle of $\mathbf{0^0}$.

2) Draw corresponding reflected rays following the laws of reflection of light (if you do not have a protractor, fold the paper first along the normal and then, along the incident ray; the crevice on other side of the normal is the reflected ray).

3) The point where the extensions of the reflected rays cross each other is the image of **A** or **A'**.

4) Measure the distance of **A'** from the mirror and the distance of **A** from the mirror. Calculate % Difference between the two measurements.

5) Describe the image in terms of real or virtual; use the location of the image to support the description.

Hint: Consult (NOT copy) Figure 1.

Part #2. Image Formation by a Curved Mirror

If you cannot print Sheet B from the end of the instructions, use a blank sheet of paper to copy each of the diagrams.

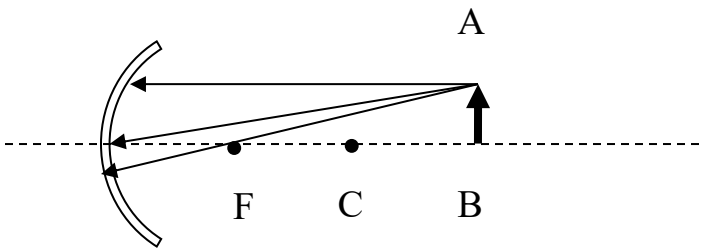
An object in the shape of an arrow **AB** is placed in front of a concave mirror. In the diagrams from Sheet B, trace the rays to *locate the image of the arrow (draw the ray from the head of the arrow)*. Call the image of **A** as **A'**. Remember that it takes tracing at least two rays starting from the arrowhead to locate where the image is. ***In the first diagram three of such incident rays have already been drawn, choose two of them.***

The ray that goes through the focus will reflect …

The ray that goes parallel to optic axis will reflect …

The ray that strikes the mirror in the middle will reflect …

Case 1: The arrow is placed farther than one radius or 2f (beyond C) from the mirror.



Describe the image following the questions below, include description into Sheet B:

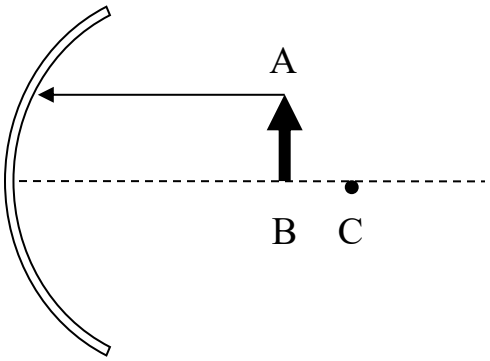
Is the image **A'B'** upright or inverted with respect to the object **AB**?

Is the size of the image **A'B'** greater or smaller than the size of the object **AB**?

Is the image real or virtual?

Case 2: The arrow is placed between the focal point **F** and the center of curvature **C or 2f**.

Locate the focal point accurately on this diagram using a ruler and add the second ray yourself.



Describe the image following the questions below, include description into Sheet B:

Is the image **A'B'** upright or inverted with respect to the object AB?

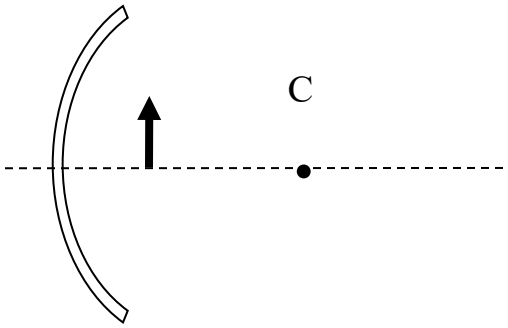
Is the size of the image **A'B'** greater or smaller than the size of the object **AB**?

Is this image real or virtual?

Case 3: The arrow is placed between the mirror and the focal point **F**.

Locate the focal point accurately on the diagram from Sheet B using a ruler.

Draw both rays coming to the mirror yourself. Choose rays wisely.



Describe the image following the questions below, include description into Sheet B:

Is the image **A'B'** upright or inverted with respect to the object AB?

Is the size of the image **A'B'** greater or smaller than the size of the object **AB**?

Is this image real or virtual?

Bonus (10 points) Case 4: The arrow is placed in front of convex mirror (rear view mirror).

Draw the bonus diagram by yourself on Bonus Sheet D.

Part #3. Image Formation by a Lens

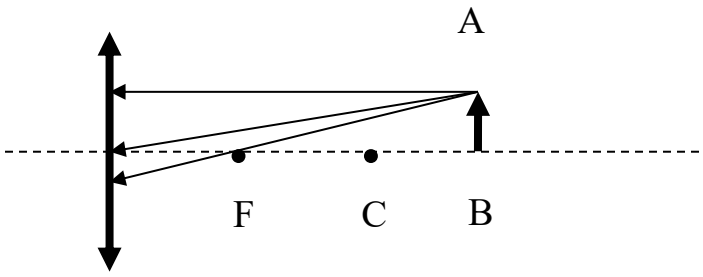
Either print Sheet C from the end of the instructions or use a blank sheet of paper to copy the diagrams.

An object in the shape of an arrow **AB** is placed in front of a convex lens. In the diagrams from Sheet C, trace the rays to *locate the image of the arrow (draw the ray from the head of the arrow)*. Call the image of **A** as **A'**. Remember that it takes tracing at least two rays starting from the arrowhead to locate where the image is.

In the first diagram three of such incident rays have already been drawn, choose two of them.

The ray that goes through the focus will refract …
The ray that goes parallel to optical axis will refract …
The ray that strikes the lens in the middle will …

Case 1: The arrow is placed farther than one radius or 2f (beyond C) from the lens.



Describe the image following the questions below, include description into Sheet C:

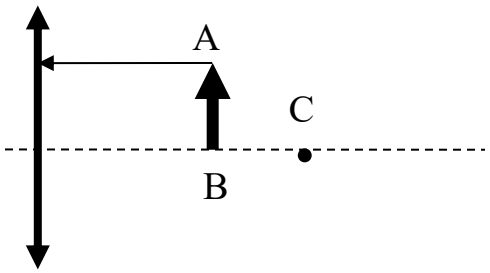
Is the image **A'B'** upright or inverted with respect to the object **AB**?

Is the size of the image **A'B'** greater or smaller than the size of the object **AB**?

Is the image real or virtual?

Case 2: The arrow is placed between the focal point **F** and the center of curvature **C, or 2f**.

Locate the focal point accurately on this diagram using a ruler and add the second ray yourself.



Describe the image following the questions below, include description into Sheet B:

Is the image **A'B'** upright or inverted with respect to the object AB?

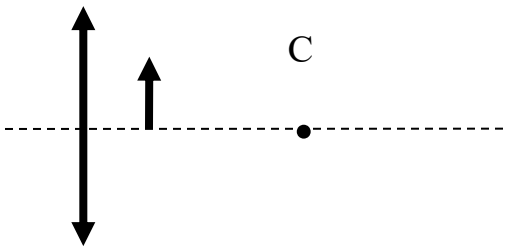
Is the size of the image **A'B'** greater or smaller than the size of the object **AB**?

Is this image real or virtual?

Case 3: The arrow is placed between the mirror and the focal point **F**.

Locate the focal point accurately on the diagram from Sheet B using a ruler.

Draw both rays coming to the lens yourself. Choose rays wisely.



Describe the image following the questions below, include description into Sheet B:

Is the image **A'B'** upright or inverted with respect to the object AB?

Is the size of the image **A'B'** greater or smaller than the size of the object **AB**?

Is this image real or virtual?

Drawing Sheet A

Distance between the mirror and the image:

Distance between the mirror and the object:

% Difference:

Description of the image:

Drawing Sheet B

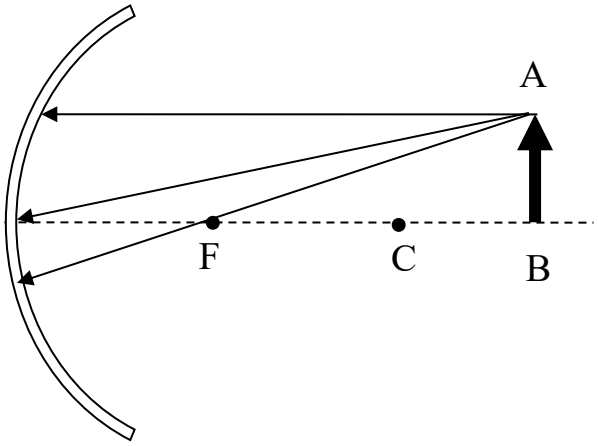


Image 1B Description:

Image 2B Description:

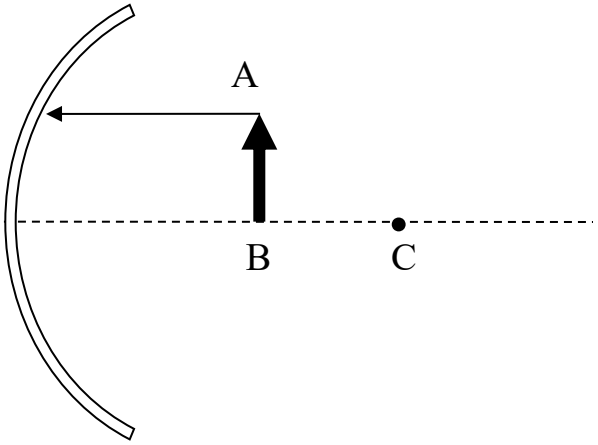
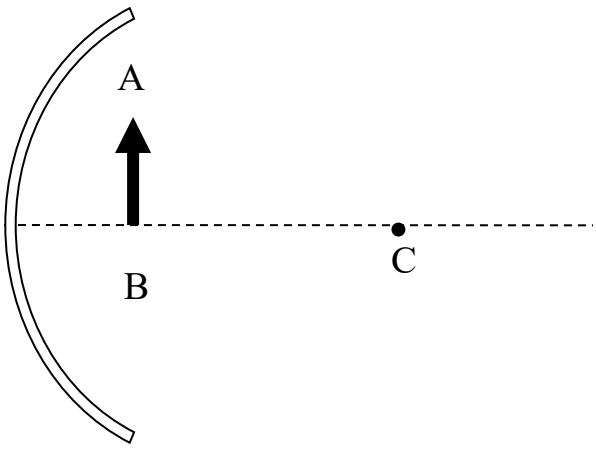


Image 3B Description:



Drawing Sheet C

Image 1C Description:

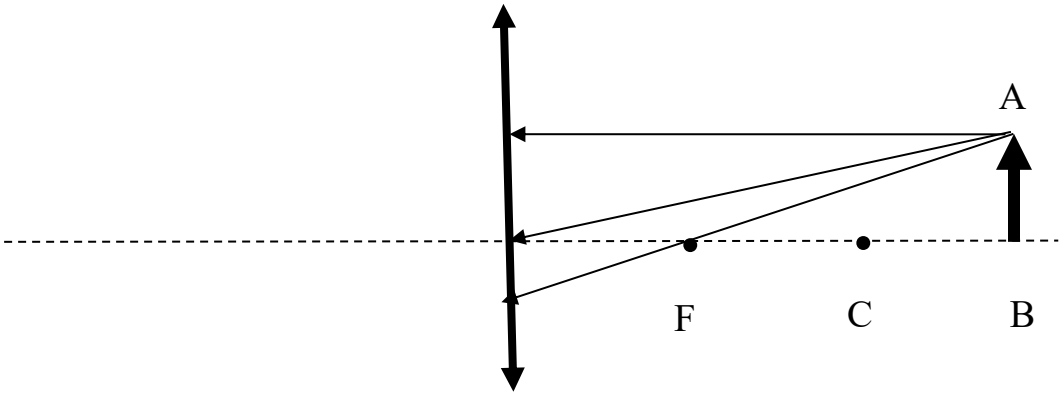
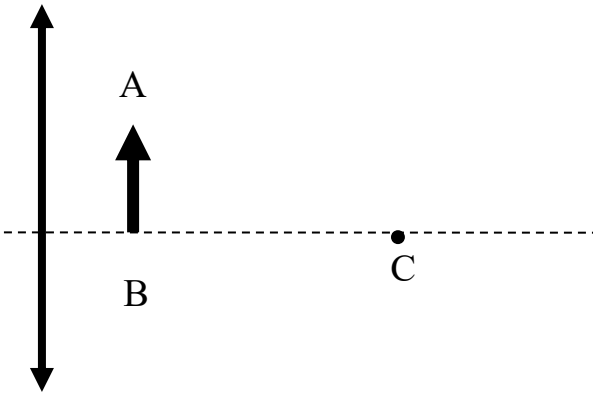


Image 2C Description:

Image 3C Description:



Bonus Sheet D