Reflection and Mirrors

Cool Things Light Does

It moves at about 300,000,000 m/sec!

So, What is Light?

Different Wavelengths Lead To: EMS

Radio Waves

- Astronomy
- Communication – AM, Shortwave, TV, FM
- VLA: Hubble (visible)
- VERA: Chandra (x-ray)
- James Webb (IR)
Frequency Allocation Chart

- The chart
- Demonstration of it (frequency modulation)
- How to apply for it

Microwave

- Radar (Airport, Police, Weather Stations)
- Cooking

Infrared

- TV remotes/remote keyboard
- Heating/Drying
- Night Vision

Visible Light

- Photography
- Photosynthesis

Ultraviolet

- Sterilize Food and Surfaces
- Run Solar Cells
- Set Dental Fillings
SteriPen® Journey Water Purifier
Uses ultraviolet light to purify water – a great choice for hiking or traveling $99.95

Veil Nebula in different spectra
- Multiple wavelengths together
- IR
- UV
- Visible?
- Xray?
- Background
- How insects see the world

Gamma Radiation
- Medical Imaging
- Cancer Treatment
- (A form of nuclear radiation)

The Law of Reflection
- The angle of incidence equals the angle of reflection.
- A plane mirror results in a virtual image (located behind the mirror).
- The distance from the object to the mirror is equal to the distance from the mirror to the image – distance is "conserved" in an image

Lab 1: Don’t Shatter My Image
KNOW THESE!!!
- The angle of incidence equals the angle of reflection.
Lab 1B: Images—The Law of Reflection
(the colored pencil one)

• The reflected rays can be extended behind the mirror to locate the position of the virtual image.
• These are the paths your brain assumes the rays must have followed.

How does reflection lead to the formation of an image?

• http://www.physicsclassroom.com/mmedia/optics/ifpm.cfm

• Ray model of light—assume light travels in straight line paths called rays.
• We use this to demonstrate how we see things. If I see a dog, I assume the light is traveling directly to my eye from the dog in straight line.
• This is, of course, an idealization. The light we “see” is only a fraction of the total light reflected/emitted from the dog—we see a very narrow beam; small bundle of photons.

• Light can be reflected, absorbed, or transmitted by matter. Very shiny mirrors can reflect almost 95% of the incident light.
• Angle of incidence vs. angle of reflection.

• Note that the rays from her feet hit the mirror and reflect at B thus hitting her eye. You don’t actually ever see any of you coming from the mirror below point B. Really, to see your whole body, you would only need a mirror half as tall as you.

• Is this a real image or a virtual image?

• Rays look like they are coming from behind the glass, rays “always” travel in straight line paths
• Use geometry and the law of reflection to show that the image will appear the same size, the same distance from the mirror, etc
  – Image distance: $s_i$ on blue sheet, $d_i$ in the textbook
  – Object distance: $s_o$ on blue sheet, $d_o$ in the textbook
Real Images vs. Virtual Images

When you think of a reflection, like looking into a mirror – that is a virtual image. The rays of visible light do not pass through the image itself, therefore the image would not appear on a paper or screen if the screen were placed at the location of the image. Can you see yourself if you put a piece of paper in front of you while you’re getting ready in the morning?

A real image is one where the rays actually do pass through the image. If you place a screen at that position, you can get the image. I bet you have all seen a real image in the last month – where? Hint: the pictures on this page.

• Worksheet 1A: Light Sources
  – You need a ruler and protractor

Three types of mirrors

• Plane – flat
• Concave – bumps inward
• Convex – bumps outward

Anish Kapoor’s 23-ton mirror

Plane Mirror Images

The “Who Tall Are You” mirror
Objective:
Find the location and characteristics of an image in a mirror (plane, concave, & convex) by drawing ray diagrams.

Let’s Review?
The Law of Reflection:
(KNOW THIS!)

- The angle of incidence is denoted by angle ___.
- The angle of reflection is denoted by angle ___.

Try It (Law of Reflection):

Answer:

The angle of incidence is denoted by angle ___.
The angle of reflection is denoted by angle ___.

Try It (Law of Reflection):

Answers:

Locating an Image in a Plane Mirror

Terms:
- Object
- Image
- Line of Sight
- Virtual Image
Locating an Image in a Plane Mirror

The image location is always directly across the mirror from the object.

\[ d_o = d_i \]

Ray Diagrams

Ray diagrams show the path of light to the eye.

Drawing a ray diagram:

Example:

Drawing a Ray Diagram (Plane Mirror):

1. Draw the image points of the objects extremes.

Object, Mirror, & Viewpoint:

Step 1:

3. Draw the incident ray for light traveling from the corresponding extreme on the object to the mirror.

3. Draw the incident ray for light traveling from the corresponding extreme on the object to the mirror.

4. Repeat steps 2 & 3 for the other extremities on the object.
Drawing a Ray Diagram (Plane Mirror):

1. Draw the image of the object: mark the extreme points.
2. Pick on extreme on the image and draw the reflected ray that will travel to the eye as it sights this point.
3. Draw the incident ray for light traveling from the corresponding extreme on the object to the mirror.
4. Repeat steps 2 & 3 for the other extremities on the object.

Let’s Try This:
Complete diagram A on the handout:

Describing Images - SALT

- **Size** - compared to the object
  - Same Size
  - Reduced (Smaller)
  - Enlarged (Bigger)
- **Attitude**
  - Upright
  - Inverted
- **Location**
  - In front of or behind the mirror
- **Type of Image**
  - Real – light rays actually go there
  - Virtual – light rays never actually go there
Curved Mirrors

Features of a spherical mirror

Collect Small Mirrors

Curved Mirrors

Convex and Concave

Pass Out Small Concave Mirrors

Curved Mirrors

Concave vs. Convex: Which is Which?

Curved Mirrors

Concave vs. Convex: Which is Which?
Spherical Mirror Anatomy

Terms:
• Center of curvature (C)
• Focal point (F)
• Vertex (A)
• Radius of curvature (R)
• Focal length (f)
• Principle Axis

Concave Mirror Ray Diagrams

All rays follow the Law of Reflection, but some are easier to predict than others.

Locating an Image with Concave Mirrors

2 rules for reflection for concave mirrors:
• Any incident ray traveling parallel to the principal axis on the way to the mirror will pass through the focal point upon reflection.
• Any incident ray passing through the focal point on the way to the mirror will travel parallel to the principal axis upon reflection.

Drawing a Ray Diagram (Concave Mirror):

1. Pick a point on top of the object and draw two incident rays travelling towards the mirror.

Drawing a Ray Diagram (Concave Mirror):

1. Pick a point on top of the object and draw two incident rays travelling towards the mirror.
2. Once these incident rays strike the mirror, reflect them according to the two rules of reflection for concave mirrors.
Drawing a Ray Diagram (Concave Mirror):

1. Pick a point on top of the object and draw two incident rays travelling towards the mirror.
2. Once these incident rays strike the mirror, reflect them according to the two rules of reflection for concave mirrors.
3. Mark the image “image top”
4. Repeat the process for the bottom of the object.

Let’s Try This:

Complete diagram on the handout:

Concave Mirrors form many kinds of images
Describe each image.

Draw a Ray Diagram (Convex Mirrors):

1. Pick a point on top of the object and draw two incident rays traveling towards the mirror.

Locating an Image with Convex Mirrors

2 revised rules for reflection for convex mirrors:

- Any incident ray traveling parallel to the principal axis on the way to a convex mirror will reflect in such a manner that its extension will pass through the focal point.

- Any incident ray traveling towards a convex mirror such that its extension passes through the focal point will reflect and travel parallel to the principal axis.
Drawing a Ray Diagram (Convex Mirrors):

1. Pick a point on top of the object and draw two incident rays traveling towards the mirror.
2. Once the incident rays strike the mirror, reflect them according to the two rules of reflection for convex mirrors.

Let’s Try This:
Complete diagram on the handout:

Drawing a Ray Diagram (Convex Mirrors):

3. Locate and mark the image of the top of the object.

Let’s Try This:
Complete diagram on the handout:
This is the only type of image formed by a convex mirror.

- Upright
- Virtual
- Reduced

Mirror Worksheet

Part A and B only (Diagrams)

Use a straight edge!
Draw the entire arrow as an image!
Draw the reflected portion of the ray!

Mirror Formulae

a.k.a. Mirror Formulas

Why a formula?

- Ray diagrams can be used to determine image location, size, orientation and type of image and create a useful object-image relationship. But fail in a quantitative form.
- Ray diagrams are approximate location and size, not exact location and size.
- Why we use the Mirror Equation and Magnification Equation.
- [http://goo.gl/MAk4xW](http://goo.gl/MAk4xW) for more examples

Formulas apply to both concave and convex mirrors.

\[
\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}
\]

\[
\frac{h_i}{h_o} = \frac{-d_i}{d_o} = M
\]

Formula Conventions

\[
\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}
\]

\[
\frac{h_i}{h_o} = \frac{-d_i}{d_o} = M
\]

- \( f \) is positive for concave mirrors and negative for convex mirrors
- \( M \) is always positive
- \( d_o \) is positive for real images and negative for virtual images
- \( h_i \) is positive for upright images and negative for inverted images
- \( M \) is greater than 1 for enlarged images, 1 for same size images, and less than 1 for reduced images
Example Problem (Convex Mirror)

- \( f = -3 \text{ cm} \) (convex mirror)
- \( h_o = 3 \text{ cm} \)
- \( d_o = 7 \text{ cm} \)

Solution for image distance

\[
\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}
\]
\[
\frac{1}{-3} = \frac{1}{7} + \frac{1}{d_i}
\]
\[
d_i = -2.1
\]

Negative means "virtual" image (behind mirror)

Seems correct

Solution for image height

\[
h_i = \frac{-d_i}{h_o}
\]
\[
\frac{h_i}{h_o} = -\frac{-2.1}{3}
\]
\[
h_i = 0.9
\]

Positive means upright

Seems correct

Example Problem (Concave Mirror)

- \( f = +3 \text{ cm} \) (concave mirror)
- \( h_o = 1.7 \text{ cm} \)
- \( d_o = 8 \text{ cm} \)

Solution for image distance

\[
\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}
\]
\[
\frac{1}{3} = \frac{1}{8} + \frac{1}{d_i}
\]
\[
d_i = 4.8
\]

Positive means "real" image (in front of mirror)

Seems correct

Solution for image height

\[
h_i = \frac{-d_i}{h_o}
\]
\[
\frac{h_i}{h_o} = -\frac{-4.8}{1.7}
\]
\[
h_i = -1.02
\]

Negative means inverted

Seems correct
**Mirror Worksheet**

Parts b (measure image with ruler), c and d (Calculations)
Round all answers to 2 decimal places.

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**Making a mirror**

- Mirrors are everywhere, and if you need to make one, you use the formulas.
- [https://youtu.be/z9TNSuZ76RQ](https://youtu.be/z9TNSuZ76RQ) How It’s Made
- The James Webb Space Telescope [https://jwst.nasa.gov/mirrors.html](https://jwst.nasa.gov/mirrors.html)
- [https://www.youtube.com/watch?v=HZyT969V0Y](https://www.youtube.com/watch?v=HZyT969V0Y) The most sophisticated mirror ever