Department of Education

Grade 10

Reflection of Light in Mirror
Second Quarter - Module 6

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EXPECTATIONS

After going through this Self Learning Module, you are expected to understand the concept reflection and demonstrate the images formed by the different types of mirrors.

Most Essential Learning Competency:
Predict the qualitative characteristics (orientation, type, and magnification) of images formed by plane and curved mirrors.

Objectives:
1. Investigate the reflection properties of light using plane mirrors.
2. Distinguish between converging and diverging mirrors.
3. Apply ray diagramming technique in describing images formed by mirrors.
4. Derive and use mirror equations in predicting the characteristics and position of an image formed by mirrors.

PRE-TEST

Directions: Encircle the letter of the CORRECT answer.

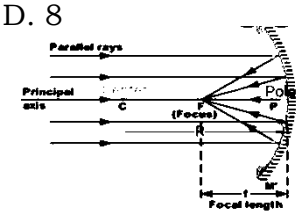
1. Shadows are formed because
   A. light is being blocked by an object.
   B. of too much light in the area.
   C. of the absence light in the room.
   D. an object reflects light.

2. What do you call the ray of light represented by an arrow approaching an optical element like mirror?
   A. Incident Ray B. Normal Line C. Reflected Ray D. Refracted Ray

3. The imaginary line perpendicular to a reflecting surface is called _____.
   A. Angular Line B. Normal Line C. Parallel Line D.Refracted Line

4. How many images will be formed if an object is placed in front of 2 adjacent plane mirrors at an angle of 45^0?
   A. 5 B. 6 C. 7 D. 8

5. What type of mirror is shown in the figure?
   A. Concave C. Diffuse
   B. Convex D. Plane



6. Where is the object located in a concave mirror if there is no image formed?
   A. At the Center of Curvature (C)
   B. At the Focus (F)
   C. Between C & F
   D. Between Vertex and Focus

7. How do you describe the image if the object is placed at center of curvature in front of concave mirror?
   A. The image formed at C has the same height and is inverted.
   B. The image formed between C and F is diminished and inverted.
   C. The image formed beyond the mirror is enlarged and upright.
   D. No imaged is formed.

8. A light ray, travelling passes through the focal point and strikes the mirror's surface. The reflected ray_____.

A. passes through the mirror's center of curvature.
B. passes through also the mirror's focal point.
C. travels at right angles to the mirror's axis.
D. travels parallel to the principal axis

9. What is the distance of a person's image from the plane mirror if he stands 2.0 m in front of it?

A. 1.0 m B. 2.0 m C. 4.0 m D. 8.0 m

10. Mark is 1.5 m tall in front of a plane mirror. What is the height of his image?

A. 4.5 m B. 3.0 m C. 2.0 m D. 1.5 m

11. An object is placed in front of convex mirror. What is the type and orientation of the image formed?

A. real and erect
B. real and inverted
C. virtual and erect
D. virtual and inverted

12. A wood cannot be used as a mirror because it_____ the light rays of light.

A. diffracts
B. diffuses
C. interferes
D. refracts

13. Which of these arrangements of two plane mirrors produces infinite number of images?

A. Two adjacent mirrors at an angle of 90^o
B. Two adjacent mirrors at an angle of 60^o
C. Two adjacent mirrors at an angle of 30^o
D. Two mirrors are arranged parallel to each other.

14. Which of the following is/are true of a convex mirror?

I. It will form a real image.
II. An inverted and upright images will be formed beyond the mirror.
III. An object in any position infront of the mirror produces reduced image.

A. I only
B. I & II
C. III only
D. I, II and III

15. Determine the image distance of an object placed infront of concave mirror at 2.5 cm with a focal length of 1.5 cm.

A. 1.5 cm
B. 2.5 cm
C. 3.50 cm
D. 3.75 cm

LOOKING BACK

Directions: Write TRUE if the statement is correct. If it is FALSE, replace the underline word(s) to make the statement correct.

_____1. Radio waves have the lowest frequency ang low energy hence they are harmless.
_____2. Radiation is known as the process of emitting energy through space.
_____3. Non-ionizing radiation has high-level of radiation which is generally perceived as harmless to humans.
_____4. A mutation is caused by exposure to specific chemicals or radiation.

_____5. Gamma Ray has the lowest ionizing energy and lowest frequency.
_____6. Minimizing the exposure time reduces the dose from the radiation source.
_____7. Ultraviolet is commonly used to observe internal structure of the human body.
_____8. The ionizing energy decreases as the frequency of EM Wave increases.
_____9. Lead is used as barrier is used as a shield to provide protection from penetrating x-rays and gamma rays.
_____10. Ultraviolet, X-Rays and Gamma rays are non-ionizing radiation.

BRIEF INTRODUCTION

Reflection is the bouncing off of light when it strikes a surface like plane mirror. We may not notice it but mirrors are very essential in our daily living. Mirrors will help us understand more comprehensively the behavior and properties of electromagnetic waves known as visible light.

To help you understand how an image is formed in a mirror, place a candle in front of a mirror as seen in Figure 1. The actual physical candle is called the **object** and the candle in the mirror is called the **image**.

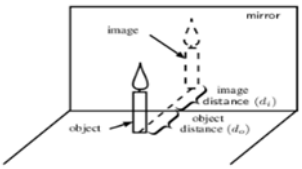


Figure 1. Image of an object in a plane mirror

In the activity, you will use a plane mirror and locate the object distance **(d_o)** and the image distance **(d_i)**. You will find out that d_o is equal to d_i. In plane mirrors, the image appears as if it is behind the mirror but actually it is not, the image is **virtual**. The value therefore of image distance is negative. The height of the image **(h_i)** in plane mirrors is always the same as the height of the object **(h_o)**, thus, its magnification **(M)** is 1. The magnification formula is written below:

$$M = \frac{h_i}{h_o} = \frac{-d_i}{d_o}$$

To learn more about reflection of light in plane mirrors, here are some important terms which you need to understand first.

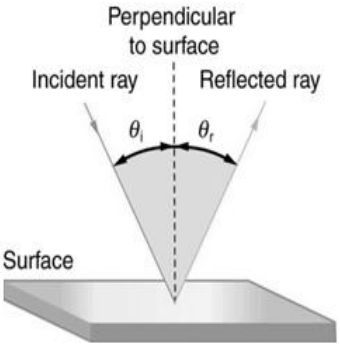


Figure 2. Reflection of Light Ray on Plane Mirror

Incident Ray. The ray of light approaching the mirror represented by an arrow approaching an optical element like mirrors.
Reflected Ray. The ray of light which leaves the mirror and is represented by an arrow pointing away from the mirror.
Normal Line. An imaginary line perpendicular to the surface of the mirror at the point of incidence where the ray strikes the mirror
Angle of incidence θ_i The angle between the incident ray and the normal line.
Angle of reflection θ_r The angle between the reflected ray and the normal line.

ACTIVITIES

Activity A : Law of Reflection

Performance Task: Reflective or Non-Reflective?

Directions: With the use of flash light and the things found at home, determine whether those things are reflective or non-reflective.

Objectives: To explain reflection of light from smooth and rough surfaces enable one to understand the Law of Reflection.

Materials: flashlight (This part works even better if you use a laser), piece of paper, mirror, 10 things found at home.

Procedure

1. Shine a flashlight at an angle at the paper, as shown in Figure 4.
2. Now shine the flashlight at a mirror at an angle, then observe.
3. Shine the flashlight on 10 various surfaces and determine whether the objects are reflective or non-reflective?
4. Answer the guide questions below.

Guide Questions:

1. Which of the 10 things you used in the experiment you found reflective? Which are non-reflective? _____
2. Why there are things refletive and non-reflective? _____
   _____
3. Do your observations confirm the predictions in Figure 4 and Figure 5?
   _____
4. Using the mirror and flashlight, can you confirm the law of reflection? Why?
   _____
5. Based on the activity, explain law of reflection. _____
   _____

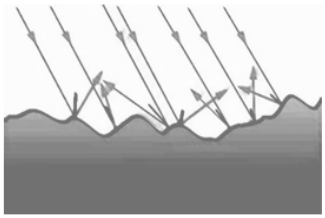


Figure 3. Light is diffused when it reflects from a rough surface. Here many parallel rays are incident, but they are reflected at many different angles since the surface is rough.

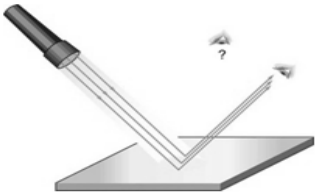


Figure 4. When a sheet of paper is illuminated with many parallel incident rays, it can be seen at many different angles, because its surface is rough and diffuses the light.

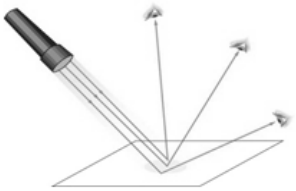


Figure 5. A mirror illuminated by many parallel rays reflects them in only one direction, since its surface is very smooth. Only the observer at a particular angle will see the reflected light.

The law of reflection is illustrated in Figure 2, which also shows how the angles are measured relative to the perpendicular to the surface at the point where the light ray strikes. We expect to see reflections from smooth surfaces, but Figure 3 illustrates how a rough surface reflects light. Since the light strikes different parts of the surface at different angles, it is reflected in many different directions, or diffused. Diffused light is what allows us to see a sheet of paper from any angle, as illustrated in Figure 4. Many objects, such as people, clothing, leaves, and walls, have

Figure 6. Moonlight is spread out when it is reflected by the lake, since the surface is shiny but uneven.

rough surfaces and can be seen from all sides. A mirror, on the other hand, has a smooth surface (compared with the wavelength of light) and reflects light at specific angles, as illustrated in Figure 5. When the moon is reflected from a lake, as shown in Figure 6, a combination of these effects takes place.

When we see ourselves in a mirror, it appears that our image is actually behind the mirror. This is illustrated in Figure 7. We see the light coming from a direction determined by the law of reflection. The angles are such that our image is exactly the same distance behind the mirror as we stand away from the mirror. If the mirror is on the wall of a room, the images in it are all behind the mirror, which can make the room seem bigger. Although these mirror images make objects appear to be where they cannot be like behind a solid wall, the images are not figments of our imagination. Mirror images can be photographed and videotaped by instruments and look just as they do with our eyes which are optical instruments themselves.

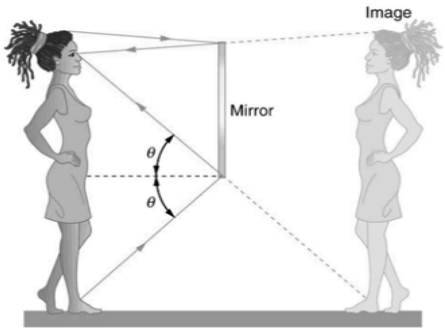


Figure 7. Our image in a mirror is behind the mirror. The two rays shown are those that strike the mirror at just the correct angles to be reflected into the eyes of the person. The image appears to be in the direction the rays are coming from when they enter the eyes.

Activity B. Multiple Reflections

Directions: In this activity, you will use the letter R – a letter which is neither horizontally nor vertically symmetric. When the letter R is reflected several times, this lack of symmetry helps us figure out how it has been reflected.

Objectives: Identify the relationships between the number of images formed and the angle between the two mirrors.

Materials: 1 set of hinged mirror or 2 plane mirrors, 1 protactor,

Directions:

1. Open the hinged mirror and look into it. Slowly change the angle using the protractor and observe the number of reflections of yourself that you see.
2. Write a large letter "R" in a bond paper and place it on the table. Open the mirror and place it on the R as shown in the Figure 8 or on two plane mirrors at an angle of 90^0.
3. Count the number of images formed. Record this in a table below.
4. Try to vary the angle between the mirrors.
5. Set the angle between the mirrors to 60^0. Count and record again the number of images formed.
6. Do again step 5 for angles 45^0 and 30^0. Enter all the values in a table below.

Angle	Number of Images Formed
90^0	
60^0	
45^0	
30^0	

Figure 8. Multiple Images Formed by Two Plane Mirrors at 90^0 Angle

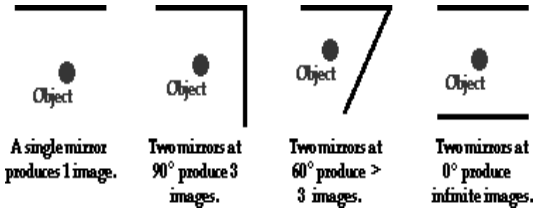
Guide Questions:

1. What happens to the number of images formed as you vary the angle between the mirrors?_____
2. Refer to the Table above. What relationship exists between the number of images formed and the angle between two mirrors_____
   _____

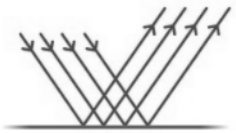
3. How should the mirrors be arranged such that an infinite number or images will be formed or seen?_____
_____

Multiple Images

Multiple images are formed by the reflection that happens when arranging at least two mirrors. The number of imahes, N, can be determined using the formula N=(360/angle between the mirror)-1. Parallel mirrors on other hand produce infinite number of images.



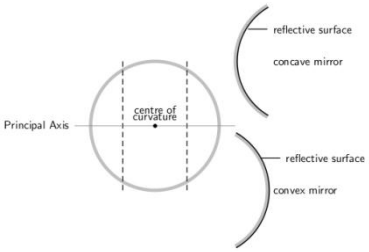
Types of Reflection:



1. Specular/Regular Reflection – This is reflection of light on smooth surfaces such as mirrors or calm body of water.

2. Diffuse/Irregular Reflection – This is a reflection of light on rough surfaces such as clothing, paper, wavy water, and the asphalt roadway.

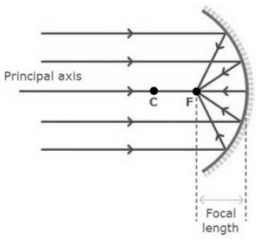
Reflection on Spherical Mirrors



Look at your reflection on a shiny metal spoon. Is your reflection the same on the two surfaces of the spoon? How will you compare your reflection on the two surfaces of the spoon? This is a reflection on curved mirrors. A curved mirror is a reflecting surface in which it surface is a slice of a sphere.

Two Kinds of Spherial Mirrors

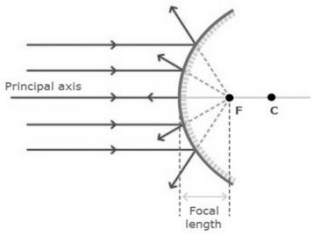
Reflection of light on a concave mirror



1. Concave Mirror

- It is curved mirror in which reflective surface bulges away from the light source.
- It is called *Converging Mirror* because the parallel incident rays converge or meet/intersect at focal point after reflection.
- The image made by the mirror is either virtual or real, depending on the position of the object that is reflected.

Reflection of light on convex mirror



2. Convex Mirror

- It is a curved mirror in which the reflective surface bulges towards the light source.
- It is called Diverging Mirror because the parallel incident rays diverge after reflection. When extending the reflected rays behind the mirror, the rays converge at the focus behind the mirror.
- This mirror always produces a virtual image.

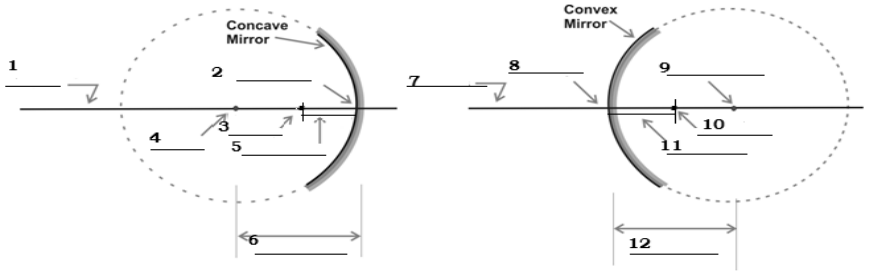
Activity C. Features of Spherical Mirrors

To be able to figure out the image formations in this type of mirror, you should familiarize with the following features of a concave and a convex mirror:

a. **Center of Curvature(C)** - The center of the circle of which the mirror represents a small arc

b. **Focus (F)** - The point where parallel light rays converge; the focus is always found on the inner part of the "circle" of which the mirror is a small arc; the focus of a mirror is one-half the radius.
c. **Vertex (V)** - The the point where the mirror crosses the principal axis.
d. **Principal axis** - A line drawn through the vertex, focus, and center of curvature of the mirror upon which the objects rests.
e. **Focal Length (f)** - The distance from the focus to the vertex of the mirror.
f. **Radius of Curvature** – The distance from the center of curvature to the vertex of the mirror; it corresponds to the radius of the circle.

Directions: Based on the terminologies above identify the parts/features of spherical mirrors.



Ray Diagramming Involving Mirrors

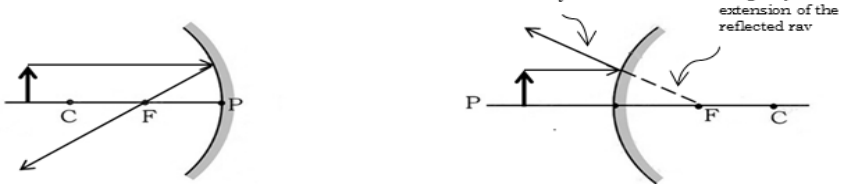
A ray diagram traces the path that light takes in order for an individual to view a point on the image of an object. On the diagram, lines with arrows called rays are drawn for the incident ray and the reflected ray. The following should be remembered when drawing ray diagrams:

1. Objects are represented by arrows whose length represents the height of the object. If the arrow points upwards, then the object is described as upright or erect. If the arrow points downwards, then the object is described as inverted.
2. From the object, draw the first rule. From the same point on the object draw the the second, third and fourth rule.
3. The intersection of the four rays is the image point corresponding to the object. The intersection of the reflected rays is also the tip of the arrow-shaped image. Thus, you can determine completely the position and characteristics of the image.
4. For a convex mirror, light rays diverge after reflection and converge from a point that seems to be behind the mirror (Virtual focus); but the procedure for locating images is the same as for concave mirror.

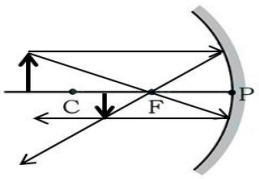
To be able to describe the **L**ocation, **O**rientation, **S**ize, and **T**ype of image formed **(LOST)** of concave and convex mirrors, the technique known as **ray diagramming** is used. In using this technique, there are four principal rays / rules you need to follow to figure out where the image of the object will appear.

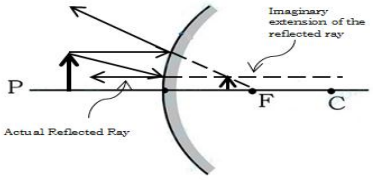
Concave Mirror (Converging Mirror) **Convex Mirror (Diverging Mirror)**

First Rule - P-F A ray light parallel to the principal axis is reflected passing through the focus, F.

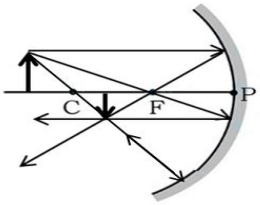


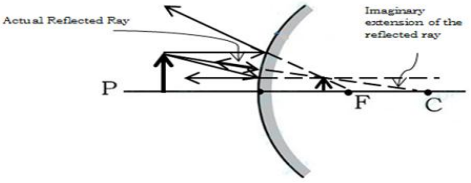
Second Rule – F-P A ray light passing through the focus, F is reflected parallel to the principal axis.



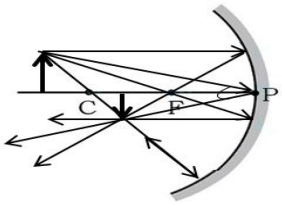


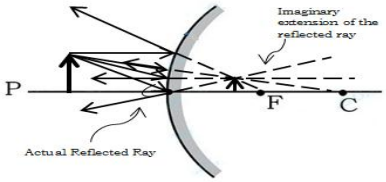
Third Rule – C-C A ray light passing through the center of curvature, C reflects back along its own path.





Fourth Rule – V Ray A ray of light directed to the vertex reflects at equal angle from the principal axis.





Activity D: Ray Digramming

Objective: Construct ray digrams to determine the location, orientation, size ad type of image formed by curved mirror.

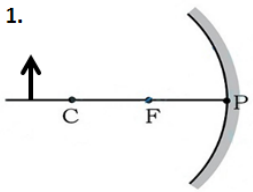
Materials: Ruler and Protractor

Procedure:

1. Using the protractor and ruler draw ray digramming following the rules above to locate the image formed in a curved mirror.
2. Base on the ray diagramming summarize the characteristics and location of the images formed in the table below.

Concave Mirror

1.



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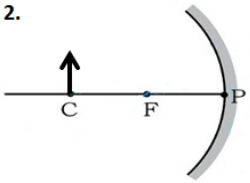

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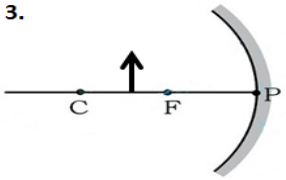

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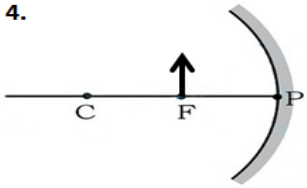

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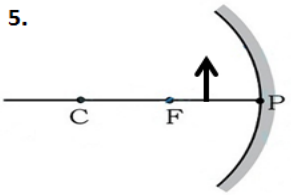
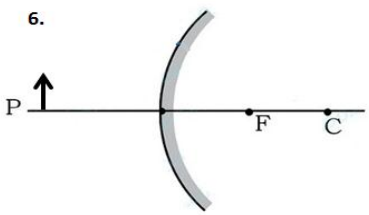
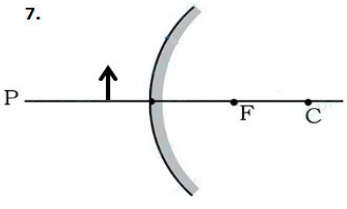


Convex Mirror

6.



7.



Location of Object	Image			
	Location	**O**rientation (upright or inverted)	**S**ize (same, reduced or enlarged)	**T**ype (Real or virtual)
Concave 1. Farther than the Center of Curvature				
2. At the Center of Curvature				
3. Between the Center of Curvature and the Focal point				
4. At the Focal Point				
5. Between the Focal point and the Vertex				
Convex 6. Farther than C in front of the Mirror				
7. Near to the surface of the Mirror				

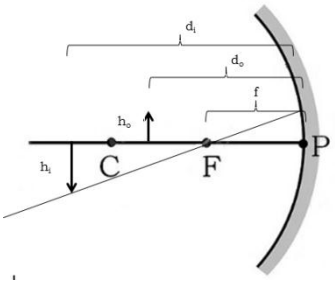
Guide Question:

1. Refer to the table above, How does the location of the object affect the characteristics and location of the image formed in concave mirror? Convex mirror?

_____

The Mirror Equation

Ray diagrams provide useful information about the image formed, yet fail to provide the quantitative information. Ray diagrams will help you determine the approximate location and size of the image, but it will not provide you with numerical information about image distance and object size. To determine the exact location and size of the image formed in a curved mirror equations are needed. The equations are stated as follow:



$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$

$$M = \frac{h_i}{h_o} = \frac{-d_i}{d_o}$$

Where:
f = focal length or distance from the mirror and the focal point, F
d_o = distance of the object from the mirror
d_i = distance of the image from the mirror
M = magnification
h_o = height of object
h_i = height of image

Sample Problem

A 4.0 cm tall light bulb is placed at a distance of 35.5 cm from a convex mirror having a focal length of -12.2 cm. Determine the image distance and the image size. Given: h_o = 4.0 cm, d_o = 35.5 cm, f = -12.2 cm Find = d_i & h_i

Distance of the image, d_i

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$

$$\frac{1}{f} - \frac{1}{d_o} = \frac{1}{d_i}$$

$$\frac{1}{(-12.2cm)} - \frac{1}{35.5cm} = \frac{1}{d_i}$$

$$\frac{35.5cm - (-12.2cm)}{(-12.2cm)(35.5cm)} = \frac{1}{d_i}$$

$$\frac{47.7cm}{-433.1cm} = \frac{1}{d_i}$$

$$d_i = -9.08\ cm$$

Height of the image, h_i

$$\frac{h_i}{h_o} = \frac{-d_i}{d_o}$$

$$\frac{h_i}{4.0cm} = \frac{-(-9.08cm)}{35.5cm}$$

$$h_i = \frac{(4.0cm)(9.08cm)}{35.5\ cm}$$

$$h_i = 1.02\ cm$$

The Sign Conventions for Mirror

- f is positive (+) if the mirror is a concave mirror
- f is negative (-) if the mirror is a convex mirror
- d_i is (+) if the image is a real image and located on the object's side of the mirror.
- d_i is (-) if the image is a virtual image and located behind the mirror
- h_i is (+) if the image is an upright image
- h_i is (-)if the image an inverted image

Activity E: Mirror Equation and Magnification

Directions:

Solve the following mirror problems. Write your solution on a separate paper.

1. An object is placed 44.7 cm from the convex mirror with a focal length of -10.7 cm. Determine the image distance.
2. A magnified, inverted image is located a distance of 35.0 cm from a concave mirror with focal length of 16.0 cm. What is the object distance?
3. A 5.0 cm tall toy is placed a distance of 8.4 cm from a concave mirror having a focal length of 14.2 cm. Determine the image distance and the image size.
4. A focal point is located -20.0 cm from a convex mirror. An object is placed 12 cm from the mirror.
   a. Determine the image distance.
   b. Determine the height of the object if the object is 7cm tall.

REMEMBER

Law of Reflection

- The angle of reflection equals the angle of incidence.
- A mirror has a smooth surface and reflects light at specific angles.
- Light is diffused when it reflects from a rough surface.

CHECK YOUR UNDERSTANDING

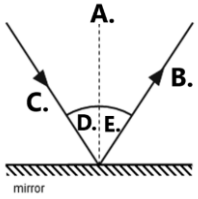
Directions: Answer the following questions.

1. How are shadows formed?
2. Why is there no reflection formed when light is absent?
3. Why is the word "AMBULANCE" in an ambulance car written in reverse?
4. Why is a convex mirror used in vehicles?
5. What kind of curved mirror do you see in most of the department stores? Why do they use such kind of mirror?

POST TEST

Directions: Read each item carefully. Choose the letter of the CORRECT answer.

For item number 1-3 refers to illustration on the side:



1. Which letter represents the angle of incidence?

2. The ray of light which leaves the mirror and pointing away from the mirror is represented by letter _____.

3. Which two letters should be equal based on the Law of Reflection?

4. If you stand 2 feet in front of a plane mirror, how far away would you see yourself in the mirror?

A. 2 feet B. 3 feet C. 4 feet D. 8 feet

5. If the angle of incidence is 55^0, what is the angle between the reflected ray and the incident ray?

A. 55^0 B. 110^0 C. 165^0 D. 180^0

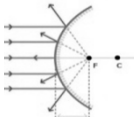
6. According to the Law of reflection, a light ray striking a mirror

A. bounces off the mirror at the same angle it hits.
B. bounces off the mirror toward the direction it came from.
C. continues moving through the mirror in the same direction.
D. moves into the mirror at a slightly different angle

7. An object is placed infront of adjacent mirrors with a certain angle. If 11 images are formed, what is the angle between the two adjacent plane mirrors?

A. 30^0 B. 45^0 C. 60^0 D. 90^0

8. The figure on the side is an example of _____ mirror.



A. concave C. plane
B. convex D. adjacent

9. When the image of an object is place infront of a concave mirror the image will ____.

A. always be real. C. be either real or virtual.
B. always be virtual. D. will always be magnified.

10. Which of the following best describes the image formed by a convex mirror when the object is located somewhere infront of the mirror?

A. virtual, upright and enlarged C. virtual, upright and reduced
B. real, inverted and reduced D. real, inverted and enlarged

11. CCTV cameras are commonly used for security purposes. Before they were invented, convenient stores used convex mirrors because

A. they give blurred images of a specific part of the store.
B. they give a clear images of a specific part of the store.
C. they narrow the reflected field of vision.
D. they broaden the reflected field of vision.

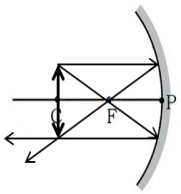
12. An object is placed 18.0 cm from a mirror of focal length 8.0 cm. The object is 4.00 cm tall. Where is the image located?

A. 0.07 cm B. 6.9 cm C. 13.8 cm D. 14.4 cm

13. How tall is the image in # 12?

A. -3.2 cm B. 3.2 cm C. -5 cm D. 5 cm

14. Based on the illustration, where does image located?



A. At C B. At F C. Between C & F D. Beyond the Mirror

15. Describe the image if an object is placed at the focus?

A. The image formed at C has the same height and is inverted.
B. The image formed between F and V is diminished and inverted.
C. The image formed beyond the mirror is enlarged and upright.
D. No imaged is formed.

Answer Key

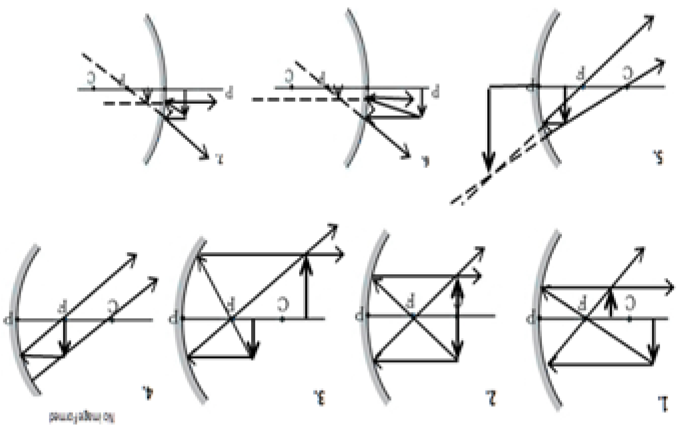
Pre-Test

1. A
2. A
3. B
4. C
5. A
6. B
7. A
8. D
9. B
10. D
11. C
12. B
13. D
14. C
15. D

Activities C

1. Principal Axis
2. Vertex
3. Focus
4. Center of Curvature
5. Focal Length
6. Radius of Curvature
7. Principal Axis
8. Vertex
9. Center of Curvature
10. Focus

Activity D



Looking Back

1. True
2. True
3. Low Level
4. True
5. Radio wave
6. True
7. X-Ray
8. Increases
9. True
10. Ionizing radiation

Location of Object	Image			
	Location	Orientation (upright or inverted)	Size (same, reduced or enlarged)	Type (Real or virtual)
Concave 1. Farther than the Center of Curvature	Between C and F	Inverted	Reduced	Real
2. At the Center of Curvature	At C	Inverted	Same	Real
3. Between the Center of Curvature and the Focal point	Beyond C	Inverted	Enlarged	Real
4. At the Focal Point	NO IMAGE FORMED			
5. Between the Focal point and the Vertex	Beyond C	Inverted	Enlarged	Real
Convex 6. Farther than C in front of the Mirror	Between F and V	Upright	Enlarged	Virtual
7. Near to the surface of the Mirror	Between F and V	Upright	Enlarged	Virtual

Activity E

1. d_i = -8.63 cm
2. d_o = 29.47 cm
3. d_i = -20.56 h_i = 12.24
4. d_i = -7.5 h_i = 4.33

Post Test

1. D
2. B
3. D & E
4. C
5. B
6. A
7. A
8. B
9. C
10. A
11. D
12. D
13. A
14. A
15. D

Reference

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