Reflection and Image Formation by Plane Mirror

Purpose

a. To study the reflection of light.

b. To study the formation and characteristics of images formed by a plane mirror.

Theory

When a light (wave) travelling in one medium encounters a boundary of another medium, part of the light bounces back to the same medium, called the *Reflection* and some part of light may pass into the second medium, called the *Refraction*. In this lab, you will study reflection of light from different mirrors.

Figure 1 shows an example of reflection from a plane surface such as mirror. The incident ray makes an angle with the normal to the surface called the *angle of incidence, θ_i*. The reflected ray makes an angle with the normal to the surface called the *angle of reflection, θ_r*. The law of reflection states that the angle of reflection (θ_r) equals the angle of incidence (θ_i),

$$\theta_r = \theta_i \qquad\qquad (1)$$

The normal, incident ray and reflected ray all lie in the same plane (Fig. 1).

In this lab, you will study the image formation by plane mirrors using an online simulation (Fig. 2 below).
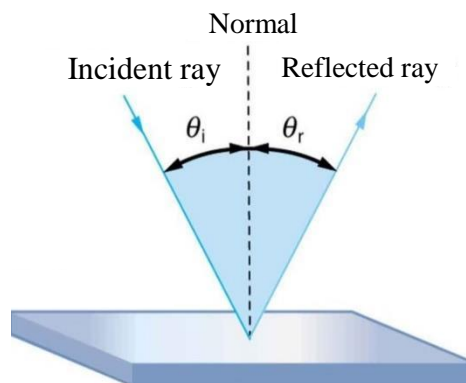

Fig. 1: Reflection of light from a mirror

Figure 2 illustrates how images are formed by a plane mirror. Consider a point 'O' on an object. The rays of light coming from the point reflect according to the laws of reflection. Out of several possible rays from the point, we need at least two rays to locate the image.
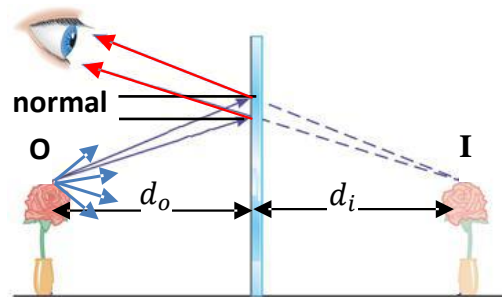

Fig. 2: Image formation by a plane mirror.

For a plane mirror, as shown in Fig. 2, the normals are parallel for both incident rays, so they reflect with different angles of reflection. The reflected rays upon incident on our eye see the image. Intersection of the reflected rays is the position of image. However, the reflected rays do not intersect as they are diverged. We have to back trace the reflected rays (by dotted lines) to find the intersection, I. Our eyes see as if the light is coming from the point I behind the mirror. Thus, it is a virtual image. Note the object distance (do) and image distance (di) is same in plane mirrors. But the distance of a virtual image is taken as a negative value. This is required by a sign convention for mirrors. For such case the magnification is 1 by the formula, $m = -d_i /d_o$. That's why you see your identical image on the mirror. But why does your right hand become left hand and vice versa in mirror?

Simulation tools

This lab uses the online simulator:

Plane mirrors: https://ophysics.com/l9.html

Procedure

Throughout, you must take screenshots of your work and include them in your final report, to show that you have conducted the simulations.

Plane mirror   (The data sheet is on pages 4 and 5)

(a) Reflection of light by a plane mirror

1. Open the plane mirror simulation at https://ophysics.com/l9.html.
2. The simulation opens with a default object which is a blue, vertical arrow. However, you can alter the length and angle of the arrow. You can also observe light rays traveling from your choice of so-called "control points".
3. Check the box at the top of the simulation marked "*Control points*". This will enable you to move the top and bottom of the object, and the 4 control points on the plane mirror.
4. Check the box at the bottom of the simulation marked "*Show Grid & Axes*". This will enable you to make measurements.

5. Move the control points for the *object* as follows:
   a. for the top of the object: (-6,2)
   b. for the bottom of the object: (-6,0).

   The object should now appear as a vertical arrow of height 2 units.

6. Move the control points on the *mirror* to the following 4 positions: (0,-3), (0,-1), (0,1) and (0,3).

7. Check the boxes marked "*Show Incident Rays*" and "*Show Reflected Rays*" and "*Show Normals*".

8. Look at the angles made by the incident and reflected rays to the normal through each control point on the mirror. What can you say about the angle of incidence (relative to the normal) and the angle of reflection (relative to the normal)?

9. Uncheck all the boxes and click and drag the object to another position on the display of your choice. Feel free to rotate the object slightly, if you would like. Now, what would you predict with respect to the relationship between the angle of incidence and angle of reflection from the object in this new position? Check all the boxes again and inspect the angles. Was your prediction correct?

(b) Image of a point object formed by plane mirror

1. You are now going to make a point object. Move the lower control point on the current object from the position (-6,0) to (-6,2), in other words so that both of the control points on the object are at (-6,2). All rays should now start from that point.

2. Click the box *"Show Image"* at the top of the screen and the box "*Show Virtual Rays*" at the bottom right of the screen. Where is the image located? Note its (x,y) coordinates. Is the image virtual or real?

3. Move the object so that it is a point object at each of the following locations:
   - (-6,0) ; (-6,-2). [in each case, the top and bottom control points of the object overlap]

   In each case, note the (x,y) coordinates where the image is formed

(c) Image of an extended object formed by a plane mirror

1. Set the control points on the object to being different, in order to form an extended object (as in part a). Specifically, set the bottom control point on the object to (-5,0) and the top control point to (-7,2).

2. What is the location of the image? Give the (x,y) coordinates of the top and bottom of the image. Is it real or virtual? Compute the object and image distances, do and di corresponding to the bottom points of object and image and repeat also for the top points. Use these values in the computation part below.

3. The whole object can be dragged by moving it using the mouse. Does the size of the image change if the object is moved towards, or away from, the mirror? What does this tell you about our eyes' perception of images in a flat mirror?

Computation

For part (c), step 2 above, use the object distance and image distance corresponding to bottom points of object and image (and then again for top points). Are the points of image located at the same distance from the mirror as the corresponding points of object? For bottom points (and then for top points), calculate the ratio *-di /do*. What does it represent? (Hint: See the theory part).

Questions

1. What is meant by a "virtual image"?
2. If you walk towards a full-length mirror, your image "walks" towards you. If your speed is 1.5 m/s, what is the speed of your image?

Data sheet

Name: **Group:**   **Date online- experiment performed:**

Part (a): Reflection of light by a plane mirror

Step 8) Angle of incidence relative to the normal:
Angle of reflection relative to the normal:
Step 9) New position of object:
With the boxes unchecked, what relation do you see between angle of incidence and angle of reflection?
Check the boxes again, and compare to your prediction. Was your prediction correct?

Part (b): Image of a point object formed by plane mirror

Step 2) Image location (x,y):
Is the image virtual or real?
Step 3) Object at (6,0): Image location (x,y):
Object at (6, -2): Image location (x,y):

Part (c) Image of an extended object formed by a plane mirror

Step 2) Location of Image: Top (x,y):   Bottom (x,y):   Is the image real or virtual?
Step 3) Does the size of the image change if the object is moved *towards* the mirror?
          Does the size of the image change if the object is moved *away* from the mirror?

What does this tell you about our eyes' perception of images in a flat mirror?

Computation: For part (c) step (2) measure the object distance, *do* and the image distance, *di* for bottom points (and repeat for top points). Are they equal for bottom (or top) points?

Calculate the ratio *-di /do* **(for bottom points):**   *-di /do* **(for top points):**

What does this ratio represent?

Answer to questions:

1.

2.

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