

Plane and Spherical Mirrors

As you work through the steps in the lab procedure, record your experimental values and the results on this worksheet. Use the exact values you record for your data to make later calculations.

Optics Lab – Simulation

Open the Virtual Optical Bench simulation to do this lab.

I. Plane Mirrors; Virtual and Real Images

1. As you drag the object toward the mirror, picture the equivalent activity of walking toward a bathroom or dressing room mirror. If you walked toward the mirror at 2 m/s, at what speed is your image moving toward the mirror?

2. At what speed is your image moving toward you? Remember, you're moving too.

3. Record the nature of the image formed by a plane mirror. Choose one for each category.

(a) Real or virtual

- real
- virtual
- no image

(b) Size

- reduced
- the same size
- enlarged

(c) Orientation

- upright
- inverted

II. Concave (Converging) Mirrors

4. What is the nature of this particular image? Check one for each category.

(a) Real or virtual

- real
- virtual
- no image

(b) Size

- reduced
- the same size
- enlarged

(c) Orientation

- upright
- inverted

5. Dentists use mirrors to clearly see what they're doing when they're working on your teeth. Would you want your dentist to use a mirror system arranged like the one on your screen now? What would be the advantage of this arrangement? What would be the disadvantage? Look at the Object and Image Close-up Screens.

II.A. Focal Length, f , Object Distance, d_o , and Image Distance, d_i

5. What did you observe about the trend in the angle between the two incident rays? That is, what is the angle between them approaching?

8. As you increase the object distance, the incident rays continued to get closer to parallel. What's happening to the reflected rays? Where does their crossing point appear to be heading?

11. From here on you'll work with mirror 5. Select the matching mirror in the apparatus. (*Note: The mirror number given may be different in the WebAssign question.*)

12. Using the techniques you used with mirror #1, measure and record your mirror's focal length.

II.B. Images Formed by a Concave Mirror – Case I

3. Take a **Screenshot** of the Ray Optics Tool. Just include the object, image, and mirror. **Save the image as “mirrors_case.I.png” and upload it.** (Submit a file with a maximum size of 1 MB. *You will upload this file in the WebAssign question.*)

5. How about the nature of the image for case I? Check one for each category.

(a) Real or virtual

- real
- virtual
- no image

(b) Size

- reduced
- the same size
- enlarged

(c) Orientation

- upright
- inverted

6. There is an enlarged image of the cow at the top left of the screen with the corresponding image next to it. **Take a Screenshot of the pair, save it as “mirrors_caseI.cows.png”,** and upload it. (Submit a file with a maximum size of 1 MB. *You will upload this file in the WebAssign question.*)

7. Drag the object back and forth, keeping outside the 2F point. How would you define the possible locations for the image?

II.B. Images Formed by a Concave Mirror – Case II

3. Take a **Screenshot** of the Ray Optics Tool. Just include the object, image, and mirror. **Save the image as “mirrors_case_II.png”, and upload it.** (Submit a file with a maximum size of 1 MB. *You will upload this file in the WebAssign question.*)

5. How about the nature of the image for case II? Check one for each category.

(a) Real or virtual

- real
- virtual
- no image

(b) Size

- reduced
- the same size
- enlarged

(c) Orientation

- upright
- inverted

6. Take a **Screenshot** of the object and image displays at the top left of the screen, save it as **“mirrors_caseII_cows.png”**, and upload it. (Submit a file with a maximum size of 1 MB. *You will upload this file in the WebAssign question.*)

7. In case I, the object could be anywhere beyond a distance of $2f$ from the mirror. In case II, the object has no room to roam. Likewise the image has a fixed position. How would you define the possible locations for the image?

II.B. Images Formed by a Concave Mirror – Case III

3. Take a **Screenshot** of the Ray Optics Tool. Just include the object, image, and mirror. **Save the image as “mirrors_case_III.png”, and upload it.** (Submit a file with a maximum size of 1 MB. *You will upload this file in the WebAssign question.*)

5. How about the nature of the image for case III? Check one for each category.

(a) Real or virtual

- real
- virtual
- no image

(b) Size

- reduced
- the same size
- enlarged

(c) Orientation

- upright
- inverted

6. Take a **Screenshot** of the object and image displays at the top left of the screen, save it as **“mirrors_caseIII_cows.png”**, and upload it. (Submit a file with a maximum size of 1 MB. *You will upload this file in the WebAssign question.*)

7. In case I, the object could be anywhere beyond a distance of $2f$ from the mirror and the image was confined between F and $2F$. In case III, the object again has a range of possible positions. How would you define the possible locations for the image?

II.B. Images Formed by a Concave Mirror – Case IV

2. After the object passes through F , where do the rays converge?

3. Drag the object back and forth through the focal point. What can you say about what must be happening to the reflected rays when the object is exactly at F ?

4. Given that the (tip of the) image is formed where the reflected rays intersect, what can you say about the image?

5. Take a **Screenshot** of the relevant section of the Ray Optics Tool. **Save the image as “mirrors_case_IV.png”, and upload it.** (Submit a file with a maximum size of 1 MB. *You will upload this file in the WebAssign question.*)

7. How about the nature of the image for case IV?

8. Take a **Screenshot** of the object and image displays at the top left of the screen, save it as “**mirrors_caseIV_cows.png**”, and upload it. (Submit a file with a maximum size of 1 MB. *You will upload this file in the WebAssign question.*)

II.B. Images Formed by a Concave Mirror – Case V

2. Discuss these three crucial points.

(a) Why did we see images on the screens in cases I-III?

(b) Why don't we see an image on the screens in this case (V)?

(c) Why then is there an image in this case and what must we do to see it?

3. Take a **Screenshot** of the relevant section of the Ray Optics Tool. **Save the image as “mirrors_case_V.png”, and upload it.** (Submit a file with a maximum size of 1 MB. *You will upload this file in the WebAssign question.*)

5. How about the nature of the image for case V? Check one for each category.

(a) Real or virtual

- real
- virtual
- no image

(b) Size

- reduced
- the same size
- enlarged

(c) Orientation

- upright
- inverted

6. Take a **Screenshot** of the enlarged object and image displays at the top left of the screen, save it as “**mirrors_caseV_cows.png**”, and upload it. (Submit a file with a maximum size of 1 MB. *You will upload this file in the WebAssign question.*)

7. In cases I and III, the object could travel between infinity and $2F$, and $2F$ and F respectively. The image locations were the reverse of this. In case V, the object again has a range of travel, this time between F and the mirror. How would you define the possible locations for the image?

III. Convex (Diverging) Mirrors

2. Using the diagram for a diverging mirror, complete the following sentences describing the matching results for a diverging mirror.

Ray 1. The **magenta, parallel ray** goes from the tip of the object, parallel to the principle axis, and then reflects back _____ .

Ray 2. The **green, focal ray** goes from the tip of the object, toward the focal point, and then reflects _____ .

Ray 3. The **orange, chief ray** goes toward the center of curvature, C , (at $2F$) and then reflects _____ .

5. Take a **Screenshot** of the relevant section of the Ray Optics Tool. Save the image as “**mirrors_diverging.png**”, and upload it. (Submit a file with a maximum size of 1 MB. *You will upload this file in the WebAssign question.*)

7. How about the nature of the image for a diverging mirror? Check one for each category.

(a) Real or virtual

- real
- virtual
- no image

(b) Size

- reduced
- the same size
- enlarged

(c) Orientation

- upright
- inverted

8. Take a **Screenshot** of the enlarged object and image displays at the top left of the screen, save it as “**mirrors_diverging_cows.png**”, and upload it. (Submit a file with a maximum size of 1 MB. *You will upload this file in the WebAssign question.*)

9. Describe the position or range of positions available to the image in this case.

10. Explore these considerations by matching up the image cases on the left with the applications on the right. Each choice gets used exactly once. (*In your WebAssign question you will be given the following list of applications in the right column.*)

Application

- telescope
- flashlight, headlights, searchlights
- dentist’s mirror
- shoplifting surveillance mirror
- photocopier in normal mode
- photocopier in enlarge mode

Table 1: Matching Image Cases to Typical Applications

		Application Name
Converging Mirror	Case I	
	Case II	
	Case III	
	Case IV	
	Case V	
Diverging Mirror		

IV.A. Sign Conventions for Mirrors and Thin Lenses for Use with the Mirror or Thin Lens Equation and the Magnification Equation

1. Let's practice. In Table 2, insert a plus or minus sign, or N/A for each choice in the table. Assume that the object is in front of the mirror in each case. Only real objects are being considered. You might want to use the sign conventions chart and Figure 14. Notice how they say similar things in different ways. It's probably instructive to do this one column at a time.

Table 2: Matching Variable Signs to Image Cases

		f	d_o	d_i	M	h_i
Converging Mirror	Case I					
	Case II					
	Case III					
	Case IV					
	Case V					
Diverging Mirror						

2. What does the sign of the magnification indicate about whether an image is upright or inverted?

(a) A positive sign indicates that the image is _____ .

(b) A negative sign indicates that the image is _____ .

3. The absolute value of the magnification can be less than 1.0, equal to 1.0 or greater than 1.0 (Ex: 0.5, 1.0, or 3.2). What does each of these indicate about the image?

(a) A magnification whose absolute value is less than 1.0 indicates that an image is _____ .

(b) A magnification whose absolute value is equal to 1.0 indicates that an image is _____ .

(c) A magnification whose absolute value is greater than 1.0 indicates that an image is _____ .

4. A magnification of +3.2 means that the image is _____ times the size of the object and _____ .

5. A magnification of -0.32 means that the image is _____ times the size of the object and _____ .

IV.B. Determining Magnification and Image Location with the Mirror and Magnification Equations

1. Use the same mirror number (5) from Part II.A. (*Note: The mirror number given may be different in the WebAssign question.*)

2. Enter the focal length you found for your mirror in Part II.A. step 12.

3. For the concave mirror – case I: $d_o > 2f(R)$, do the following using the above procedure.

(a)–(c) Complete Table 3.

Table 3: Concave Mirror – Case I: $d_o > 2f(R)$

Experimental	d_o (cm)	
	d_i (cm)	
	h_o (cm)	2.3
	h_i (cm)	
	$M_{\text{experimental}} = h_i/h_o$	
Calculated	d_i (cm)	
	$M_{\text{calculated}} = -d_i/d_o$	
% difference	% diff. in d_i	
	% diff. in M	

(d) Show your calculations of $M_{\text{experimental}}$, d_i calculated, $M_{\text{calculated}}$, and both percent differences.

4. For the concave mirror – case II: $d_o = 2f(R)$, do the following using the above procedure.

(a)–(c) Complete Table 4.

Table 4: Concave Mirror – Case II: $d_o = 2f(R)$

Experimental	d_o (cm)	
	d_i (cm)	
	h_o (cm)	2.3
	h_i (cm)	
	$M_{\text{experimental}} = h_i/h_o$	
Calculated	d_i (cm)	
	$M_{\text{calculated}} = -d_i/d_o$	
% difference	% diff. in d_i	
	% diff. in M	

(d) Show your calculations of $M_{\text{experimental}}$, d_i calculated, $M_{\text{calculated}}$, and both percent differences.

5. For the concave mirror – case III: $f < d_o < 2f(R)$, do the following using the above procedure. (Be sure your object image does not go outside of the window.)

(a)–(c) Complete Table 5.

Table 5: Concave Mirror – Case III: $f < d_o < 2f(R)$

Experimental	d_o (cm)	
	d_i (cm)	
	h_o (cm)	2.3
	h_i (cm)	
	$M_{\text{experimental}} = h_i/h_o$	
Calculated	d_i (cm)	
	$M_{\text{calculated}} = -d_i/d_o$	
% difference	% diff. in d_i	
	% diff. in M	

(d) Show your calculations of $M_{\text{experimental}}$, d_i calculated, $M_{\text{calculated}}$, and both percent differences.

6. For the concave mirror – case IV: $d_o = f$, do the following using the above procedure.

(a)–(c) Complete Table 6.

Table 6: Concave Mirror – Case IV: $d_o = f$

Experimental	d_o (cm)	
	d_i (cm)	N/A
	h_o (cm)	2.3
	h_i (cm)	N/A
	$M_{\text{experimental}} = h_i/h_o$	N/A
Calculated	d_i (cm)	N/A
	$M_{\text{calculated}} = -d_i/d_o$	N/A
% difference	% diff. in d_i	N/A
	% diff. in M	N/A

(d) No calculations can be done for this case.

7. For the concave mirror – case V: $d_o < f$, do the following using the above procedure. (Be sure your object image does not go outside of the window.)

(a)–(c) Complete Table 7.

Table 7: Concave Mirror - Case V: $d_o < f$

Experimental	d_o (cm)	
	d_i (cm)	
	h_o (cm)	2.3
	h_i (cm)	N/A
	$M_{\text{experimental}} = h_i/h_o$	N/A
Calculated	d_i (cm)	
	$M_{\text{calculated}} = -d_i/d_o$	
% difference	% diff. in d_i	
	% diff. in M	N/A

(d) Show your calculations of d_i calculated, $M_{\text{calculated}}$, and the percent difference in d_i .

8. For the convex mirror, do the following using the above procedure.

(a)–(c) Complete Table 8.

Table 8: Convex Mirror

Experimental	d_o (cm)	
	d_i (cm)	
	h_o (cm)	2.3
	h_i (cm)	N/A
	$M_{\text{experimental}} = h_i/h_o$	N/A
Calculated	d_i (cm)	
	$M_{\text{calculated}} = -d_i/d_o$	
% difference	% diff. in d_i	
	% diff. in M	N/A

(d) Show your calculations of d_i calculated, $M_{\text{calculated}}$, and the percent difference in d_i .