Experiment: Mirror Optics

Objectives:
The purpose of this experiment is

- to investigate the images formed by mirrors
- to determine the focal length of a concave mirror.
- to verify the mirror equation

Introduction
Mirrors reflect light and can form images of objects located in front of them. Convex mirrors always produce virtual images, while concave mirrors can produce virtual or real images, depending on the distance between the object and the mirror.

The distance between the object and the mirror (d_o), the focal distance (f) and the distance between the image and the lens (d_i) are related as follows:

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \qquad (1)$$

The magnification equation relates the height of the image h_i to the height of the object h_o

$$m = \frac{h_i}{h_o} = -\frac{d_i}{d_o} \qquad (2)$$

Materials:

- optical bench
- a concave mirror
- illuminated object box
- screen
- meter stick
- Windows-based PC

Preliminary Questions:

1) An object with a height of 5 cm is placed at a distance (d) of 30 cm in front of a concave mirror whose focal distance is +10 cm.
   a) Trace the significant rays to obtain the image.

   b) Describe the image (real or virtual; greater or smaller than the object; upright or inversed)

   c) Calculate the position and the height of the image.

   d) Solve the same problem for the same object located 15 cm from the mirror (a,b,c)

Part A. Mirrors

1. Open the following web page: http://www.phy.ntnu.edu.tw/ntnujava/viewtopic.php?=65

2. From the pull-down menu, select " Mirror" instead of "Lens". The object distance is labeled "p" in this applet. For the object distance "p" and focal distance "f", enter the values from the Preliminary Question 1. (*Remember the algebraic sign!*)

3. Place the cursor at the top of the object. The top left window will display the (x,y) coordinates of the cursor. Since y is measured from the axis, the y value displayed represents the height of the object. Click and drag to set the height of the object to 10 cm, as in Preliminary Question 1. Record the height of the object $\mathbf{h_o}$ in Table I below.

4. Move the cursor at the top of the image and read the height of the image. Record your reading in the table.

5. Record the image distance "q", object distance and the focal distance in Table I. Compare the ray diagram to your answers to the Preliminary Question 1. Was your answer correct?

6. Predict what would happen if the object is located 5 cm in front of the same mirror (image distance, image height, describe the image, draw a ray diagram). Write your prediction below.

7. Verify your prediction by entering the corresponding values in the applet windows. Compare the applet results to your prediction. Enter the results in Table I.

8. For the following object positions, predict and then verify (by running the applet) the **position**, **type** and **height** of the image for the following points. Draw the ray diagram in each case and record d_i, h_i and the type of image (*real or virtual, upright or inversed, larger or smaller than the object*)

a) object located at the focal point

b) object located at infinity

c) object located at the center of curvature of the mirror

9. Replace the concave mirror by a convex mirror whose focal length is -10 cm. Place the same object at 30 cm, 15 cm and 5 cm from the mirror and record the image distance and the height of the object and the image in Table I:

Table I

Trial	Object distance (cm)	Image distance (cm)	h_o (cm)	h_i (cm)	f (cm)	h_i/h_o	$-d_i/d_o$
1	30				10		
2	5				10		
3	30				-10		
4	15				-10		
5	5				-10		

Analysis

1. Calculate h_i/h_o and $-d_i/d_o$ for each measurement. According to the magnification equation (2) these ratios should be equal. Do your data support the magnification equation? Explain.

2. What kind of images are formed by a convex mirror?

3. What kind of images are formed by concave mirrors?

Part B. Focal Length of Concave Mirror

1. Set the object box near one end of the optical bench and the concave mirror at a distance of about 30 cm (for f=+200mm) or 40 cm (for f=300mm).

2. Move the screen in front of the mirror until a clear image is observed on the screen. Describe the image below: (*real or virtual, upright or inverted, smaller or larger than the object*)

3. Record the position and the height of the image and object below, including the algebraic sign:

Object:

d_o = ________

h_o = ________

Image:

d_i = _________

h_i =_________

4. Does your data support the magnification equation? Show your calculations.

5. Calculate the focal length (f_1) and the curvature radius (R) of the mirror using equation (1).

f_1 = __________ **R = ___________**

6. A concave mirror can form real images that are either larger or smaller than the object, depending on the position of the object. What is range of object distance values where you where you would expect to observe a smaller real image? Try to formulate an equation to justify your answer.

7. Choose an object distance representative of your answer in (6) and use it to predict the corresponding image distance and image height. Show your calculations below.

d_o = _________ **d_i = _________**
h_o = _________ **h_i = __________** *{don't forget the algebraic sign}*

7. Verify your prediction by placing the screen and the object at the corresponding positions determined in (7). *If the image is not clear*, move the object until the image is clear. Measure the new object distance and the new image distance and record the values below.

d_o = _________ **d_i = _________**
h_o = _________ **h_i = __________** *{don't forget the algebraic sign}*

8. Was your prediction correct?

9. Using the measured values in (8), calculate the focal length again and compare it to the value calculated in Step 5 above.

f_2 = ___________ **% Error = ____________**