Spherical Mirrors and Lenses                        Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Course:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Time:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Partners:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Theory: For a spherical mirror or thin lens (shown below), the focal length (*f*) is given by (*do* = object distance, *di* = image distance):

|  |  |
| --- | --- |
|  | lenson4 |

The object distance is from the object to the lens or mirror and the image distance is from the image to the lens or mirror.

Magnification, *m* is given by the following equations. (*Si* = image size, *So* = object size).                     

Power (*P*) of a lens of focal length (*f*):

, *P* is in diopter (D) when f is in m.

Make a sketch of the following lenses & mirrors below:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Convex Lens | Concave Lens | Plane Mirror | Concave Mirror | Convex Mirror |
|  |  |  |  |  |

|  |  |  |
| --- | --- | --- |
| Sign Convention | | |
| Object & Image distances------> | Real--------> (+) | Virtual------> (-) |
| Focal Lengths----------> | Convex lens & Concave mirror----> (+) | Concave lens & Convex mirror----> (-) |

A. Purpose: Investigate the difference between a convex lens and a concave lens in forming real images.

Apparatus: Optical bench and accessories w/translucent screen, convex lens (f = 5 cm), and concave lens.

Procedure: The light bulb is placed next to the object to illuminate it. Put the convex lens in the lens holder and place it in the optical bench so that the object distance is 10 cm. Move the screen and see whether you get a real image on the screen. Repeat the above procedure for other object distances and for the concave lens.

Data:

|  |  |  |
| --- | --- | --- |
| Object Distance (cm) | For convex lens (f =5 cm), Real image YES/NO | For concave lens,  Real image YES/NO |
| 10 | - | - |
| 20 | - | - |
| 30 | - | - |
| 40 | - | - |
| 50 | - | - |
| 60 | - | - |

Results (summarized):

B. Purpose: For convex lenses, investigate and find out the range of object distances for which there are real images, and predict a correlation between the focal length and object distances for real images.

Apparatus: Optical bench and accessories and convex lenses: f = 10, 15, 20, and 30 cm.

Data: Calculate the powers in diopter, D.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Power (D) | - | - | - | - |
| Object Distance (cm) | F = 10 cm,  Real image YES/NO | f = 15 cm,  Real image YES/NO | f = 20 cm,  Real image YES/NO | f = 30 cm,  Real image YES/NO |
| 5 | - | - | - | - |
| 10 | - | - | - | - |
| 15 | - | - | - | - |
| 20 | - | - | - | - |
| 25 | - | - | - | - |
| 30 | - | - | - | - |
| 35 | - | - | - | - |
| 40 | - | - | - | - |
| 50 | - | - | - | - |
| 60 | - | - | - | - |

Results (summarized):

C. Purpose: To investigate the magnifications of real images formed by a convex lens and determine the focal length.

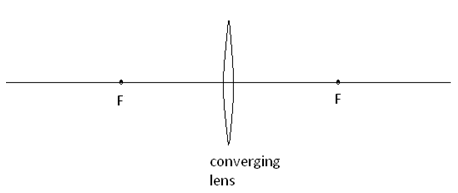
Apparatus: Convex lenses (f = 20 cm), optical bench & accessories, and foot ruler.

Procedure: Measure the object size. Place the 20-cm lens in the lens holder and set up the lens holder 30 cm from the object. Move the screen and obtain a sharp image. Measure the image distance and the image size. Calculate the following: focal length, magnification using image size and object size, and magnification using image distance and object distance. Repeat your measurements for object distances 35 cm, 40 cm, 45 cm, 50 cm, 55 cm, and 60 cm.

DATA Object size = so = \_\_\_\_\_\_\_\_\_\_\_\_\_

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Object  Distance, do (cm) | Image  Distance, di ( ) | Image Size, si ( ) | Focal Length, f ( ) | Magnification, |m| = si /so | Magnification, | m| = di /do |
| 30 |  |  |  |  |  |
| 35 |  |  |  |  |  |
| 40 |  |  |  |  |  |
| 45 |  |  |  |  |  |
| 50 |  |  |  |  |  |
| 55 |  |  |  |  |  |
| 60 |  |  |  |  |  |

Draw a ray diagram ([Help](https://www.youtube.com/watch?v=c6mLLaqLdvg&t=3s)) and show the formation of image for any one of the above cases.



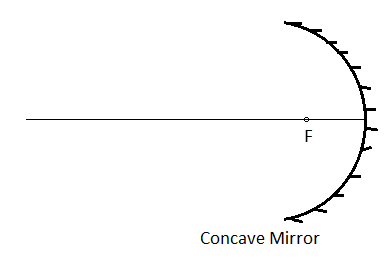
D. Purpose: To investigate the magnifications of real images formed by a concave mirror and determine the focal length.

Apparatus: Concave mirror, optical bench & accessories, opaque screen, and foot ruler.

Procedure: Measure the object size. Place the concave mirror in the mirror holder and set up the holder 35 cm from the object. Replace the translucent screen with an opaque screen and place it between the object and mirror. Move the screen and obtain a sharp image. Measure the image distance and the image size. Calculate the following: focal length, magnification using image size and object size, and magnification using image distance and object distance. Repeat your measurements for object distances 40 cm, 45 cm, 50 cm, 55 cm, and 60 cm.

DATA Object size = so = \_\_\_\_\_\_\_\_\_\_\_\_\_

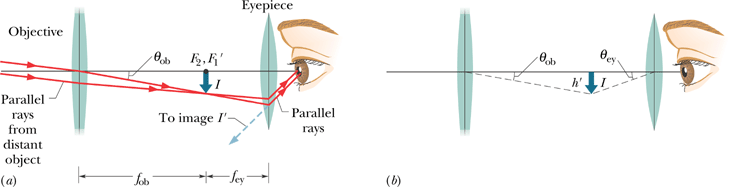
|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Object  Distance, do (cm) | Image  Distance, di ( ) | Image Size, si ( ) | Focal Length, f ( ) | Magnification, |m| = si /so | Magnification, | m| = di /do |
| 35 |  |  |  |  |  |
| 40 |  |  |  |  |  |
| 45 |  |  |  |  |  |
| 50 |  |  |  |  |  |
| 55 |  |  |  |  |  |
| 60 |  |  |  |  |  |

Draw a ray diagram (Help: [concave mirror](https://www.youtube.com/watch?v=7iK1nIJs49Y&t=2s)) and show the formation of image for any one of the above cases.  
 

E) **Astronomical telescope**1) Mount the two convex lenses (+ 10 and +20) so that the distance between them is 30 cm. If you look through the short-focus lens, you can see distant objects.

2) To measure the magnification of the telescope: look at a distant object ([blocks](BD.pdf) on the white board) through the telescope with one eye and directly at the blocks with the other eye. Move your eyes until the magnified image of the block is superimposed on the unmagnified blocks. Count the number of blocks viewed directly that cover exactly one of the magnified blocks. This number will give magnification.

3) Go to this (Measuring [Technique](http://www.ifa.hawaii.edu/~barnes/ASTR110L_F05/simplescopehelp.html)) website and see how to measure the magnification.



The angular magnification http://edugen.wiley.com/edugen/courses/crs1650/art/math/halliday8019c34/math067.gifof the telescope is http://edugen.wiley.com/edugen/courses/crs1650/art/math/halliday8019c34/math071.gif. From Fig. [34-21](http://edugen.wiley.com/edugen/courses/crs1650/reference/xlinks/halliday8019c34xlinks.xform?id=halliday8019c34-fig-0021)*b*, for rays close to the central axis, we can write http://edugen.wiley.com/edugen/courses/crs1650/art/math/halliday8019c34/math072.gifand http://edugen.wiley.com/edugen/courses/crs1650/art/math/halliday8019c34/math073.gif, which gives us

|  |  |
| --- | --- |
| http://edugen.wiley.com/edugen/courses/crs1650/art/common/pixel.gif | |
| http://edugen.wiley.com/edugen/courses/crs1650/art/math/halliday8019c34/math074.gif | (34-15) |
|  | |

where the minus sign indicates that *I*′ is inverted. In words, the angular magnification of a telescope is a comparison of the angle occupied by the image the telescope produces with the angle occupied by the distant object as seen without the telescope.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Focal length of the objective, *fob* | Focal length of the eyepiece, *fey* | Distance between objective & eyepiece | Absolute value of the magnification | | |
| Theoretical | Measured | % Error |
| 20 cm | 10 cm |  |  |  |  |
| 30 cm | 10 cm |  |  |  |  |
| 50 cm | 10 cm |  |  |  |  |

Conclusion (for C, D, and E):