Department of Education

Grade 10

Refraction of Light in Lenses
Second Quarter - Module 7

Adrian R. Suarnaba
Writer

Webena F. Gerona
Jinky Santos
Validators

Dr. Onofre C. Santos
Armida S. Oblinada
Quality Assurance Team

Schools Division Office – Muntinlupa City
Student Center for Life Skills Bldg., Centennial Ave., Brgy. Tunasan, Muntinlupa City
(02) 8805-9935 / (02) 8805-9940

EXPECTATIONS

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

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

Objectives:
1. Investigate the refraction properties of light using concave and convex lenses.
2. Distinguish between converging and diverging lenses.
3. Apply ray diagramming technique in describing images formed by lenses.
4. Derive and use lens equations in predicting the characteristics and position of an image formed by lenses.

PRE-TEST

Directions: Encircle the letter of the CORRECT answer.

1. What type of lens is wider in the middle than on the edges?
   A. Concave B. Convex C. Objective D. Ocular

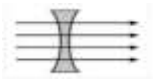
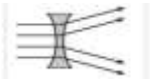
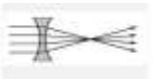
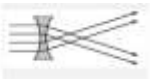
2. What do you call the distance between a convex lens and its focal point?
   A. Amplitude B. Focus C. Focal Length D. Wave length

3. In the lens equation, d_i represents
   A. distance of the object from the lens
   B. distance of the image from the lens
   C. height of the image
   D. height of the object

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

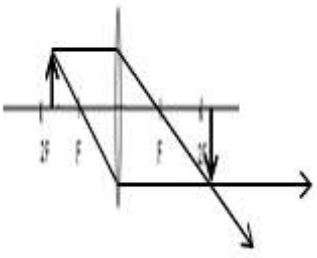
4. Bouncing of Light: Reflection, Bending of Light: _____
   A. Diffraction B. Dilation C. Interference D. Refraction

5. Which lens represents the path that light takes through a diverging lens?
   A. B. C. D.

Fort items # 6 to 7, refer to ray digram.

6. Where is the location of the image?
   A. At 2F C. Beyond 2F
   B. Between F & 2F D. No image formed



7. How do you describe the image orientation, size and type?
   A. inverted, reduced & real
   B. inverted, same size & real
   C. inverted, enlarged & real
   D. upright, enlarged & virtual

8. Where is the object located in convex lens if there is no image formed?

A. Between Vertex and Focus
B. Between 2F & F
C. At the Focus (F)
D. Beyond 2F

9. How do you describe the image if the object is placed at 2F from a convex lens?

A. The image formed between 2F and F is diminished and inverted.
B. The image formed at 2F is of the same height and inverted.
C. The image formed beyond 2F is reduced and upright.
D. There is no image formed.

10. What type of lens produces smaller and inverted images?

A. Concave lens
B. Convex Lens
C. Diverging Lens
D. Can't be determined

11. Evaluate the statements below:

1st - Convex lenses produce real and virtual images.
2nd - Concave lenses produce real images only.

A. 1st is True, 2nd is False
B. 1st is False, 2nd is True
C. Both are False
D. Both are True

12. A light ray, traveling parallel to a convex lens' axis and strikes the lens, will refract and _____.

A. continue to travel in the same direction
B. pass through the lens' focal point
C. travel at right angles to the principal axis
D. travel parallel to the principal axis

13. This optical instrument has 2 convex lenses and is used to observe tiny objects like cells.

A. Camera B. Microscope C. Oscilloscope D. Telescope

14. Which of the following optical instruments will be used to produce an enlarged virtual and upright object?

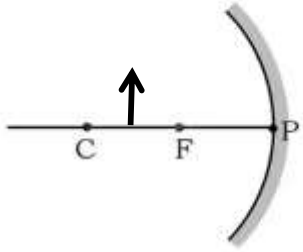
A. Binocular B. Camera C. Microscope D. Periscope

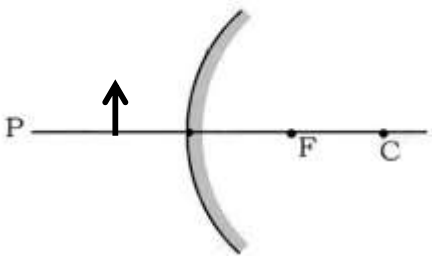
15. A photocopier ("Xerox" machine) produces an image that is of equal size as the object. Considering the location of an object in a convex lens, where is the object located or placed to produce an image that is of equal size to the object?

A. At F B. At 2F C. Between F' and V D. Between 2F' and F'

LOOKING BACK

Directions: Use the four principal rays to locate the image formed in curved mirrors and indicate its image LOST (Location, Orientation, Size, Type of Image).

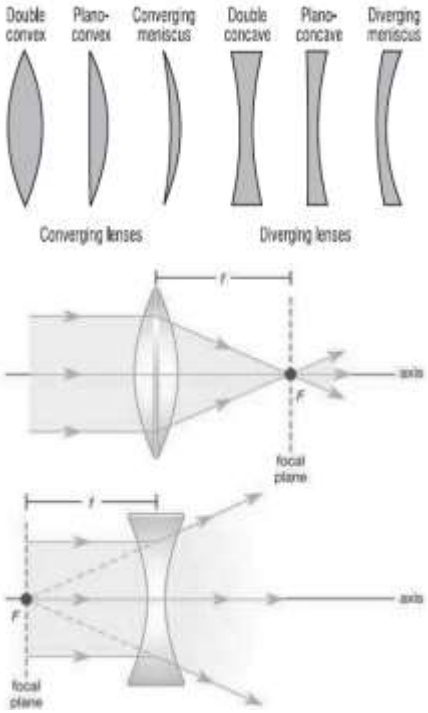




BRIEF INTRODUCTION

Refraction is the bending of light when it travels from one medium to another. Images are formed when light refracts as it encounters a boundary between two diferent materials. Look at the fish inside an aquarium. Do you know that what you see is not exactly the object but the image formed by refraction? Amazingly, we have a sense of sight due to refraction through two boundaries. Our eyes have lenses that form images that enable us to see the objects. A Lens is a transparent material made of glass or plastic that refracts light rays and focuses (or appear to focus) them at a point.

Types of Lenses



1. Convex Lens or Converging lens
- It is thicker in the center than edges.
- It forms real images and virtual images depending on position of the object.
- It is also called Converging Lens because the light that passes through it tends to converge at a particular point called the focal point.

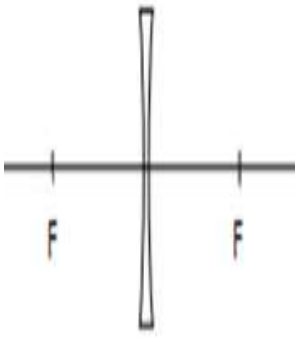
2. Concave Lens or Diverging Lens
- It is thicker at the edges and thinner in the center.
- It forms upright and reduced images.
- It is also called Diverging Lens because the light that passes through it tends to diverge at a particular point called the focal point.

Images Formed by Lenses

In locating the image formed in lenses graphically, two important points are considered. The following important points are enumerated below.

Verter V – The geometric center of the lens

Focal point / Focus, F – A point where light rays converge or appears to converge when parallel light rays pas through a lens. Its distance from the vertex is called the focal length.

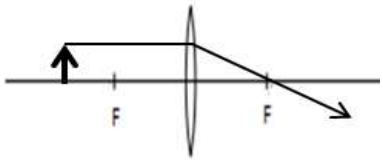


Ray Diagramming Involving Lenses

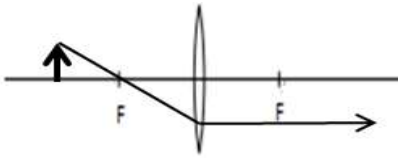
Image formed in a lens can be located and described through ray digrammng. Here are the three disctinct rays that will be used for convex and concave lenses:

Convex Lens (Converging Lens)

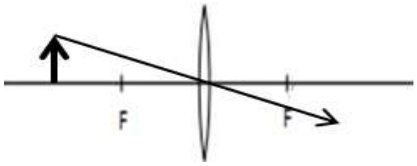
1. Parallel ray or P-F Ray A ray light parallel to the principal axis is refracted passing through the principal focus, F behind the lens.



2. Focal ray or F-P Ray A ray of light passing through the focus, F in front of the lens is refracted parallel to the principal axis.

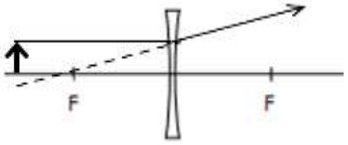


3. V Ray A ray of light passing through the exact center of the lens (vertex) continues to travel in the same direction

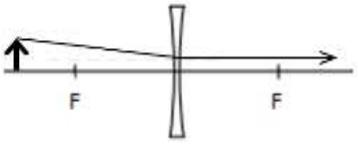


Concave Lens (Diverging Lens)

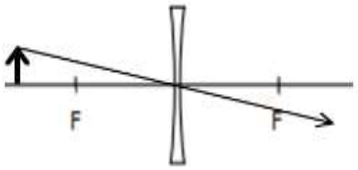
1. Parallel ray or P-F Ray A ray light parallel to the principal axis is refracted passing through the principal focus, F in front of the lens.



2. Focal ray or F-P Ray A ray of light directed towards the focus, F behind the lens is refracted parallel to the principal axis.



3. V Ray A ray of light passing through the exact center of the lens (vertex) continues to travel in the same direction



Consider the following steps using the three major rays to determine the position and kind of the image formed.

1. From the object, draw the first ray (P-F ray). From the same point on the object, draw the second (F-P ray), and the third (V ray).
2. The intersection of the rays is the image point corresponding to the object point. For example, if you started diagramming from the tip of the arrow-shaped object, the intersection of the refracted rays is also the tip of the arrow-shaped image. Thus, you can determine completely the position and characteristic of the image.
3. For a concave lens, light rays diverge from a virtual focus; but the procedure for locating images is the same as for convex lenses.

ACTIVITIES

Activity A: Ray Digramming in Lenses

Objectives:

- Construct ray diagrams for lenses.

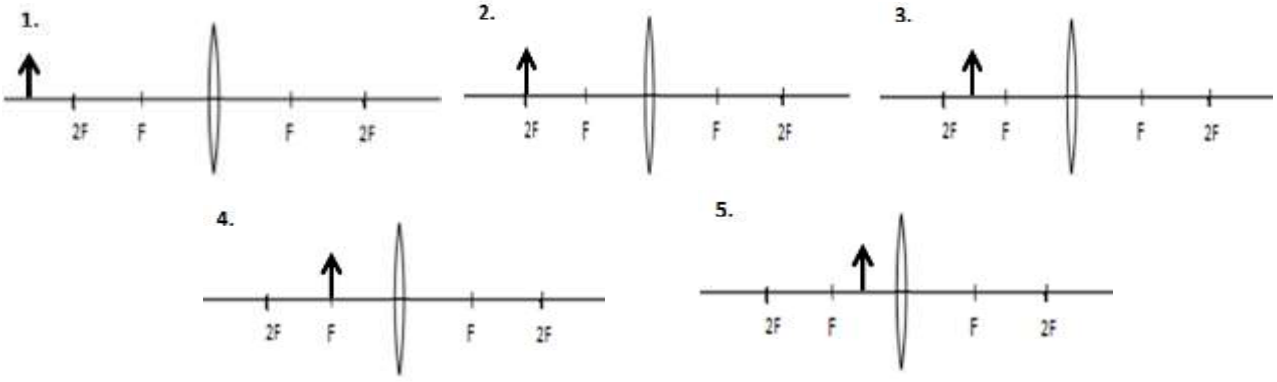
- Determine graphically the location, orientation, size, and type of image formed.
- Show in table the changes in the image formed as an object's position is changed.

Materials: Ruler and Protractor

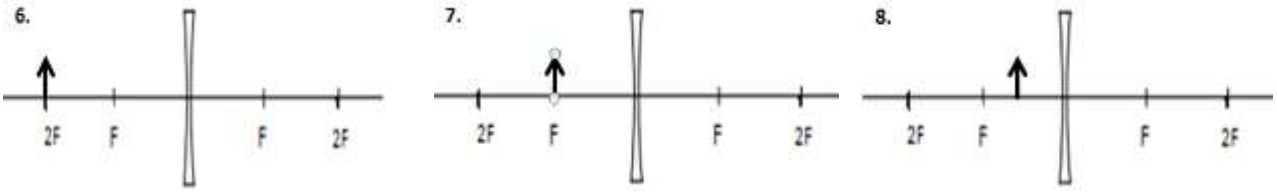
Procedure:

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

Convex Lens:



Concave Lens:



Location of Object	**Image**			
	Location	**O**rientation (upright or inverted)	**S**ize (same, reduced or enlarged)	**T**ype (Real or virtual)
Convex Lens 1. Beyond 2F'				
2. At 2F'				
3. Between 2F' and F'				
4. At the Focal Point, F'				
5. Between the F' and the V				
Concave Lens 6. At 2F'				
7. At the Focal point, F'				
8. Between F' and V				

Guide Question:

1. Refer to the table above, how does the image change in its size and location, as the object comes nearer the convex lens? concave lens? _____

_____

2. Why is it impossible for a concave lens to form a real image? _____

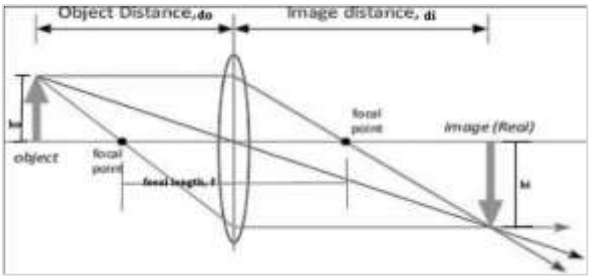
_____

The Lens Equation

Ray diagram does not provide exact location and numerical information about the image formed in lenses, as in the image formed in curved mirrors through ray diagram. To determine the exact location and size of the image formed in lenses, a lens equation is needed. The following is the lens equation using the results from ray diagram.

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} \qquad M = \frac{h_i}{h_o} = \frac{-d_i}{d_o}$$

ere:



focal length or distance from the mid part of the lenses to the focal point, F
d_o = distance of the object from the lens
d_i = distance of the image from the lens
M = magnification
h_o = height of object
h_i = height of image

The equation above, called lens equation, applies to both convex and concave lenses. However, in the case of concave lens, the image will always be located on the side where the object is also located. It is therefore considered that the value of image distance, d_i is negative. The focal length, f, in a concave lens is negative while positive in a convex lens.

Sample Problem

What is the image distance and image size if a 5.00-cm tall light bulb is placed a distance of 45.5 cm from a convex lens having a focal length of 15.4 cm?
Given: $h_o = 5.00$ cm, $d_o = 45.5$ cm, $f = 15.4$ cm Find: d_i and h_i

Distance of the image, d_i

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

$$\frac{1}{(15.4\ cm)} = \frac{1}{45.5\ cm} = \frac{1}{d_i}$$

$$\frac{1}{(15.4\ cm)} - \frac{1}{(45.5\ cm)} = \frac{1}{d_i}$$

$$\frac{(45.5\ cm - 15.4\ cm)}{(15.4\ cm)(45.5\ cm)} = \frac{1}{d_i}$$

$$d_i = 23.3\ cm$$

Height of the image, h_i

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

$$\frac{h_i}{5.0\ cm} = \frac{-23.3\ cm}{45.5\ cm}$$

$$h_i = \frac{(5.0\ cm)(-23.3\ cm)}{45.5\ cm}$$

$$h_i = -2.54\ cm$$

The Sign Convention for Lenses

- f is (+) if the lens is a double convex lens (converging lens)
- f is (-) if the lens is a double concave lens (diverging lens)
- d_i is (+) if the image is a real image and located behind the lenses
- d_i is (-) if the image is a virtual image and located on the object's side of the lens
- h_i is (+) if the image is an upright image (and therefore, also virtual)
- h_i is (-) if the image an inverted image (and therefore, also real)

Activity B: Lens Equation and Magnification

Directions: Solve the following lens problems. Write your solution on a separate paper.

1. A tree 20 m high is located 40 m from the converging lens of focal length 0.08 m. Calculate the distance from the lens to the image.
2. Determine the image distance and image height for 7.00 cm tall object placed 45.5 from a concave lens having a focal length of -16.0 cm.
3. A magnified, inverted image is located a distance of 36.0 cm from a converging lens with a focal length of 10.0 cm. Determine the object distance and tell whether the image is real or virtual.
4. Determine the image distance and image height for a 5.8-cm tall object placed 24.0-cm from a converging lens having a focal length of 15.0 cm.
5. A diverging lens has a focal length of -15.8 cm. An object is placed 40 cm from the lens's surface. Determine the image distance.

REMEMBER

- **REFRACTION** is the bending of light when it travels from one medium to another.
- **LENS** is a transparent material made of glass or plastic that refracts light rays and focuses (or appear to focus) them at a point.

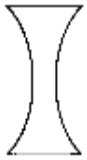
CHECK YOUR UNDERSTANDING

Directions: Refer to the size of object and the size of image from the drawn ray digrams for convex lens. Identify the location of object in which the following optical instruments are used. Complete the table with the choices from the box below and describe why you chose that answer.

At infinity	Beyond 2F'	At2F	Between 2F' and F'	Between F and V

Optical Instrument	Location of Object	Description
Photocopier ("Xerox" Machine)		
Camera		
Telescope		
Projector		
Magnifying Glass		

POST TEST



1. What type of lens is shown in the figure?
   A. Concave B. Convex C. Objective D. Ocular

2. What does light that passes through a convex lens do?
   A. Converge, or come together
   B. Create a rainbow
   C. Diverge, or spread apart
   D. Reflect, or bounce off

3. Which of the following best describes a converging lens?
   A. A lens that causes light rays to scatter.
   B. A lens that causes light rays to reflect.
   C. A lens that will cause light rays to bend to a specific focal point.
   D. A lens that will cause light rays from a specific focal point to spread out.

4. The principal axis is a _____ line drawn through the center of the lens.
   A. horizontal B. vertical C. 45 degree D. 90 degree

5. Which lens represents the path that light takes through a converging lens?
   A. B. C. D.

6. Which of the following statements does NOT describe a convex lens?
   A. The rays converge at a common point.
   B. The image formed can be both real and virtual.
   C. The rays incident on the lens diverged when refracted.
   D. The lens is thicker at the middle and thinner at the edges.

7. How do you describe the image of the object placed at the focus of a concave lens?
   A. The image formed at 2F is of the same height and erect.
   B. The image formed between F and V is reduced and upright.
   C. The image formed beyond 2F is magnified and upright.
   D. No image is formed.

8. Which of the following is/are true of a convex lens?
   I. It will form real and virtual images.
   II. The image formed has the same size when object is placed at 2F.
   III. It produces upright images in all locations of the object.

   A. I only B. II only C. I and II D. All are True

9. A light ray traveling parallel to the axis of a convex lens strikes the lens. What happens to this ray after traveling through the lens?
   A. It travels crossing the axis at a point equal to twice the focal length.
   B. It travels to the axis passing between the lens and its focal point.
   C. It travels to the axis passing through its focal point.
   D. It travels parallel to the principal axis.

10. An optical instrument that produces upright and enlarged images when the object is in between focal point and the vertex is _____.
   A. Magnifying Glass B. Microscope C.Photocopier D. Projector

11. A convex lens has a focal length of 25.5 cm. If an object is placed 72.5 cm from the lens, the image's distance from the lens will be _____.

A. 31.7 cm B. 33.5 cm C. 39.3 cm D. 40.2 cm

12. A converging lens has a focal length of 30 cm. A 5-cm tall candle is placed at a distance of 10 cm in front of the lens. Determine the image distance.

A. - 45 cm B. -30 cm C. -15 cm D. 6 cm

13. What is the image distance if a candle is placed on the principal axis of a convex lens at a distance of 30 cm from the lens? The focal length of the lens is 10 cm.

A. 10 cm B. 15 cm C. 20 cm D. 30 cm

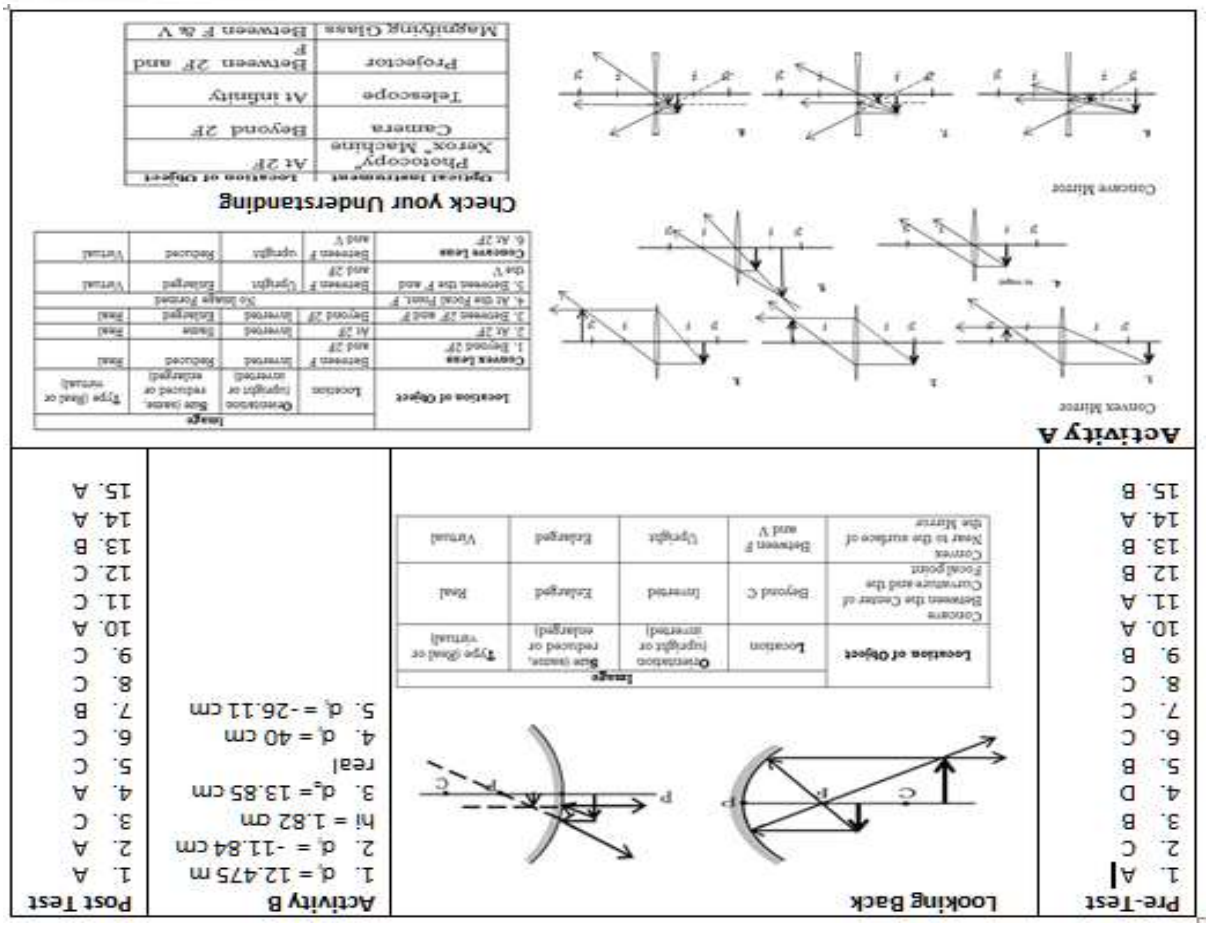
14. Compute the height of the formed image in #13 if the candle is 5 cm tall.

A. – 2.5 cm B. -10 cm C. 2 cm D. 10 cm

15. The image formed in #13 will be

A. Real, inverted, and reduced
B. Real, inverted, and enlarged
C. Real, upright, and enlarged
D. Virtual, upright, and enlarged

Answer Key



Reference

Grade 10 DepEd Learning Material pp. 194-208

Aquino, Marites D., Valdoz,Meliza P., Biong, Jonna A., Andaya,Mylene O., Science Links 10, Rex Book Store, 2015, pp. 146-148

http://www.physics.louisville.edu/cldavis/phys299/notes/lo_lenses.html

https://www.best-home-remedies.com/eyes_disorders/refractive_error.htm