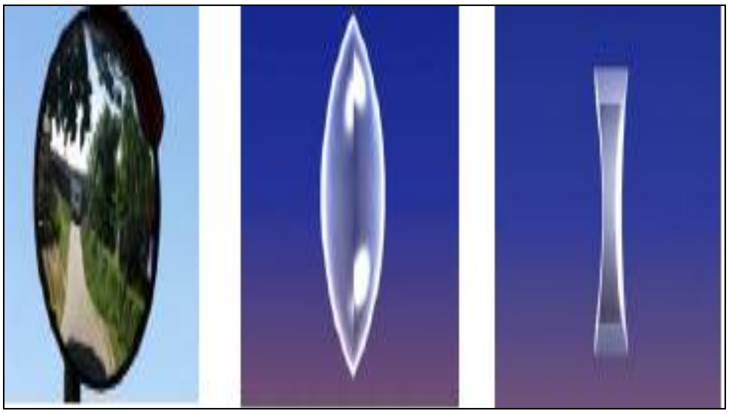
Kirkuk University

Science College

Physics Department

Lectures of GEOMETRIC OPTICS

Lecture – 15 –



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Lecture 15: Diverging Lenses (double concave lens) -Part 2

15 - 1 Image Characteristics of Diverging concave Lenses (double concave lens)

- Ray diagrams were constructed in order to determine the location, size, orientation, and type of image formed by double concave lenses (i.e., diverging lenses).
- The ray diagram constructed earlier for a diverging lens revealed that the image of the object was virtual, upright, reduced in size and located on the same side of the lens as the object.
- But will these always be the characteristics of an image produced by a double concave lens? Can concave lenses produce real images? Inverted images? Magnified Images?
- To answer these questions, we will look at three different ray diagrams for objects positioned at different locations along the principal axis in front of double concave lenses, as shown in Fig.(**15-1**) .

- Note that only two sets of incident and refracted rays were used in the diagram in order to avoid overcrowding the diagram with rays.

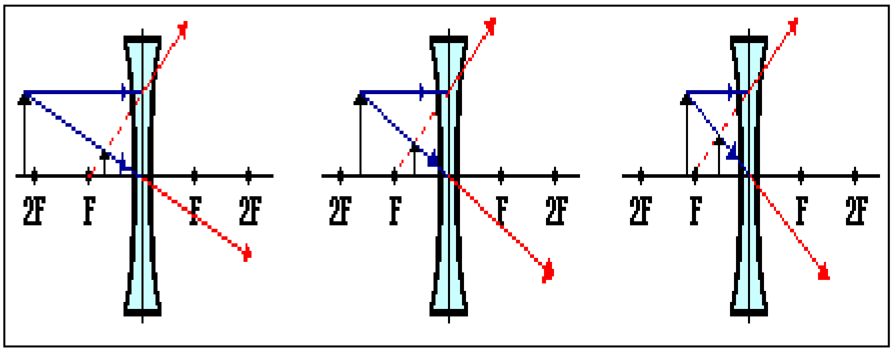

Fig.(15-1) : The three different ray diagrams for objects positioned at different locations along the principal axis in front of concave lenses

- The diagrams above show that in each case, the image is :

- Located on the object' side of the lens.
- A virtual image.
- An upright image.
- Reduced in size (i.e., smaller than the object).

- Unlike converging lenses, diverging lenses always produce images that share these characteristics.
- As such, the characteristics of the images formed by diverging lenses are easily predictable.

- Another characteristic of the images of objects formed by diverging lenses pertains to how a variation in object distance affects the image distance and size.
- The Fig.(**15-2**) below shows five different object locations in front of concave lens and their corresponding image locations.

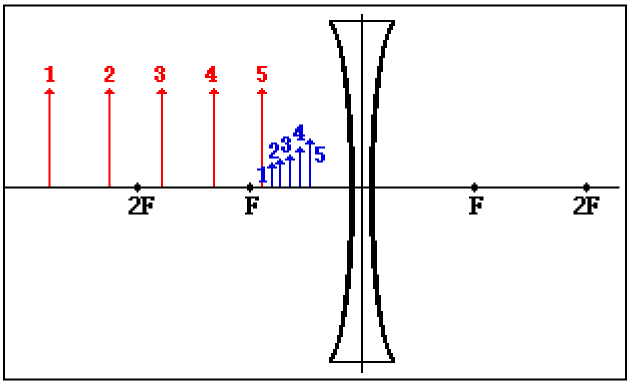

Fig.(15-2) : Five different object locations in front of concave lens and their corresponding image locations

- The Fig.(**15-2**) above shows that as the object distance is decreased, the image distance is decreased and the image size is increased.
- So as an object approaches the lens, its virtual image on the same side of the lens approaches the lens as well; and at the same time, the image becomes larger.

15 - 2 The Mathematics of Diverging concave Lenses (double concave lens)

- Ray diagrams can be used to determine the image location, size, orientation and type of image formed of objects when placed at a given location in front of a lens.
- The use of these diagrams was demonstrated earlier in past lectures for both converging and diverging lenses.
- Ray diagrams provide useful information about object-image relationships, yet fail to provide the information in a quantitative form.
- While a ray diagram may help one determine the approximate location and size of the image, it will not provide numerical information about image distance and image size.
- To obtain this type of numerical information, it is necessary to use the **Lens Equation** and the **Magnification Equation.**
- The lens equation expresses the quantitative relationship between the object distance ($d_\circ$), the image distance (d_i), and the focal length (f).
- The equation is stated as follows:

$$\frac{1}{f} = \frac{1}{d_\circ} + \frac{1}{d_i} \quad ...(15-1)$$

- The magnification equation relates the ratio of the image distance and object distance to the ratio of the image height (h_i) and object height (h_o).
- The magnification equation is stated as follows:

$$M = \frac{h_i}{h_\circ} = -\frac{d_i}{d_\circ} \quad ...(15-2)$$

- These two equations can be combined to yield information about the image distance and image height if the object distance, object height, and focal length are known.
- As a demonstration of the effectiveness of the lens equation and magnification equation, consider the examples and its solution in the next lecture.

15 – 3 The Sign Conventions of Diverging concave Lenses (double concave lens)

- The sign conventions for the given quantities in the lens equation and magnification equations are as follows:

- (f) is ($-$) if the lens is a (diverging lens).
- (d_i) is ($-$) if the image is a virtual image and located on the object' side of the lens.
- (h_i) is ($+$) if the image is an upright image (and therefore, also virtual).
- (M) is ($+$), image is upright.