Kirkuk University

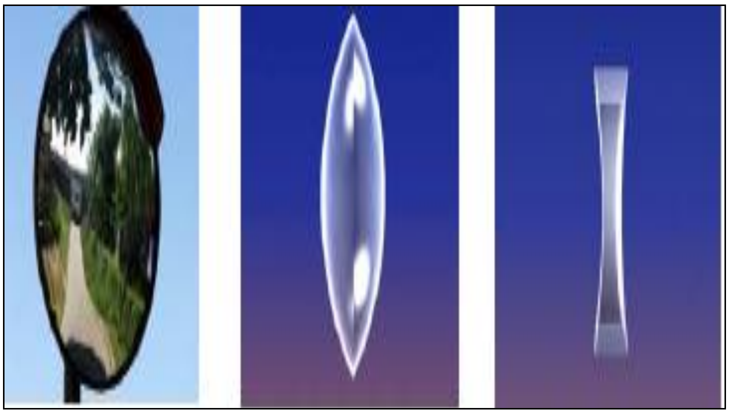
Science College

Physics Department

Lectures of

GEOMETRIC OPTICS

Lecture – 12 –



Assistant professor Dr.Jawdet Hedayet Mohammed

Lecturer in Kirkuk University

Science College – Physics Department

Lecture 12: Converging Lenses (double convex lens) – Part 2

12 - 1 Ray Diagrams of Converging Lenses (double convex lens)
12 - 2 The Mathematics of Converging Lenses (double convex lens)
12 – 3 The +/- Sign Conventions for Converging Lenses (double convex lens)

12 – 1 Ray Diagrams of Converging Lenses (double convex lens)

Case 1: The object is located *beyond* 2F

- When the object is located at a location beyond the **2F** point, the image will always be located somewhere in between the **2F** point and the focal point (**F**) on the other side of the lens, as shown in Fig.(**12-1**).

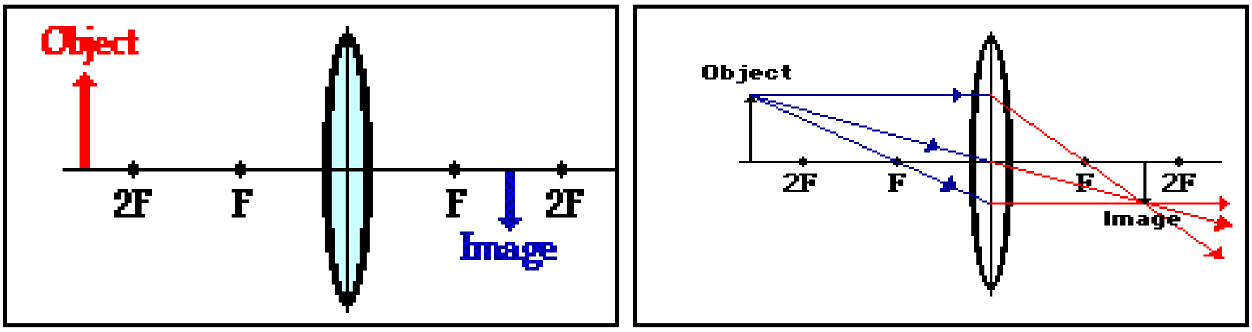


Fig.(12-1) : The object is located at a location beyond the 2F point

- Regardless of exactly where the object is located, the image will be located in this specified region**.**
- In this case, the image will be an **inverted image.**
- In this case, the image is **reduced in size**; in other words, the image dimensions are smaller than the object dimensions**.**
- Earlier in past lectures, the term magnification was introduced; the **magnification** is the ratio of the height of the image to the height of the object**.**
- In this case, the magnification is a number with an absolute value **less than 1.**
- Finally, the image is a **real image.**

Case 2: The object is located at 2F

- When the object is located at the **2F** point, the image will also be located at the **2F** point on the other side of the lens, as shown in Fig.(**12-2**) and Fig.(**12-4a**).

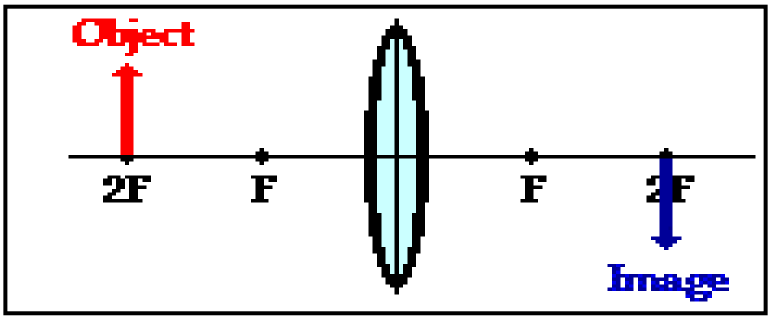


Fig.(12-2) : The object is located at the 2F point

- In this case, the image will be **inverted.**
- The image dimensions are equal to the object dimensions**.**
- The absolute value of the magnification is **exactly 1.**
- Finally, the image is a **real image.**

Case 3: The object is located between 2F and F

- When the object is located *in front of* the **2F** point, the image will be located *beyond* the **2F** point on the other side of the lens, as shown in Fig. (**12-3**) and Fig.(**12-4b**) **.**

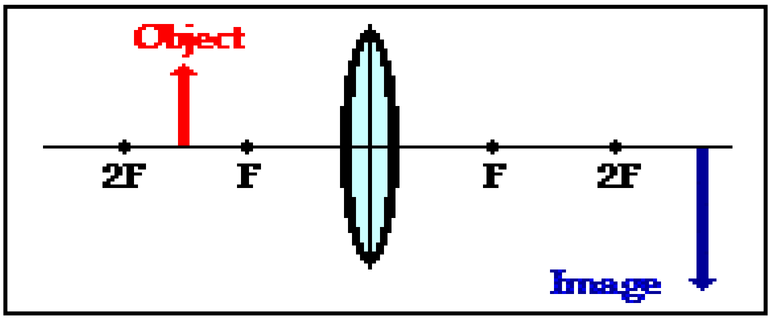
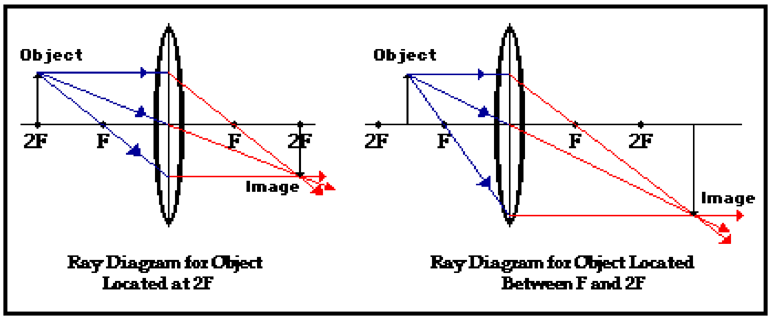


Fig.(12-3) : The object is located *in front of* the 2F point

- Regardless of exactly where the object is located between **2F** and **F**, the image will be located in the specified region**.**
- In this case, the image will be **inverted.**
- The image dimensions are larger than the object dimensions**.**
- The absolute value of the magnification is **greater than 1.**
- Finally, the image is a **real image.**



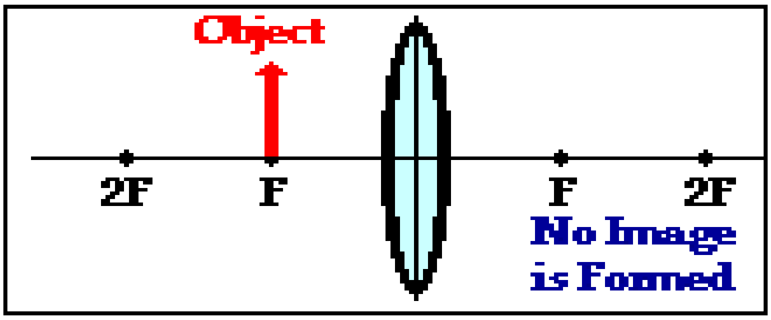
(12-4a) (12- 4b)

Fig.(12-4a) : The object is located at the 2F point

Fig.(12-4b) : The object is located *in front of* the 2F point

Case 4: The object is located at F

- When the object is located at the focal point, no image is formed, as shown in Fig.(**12-5**).



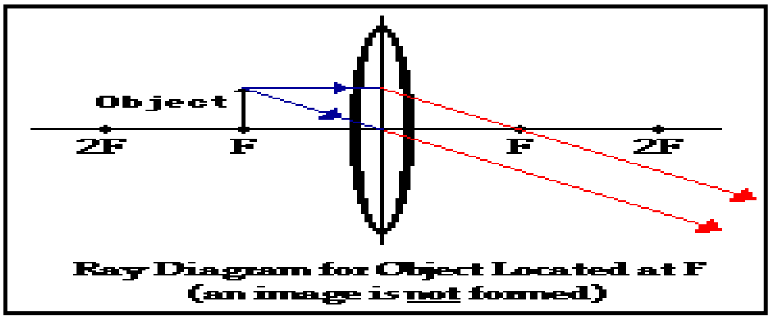


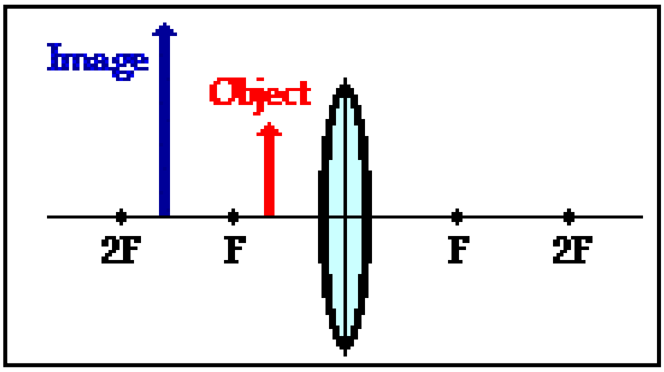
Fig.(12-5) : The object is located at the F point

- As discussed in past lectures, the refracted rays neither converge nor diverge**.**

- After refracting, the light rays are traveling parallel to each other and cannot produce an image**.**

Case 5: The object is located *in front of F*

- When the object is located at a location in front of the focal point, the image will always be located somewhere on the same side of the lens as the object, as shown in Fig.(**12-6**).



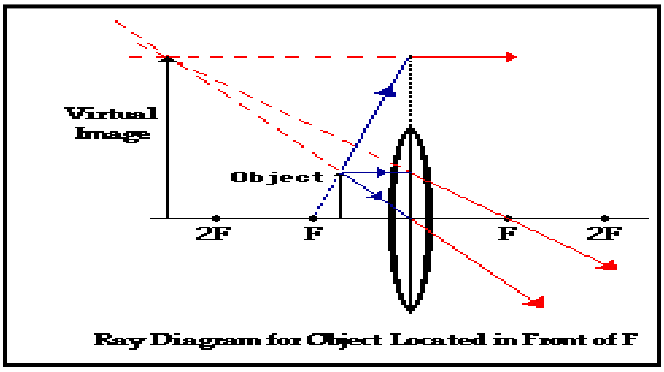


Fig.(12-6) : The object is located at a location in front of the focal point

- Regardless of exactly where in front of **F** the object is located, the image will always be located on the object's side of the lens and somewhere further from the lens.
- In this case, the image will be an **upright image.**
- In this case, the image is **enlarged**; in other words, the image dimensions are greater than the object dimensions.
- The magnification is **greater than 1.**
- Finally, the image is a **virtual image.**
- Light rays diverge upon refraction; for this reason, the image location can only be found by extending the refracted rays backwards on the object's side the lens.
- The point of their intersection is the virtual image location.

12 - 2 The Mathematics of Converging Lenses (double convex 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 Mirrors.
- 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 in Fig.(**12-7**):

$$\frac{1}{f}=\frac{1}{d_\circ}+\frac{1}{d_i}\quad ...(12-1)$$

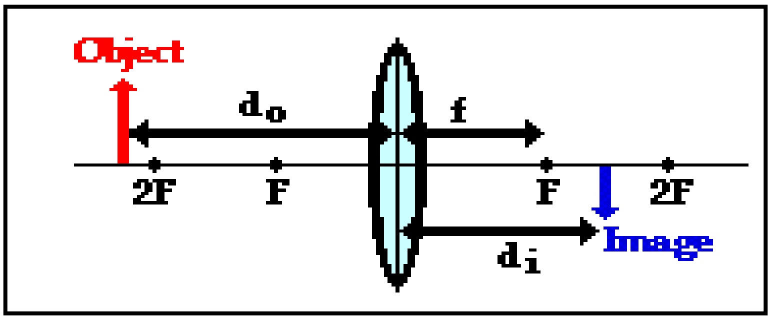


Fig.(12-7) : The Variables of Lens Equation – Converging Lens

- 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:

$$M=\frac{h_i}{h_\circ}=-\frac{d_i}{d_\circ}\quad ...(12-2)$$

- 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.

12 – 3 The +/- Sign Conventions for Converging Lenses (double convex 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 (converging lens)**.**
- (d_i) is ($+$) if the image is a real image and located in back of lens (or on the other side of the lens)**.**
- (d_i) is ($-$) if the image is a virtual image and located in front of lens (or on the same side of the lens as the object)**.**
- (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)**.**
- (M) is ($+$), image is **upright.**
- (M) is ($-$), image is **inverted.**