Kirkuk University

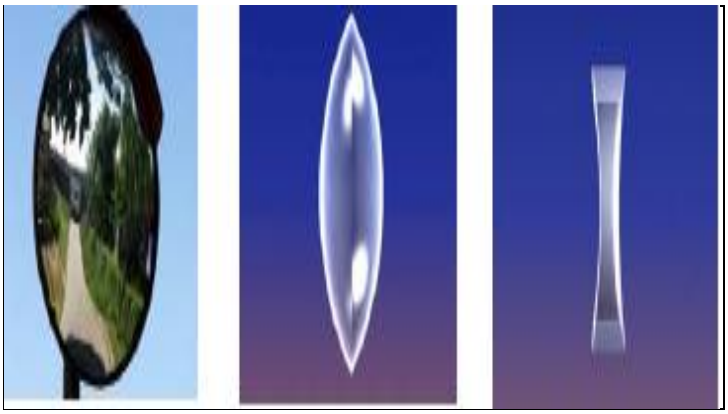
Science College

Physics Department

Lectures of

GEOMETRIC OPTICS

Lecture – 14 –



Assistant professor Dr.Jawdet Hedayet Mohammed

Lecturer in Kirkuk University

Science College – Physics Department

Lecture 14: Diverging Lenses (double concave lens) -Part 1

14 - 1 The Anatomy of Diverging concave Lenses (double concave lens)
14 - 2 Rules of Refraction for Diverging concave Lenses (double concave lens)
14 – 3 *Ray Diagrams for Diverging Lenses (double concave lens)*

14-1 The Anatomy of Diverging Lenses (double concave lens)

- In this Lecture, we will categorize lenses as diverging lenses**.**
- A diverging lens is a lens that diverges rays of light that are traveling parallel to its principal axis**.**
- Diverging lenses can also be identified by their shape; they are relatively thin across their middle and thick at their upper and lower edges, as shown in Fig.(**14-1**)**.**

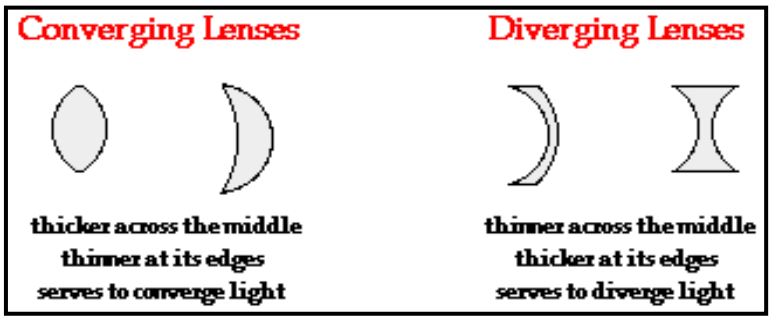


Fig.(14-1) : The two types of lenses

- A double concave lens is also symmetrical across both its horizontal and vertical axis**.**
- The fact that a double concave lens is thinner across its middle is an indicator that it will diverge rays of light that travel parallel to its principal axis**.**
- A double concave lens is a diverging lens**.**

14-2 Rules of Refraction for Diverging Lenses (double concave lens)

- Now let's investigate the refraction of light by double concave lens**.**
- Suppose that several rays of light approach the lens; and suppose that these rays of light are traveling parallel to the principle axis **.**
- Upon reaching the front face of the lens, each ray of light will refract towards the normal to the surface**.**
- At this boundary, the light ray is passing from air into a more dense medium (for example glass)**.**
- Since the light ray is passing from a medium in which it travels relatively fast into a medium in which it travels relatively slow, it will bend towards the normal line**.**
- This is shown for two incident rays in the Fig.(**14-2**) below**.**
- Once the light ray refracts across the boundary and enters the lens, it travels in a straight line until it reaches the back face of the lens**.**
- At this boundary, each ray of light will refract away from the normal to the surface**.**
- Since the light ray is passing from a medium in which it travels relatively slow to a medium in which it travels fast, it will bend away from the normal line**.**

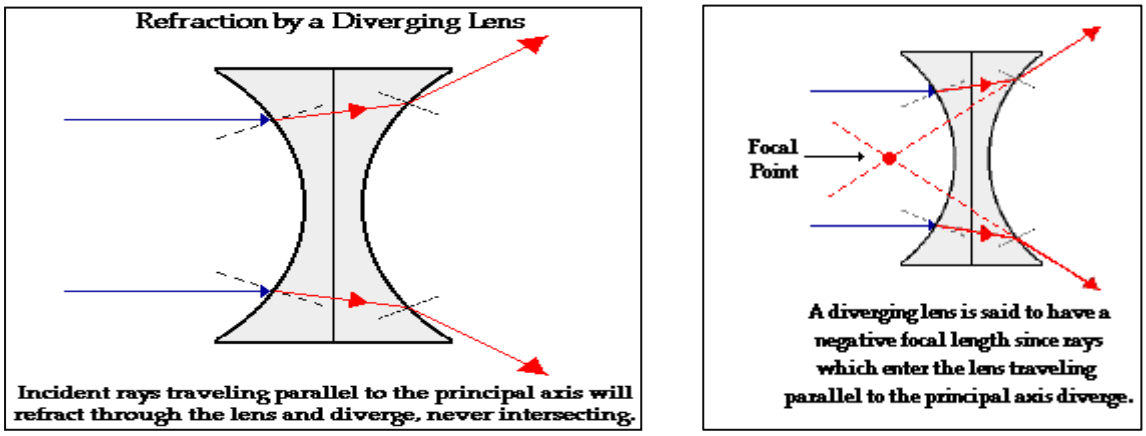


Fig.(14-2) : The behavior of two Incident rays travel parallel to the principal axis of Diverging Lens

- The above diagram shows the behavior of two incident rays approaching parallel to the principal axis of the double concave lens**.**
- Light bends towards the normal when entering and away from the normal when exiting the lens**.**
- Yet, because of the different shape of the double concave lens, these incident rays are not converged to a point upon refraction through the lens**.**
- Rather, these incident rays diverge upon refracting through the lens**.**
- For this reason, a double concave lens can never produce a real image**.**
- Double concave lenses produce images that are virtual**.**
- If the refracted rays are extended backwards behind the lens, an important observation is made**.**
- The extension of the refracted rays will intersect at a point**.**
- This point is known as the focal point**.**
- Notice that a diverging lens such as this double concave lens does not really focus the incident light rays that are parallel to the principal axis; rather, it diverges these light rays**.**
- For this reason, a diverging lens is said to have a negative focal length**.**
- The first generalization can now be made for the refraction of light by a double concave lens**:-**

1- Any incident ray traveling parallel to the principal axis of a diverging lens will refract through the lens and travel in a direction such that its extension will pass through the focal point**.**

- Now suppose that the rays of light are traveling towards the focal point on the way to the lens**.**
- Because of the negative focal length for double concave lenses, the light rays will head towards the focal point on the opposite side of the lens**.**
- These rays will actually reach the lens before they reach the focal point.
- These rays of light will refract when they enter the lens and refract when they leave the lens**.**
- As the light rays enter into the more dense lens material, they refract towards the normal; and as they exit into the less dense air, they refract away from the normal**.**
- These specific rays will exit the lens traveling parallel to the principal axis, as shown in Fig.(**14-3**) below**.**

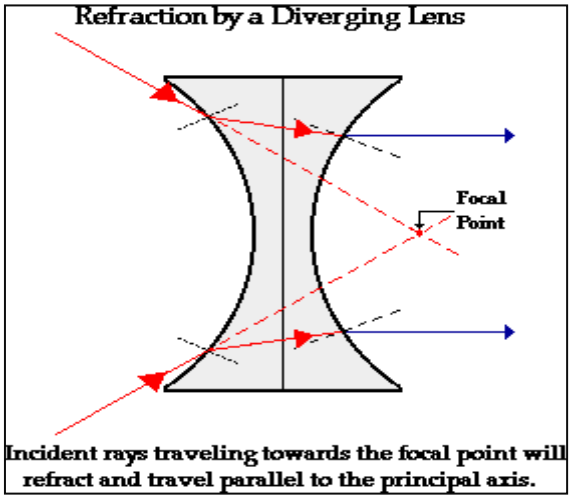


Fig.(14-3) : The behavior of two Incident rays traveling towards the focal point on the way to the diverging Lens

- The above diagram shows the behavior of two incident rays traveling towards the focal point on the way to the diverging Lens**.**
- Note that the two rays refract parallel to the principal axis**.**
- A second generalization for the refraction of light by a double concave lens can be added to the first generalization**.**

2- Any incident ray traveling towards a diverging lens such that its extension passes through the focal point will refract and travel parallel to the principal axis**.**

A Third Rule of Refraction for Lenses

- The above discussion focuses on the manner in which diverging lenses refract incident rays that are traveling parallel to the principal axis or are traveling through (or towards) the focal point**.**
- But these are not the only two possible incident rays**.**
- There are a multitude of incident rays that strike the lens and refract in a variety of ways**.**
- Yet, there are three specific rays that behave in a very predictable manner**.**
- The third ray that we will investigate is the ray that passes through the precise center of the lens - through the point where the principal axis and the vertical axis intersect**.**
- This ray will refract as it enters and refract as it exits the lens, but the net affect of this dual refraction is that the path of the light ray is not changed**.**

- For a lens, the refracted ray is traveling in the same direction as the incident ray and is approximately in line with it**.**
- The behavior of this third incident ray is depicted in the Fig.(**14-4**) below**.**

3- Any incident ray traveling through the exact center of the lens will continue to travel in the same direction after refracting through the lens**.**

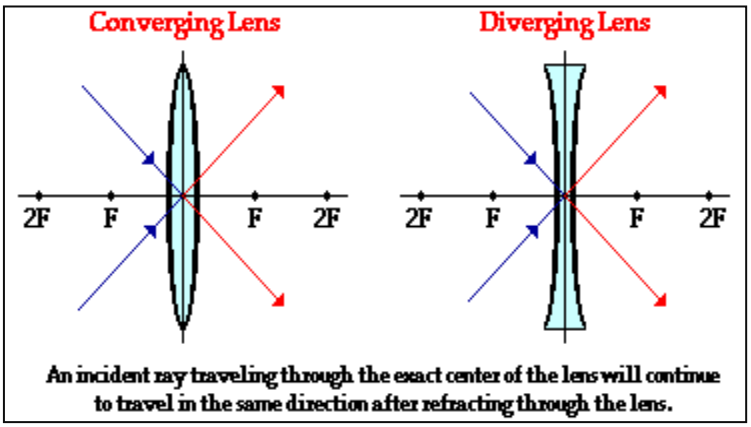


Fig.(14-4) : The behavior of Incident rays that passes through the precise center of the lens Converging and Diverging Lenses

14 - 3 Ray Diagrams for Diverging Lenses (double concave lens)

- In the first section of Lecture **14**, we learned that there are three simple rules of ray refraction for double concave lens**.**
- These three rules will be used to construct ray diagrams**.**
- A ray diagram is a tool that is used to determine the location, size, orientation, and type of image formed by a lens**.**
- The method for constructing ray diagrams for double concave lens shown in the following steps **:**

1. Pick a point on the top of the object and draw three incident rays traveling towards the lens, as shown in Fig (**14-5**)**.**

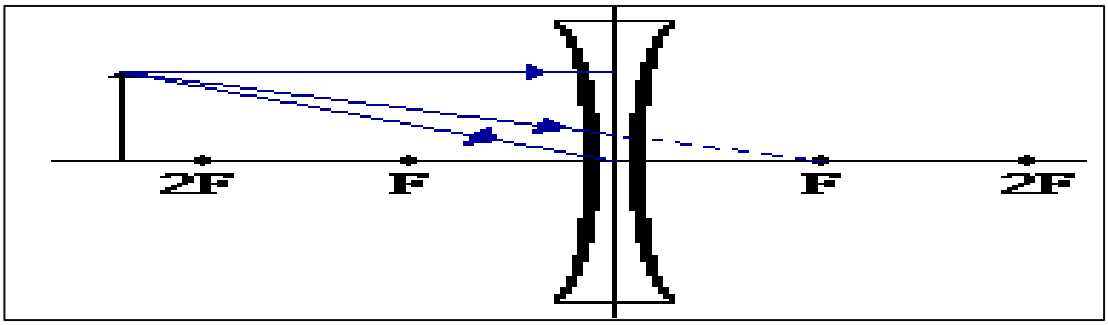


Fig.(14-5) : First step of the method of drawing ray diagrams for double concave lens

2. Once these incident rays strike the lens, refract them according to the three rules of refraction for double concave lens, as shown in Fig.(**14-6**)**.**

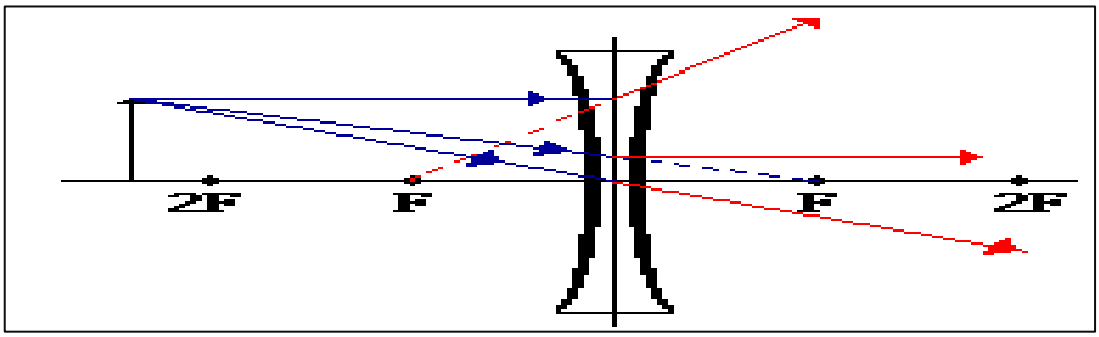


Fig.(14-6) : Second step of the method of drawing ray diagrams for double concave lens

3. Locate and mark the image of the top of the object**.**

- The image point of the top of the object is the point where the three refracted rays intersect**,** as shown in Fig.(**14-7**) **.**

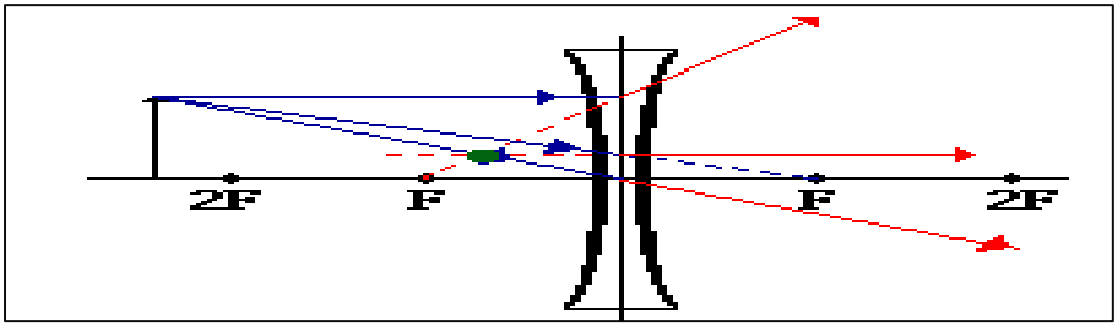


Fig.(14-7) : Third step of the method of drawing ray diagrams for double concave lens

- The goal of a ray diagram is to determine the location, size, orientation, and type of image that is formed by the double concave lens**.**
- The bottom of the object lies upon the principal axis (as it does in below diagram), then the image of this point will also lie upon the principal axis and be the same distance from the lens as the image of the top of the object**.**
- At this point we can obtain the complete image, as shown in Fig (**14-8**)**.**

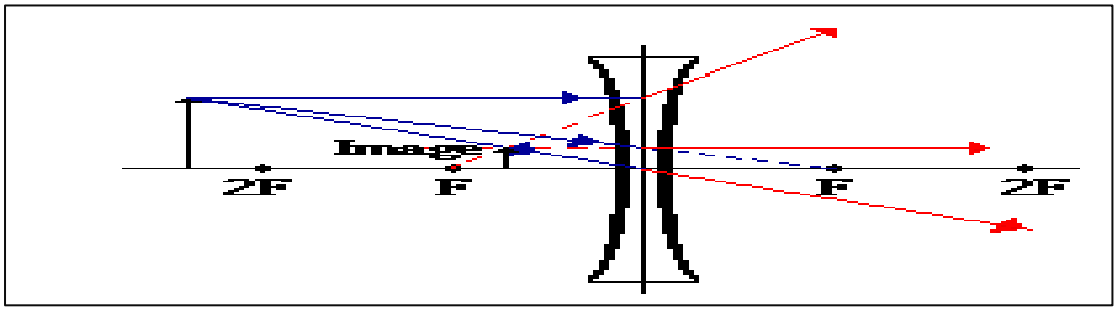


Fig.(14-8) : The complete image for double concave lens

- The ray diagram for a double concave lens reveal that the image of the object was virtual, upright, reduced in size and located on the same side of the lens as the object**.**