Kirkuk University

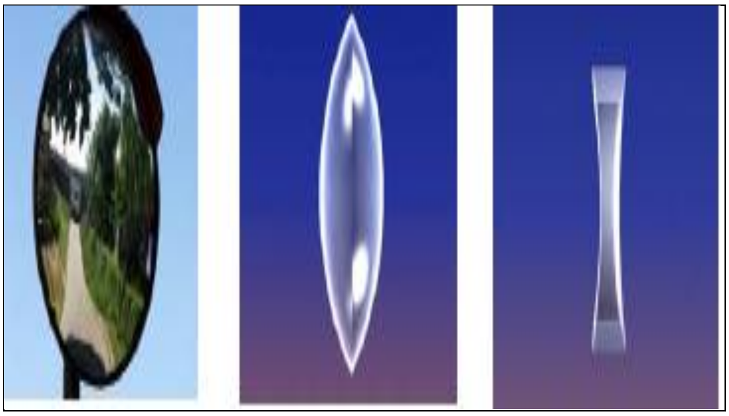
Science College

Physics Department

Lectures of

GEOMETRIC OPTICS

Lecture – 20 –



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Lecture 20: The Optical Devices

20-1 Angular magnification (magnifying power), ***Ma***
20-2 Compound Microscope
20-3 Astronomical (refracting) Telescope
20-4 Magnifier

20. Optical Devices

- There are **3** optical devices that extend human vision**.**
- It is **magnifier, compound microscope** and **telescope.**

20-1 Angular magnification (magnifying power), Ma

- The angular magnification of an optical device is defined *as the ratio of the angle subtended at the eye by the image ,* **β** *to the angle subtended at the unaided eye by the object (without lens),* **α.**
- In order to determine the angle α it is necessary to specify the position of the object**.**
- For **microscope**, the best object position is at the **near point.**
- For telescope, the object position is not meaningful because the telescope is used for viewing distant object**.**
- Near point is defined as *the nearest point at which an object is seen most clearly by the human eye***.**
- The distance between the near point to the eye is **25 cm** and is known as distance of distinct vision (***D***)**.**

20-2 Compound Microscope

- Because it makes use of two lenses, the magnifying power of the compound microscope is much greater than that of the magnifier.
- The two lenses are converging lens and is known as objective lens (close to the object) and eyepiece lens (close to the eye).
- The figure (**20-1**) below shows the schematic diagram of the compound microscope.

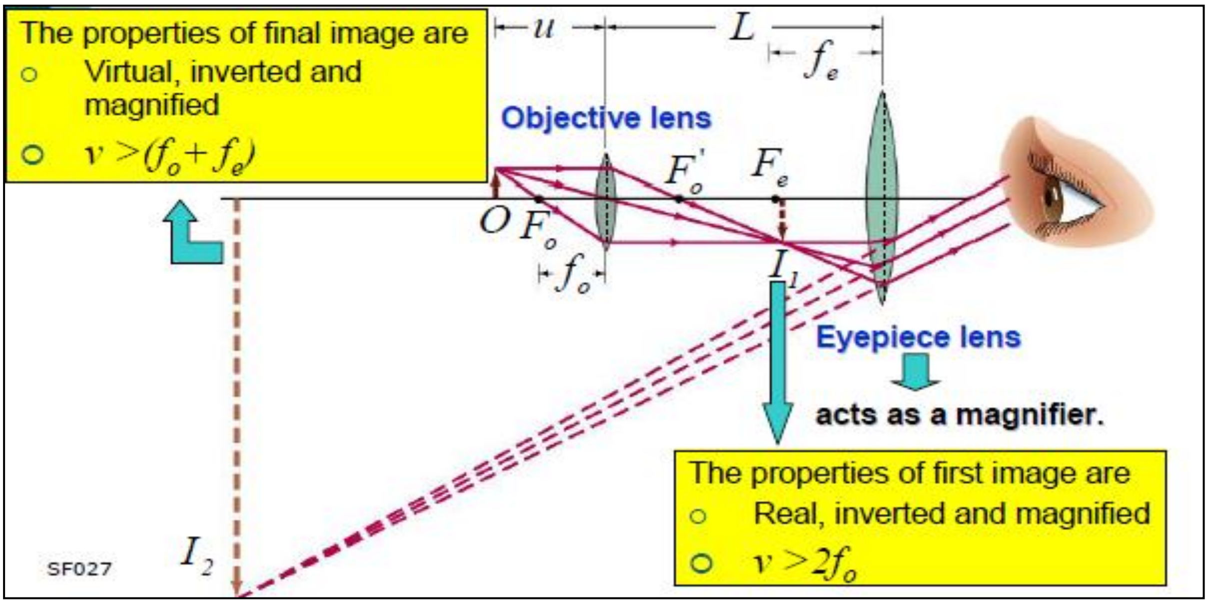

Fig.(20-1): The schematic diagram of the compound microscope

- The properties of the compound microscope are **:-**

1- *The distance between two lenses,* $L > (f_o + f_e)$.

2- $f_o < f_e$.

3- *The final image is* I_2.

4- *The angular magnification formula is given by:*

$$M_a = -\frac{L}{f_o}\left(\frac{D}{f_e}\right)$$

Where**:**

M_a **:** The angular magnification**.**

L **:** The distance between two lenses**.**

f_o **:** Focal length of the objective lens**.**

f_e **:** Focal length of the eyepiece lens**.**

D **:** Distance of distinct vision = **25** cm**.**

The negative sign indicates that the image is inverted**.**

- It is used for viewing small objects that are very close to the objective lens**.**

20-3 Astronomical (refracting) Telescope

- This telescope consists of two converging lenses.
- Like compound microscope, the two lenses are **objective** and **eyepiece** lens.
- It is used to magnify objects that are very far away (considered to be at infinity).
- The figure (**20-2**) below shows the schematic diagram of the telescope.

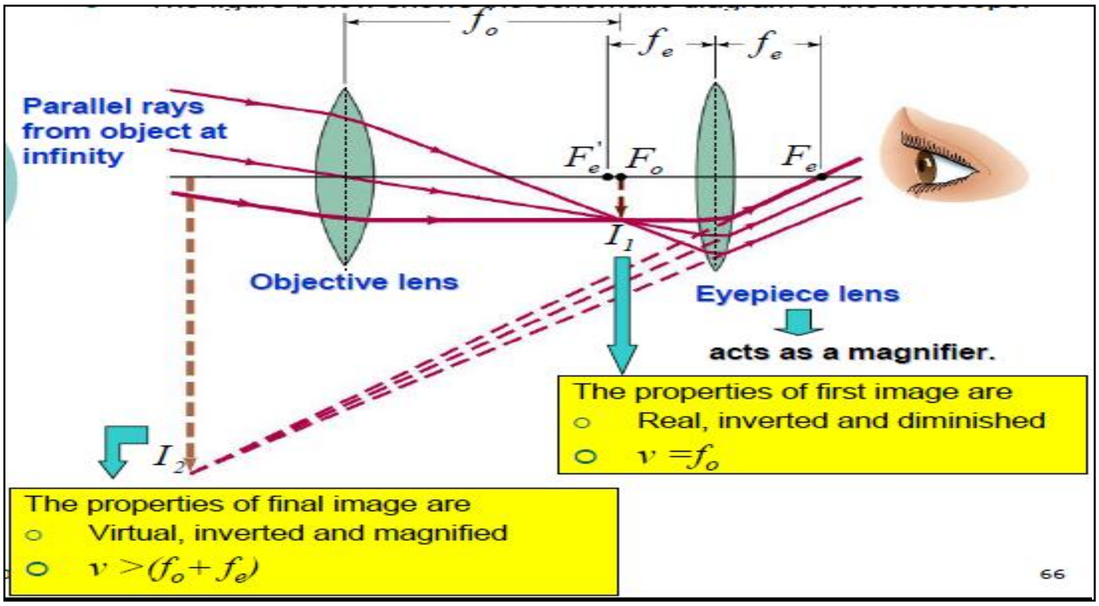

Fig.(20-2): The schematic diagram of the telescope

➢ The properties of the telescope are **:**

1- *The distance between two lenses,* $\mathbf{L < (f_o + f_e)}$**.**

2- $f_o > f_e$ **.**

3- *The final image is* $\mathbf{I_2}$**.**

4- *The angular magnification formula is given by***:**

$$M_a = -\frac{f_o}{f_e}$$

Where**:**

M_a **:** The angular magnification**.**

f_o **:** Focal length of the objective lens**.**

f_e **:** Focal length of the eyepiece lens**.**

The negative sign indicates that the image is inverted**.**

20-4 Magnifier

- It also known as **magnifying glass** or **simple microscope.**
- It is an optical device used for viewing near object**.**
- It consists of single converging (biconvex) lens**.**
- Suppose a leaf is viewed at near point of the human eye as shown in figure (**20-3**) below**.**

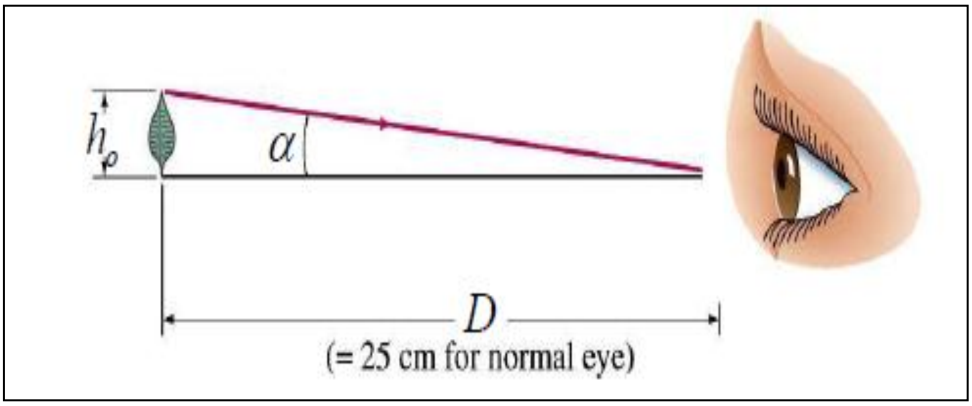

Fig.(20-3): A leaf is viewed at near point of the human eye

- From the figure(**20-3**)**:**

$$\tan\alpha = \frac{h_o}{D}$$

- By making small angle approximation, we get**:**

$$\tan\alpha \approx \alpha = \frac{h_o}{D}$$

- To increase the apparent size of the leaf, a converging lens can be placed in front of the eye as shown in figure (**20-4**) below**.**

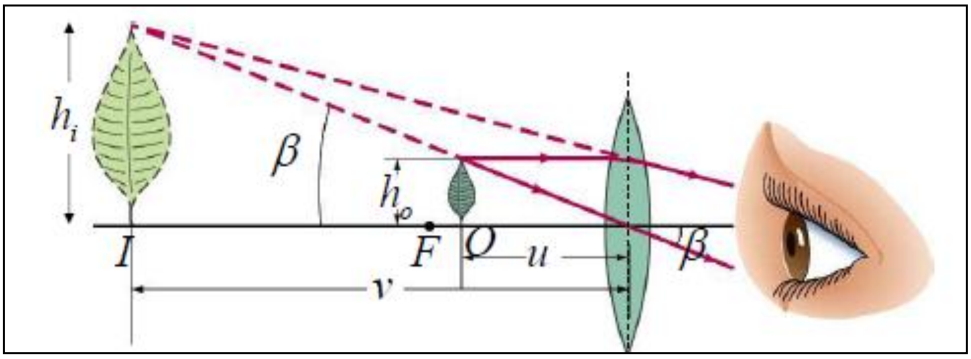

Fig.(20-4): A converging lens can be placed in front of the eye

- The apparent size of the leaf is **maximum** when the image is at the near point where**:**

$$v = -D = -25cm$$

- From the figure (**20-4**) above**:**

$$\tan\beta = \frac{h_i}{D} = \frac{h_o}{u}$$

- By making small angle approximation, we get**:**

$$\tan\beta \approx \beta = \frac{h_i}{D} = \frac{h_o}{u}$$

- The properties of the image are**:**

1- Virtual**.**

2- Upright**.**

3- Magnified**.**

4- $\tan\beta = \frac{h_i}{D} = \frac{h_o}{u}$ ⟹ $u < f$.

- The angular magnification in terms of ***D*** and ***f*** can be evaluated by derivation below**.**
- By applying the thin lens formula**:**

$$\frac{1}{f}=\frac{1}{u}+\frac{1}{v} \quad \text{where } v=-D$$

$$u=\frac{Df}{D+f} \quad ...(1)$$

- From the definition of angular magnification**:**

$$M_a=\frac{\beta}{\alpha}=\frac{(\frac{h_o}{u})}{(\frac{h_o}{D})}$$

$$M_a=\frac{D}{u} \quad ...(2)$$

- By substituting eq. (**1**) into eq. (**2**), thus**:**

$$\boxed{M_a=\frac{D}{f}+1}$$

Where**:**

***M_a*: ** Angular magnification**.**

***D* :** Distance of distinct vision = **25 cm .**

***f* :** Focal length **.**

- The relationship between linear magnification, ***M*** with angular magnification, M_a
- From the definition of angular magnification**:**

$$M_a = \frac{\beta}{\alpha} = \frac{(\frac{h_i}{D})}{(\frac{h_o}{D})}$$

Then**:**

$$\boxed{M_a = \frac{h_i}{h_o} = M}$$

- Note: If the object placed at the focal point of the converging lens, the **image formed at infinity** , thus **:**

$$\beta = \frac{h_o}{f}$$

- Therefore , since $M_a = \frac{\beta}{\alpha}$ then **:**

$$M_a = \frac{(\frac{h_o}{f})}{\frac{h_o}{D}} \qquad \boxed{\Rightarrow M_a = \frac{D}{f}}$$