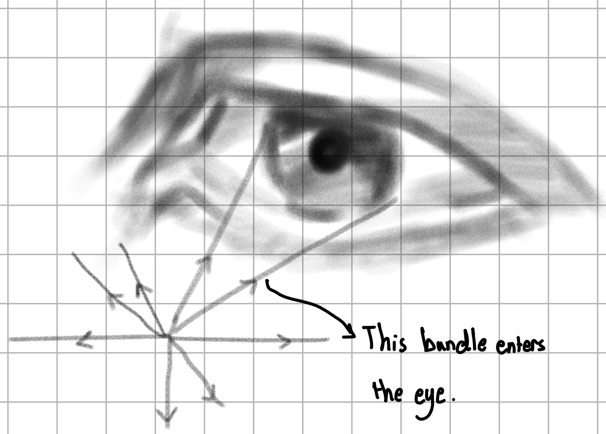
Chapter 23

23_1 The Ray Model of light



- The ray model of light. This model assumes that light travels in straight-line paths Called light rays in transparent media

- When we see an object, according to ray model light reaches our eyes from each point an the object. Although light rays leave each point in many different directions normally only a small bundle of these rays Can enter the pupil of an observer's eye.

- the ray model has been very successful in describing many aspects of light such as reflection, refraction and the formation of images by mirros and lenses. Because these explanations involve straghit-line rays at various angels, this subject is referred to as geometric optics

23-4 Index of Referaction

- the speed of light in vacuum = 3.00×10^8 m/s

In air, the speed is only slightly less. In other transparent materials, such as glass and water, the speed is always less than that in vacuum. For example, in water light travels at about $\frac{3}{4}c$. The ratio of the speed of light in vacuum to the speed v in a given material is called the **index of refraction**, n, of that material:

$$n = \frac{c}{v} > 1 \qquad (23\text{–}4)$$

البسط أكبر من المقام
دائماً الجواب أكبر من 1

The index of refraction is never less than 1, and values for various materials are given in Table 23–1. For example, since $n = 1.33$ for water, the speed of light in water is

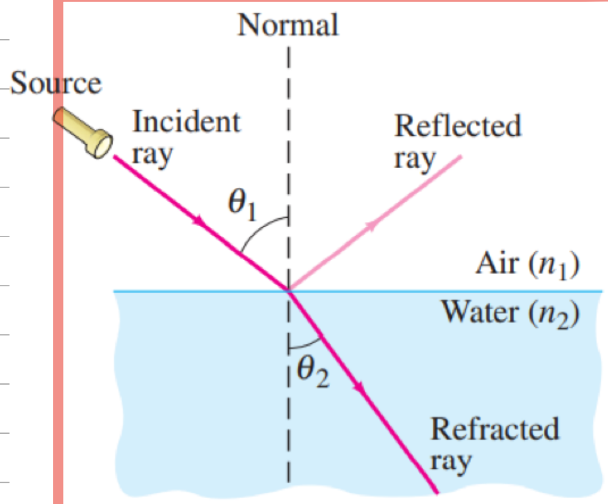
$$v = \frac{c}{n} = \frac{(3.00 \times 10^8\ \text{m/s})}{1.33} = 2.26 \times 10^8\ \text{m/s}.$$

TABLE 23–1 Indices of Refraction†

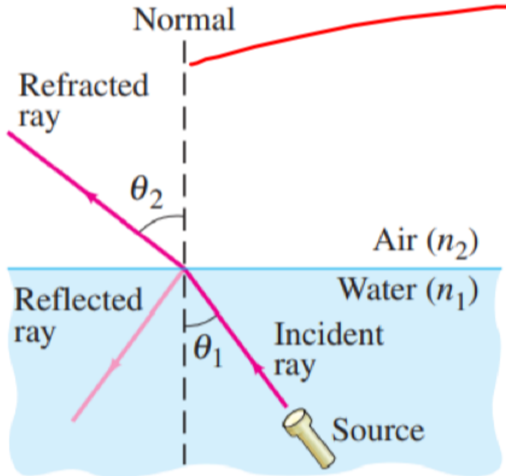
Material	$n = \frac{c}{v}$
Vacuum	1.0000
Air (at STP)	1.0003
Water	1.33
Ethyl alcohol	1.36
Glass	
Fused quartz	1.46
Crown glass	1.52
Light flint	1.58
Plastic	
Acrylic, Lucite, CR-39	1.50
Polycarbonate	1.59
"High-index"	1.6–1.7
Sodium chloride	1.53
Diamond	2.42

† $\lambda = 589$ nm.

- The change in light direction is called refraction



(a) $n_2 > n_1$: Ray bends toward $\perp$



(b) $n_1 > n_2$: Ray bends away from $\perp$

perpendicular to the two media

انتقل الضوء من وسط أقل معامل انكسار (n_1)
إلى وسط أعلى معامل انكسار (n_2)
بالتالي $\theta_2 < \theta_1$

$\downarrow n \frac{1}{\propto} \theta \uparrow$

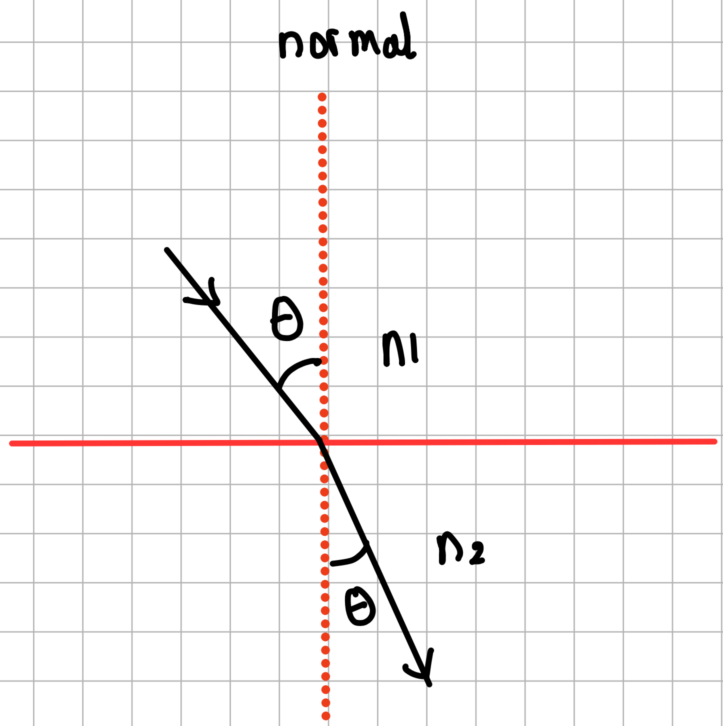
انتقل الضوء من وسط أعلى معامل انكسار (n_1)
إلى وسط اقل معامل انكسار (n_2)
$\theta_2 < \theta_1$

θ_1 Angle of incidence
θ_2 Angle of refraction

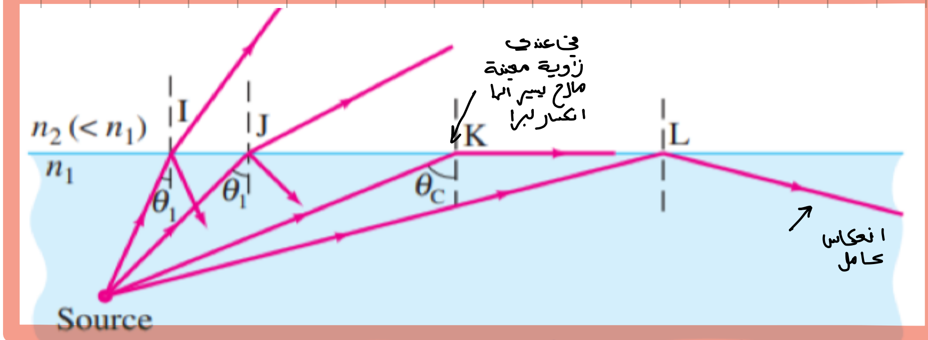
So we can conclude:
Light bends toward the normal when we moves from lower density to higher density area
Light bends away from the normal when we moves from higher density to lower density area

23_5 Refraction: Snell's Law

- Snell's Laws $\boxed{n_1 \sin\theta_1 = n_2 \sin\theta_2}$



23-6 Total Internal Reflection, fiber optics



Source

The incident angle at which this occurs is called the **critical angle**, θ_C. From Snell's law, θ_C is given by

$$\sin\theta_C = \frac{n_2}{n_1}\sin 90^\circ = \frac{n_2}{n_1}. \Longrightarrow n_1 \sin\theta_1 = n_2 * \cancel{\sin 90}^{\,1} \qquad (23\text{–}6)$$

$$n_1 \sin\theta_1 = n_2$$

For any incident angle less than θ_C, there will be a refracted ray, although part of the light will also be reflected at the boundary. However, for incident angles θ_1 greater than θ_C, Snell's law would tell us that $\sin\theta_2$ $(= n_1 \sin\theta_1 / n_2)$ would be greater than 1.00 when $n_2 < n_1$. Yet the sine of an angle can never be greater than 1.00. In this case there is no refracted ray at all, and *all of the light is reflected*, as for ray L in Fig. 23–26. This effect is called **total internal reflection**. Total internal reflection occurs only when light strikes a boundary where the medium beyond has a *lower* index of refraction.

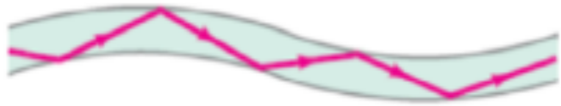
NOTE: Critical angel و total internal reflection

تظهر عند انتقال الضوء من n كبيرة ← n صغيرة

مستحيل العكس

fiber optics: Medical instruments

FIGURE 23–29 Light reflected totally at the interior surface of a glass or transparent plastic fiber.



- Total internal reflection is the principle underlying the use fibre Optics.

- Glass and plastic fibers as thin as few micrometers are used to manufacture optic fibres.
  Radius

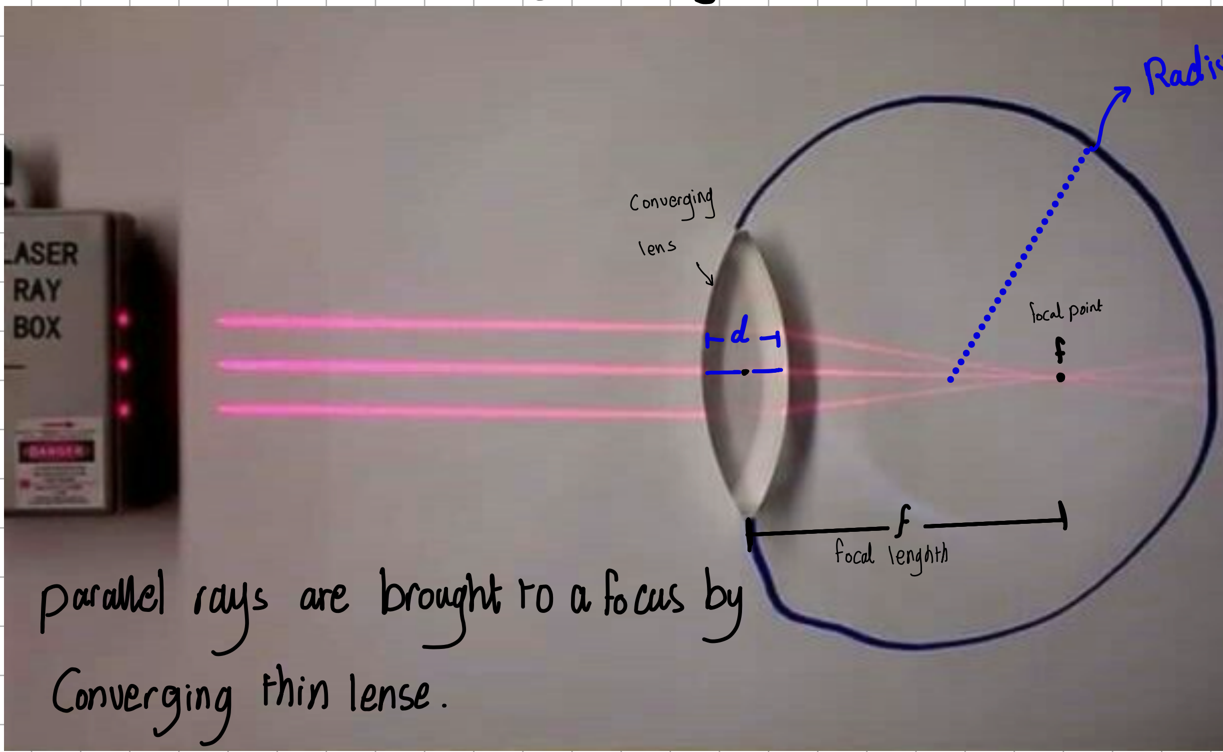
- A bundle of such transparant fibres is Called a fibre-optic Cable of lite pipe

Fibre-optic cables are use in:

- communications: lead to very fast and larg transmission of data. Fibres can support more than 100 separate wavelengths, each can carry more than 10 gigabits of data per second.

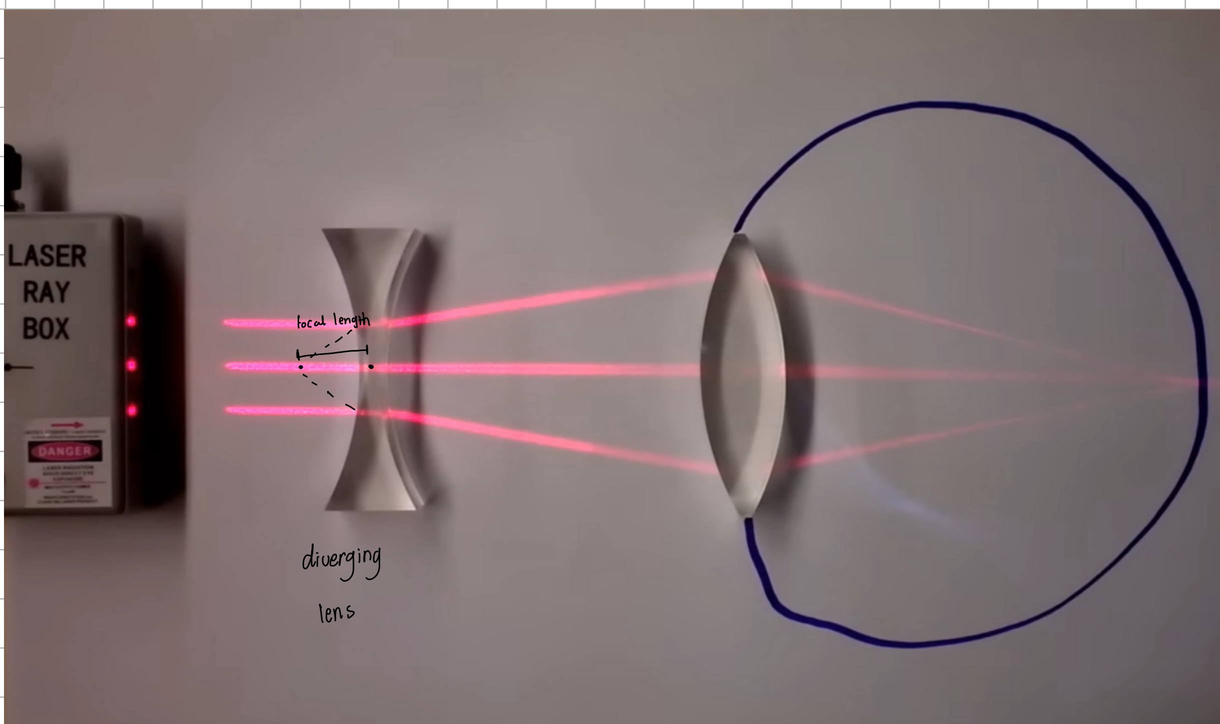
- medicine: Optic-fibres are used in medicine to provide clear pictures of human organs.
  bronchoscope: optic-fibre cable used to view the lungs.
  Colonoscope: optic-fibre cable used to view the colon.

23-7 Thin lenses, Ray Tracing



parallel rays are brought to a focus by Converging thin lense.

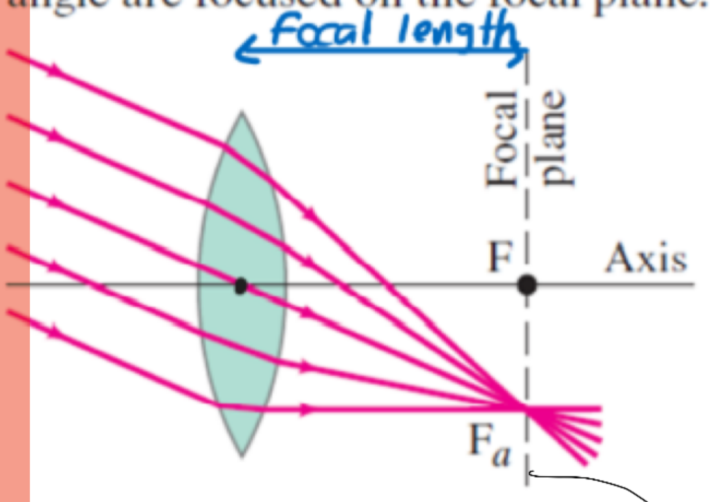
- When diameter of lens (d) << radious of Curvature
  $\Rightarrow$ lens is Called a thin lens



Diverging lens: It divergs the parallel rays falling on it. Refracted rays seem to originate from the focal point F.

- Rays that are parallel to the principal axis refract passing through the focal point $\Rightarrow$ Converging lens.

FIGURE 23–35 Parallel rays at an angle are focused on the focal plane.



- center of the lens.

- parallel rays falling on the lens at an angle are focused on a point F_a that lies on the focal plane

دائمًا اي focal length
رح تتشكل رح تتشكل عن
محور الأصلي للـ focal length

lens power

Optometrists and Optholmologists define the lens power as

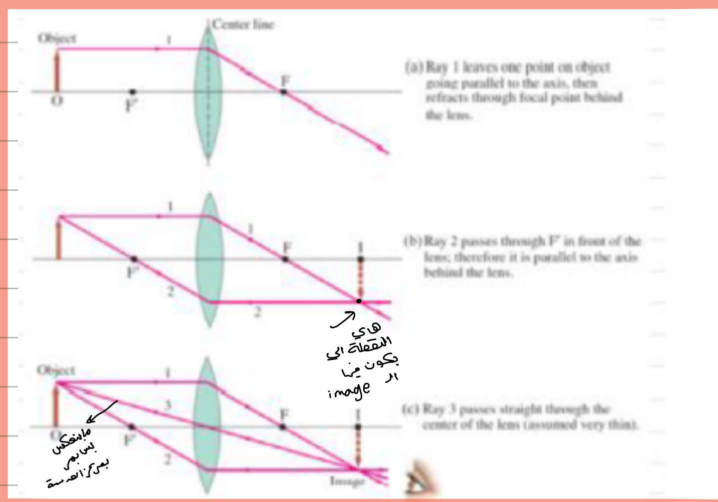
$$P = \frac{1}{f} \quad , \quad f \text{ is the focal length}$$

A lens whose focal lenth $f = 20\ cm = 0.2\ m$ has a lens power of

$$P = \frac{1}{0.2} = 5\ m^{-1} = 5\ D$$

diopter

So the unit used for lens power is diopter $D = m^{-1}$



Ray ① falls parallel to the lens axis is refracted through the focal point

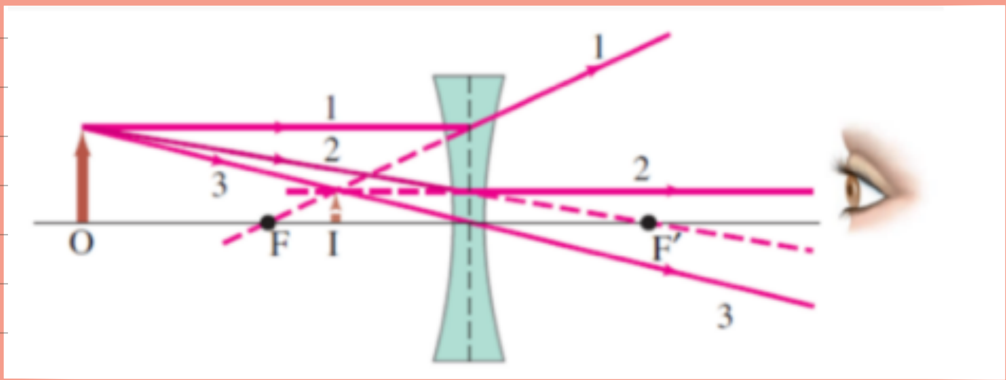
Ray ② passes through the focal point of the lens is refracted parallel to the lens axis

Ray ③ It passes through the Center of the thin lens as shown

The image of the tip of the of the arrow is at the position of intersection of the three rays. The same technique can be applied to all points of the object ⇒ leading to the image shown in the figure.

The image is a result of intersection of the actual rays and can be observed on a screen

⇒ **Real Image.** ⇒ لانها تشكلت من امتدادات الضوء الحقيقية .



- **Diverging lens**

It diverges the refrated rays as shown.

Note: انعكاس الصورة بيجي قبل العدسة

- the refracted rays appear as if they Originate from the focal point (F) infornt of the lens.

Ray①: Incident parallel to the lens axis. It is refracted such that it extrapolotion passes through the focal point (F).

بقطع الـ focal point الي قبل العدسة

Ray②: It falls on the lens such that its extrapolation passes through the focal point (F′). This ray is refracted parallel to the lens axis.

يقطع الـ focal point الي بعد العدسة

Ray③: It passes through the center of the lens and passes through the thin lens along the same direction.

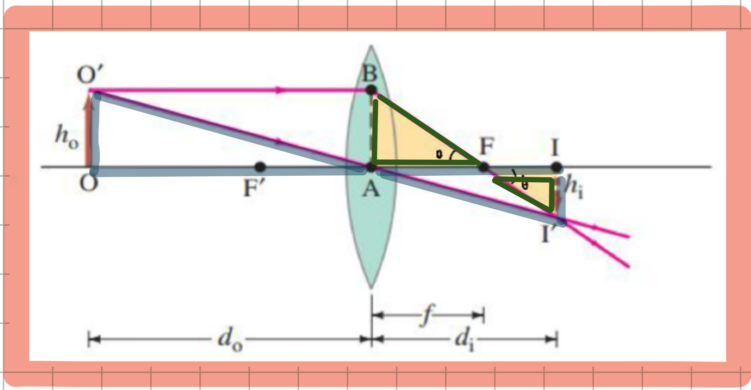
يمر في مركز العدسة دون أن ينكسر

The same can be done to find the position of the image corresponding to all the other points on the object

All refracted rays seem as if they originate from a point on the left of the lens, which is the position of the image. This is a virtual image since it is NOT formed at the point of intersection of the rays.

تشكلت من امتدادات تقاطع الضوء

23-8 Thin lens equation



- تشابه المثلثات الي بلون الأزرق

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

- تشابه المثلثات الي بلون الأخضر

$$\boxed{\frac{BA}{II'} = \frac{AF}{FI}}$$

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

$$\frac{d_o}{d_i} = \frac{f}{d_i - f}$$

$$\frac{d_i}{d_o} = \frac{d_i - f}{f}$$

$$d_i f = d_o (d_i - f)$$

$$[d_i f = d_o d_i - d_o f] \div d_o d_i f$$

$$\frac{\cancel{d_i f}}{d_o \cancel{d_i f}} = \frac{\cancel{d_o d_i}}{\cancel{d_o d_i} f} - \frac{\cancel{d_o f}}{\cancel{d_o} d_i \cancel{f}}$$

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

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

The Thin lens equation

NOTE:

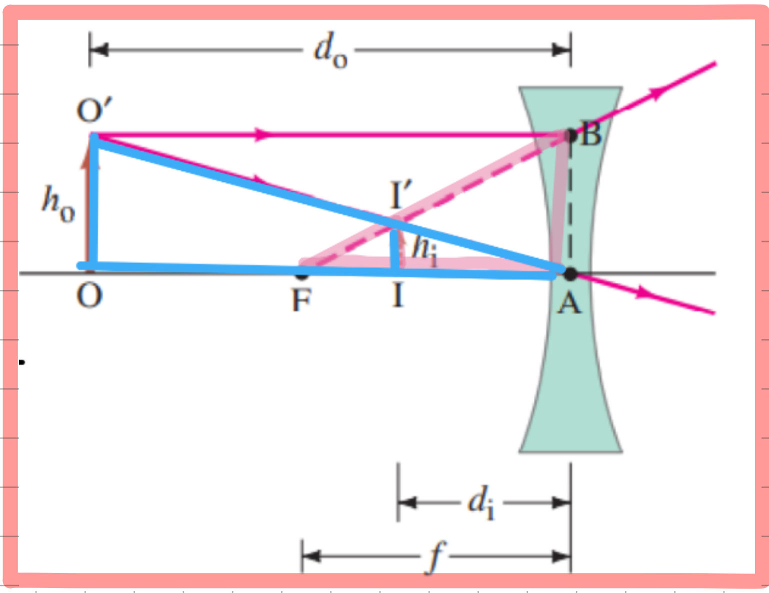
فرضا المسافة بين مركز العدسة و
ال object كثير بعيدة (d_o) لدرجة
أنو ال lens مش عم بترصدها
هون بنحكي انو المسافة تقريبًا

$$d_o = \infty$$

رقم صغير / رقم ضخم يؤول الى الصفر

$$\cancel{\frac{1}{\infty}} + \frac{1}{d_i} = \frac{1}{f}$$

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



من تشابه المثلث الأزرق

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

من تشابه المثلث الزهري

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

$$\frac{d_o}{d_i} = \frac{f}{f-d_i}$$

$$\frac{d_i}{d_o} = \frac{f-d_i}{f}$$

$$d_i f = (f-d_i)\, d_o$$

$$(d_i f = f d_o - d_i d_o) \div f d_i d_o$$

$$\frac{\cancel{d_i}\cancel{f}}{\cancel{f}\cancel{d_i} d_o} = \frac{\cancel{f}\cancel{d_o}}{\cancel{f} d_i \cancel{d_o}} - \frac{\cancel{d_i}\cancel{d_o}}{f \cancel{d_i}\cancel{d_o}}$$

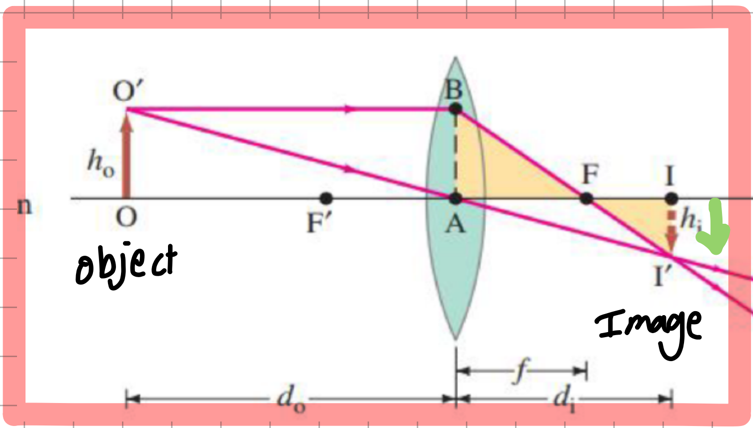
$$\frac{1}{d_o} = \frac{1}{d_i} - \frac{1}{f}$$

$$\boxed{\frac{1}{d_o} - \frac{1}{d_i} = -\frac{1}{f}}$$

س: ليش سالب هون
مش زي المحدبة ؟!

ج: لأنو بالأصل ال
focal length
يكون بعد العدسة

NOTES :



١) هون الـ f موجب لأنو
جاي بعد العدسة

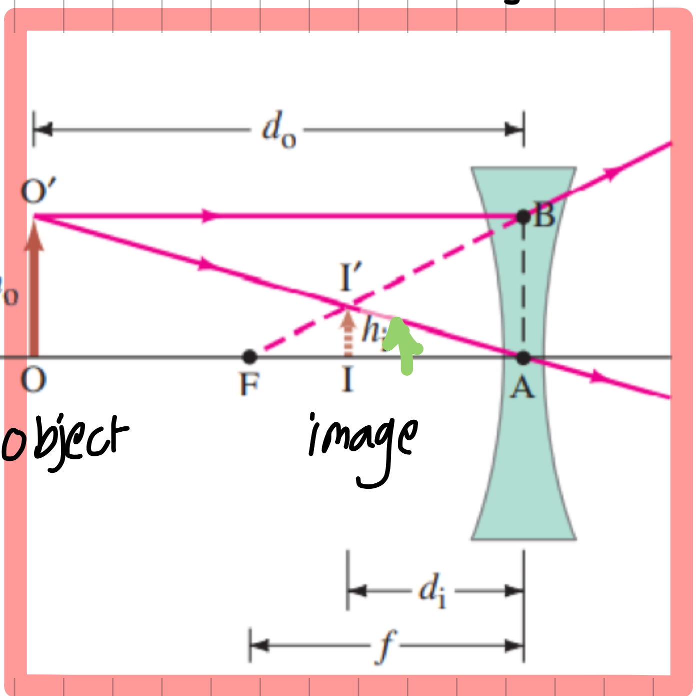
٢) Image هون حقيقة
المسافة تكون موجبة

٣) هون الـ height of The Image سالب لأنو للأسفل

١. هون الـ f
سالب لأنو قبل العدسة

٢. Image الي على نفس
جهة الـ object تكون
غ حقيقة، المسافة
تكون سالبة

٣. هون heigh of image يكون موجب
لأنه لفوق



magnification

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