

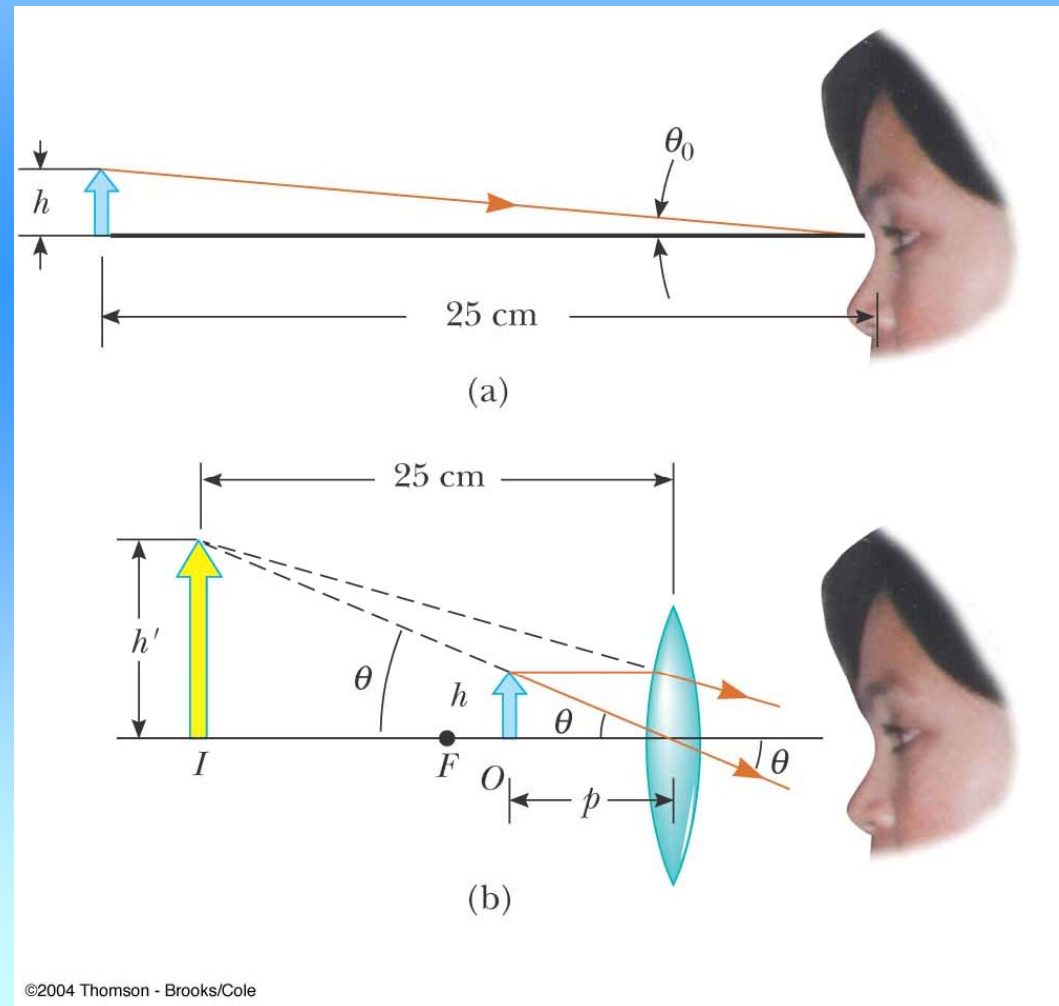


The Simple Magnifier

Compound Microscope

The Size of a Magnified Image

- When an object is placed at the near point, the angle subtended is a maximum
 - The near point is about 25 cm
- When the object is placed near the focal point of a converging lens, the lens forms a virtual, upright, and enlarged image



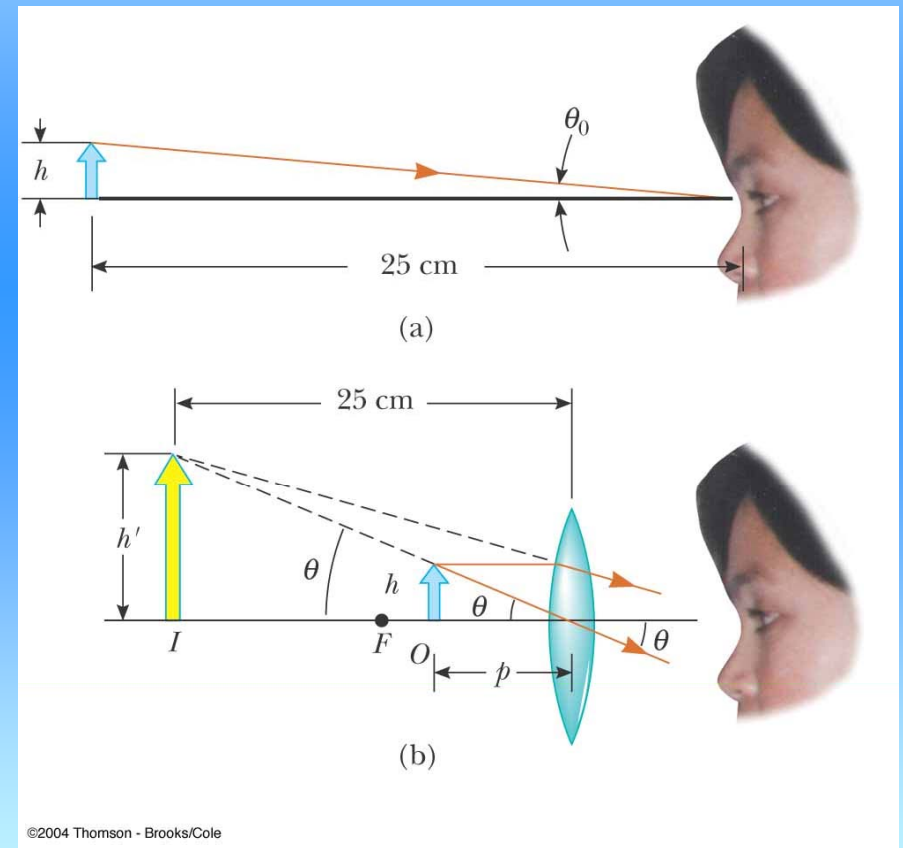
The Size of a Magnified Image

Angular magnification is defined as

$$m = \frac{\theta}{\theta_0}$$

The angular magnification is at a maximum when the image formed by the lens is at the near point of the eye

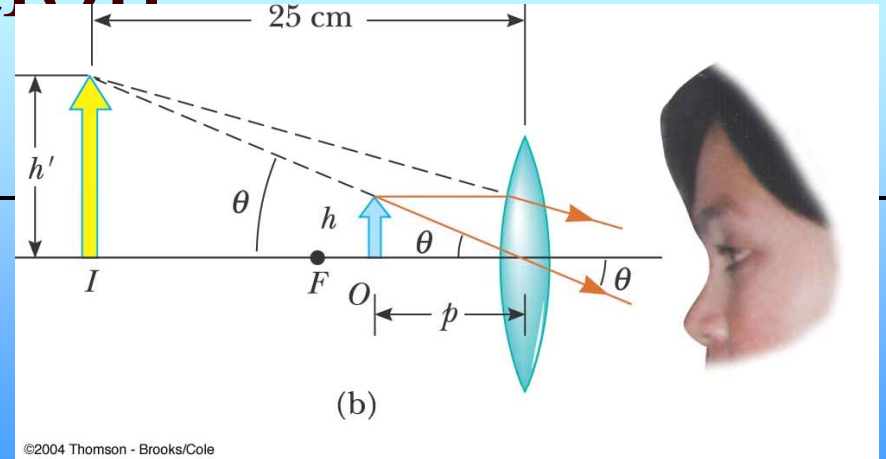
$$q = -25 \text{ cm}$$



Angular Magnification

$$\frac{1}{p} + \frac{1}{-25\text{cm}} = \frac{1}{f}$$

$$\tan \theta_0 \approx \theta_0 \approx \frac{h}{p} \quad \tan \theta \approx \theta \approx \frac{h}{25\text{cm}}$$



$$m_{\max} = \frac{\theta}{\theta_0} = \frac{h/p}{h/25\text{cm}} = \frac{25\text{cm}}{p} = \frac{25\text{cm}}{25\text{cm} \cdot f / (25\text{cm} + f)}$$

$$p = \frac{25f}{25 + f} \text{ cm}$$

$$m_{\max} = 1 + \frac{25 \text{ cm}}{q}$$

The image is at infinity – the eye is most relaxed

Hence, the object is at the focal point

$$\theta_0 \approx \frac{h}{25} \quad \theta \approx \frac{h}{f} \quad m_{\min} = \frac{\theta}{\theta_0} = \frac{25\text{cm}}{f}$$

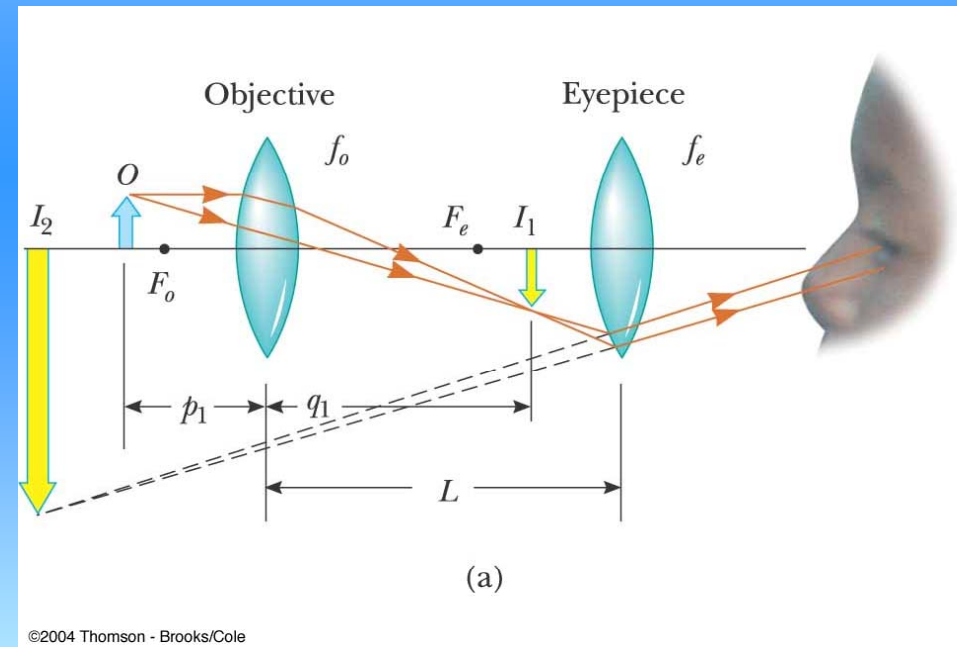
Angular Magnification

- The eye is most relaxed when the image is at infinity
 - Although the eye can focus on an object anywhere between the near point and infinity
- For the image formed by a magnifying glass to appear at infinity, the object has to be at the focal point of the lens
- The angular magnification is

$$m_{\min} = \frac{\theta}{\theta_0} = \frac{25\text{cm}}{f}$$

Compound Microscope

- A compound microscope consists of two lenses
 - Gives greater magnification than a single lens
 - The objective lens has a short focal length, $f_o < 1$ cm
 - The eyepiece has a focal length, f_e of a few cm



Magnifications of the Compound Microscope

- The *lateral magnification* by the objective is

$$M_o = -L / f_o$$

- The *angular magnification* by the eyepiece of the microscope is

$$m_e = 25 \text{ cm} / f_e$$

- The *overall magnification* of the microscope is the product of the individual magnifications

$$M = M_o m_e = -\frac{L}{f_o} \left(\frac{25 \text{ cm}}{f_e} \right)$$

A compound microscope has an objective of focal length 0.3 cm and an eyepiece of focal length 2.5 cm. If an object is 3.4 mm from the objective , what is the magnification?

□ For the objective: $\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$ becomes $\frac{1}{3.40 \text{ mm}} + \frac{1}{q} = \frac{1}{3.00 \text{ mm}}$

□ $q = 25.5 \text{ mm}$

□ The objective produces magnification

$$M_1 = -q/p = -\frac{25.5 \text{ mm}}{3.40 \text{ mm}} = -7.50$$

□ For the eyepiece as a simple magnifier,

$$m_e = \frac{25.0 \text{ cm}}{f} = \frac{25.0 \text{ cm}}{2.50 \text{ cm}} = 10.0$$

□ and overall

$$M = M_1 m_e = -75$$