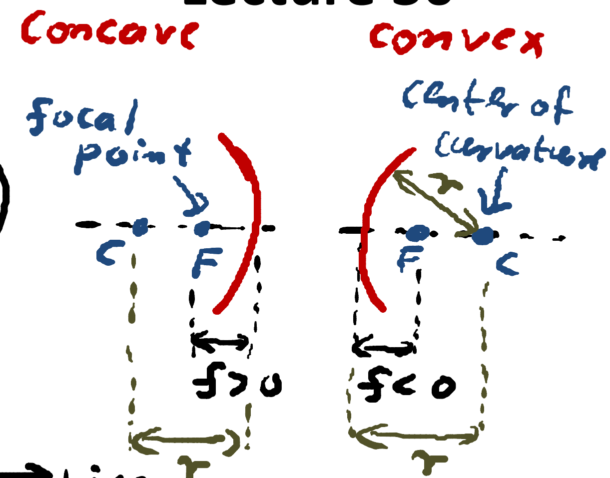
Recap I

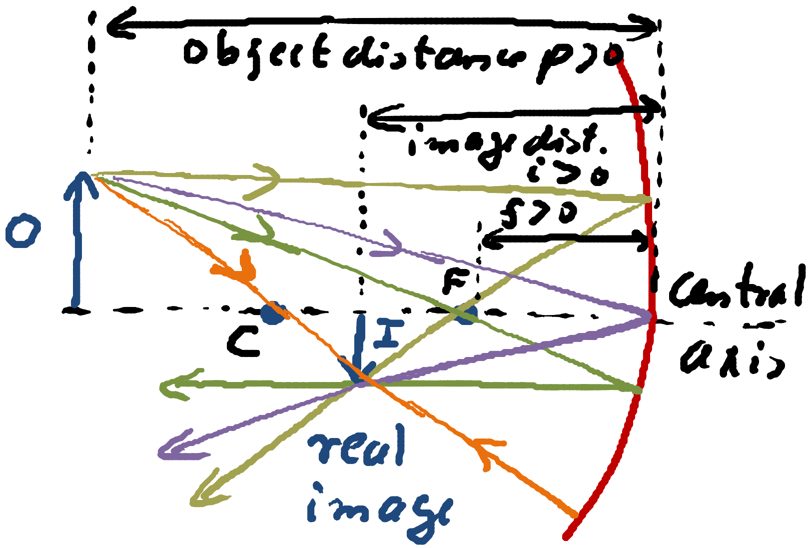
Lecture 30

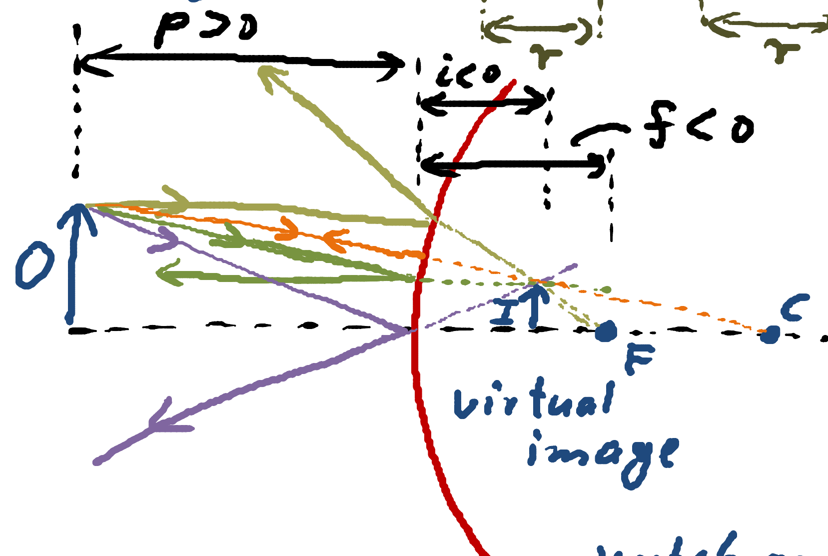
• Sperical Mirrors:

– focal length $f = \frac{1}{2}$ (radius of curvature of mirror)



• Drawing Rays and locating Images:





$$\frac{1}{p} + \frac{1}{i} = \frac{1}{f}$$

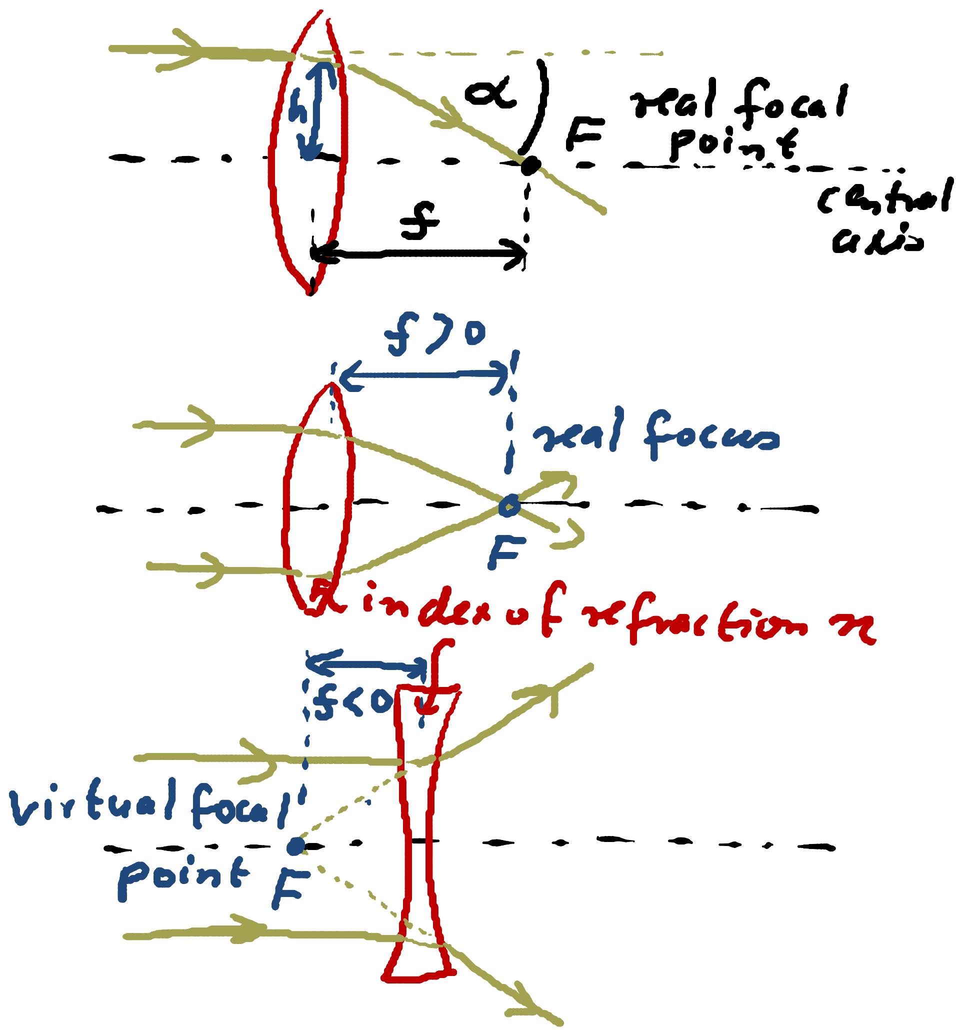
$$m = \frac{\text{image height}}{\text{object height}} = -\frac{i}{p}$$

watch out for correct signs!

- real image, focus: $i > 0$; $f > 0$
- virtual image, focus $i < 0$; $f < 0$

Recap II

- **Thin Lenses:**



deflecting angle:

$$|\alpha| = |P|\, h$$

⇒ same h → same α for given lens

Lens Power P: $P = 1/f$

"Lens maker's equation":

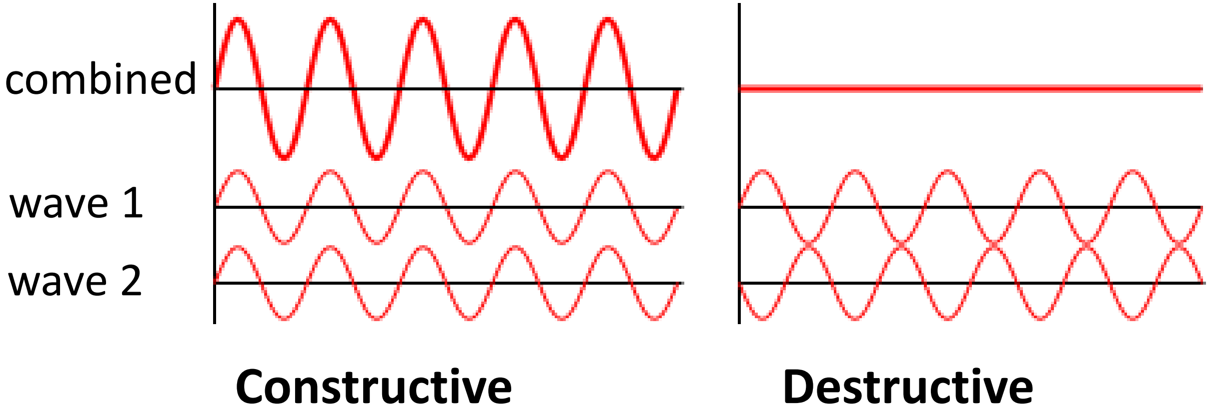
$$\frac{1}{f} = (n-1)\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$

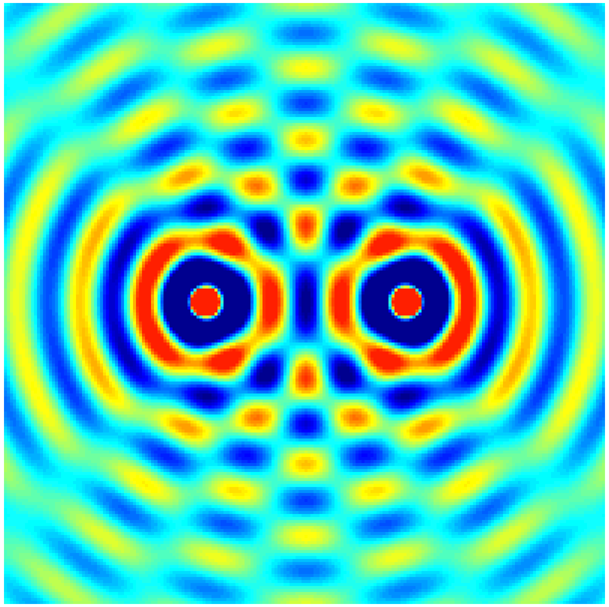
r_1 = radius of curvature of surface near object

r_2 = radius of curvature of other surface of lens

Today:

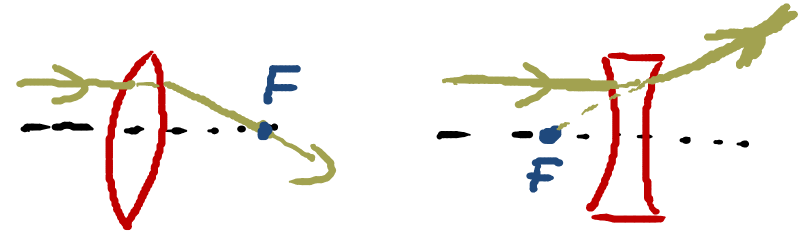
- **Lenses**
  - Optical instruments
- **Interference**



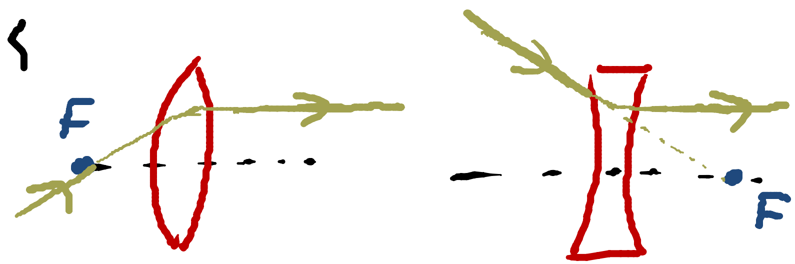


Lenses: Locating Images by Drawing Ray

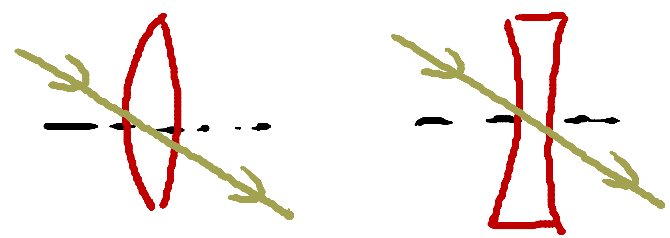
(1) A ray that is initially parallel to the central axis will "pass" through the focal point.



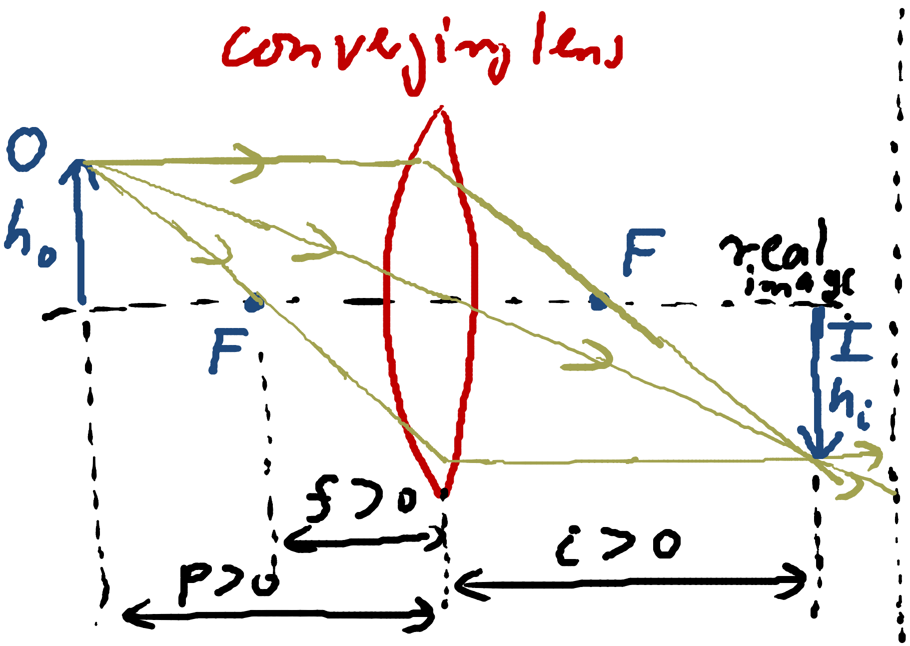
(2) A ray that "passes" through a focal point will emerge from the lens parallel to the central axis.

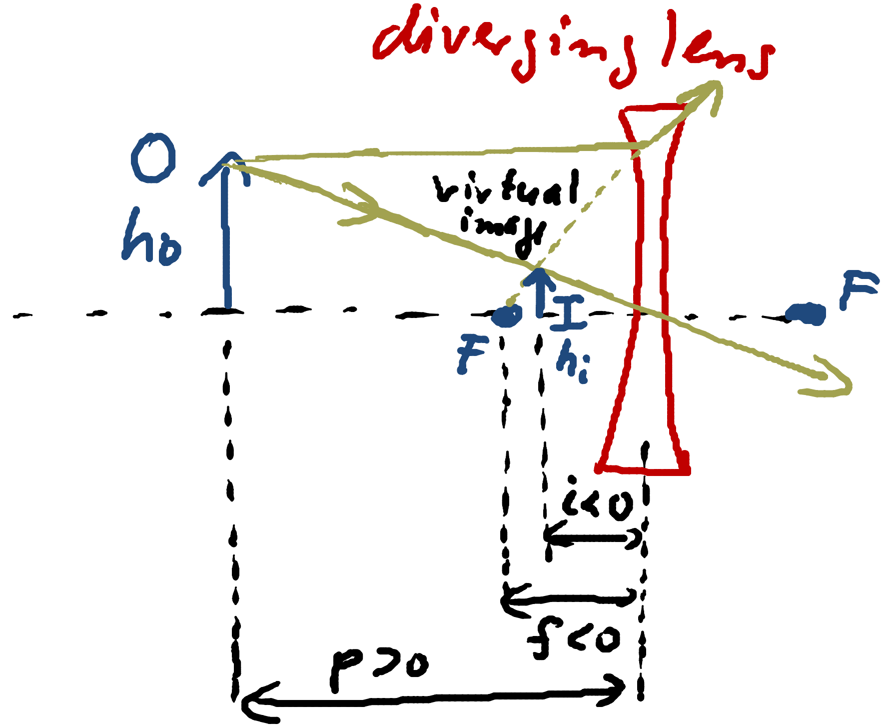


(3) A ray that is initially directed toward the center of the lens will emerge from the lens without a change in direction.



Images from thin lenses:





- for both lenses:

$$\frac{1}{p} + \frac{1}{i} = \frac{1}{f}$$

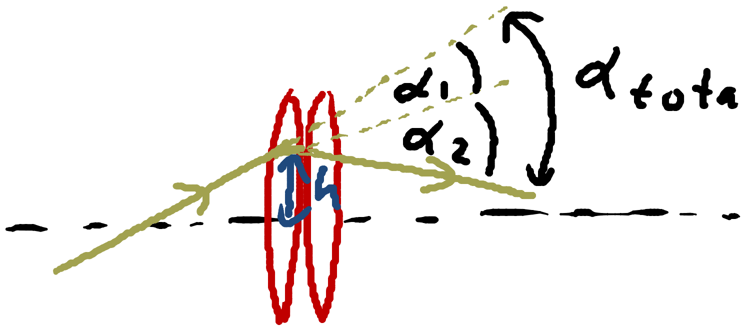
Lateral magnif. = $m = \dfrac{\text{image height}}{\text{object height}} = \dfrac{h_i}{h_o} = -\dfrac{i}{p}$

$m > 0$: upright

$m < 0$: inverted image

- sign convention:
  - $f > 0$ for converging lens; $f < 0$ for diverging lens
  - $p > 0$ always
  - $i > 0$ for real image; $i < 0$ for virtual image

Thin Lenses in Contact:



total deflection due to individual lenses:

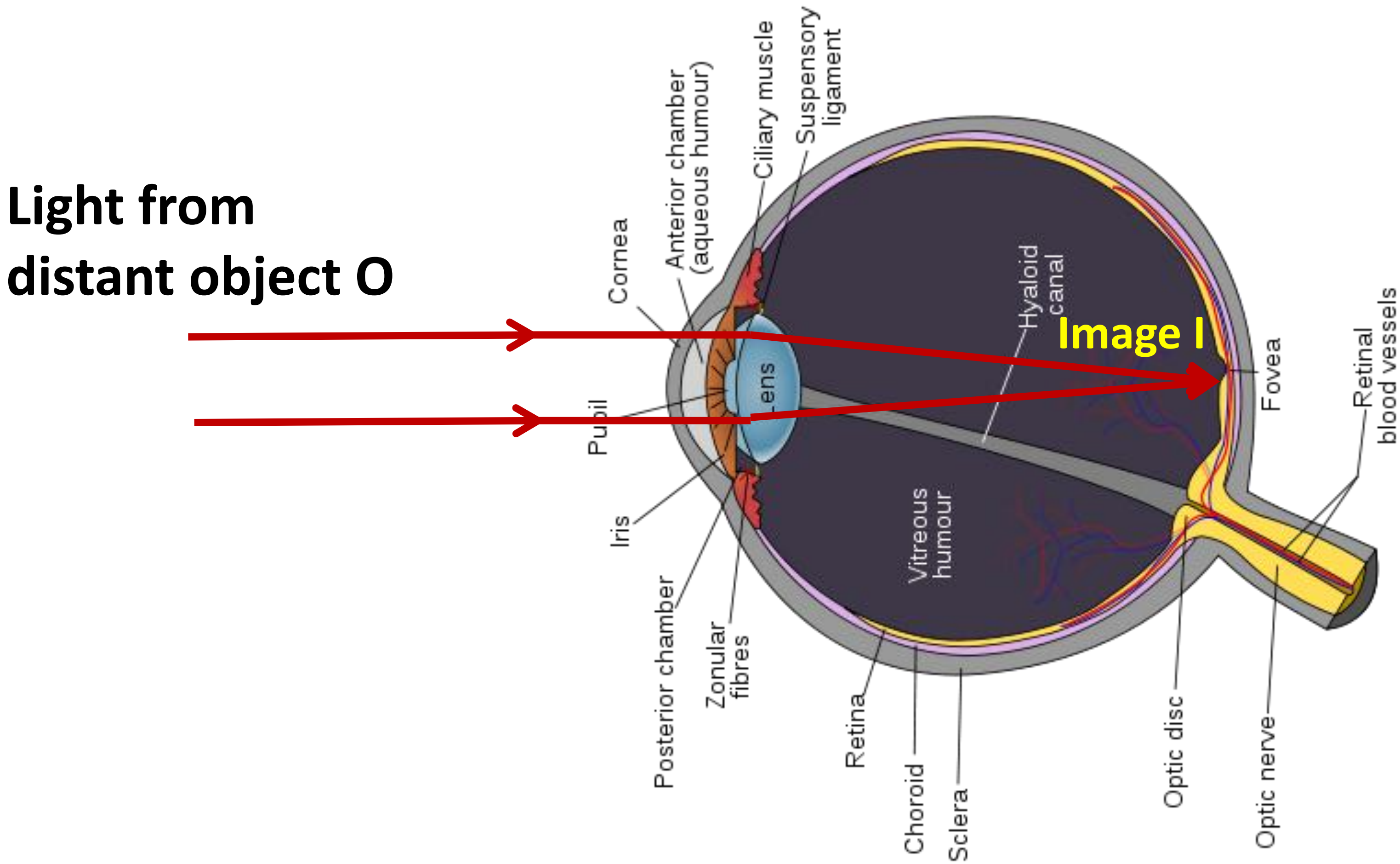
$$\underbrace{\alpha_{total} = \alpha_1 + \alpha_2}_{\text{deflection add up}} = P_1 h + P_2 h = (P_1 + P_2) h = P_{total}\, h$$

assume that h is not changing signif. between the thin lenses in contact

⇒ total lens power: $P_{total} = P_1 + P_2$

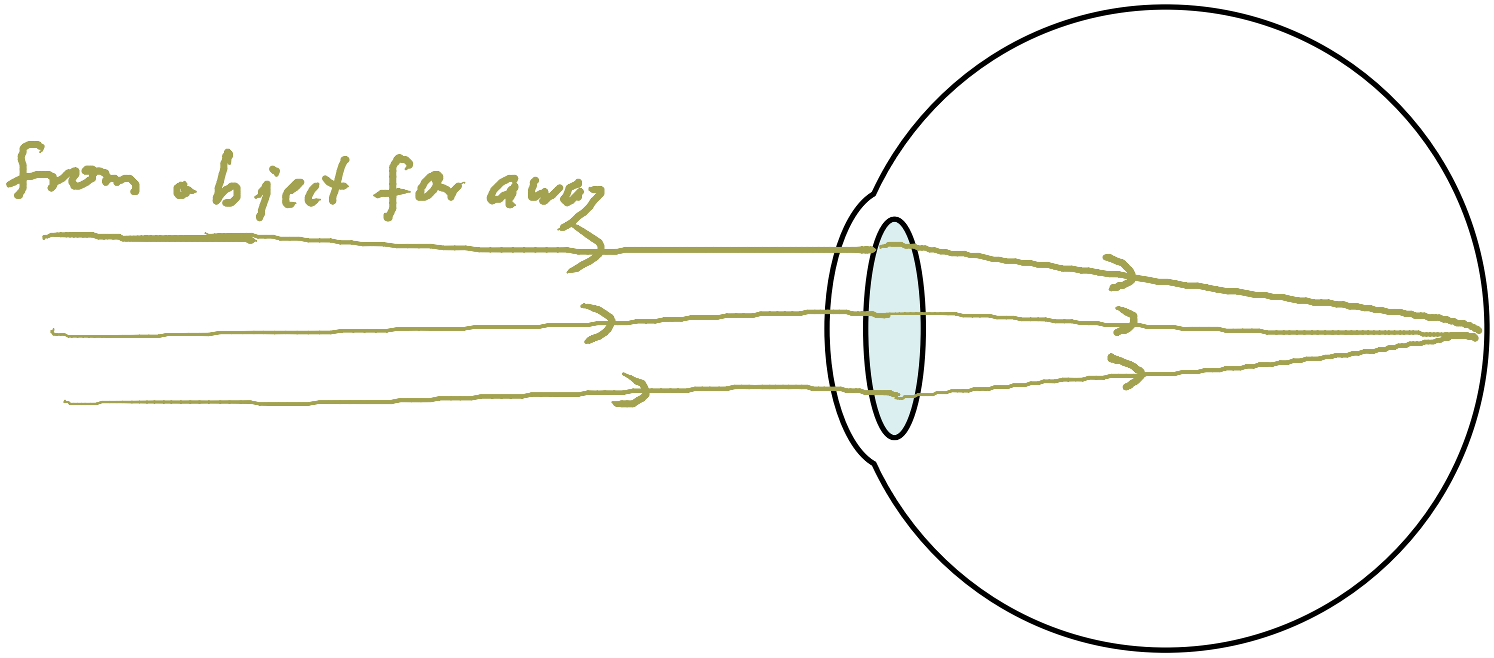
⇒ effective focal length: $\frac{1}{f_{eff}} = \frac{1}{f_1} + \frac{1}{f_2}$

The Eye:



- **Near point**: closest distance at which you can focus on an object
- **Far point**: furthest distance at which you can focus on an object

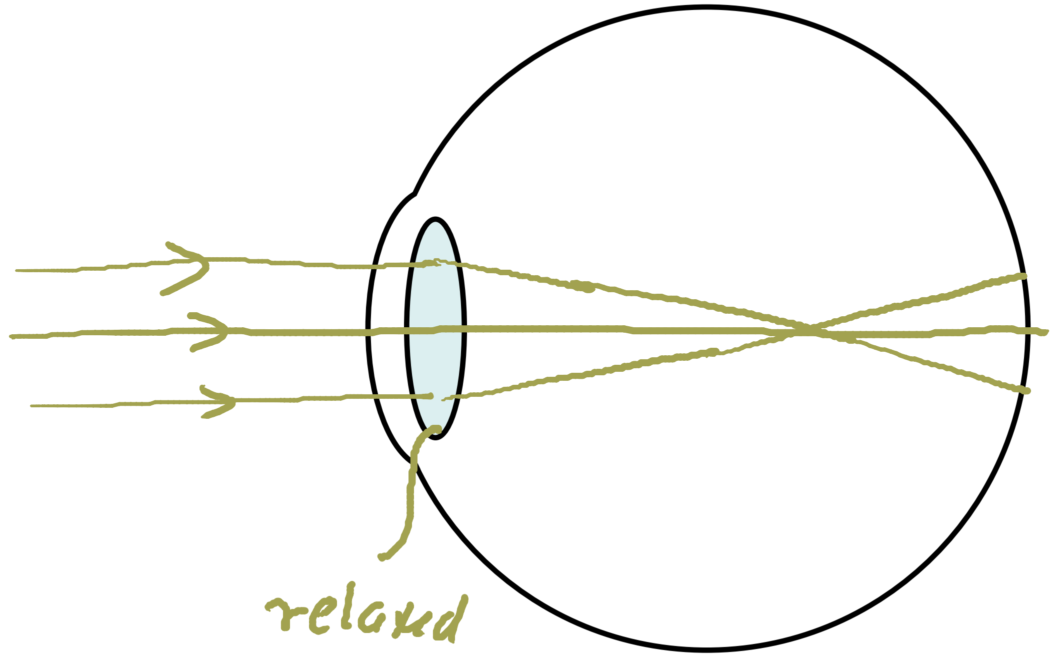
Normal (emmetropic) eye:



The **image point of an object point at infinity is formed on the retina when the eye is relaxed**.

The far point for this eye is at infinity (effectively anywhere beyond ~ 5 m).

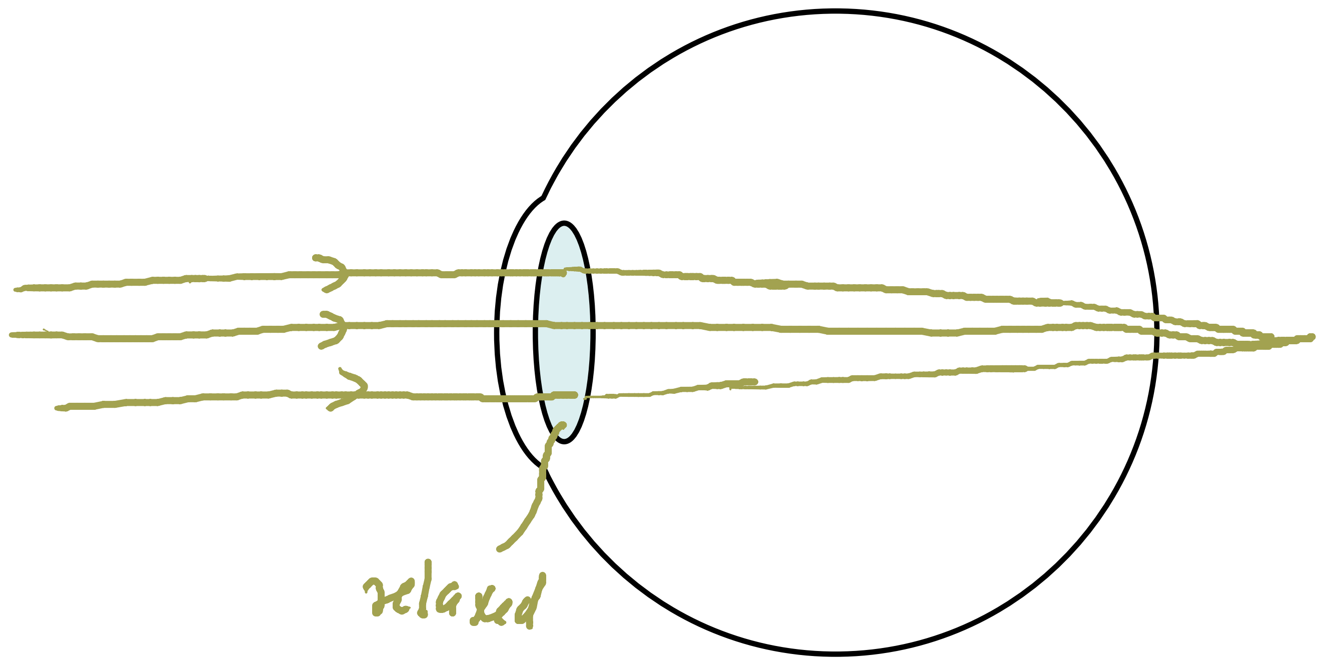
Nearsighted (myopic) eye:



The **image point of an object point at infinity is formed in front of the retina**.

The <u>far point</u> of this eye is closer than infinity; the eye cannot form a clear image of any object point beyond this far point.

Farsighted (hyperopic) eye:



The **image point of an object point at infinity is formed behind the retina when the eye is relaxed**.

The near point of this eye is too far away; the eye cannot form a clear image of any object point closer than this near point.

A (pathetic) nearsighted eye has its far point at 0.20 m.

without contact lens:

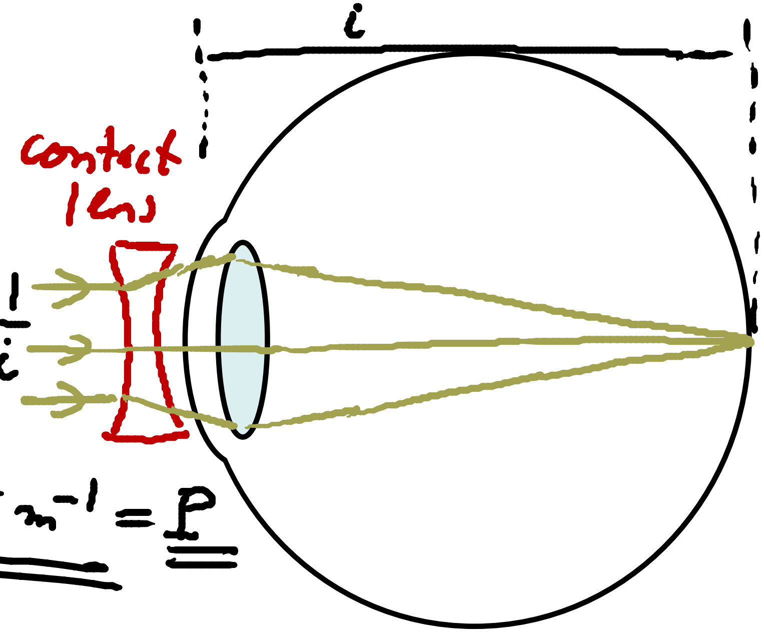
$$\frac{1}{p_{far}} + \frac{1}{i} = \frac{1}{f_{eye}} = \frac{1}{0.2\,m} + \frac{1}{i}$$

with contact lens:

$$\frac{1}{p_{far}} + \frac{1}{i} = \frac{1}{f_{total}} = \frac{1}{f_{lens}} + \frac{1}{f_{eye}} = \frac{1}{\infty} + \frac{1}{i}$$

combine:

$$\frac{1}{f_{lens}} = \frac{1}{i} - \frac{1}{f_{eye}} = -\frac{1}{0.2\,m} = -5\,m^{-1} = P$$



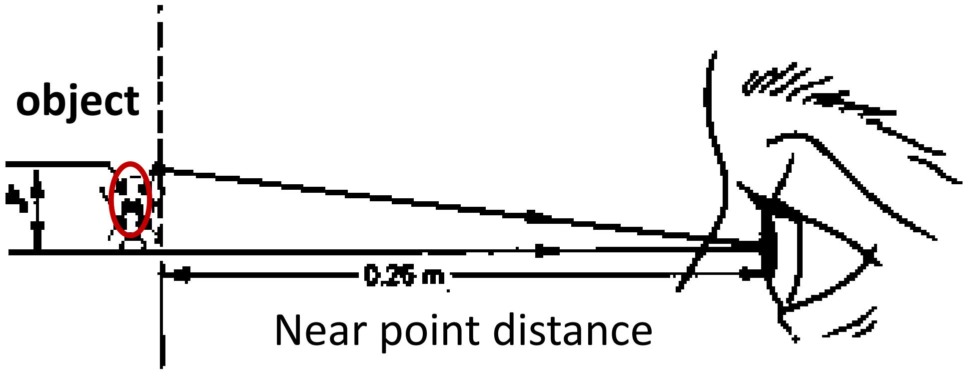
What should be the power of a contact lens such that the far point is at infinity when the eye is wearing the contact lens?

A. $0.20\ m^{-1}$ B. $-0.20\ m^{-1}$ C. $5.0\ m^{-1}$

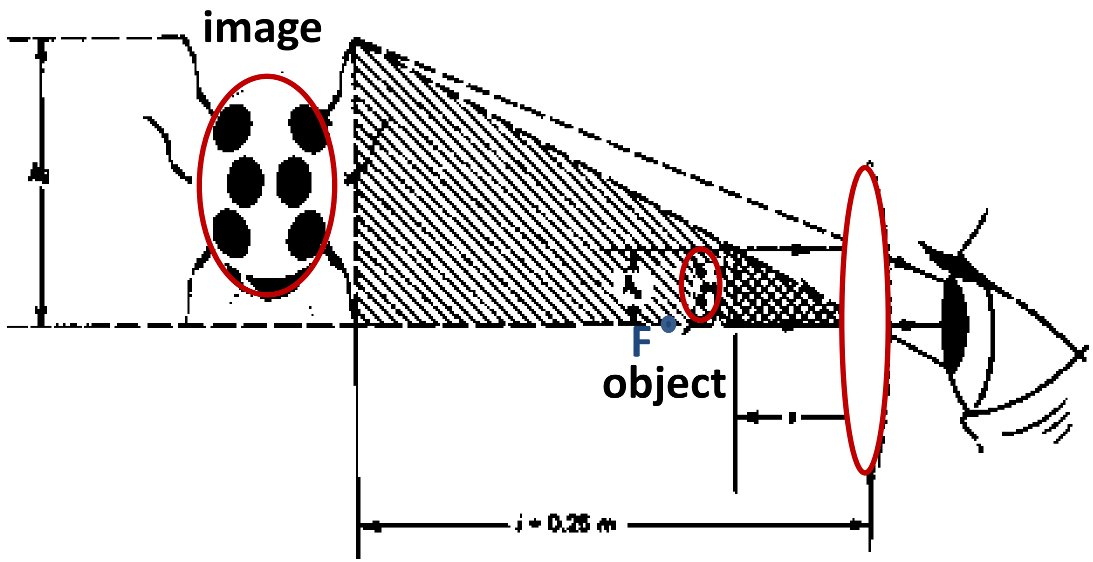
D. $-5.0\ m^{-1}$ E. Not enough information.

Optical Instruments: Simple Magnifying Glass

Without magnifying lens:

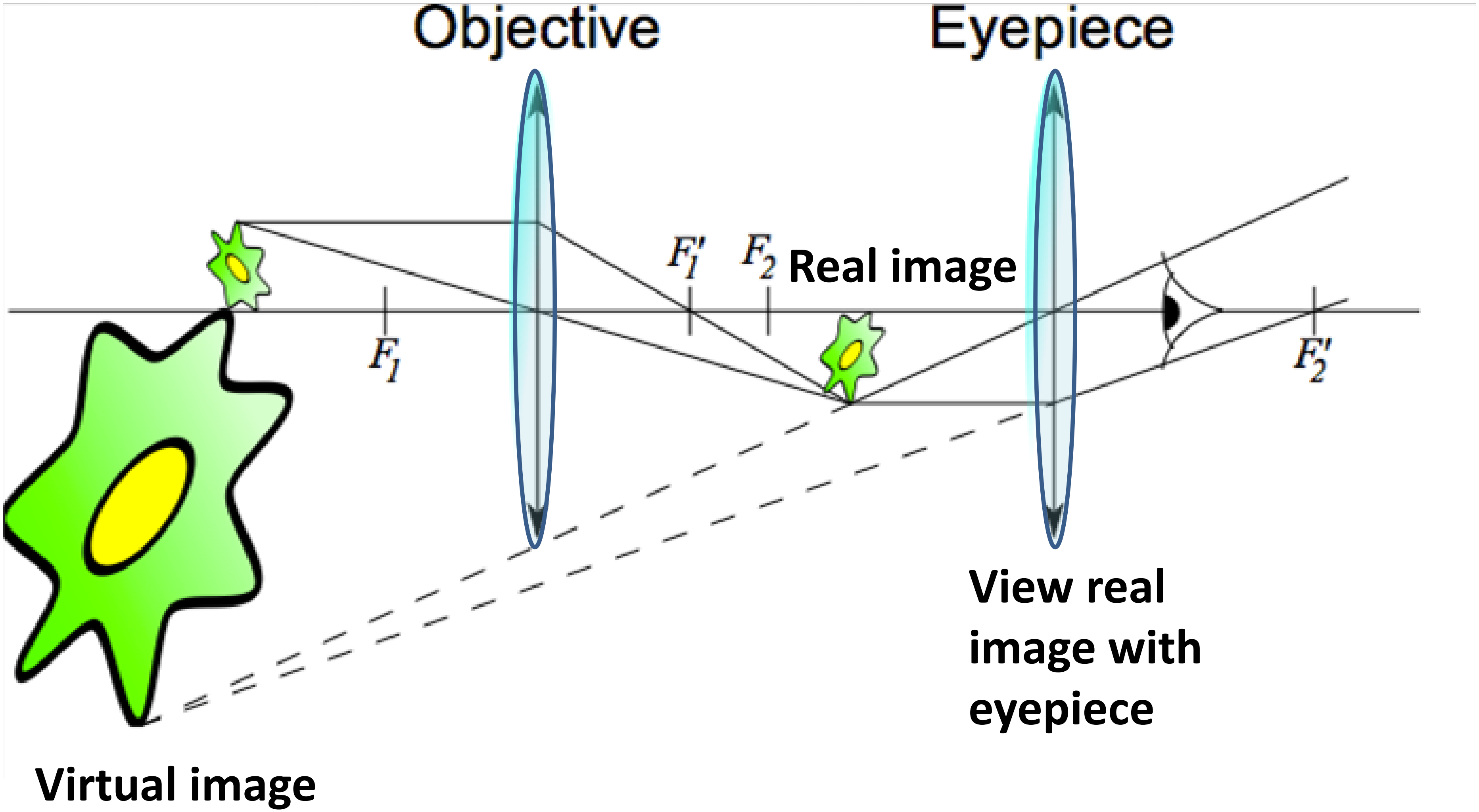


With magnifying lens: object just inside the focal point

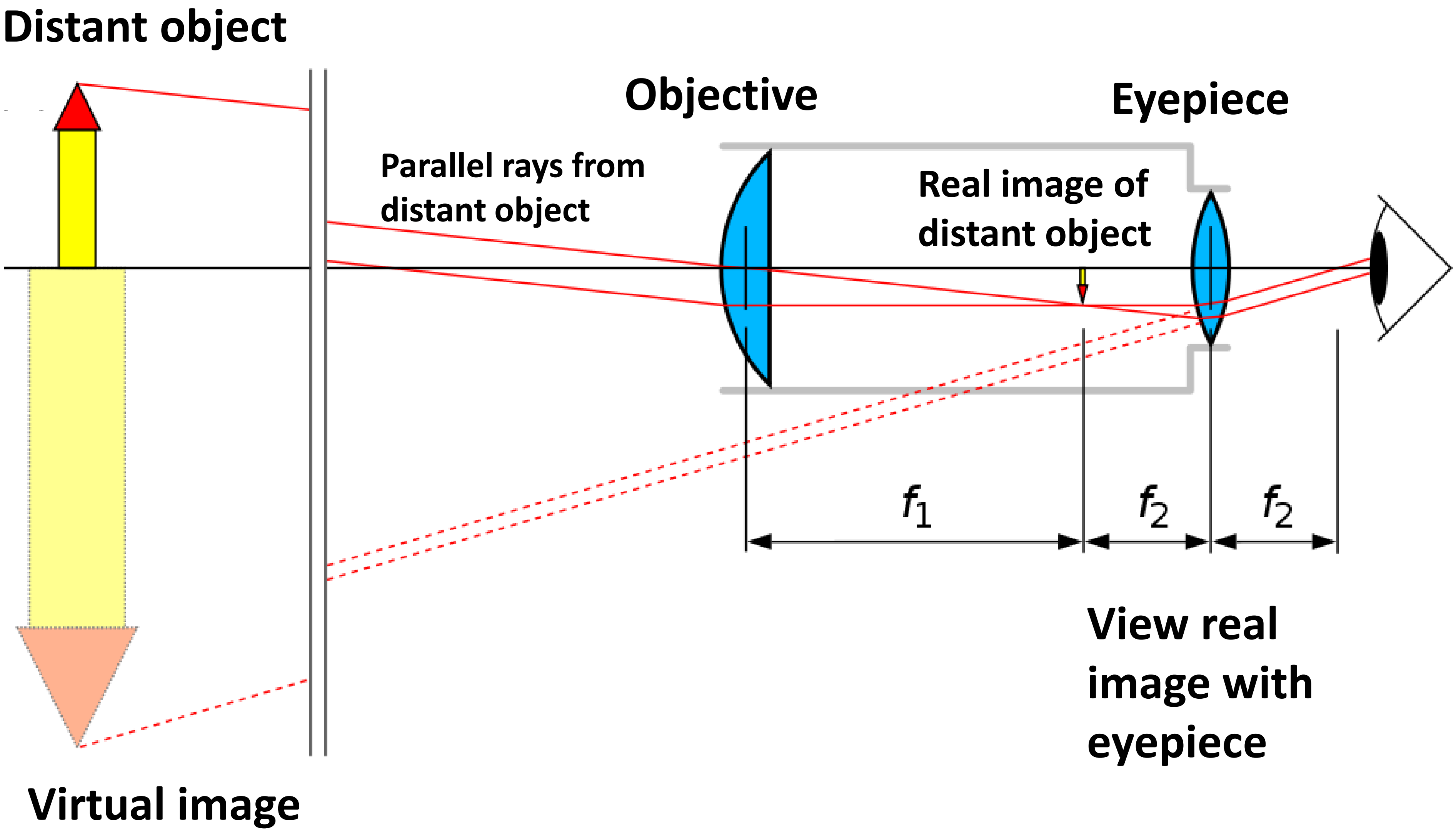


m ~ 25 cm/f

Optical Instruments: Microscope



Optical Instruments: Telescope



Interference (of EM waves):

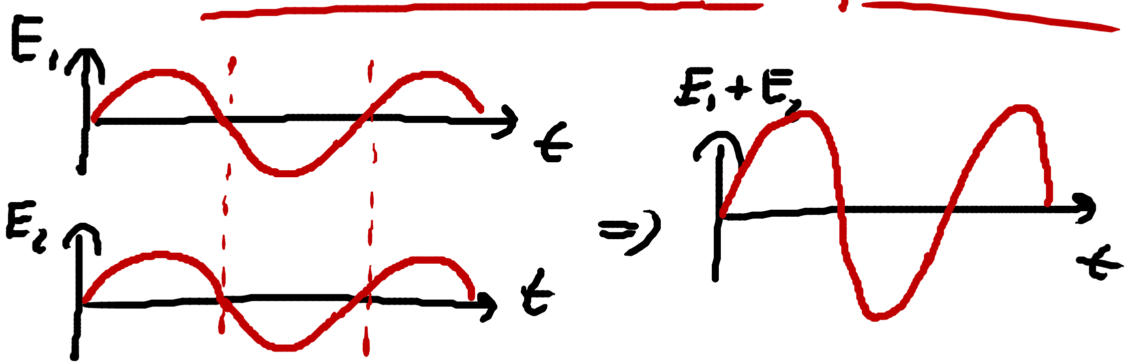
- **Interference:** result of two (or more) overlapping (EM) waves
- **Principle of superposition:** need to add fields of individual waves to get fields of resulting wave
- **Example:** consider two waves of same frequency, same amplitude, same direction of propagation, and same plane-polarization: observe "overlapp" at position P at $x_0 = 0$

wave #1: $E_1 = E_{max} \cos(k x_0 - \omega t + \phi_1)$

wave #2: $E_2 = E_{max} \cos(k x_0 - \omega t + \phi_2)$

⇒ Two extreme cases:

I Constructive Interference:

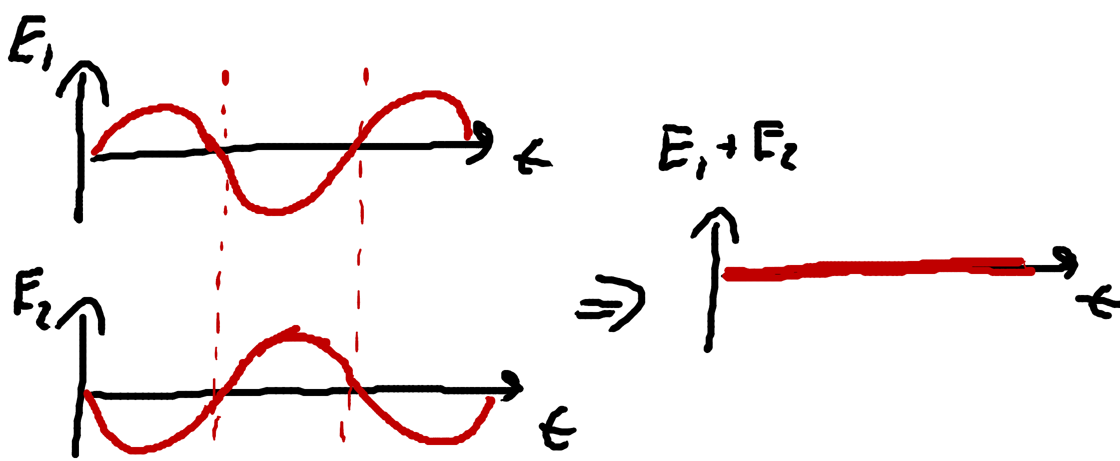


waves are in phase or shifted by an integer number of periods:

$$\Delta\phi = \phi_2 - \phi_1 = m(2\pi)$$

$$m = 0, \pm 1, \pm 2 \ldots$$

II Destructive Interference:



waves are shifted in phase by an odd integer of π

$$\Delta\phi = \phi_2 - \phi_1 = \left(m+\tfrac{1}{2}\right)2\pi$$

$$m = 0, \pm 1, \pm 2 \ldots$$

Phase shift between two waves may be introduced when the waves comming from a source travel along paths of differing lenghts before arriving at a common location:

$$\Delta\phi = \underbrace{\frac{2\pi}{\lambda}}_{k = \text{wavenumber}} (\Delta \text{ path length})$$

1st Example: