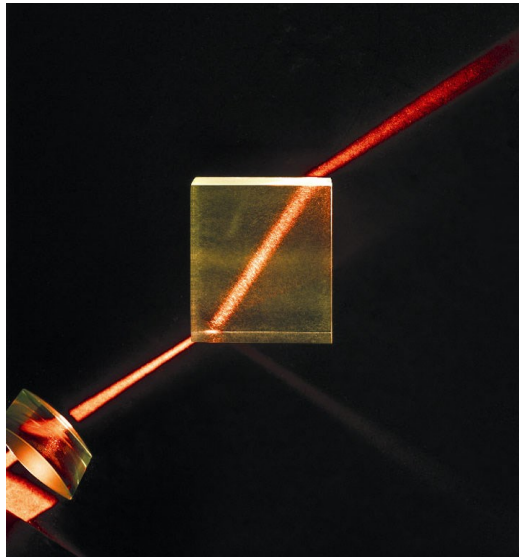
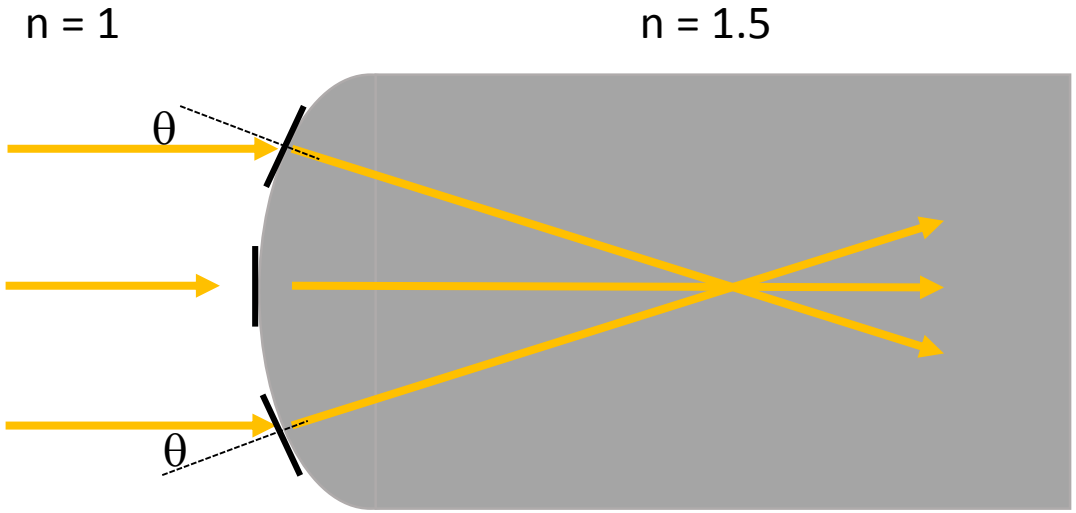
Imaging, reflection, and diffraction

- Last class
  - Refraction
  - Thin lens equation, magnification
  - Imaging with different lenses
- This class
  - Reflection off mirrors
  - Reflection off glass
  - Components of a microscope





$$\frac{1}{f} = (n-1)\left[\frac{1}{R_1} - \frac{1}{R_2} + \frac{(n-1)d}{nR_1R_2}\right],$$

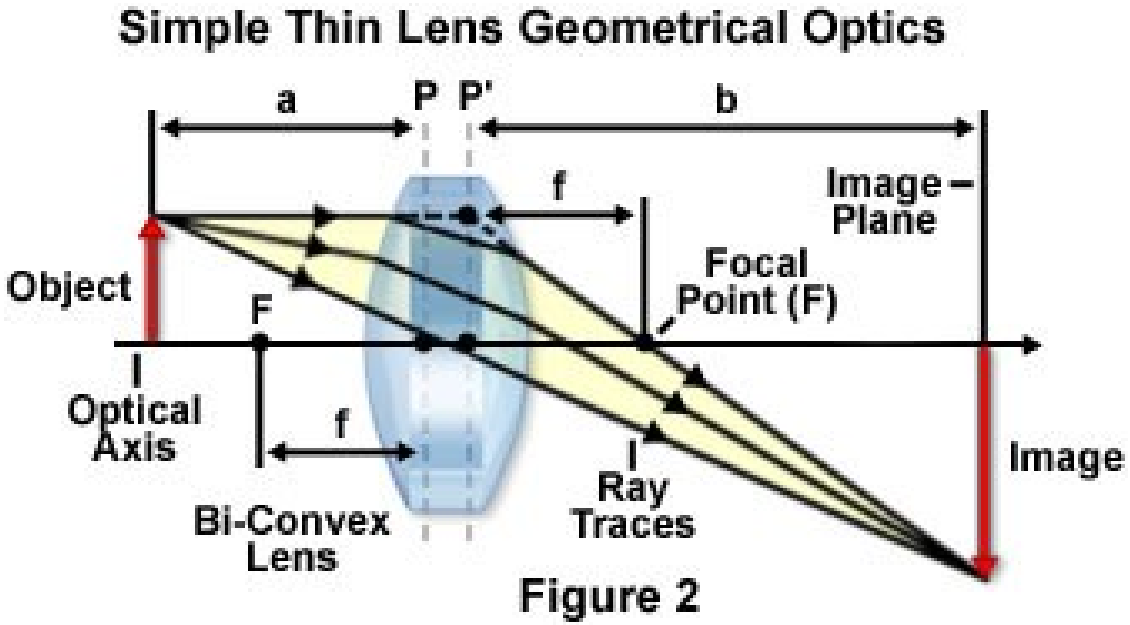
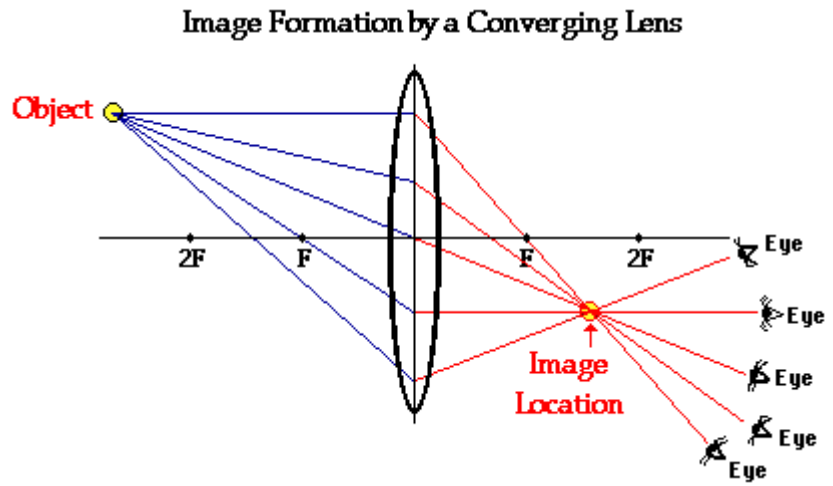
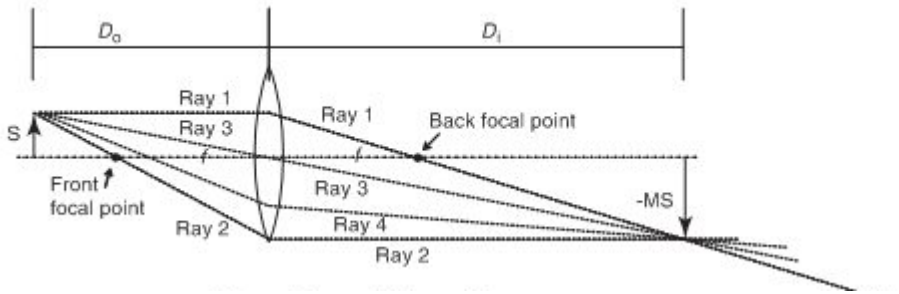


Figure 2

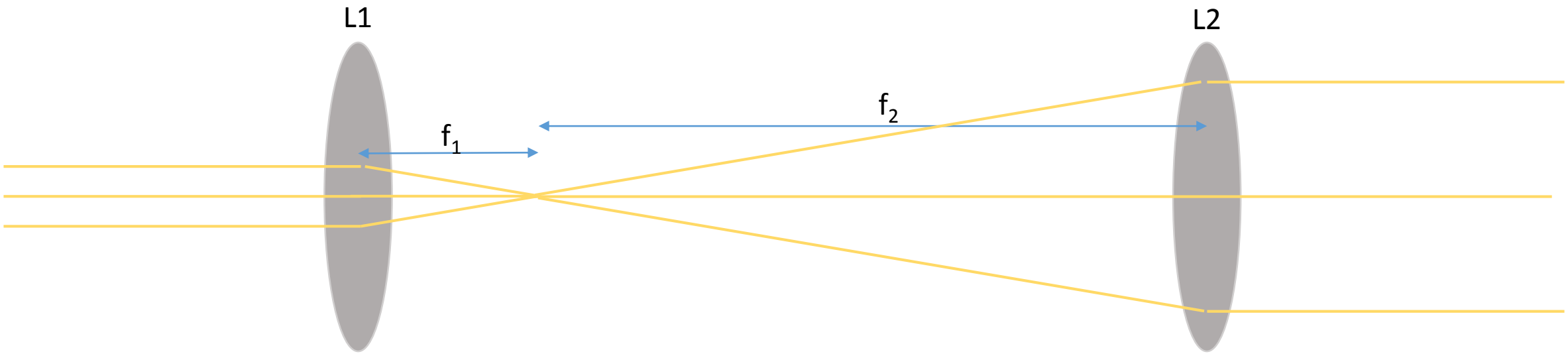
Lenses and imaging

- Three rules of ray tracing:
  - Rays impinging on center of lens are unperturbed
  - Parallel ray goes through focal point
  - Ray that goes through focal point emerges parallel



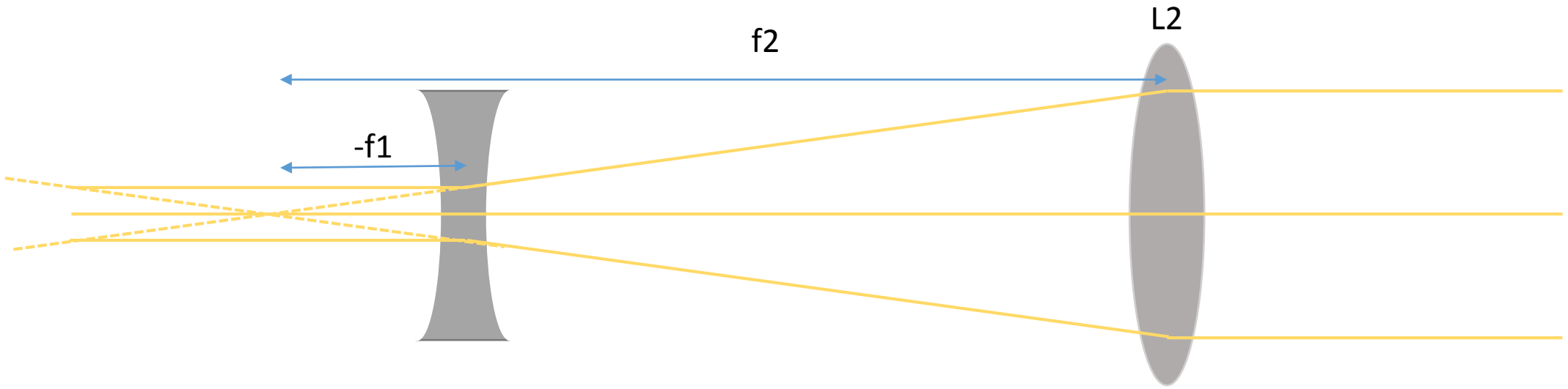


Beam expanders/condensers



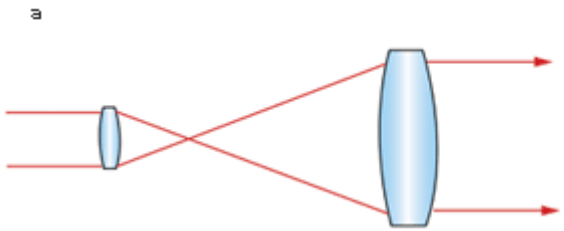
$d = f2+f1 \qquad M = f2/f1$

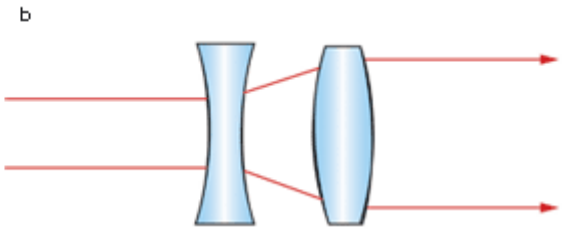
Galilean Beam expanders

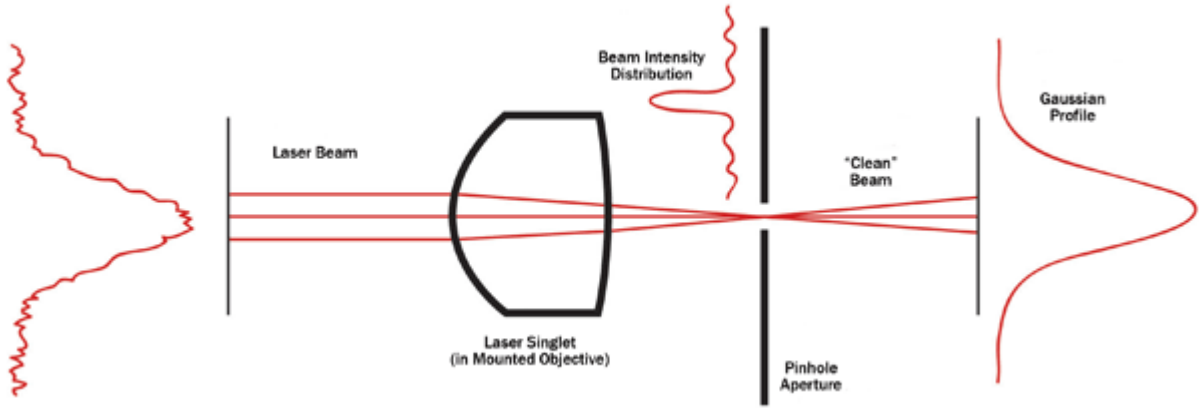


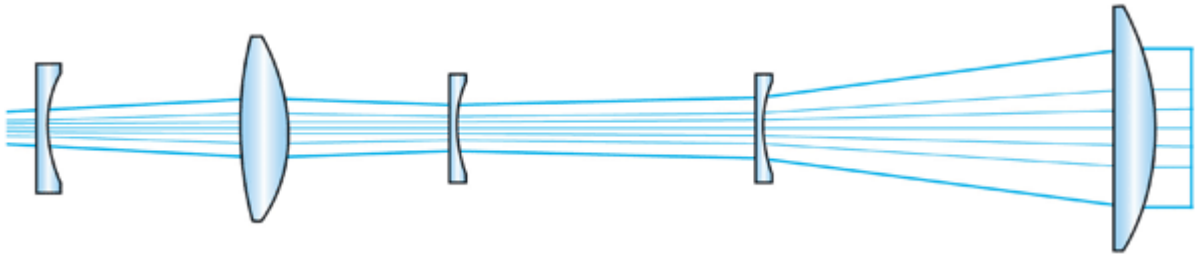
$d = f2 - f1 \qquad M = f2/f1$

General considerations for beam expanders







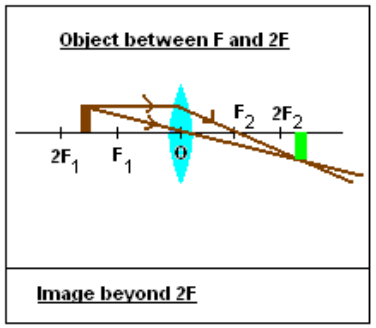


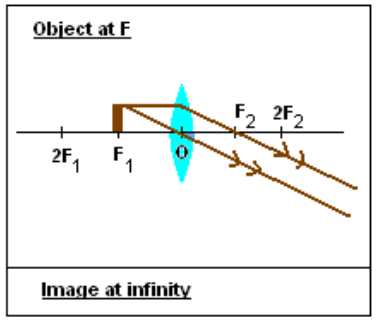
Imaging with lenses

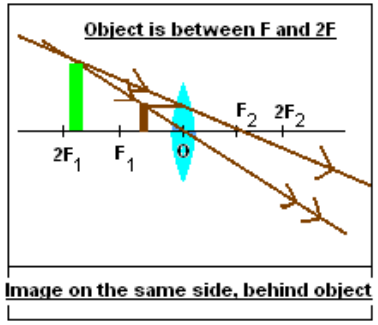
Imaging

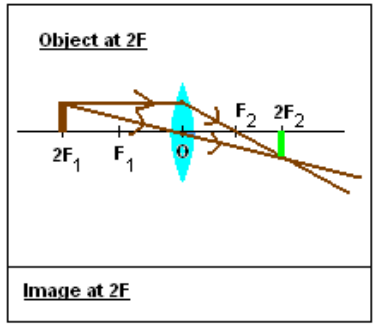
$$\frac{1}{f} = (n-1)\left[\frac{1}{R_1} - \frac{1}{R_2} + \frac{(n-1)d}{nR_1R_2}\right],$$

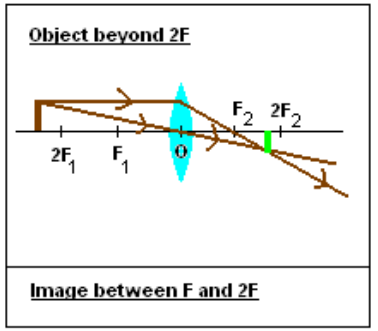
$$\frac{1}{o} + \frac{1}{i} = \frac{1}{f}$$ Thin lens equation

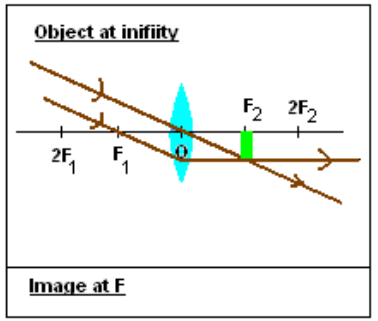


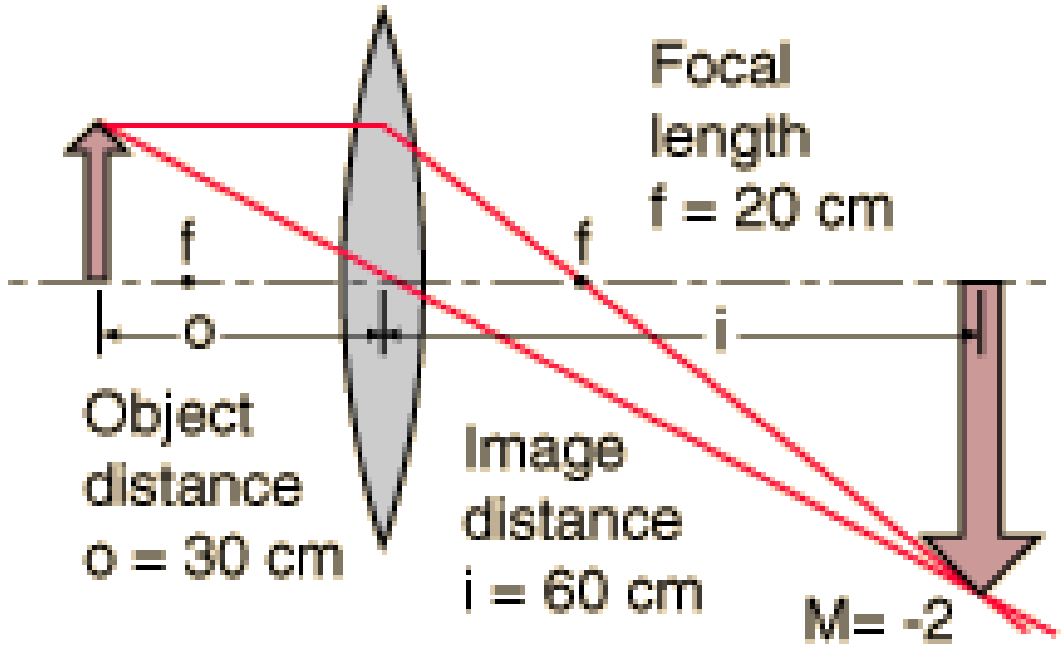








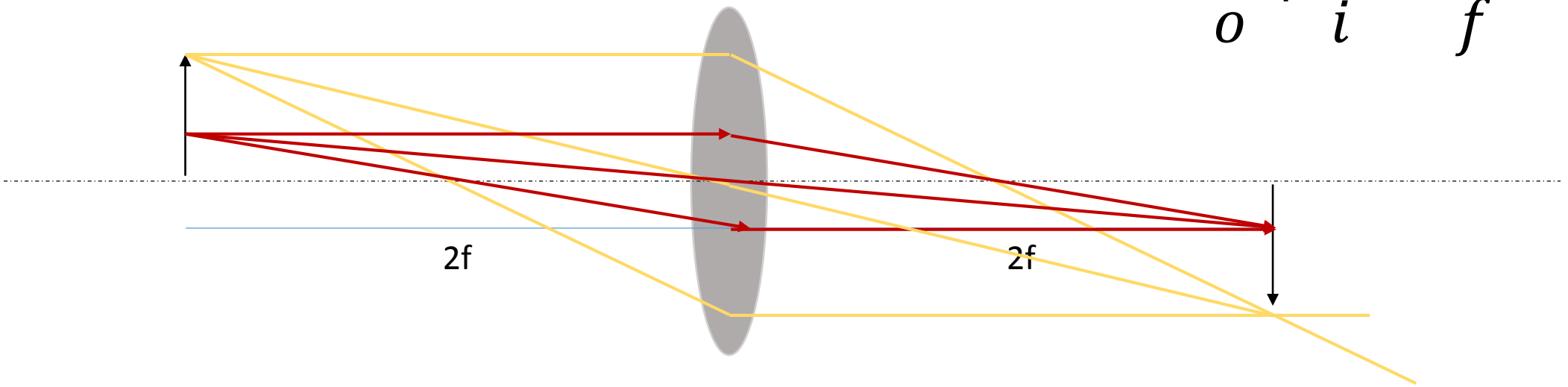




	Lenses
Focal Length (*f*)	+ for a converging lens
	- for a diverging lens
Object Distance (d_o)	+ if the object is to the left of the lens (real object)
	- if the object is to the right of the lens (virtual object)*
Image Distance (d_i)	+ for an image (real) formed to the right of the lens by a real object
	- for an image (virtual) formed to the left of the lens by a real object
Magnification (*m*)	+ for an image that is upright with respect to the object
	-for an image that is inverted with respect to the object.

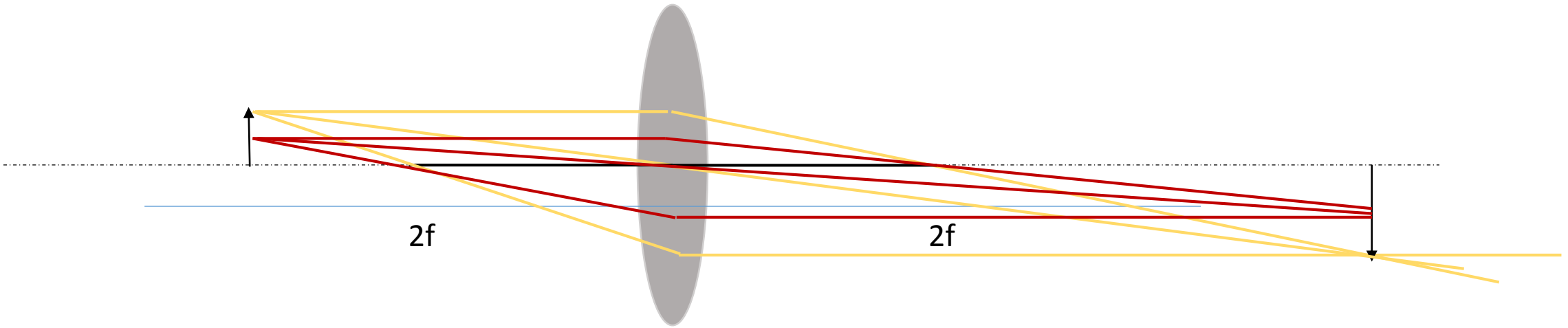
Relay lens – 2f away

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

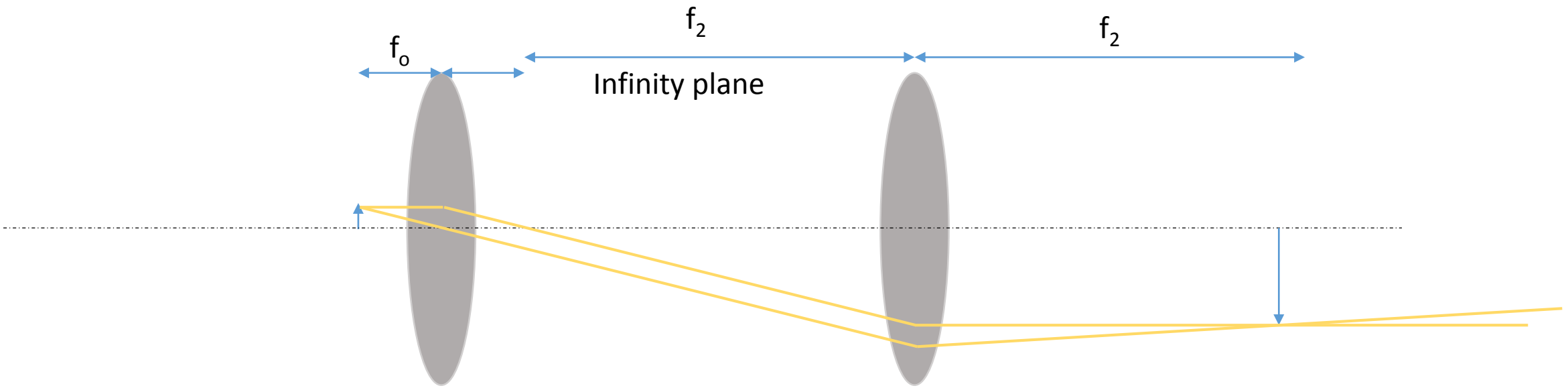


$M = -h_i/h_o = i/o$

Object is between 2f and f



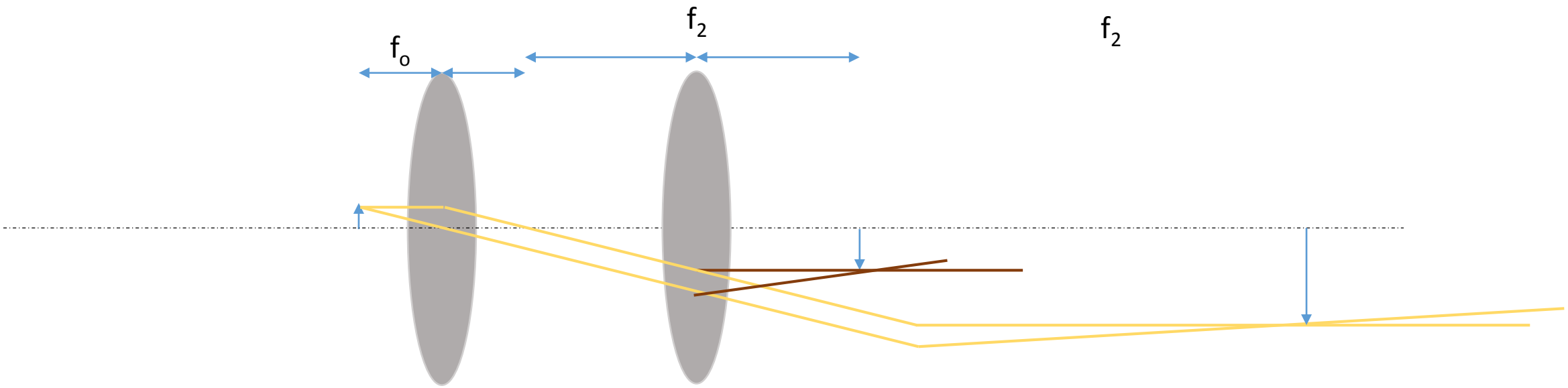
Infinity imaging system (4f imaging)



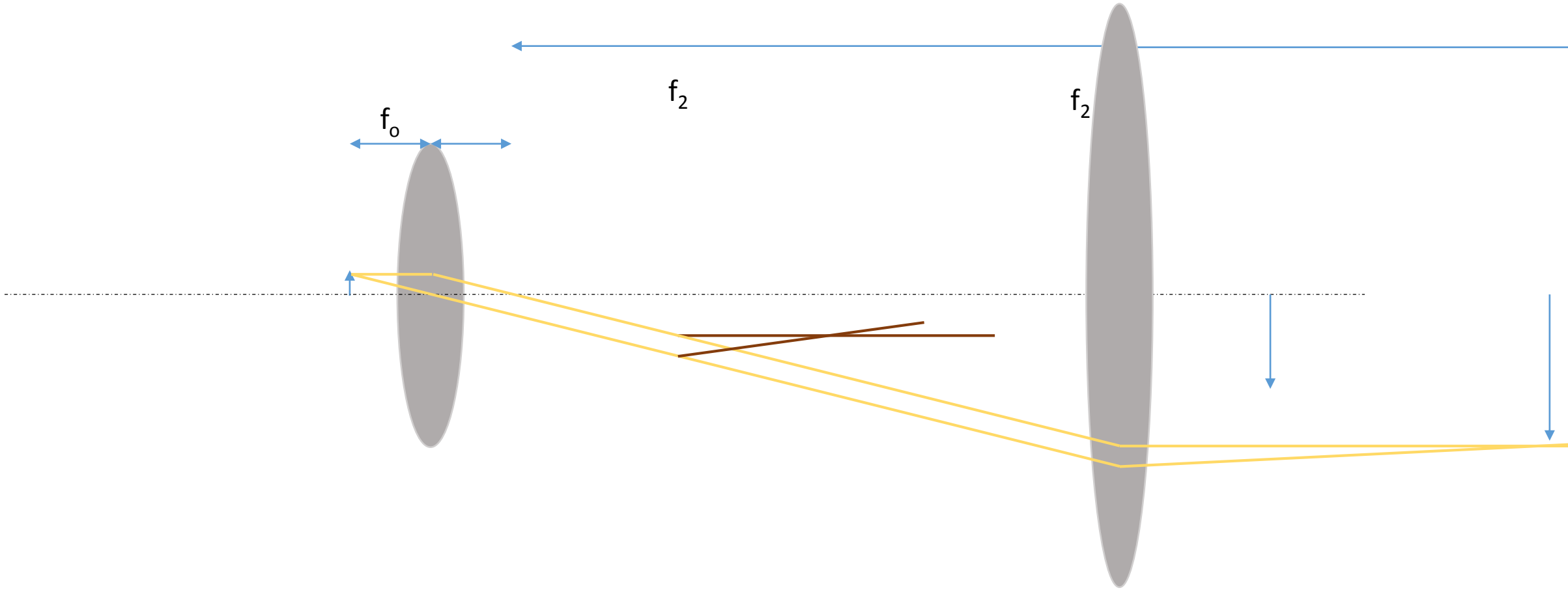
$M = f_2/f_1$

Camera chip sizes – 6-13 mm big
Pixel sizes are ~6-16 μm

Changing second lens



Changing second lens



Modern infinity systems

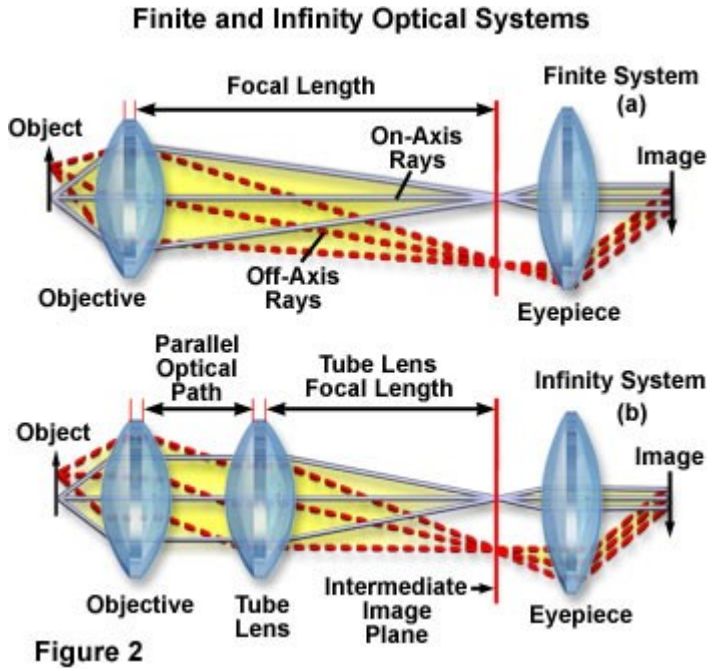


Figure 2

Manufacturer	Tube Lens Focal Length (Millimeters)	Parfocal Distance (Millimeters)	Thread Type
Leica	200	45	M25
Nikon	200	60	M25
Olympus	180	45	RMS
Zeiss	165	45	RMS

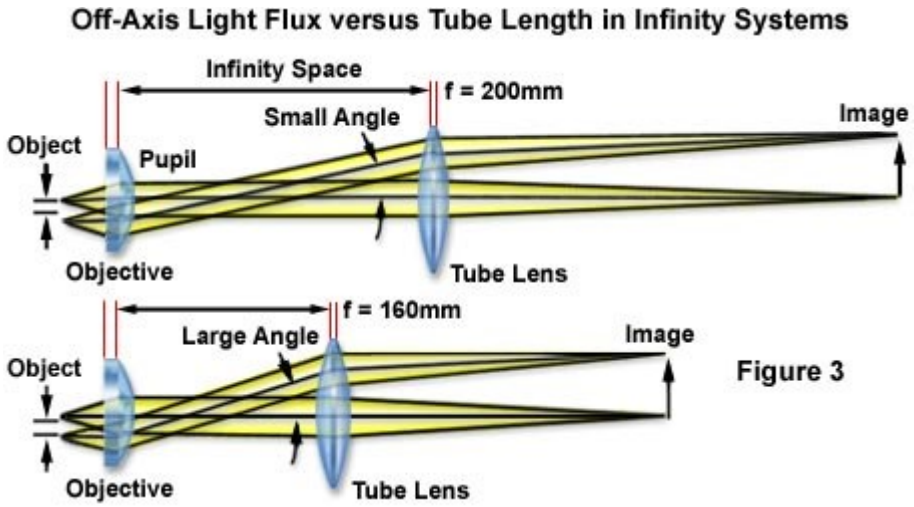


Figure 3

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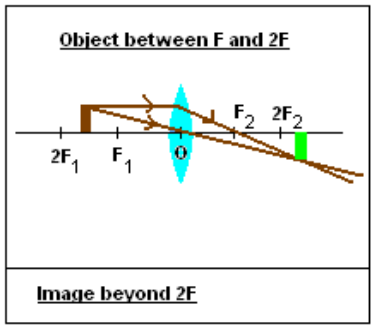

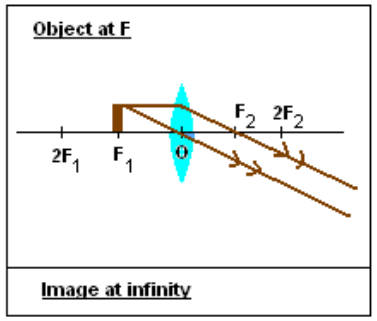

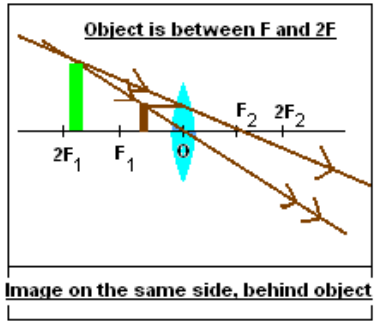

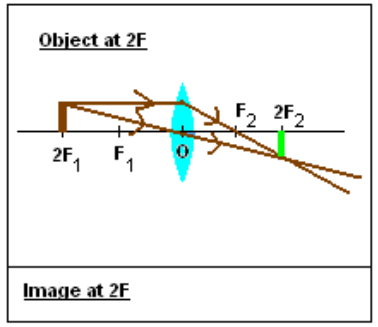

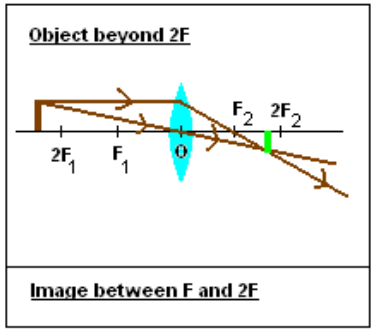

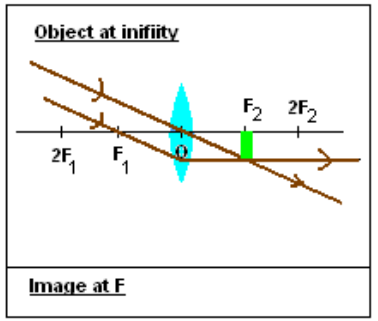

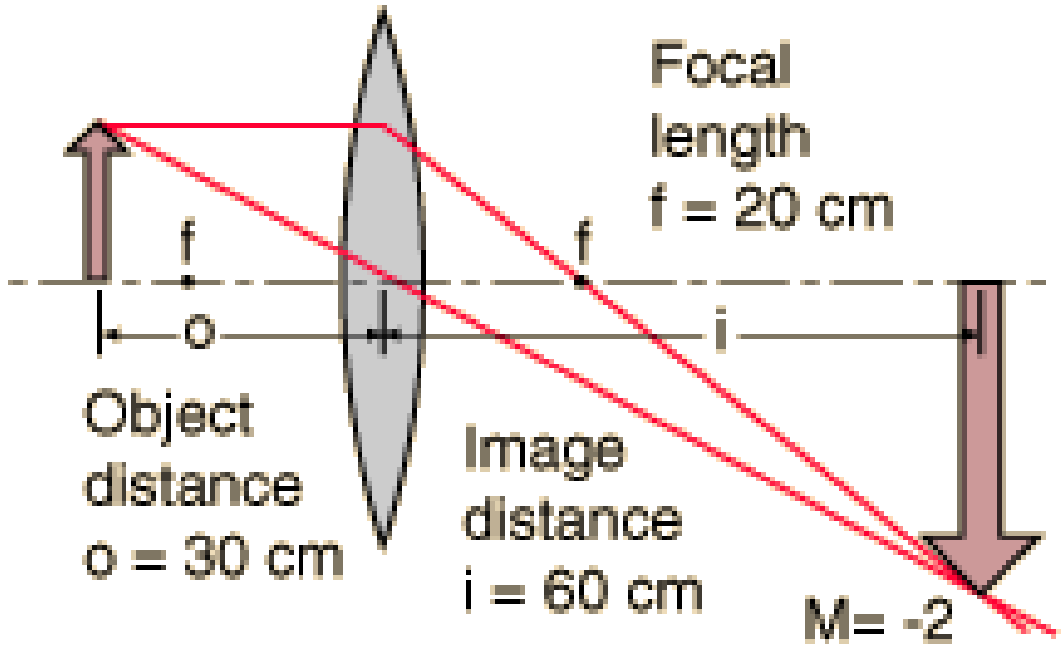

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On to Matlab…