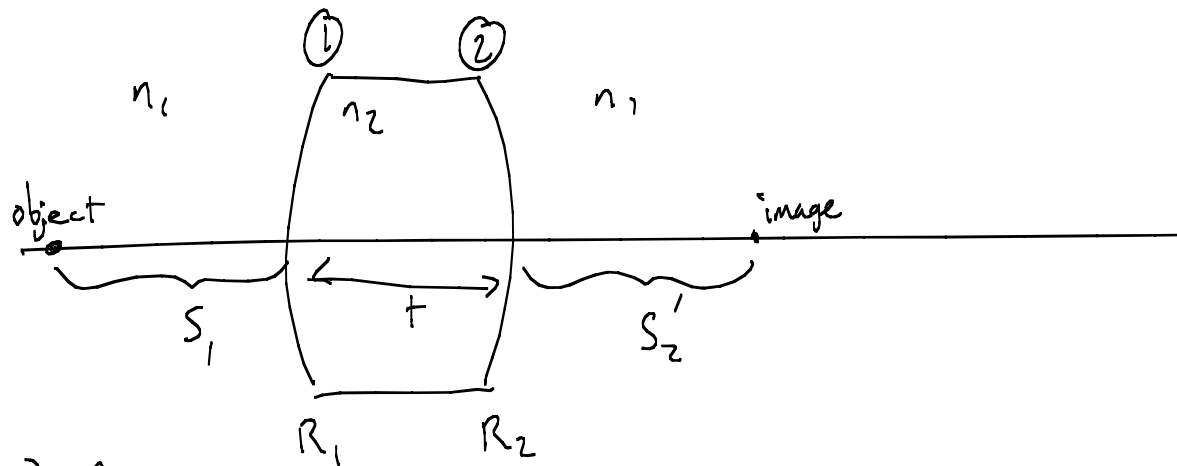


Lenses



$$(1) \frac{n_1}{s_1} + \frac{n_2}{s_1'} = \frac{n_2 - n_1}{R_1}$$

$$(2) \frac{n_2}{s_2} + \frac{n_1}{s_2'} = \frac{n_1 - n_2}{R_2}$$

$$-\frac{n_2}{s_1'} + \frac{n_1}{s_2'} = \frac{n_1 - n_2}{R_2}$$

Note: $s_2 = t - s_1'$
 $\approx -s_1'$

Add (1) + (2): $\frac{n_1}{s_1} + \frac{n_1}{s_2'} = (n_2 - n_1) \left(\frac{1}{R_1} - \frac{1}{R_2} \right)$

In air, $n_1 = 1$: $\frac{1}{s_1} + \frac{1}{s_2'} = (n_2 - 1) \left(\frac{1}{R_1} - \frac{1}{R_2} \right)$

for object @ infinity, $\frac{1}{f} = (n_2 - 1) \left(\frac{1}{R_1} - \frac{1}{R_2} \right)$

"lensmaker's equation"

Examples

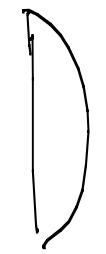
"plano-convex" :



$$R_1 > 0$$

$$R_2 = \infty$$

$$\frac{1}{f} = \frac{(n-1)}{R_1} > 0$$



$$R_1 = \infty$$

$$R_2 < 0$$

$$\frac{1}{f} = \frac{n-1}{|R_2|} > 0$$

Both
converging
lenses

"Biconvex" :

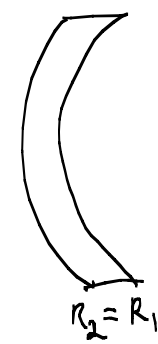


$$R_1 > 0$$

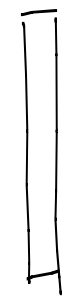
$$R_2 < 0$$

$$|R_1| = |R_2| = R$$

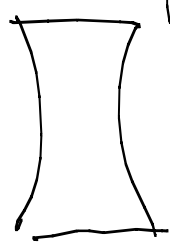
$$\frac{1}{f} = (n-1) \frac{2}{R} > 0$$



$$R_2 = R_1$$



"Biconcave" :



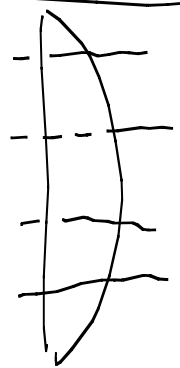
$$R_1 < 0$$

$$R_2 > 0$$

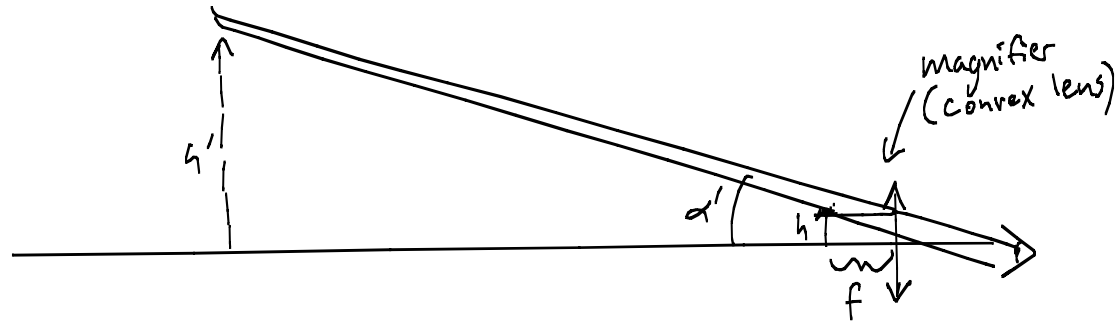
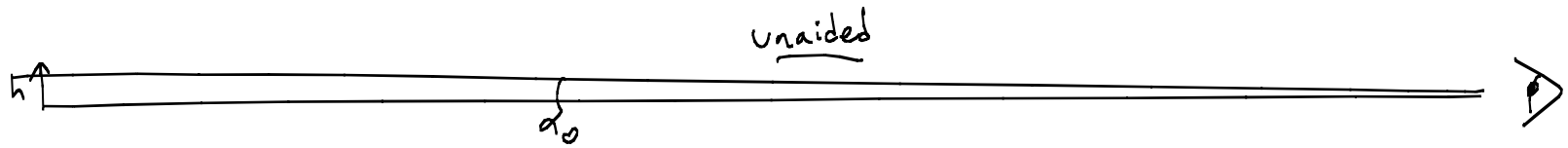
$$|R_1| = |R_2| = R$$

$$\frac{1}{f} = (n-1) \left(-\frac{2}{R} \right) < 0$$

Fresnel lens

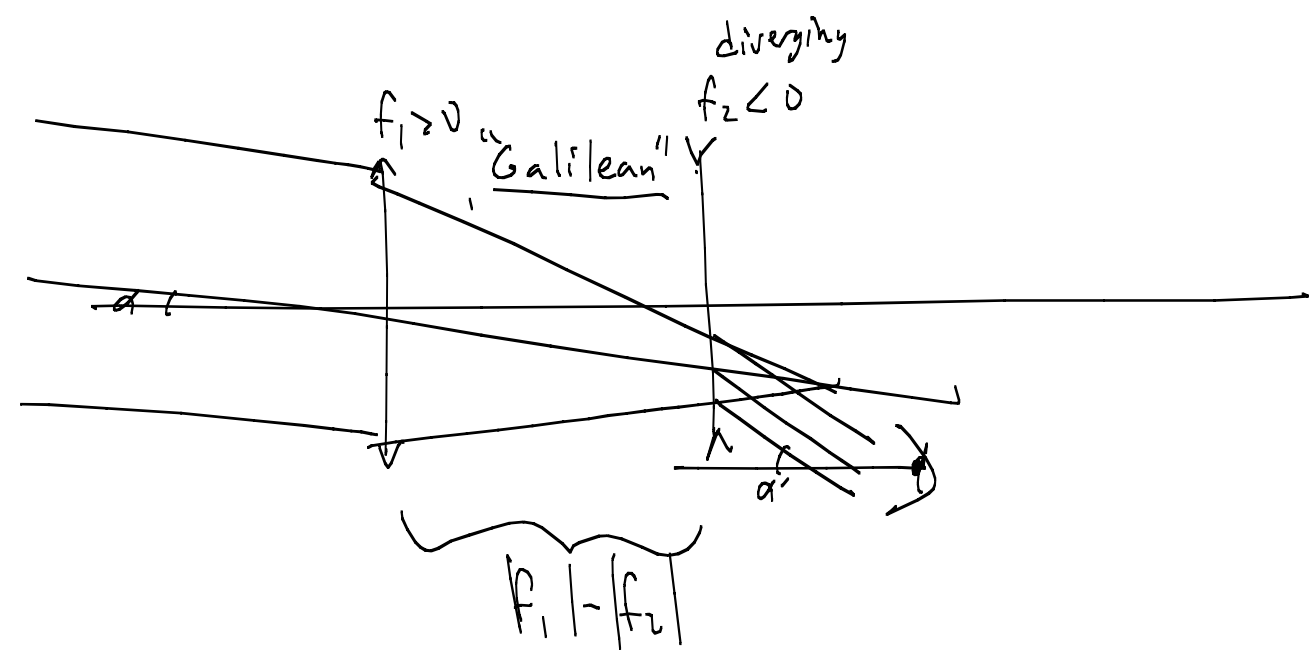
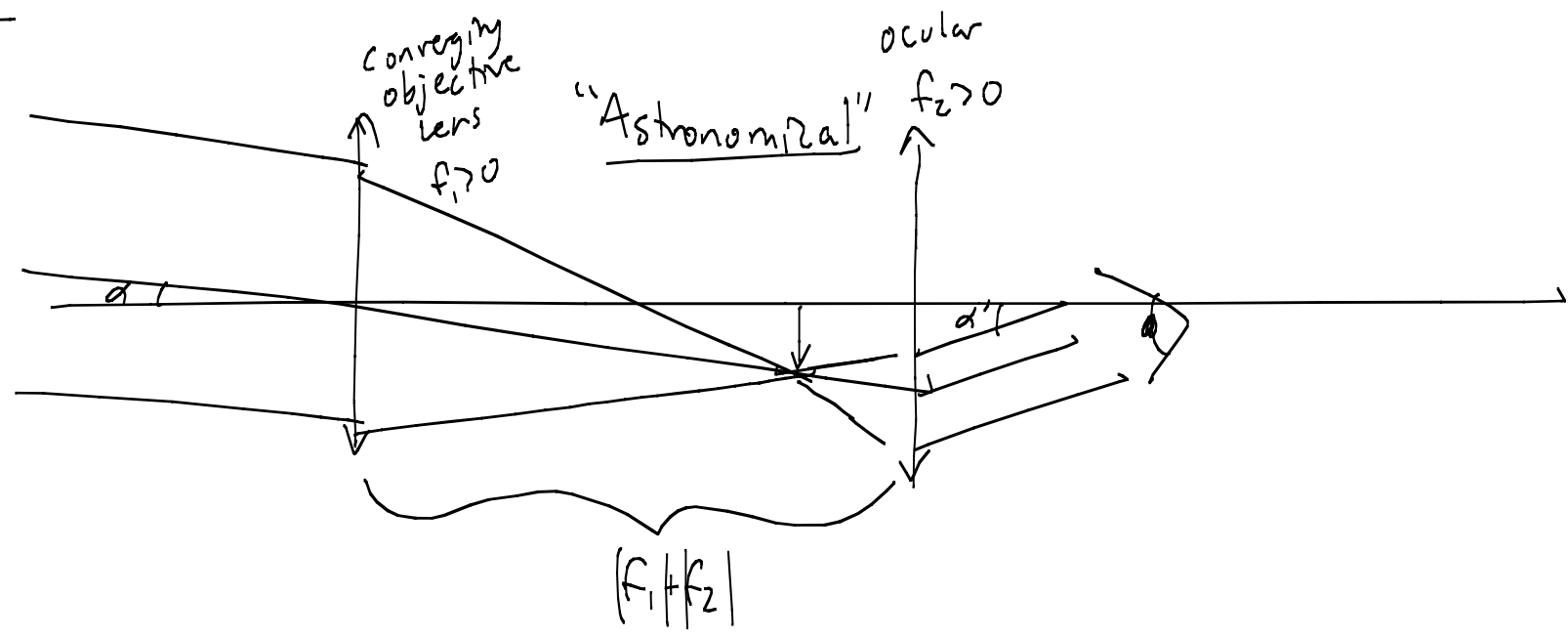


Magnifiers



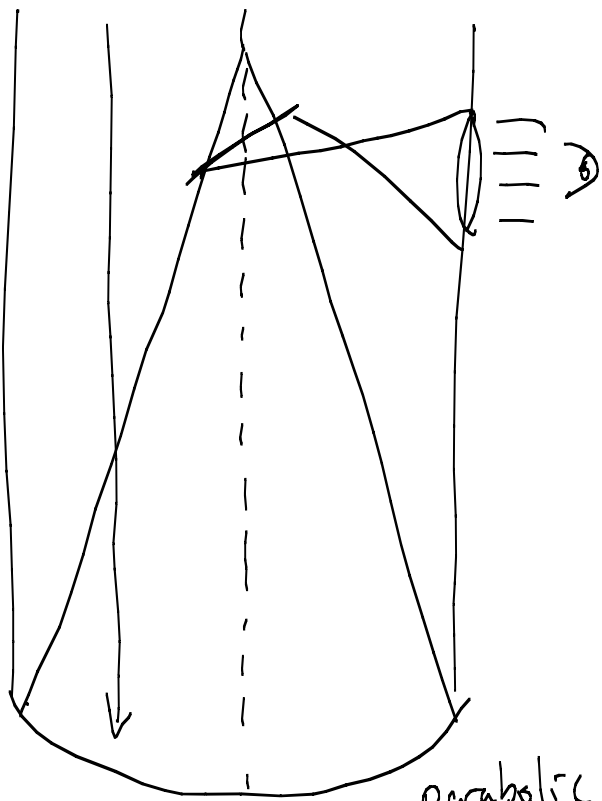
$$\text{Magnification} = \frac{\alpha'}{\alpha_0}$$

(Refraction)
Telescope



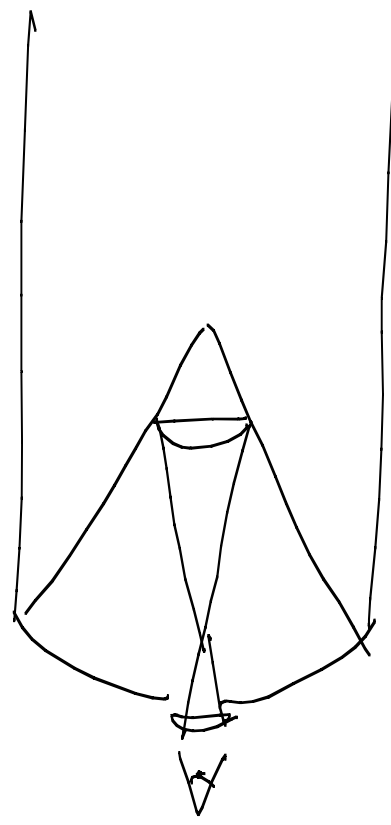
Reflecting Telescopes

"Newtonian"



parabolic mirror
(focuses parallel rays to a point)

"Cassegrain"



"Gregorian"

