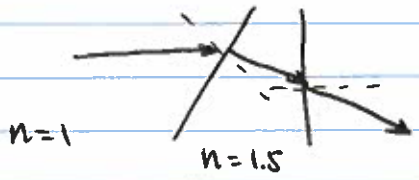
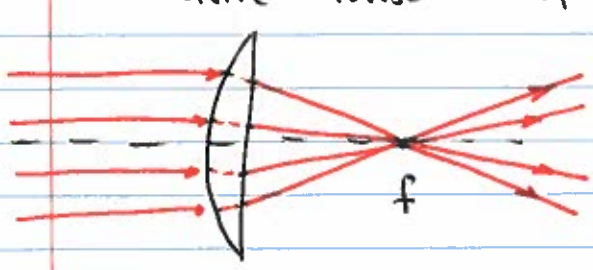
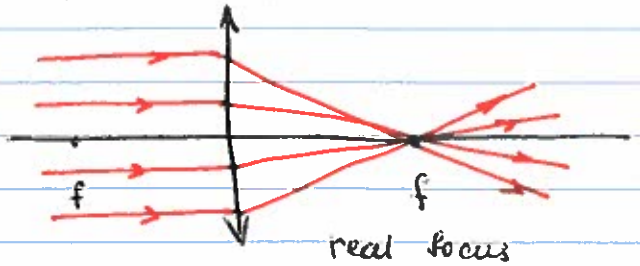
Thin lenses → beam propagation is affected by refraction



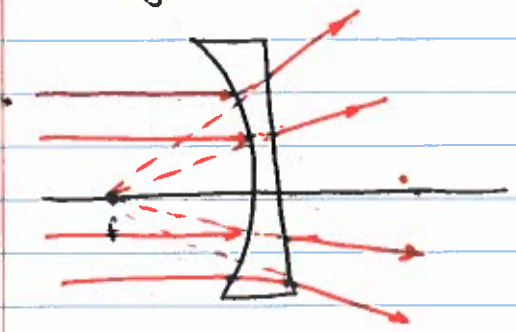
Positive lense (plano-convex, double-convex)

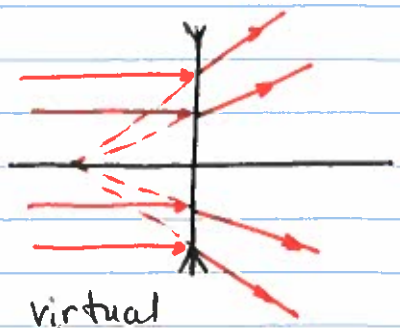




real focus
($f > 0$)

Negative lense (plano-concave, doublet)



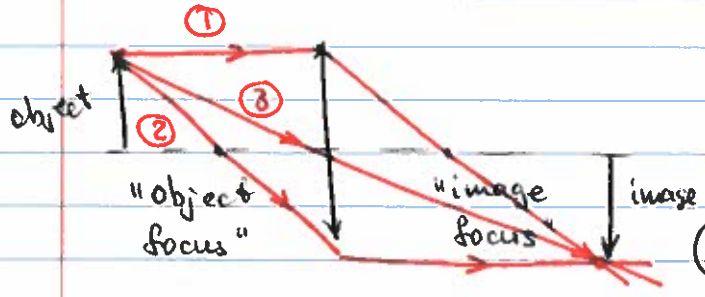


virtual focus ($f < 0$)

Object $\frac{1}{do} + \frac{1}{di} = \frac{1}{f}$

"Thin lens" imply that the beam displacement inside the lens is neglected

Principle rays



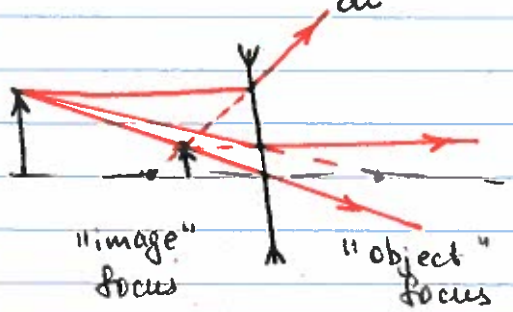
① Parallel to optical axis → through the image focus

② Through the "object" focus → parallel ~~at~~ to optical axis

③ Hits the center → unchanged

$d_o = 2f$ $\quad \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \Rightarrow \frac{1}{2f} + \frac{1}{d_i} = \frac{1}{f} \quad d_i = 2f$

$M = -\frac{d_i}{d_o} = -1$ (inverted real image)



$f<0$

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

$\frac{1}{2|f|} + \frac{1}{d_i} = -\frac{1}{|f|}$

$d_i = -\frac{2|f|}{3}$

$M = -\frac{d_i}{d_o} = \frac{1}{3}$

} Virtual erect image