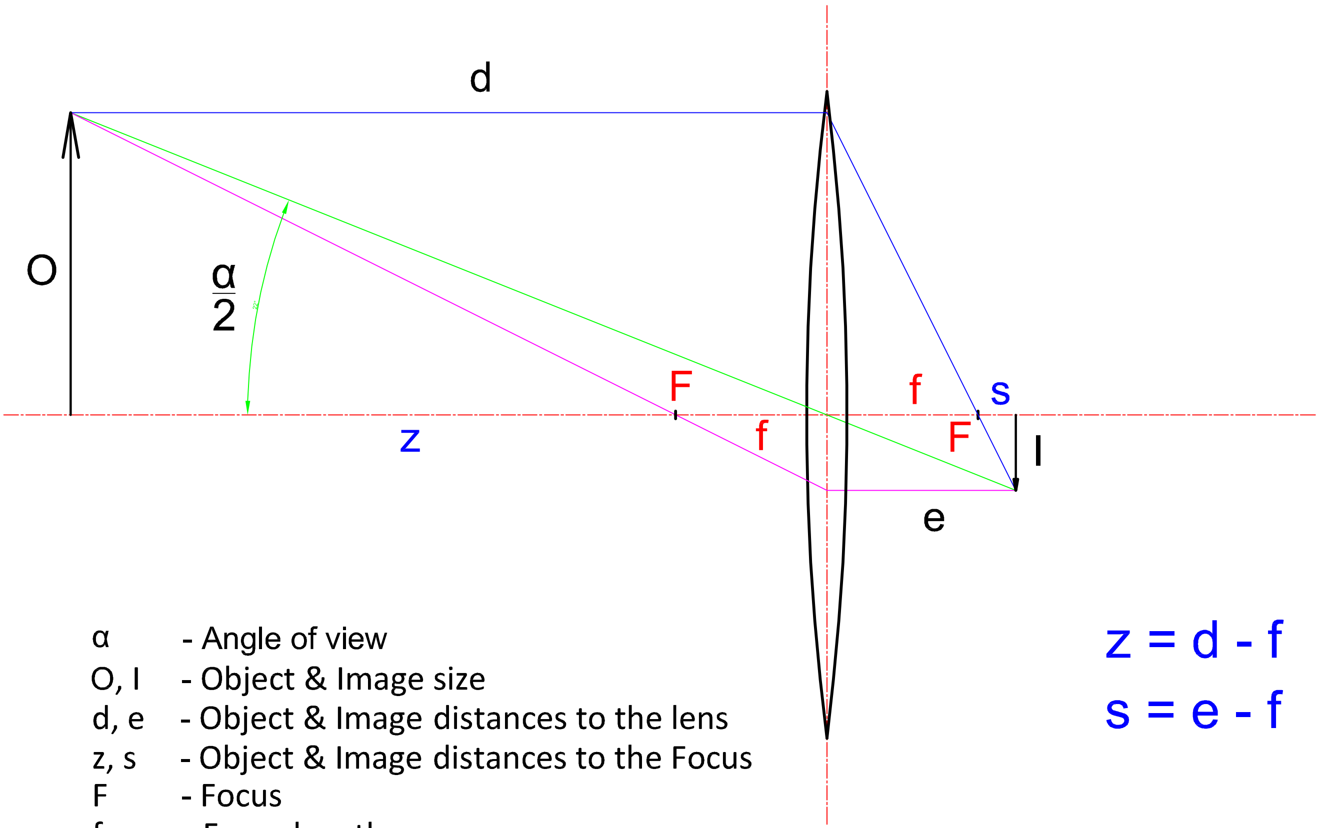
Thin Lens Optics



α	- Angle of view
O, I	- Object & Image size
d, e	- Object & Image distances to the lens
z, s	- Object & Image distances to the Focus
F	- Focus
f	- Focus length
M	- Magnification factor

$$z = d - f$$
$$s = e - f$$

$$\frac{O}{d} = \frac{I}{e} \implies \frac{I}{O} = \frac{e}{d} = M$$

$$\frac{O}{d-f} = \frac{I}{f} \implies \frac{I}{O} = \frac{f}{d-f} = M$$

drawing by: Adam Wiktor Kamela

$$\boldsymbol{M = \frac{f}{d-f}} \quad \& \quad \boldsymbol{M = \frac{e}{d}}$$

$$==> \quad \frac{d}{e} = \frac{d}{f} - 1 \quad ==> \quad \frac{1}{e} = \frac{1}{f} - \frac{1}{d} \quad ==>$$

$$\boldsymbol{\frac{1}{f} = \frac{1}{d} + \frac{1}{e}} \quad \& \quad \boldsymbol{f = \frac{e*d}{e+d}}$$

$$e = s + f \;\; \& \;\; d = z + f \quad ==> \; f = \frac{(s+f)*(z+f)}{s+f+z+f} \quad ==> \quad f = \frac{sz++sf+fz+f^2}{s+z+2f} \quad ==>$$

$$==> \quad fs + fz + 2f^2 = sz + sf + fz + f^2 \quad ==>$$

$$\boldsymbol{f^2 = s*z} \quad \& \quad \boldsymbol{\frac{f}{z} = \frac{s}{f}}$$

$$M = \frac{f}{d-f} \quad \& \quad z = d - f \quad ==>$$

$$\boldsymbol{\frac{f}{z} = M} \quad \& \quad \boldsymbol{\frac{f}{z} = \frac{f}{d-f}}$$

$$\frac{f}{z} = M \quad \& \quad f^2 = s*z \quad ==>$$

$$\boldsymbol{\frac{s}{f} = M}$$

$$M = \frac{f}{d-f} \quad \& \quad \frac{s}{f} = M \quad ==>$$

$$\boldsymbol{\frac{s}{f} = \frac{f}{d-f}} \quad \& \quad \boldsymbol{\frac{s}{f} = \frac{1}{\frac{d}{f}-1}} \quad \& \quad \boldsymbol{\frac{f}{s} = \frac{d}{f} - 1}$$

$$f=\frac{e*d}{e+d} \quad \& \quad M=\frac{e}{d} \quad ==> \quad \frac{e}{f}=\frac{e}{d}+1 \quad ==>$$

$$\boldsymbol{\frac{e}{f}=M+1}$$

$$M=\frac{f}{d-f} \quad \& \quad \frac{e}{f}=M+1 \quad ==> \quad \frac{e}{f}=\frac{f}{d-f}+1 \quad ==>$$

$$\boldsymbol{\frac{e}{f}=\frac{d}{d-f} \quad \& \quad \frac{e}{f}=\frac{1}{1-\frac{f}{d}} \quad \& \quad \frac{f}{e}=1-\frac{f}{d}}$$

$$M=\frac{f}{d-f} \quad ==> \quad \frac{1}{M}=\frac{d-f}{f} \quad ==> \quad \frac{1}{M}=\frac{d}{f}-1 \quad ==>$$

$$\boldsymbol{\frac{d}{f}=1+\frac{1}{M}}$$

$$\boldsymbol{M=\frac{e}{d}=\frac{e}{f}-1=\frac{1}{\frac{d}{f}-1}=\frac{f}{z}=\frac{s}{f}}$$

$$\tan\left(\frac{\alpha}{2}\right)=\frac{O}{d} \quad \& \quad O=\frac{I}{M} \quad ==> \quad \tan\left(\frac{\alpha}{2}\right)=\frac{I}{d*M} \quad ==>$$

$$M=\frac{f}{d-f} \quad \& \quad I=\frac{h}{2} \quad ==> \quad \tan\left(\frac{\alpha}{2}\right)=\frac{h}{2}*\frac{d-f}{fd}=\frac{h}{2}*\left(\frac{1}{f}-\frac{1}{d}\right) \quad ==>$$

$$\boldsymbol{\propto=2*atan\left[\frac{h}{2}*\left(\frac{1}{f}-\frac{1}{d}\right)\right]}$$