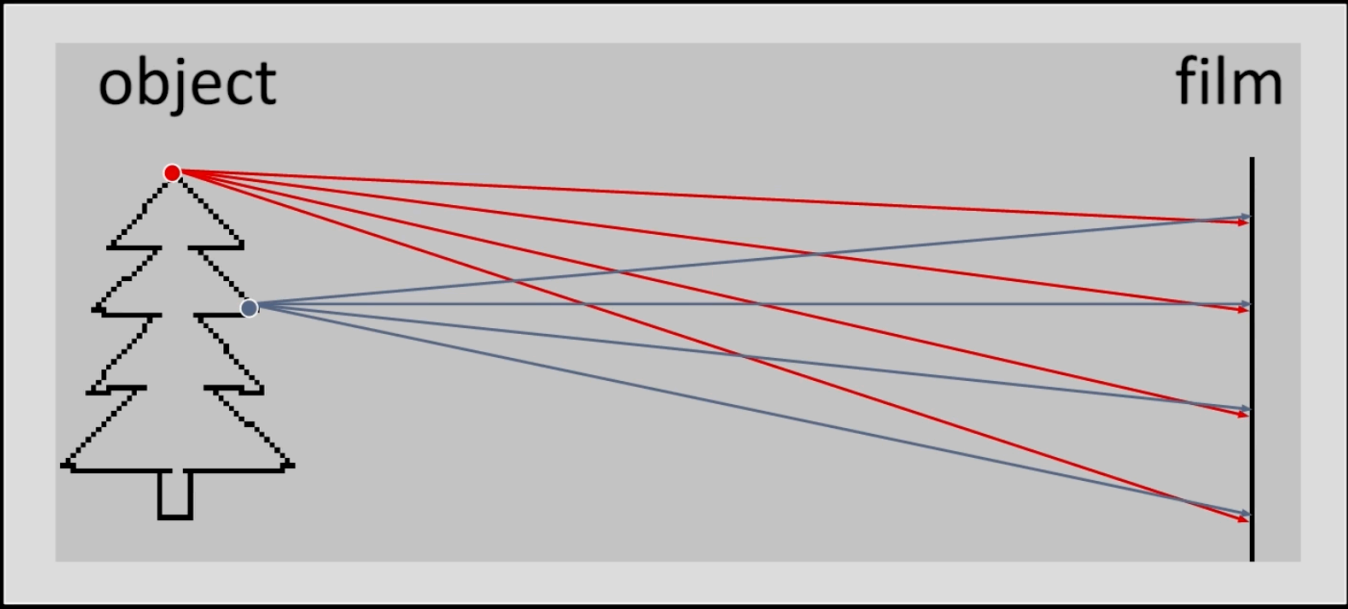
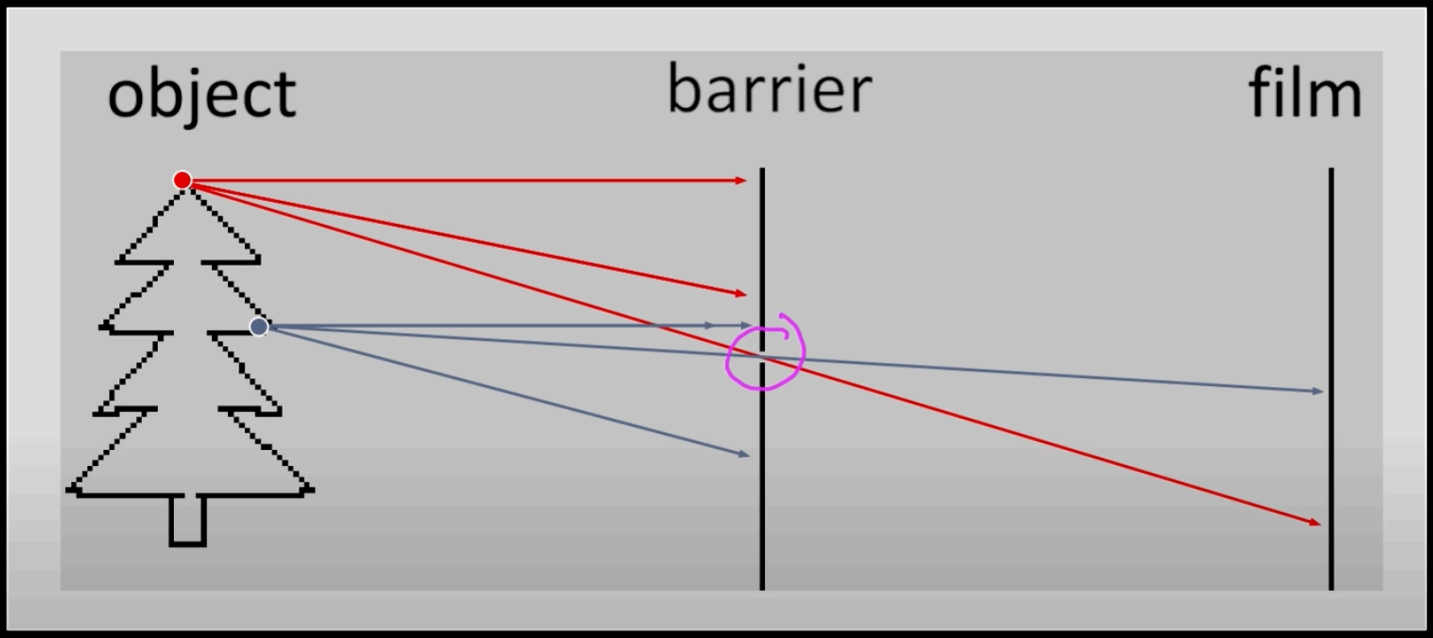
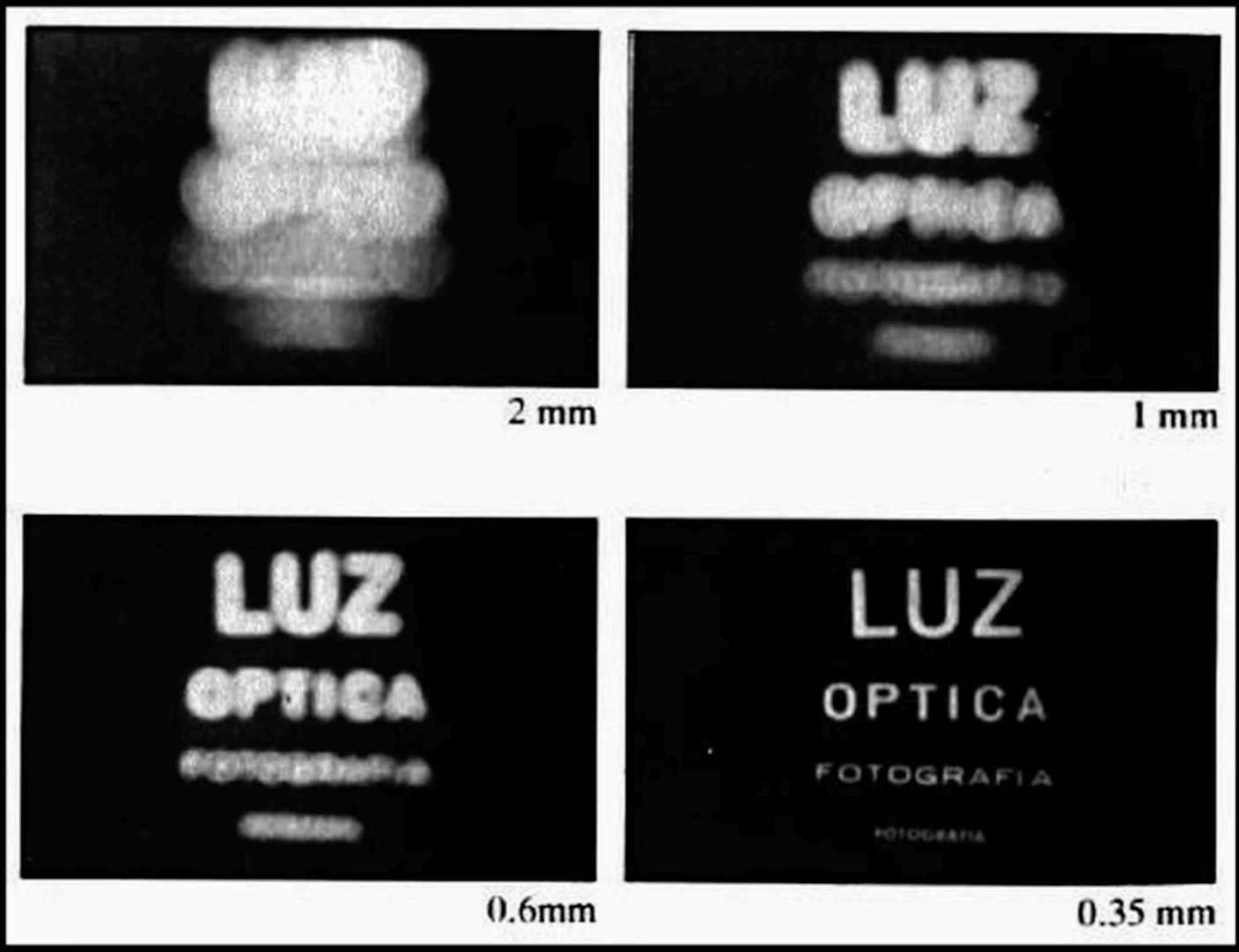
Image formation – (bad) method

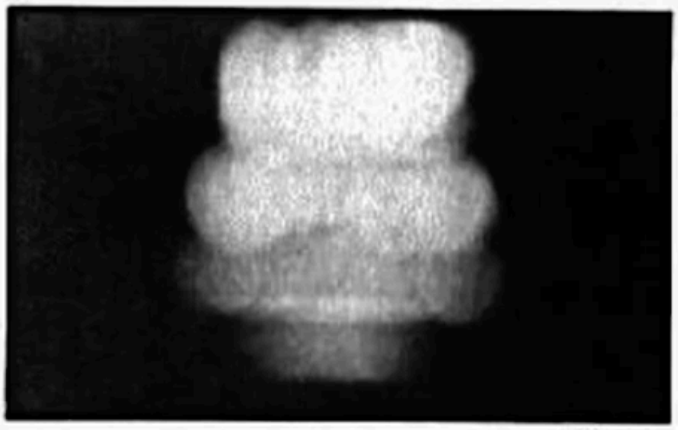


Pinhole camera



Shrinking the aperture





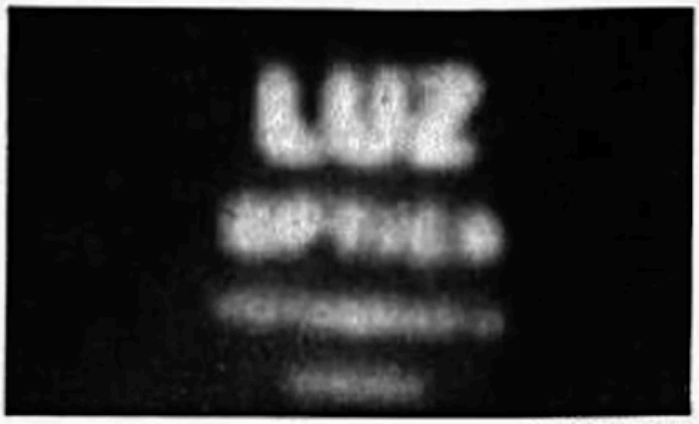
2 mm

1 mm

0.6mm

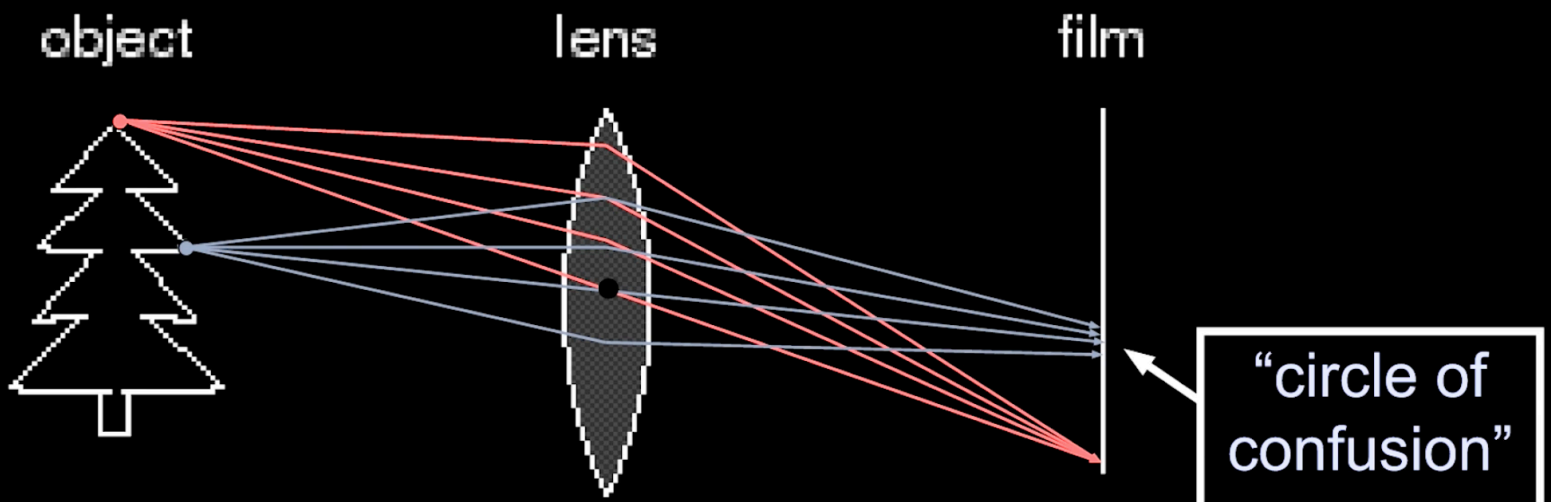
0.35 mm

0.15 mm

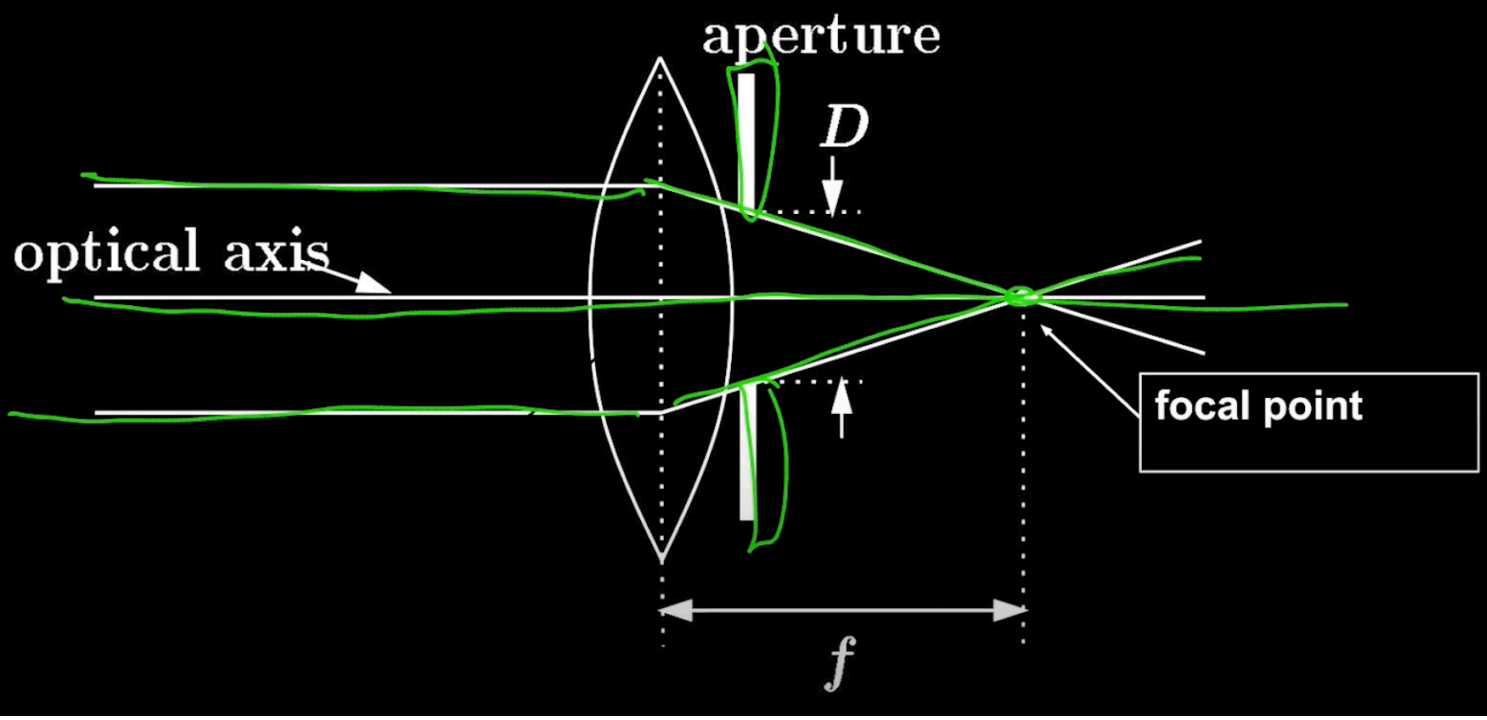


0.07 mm

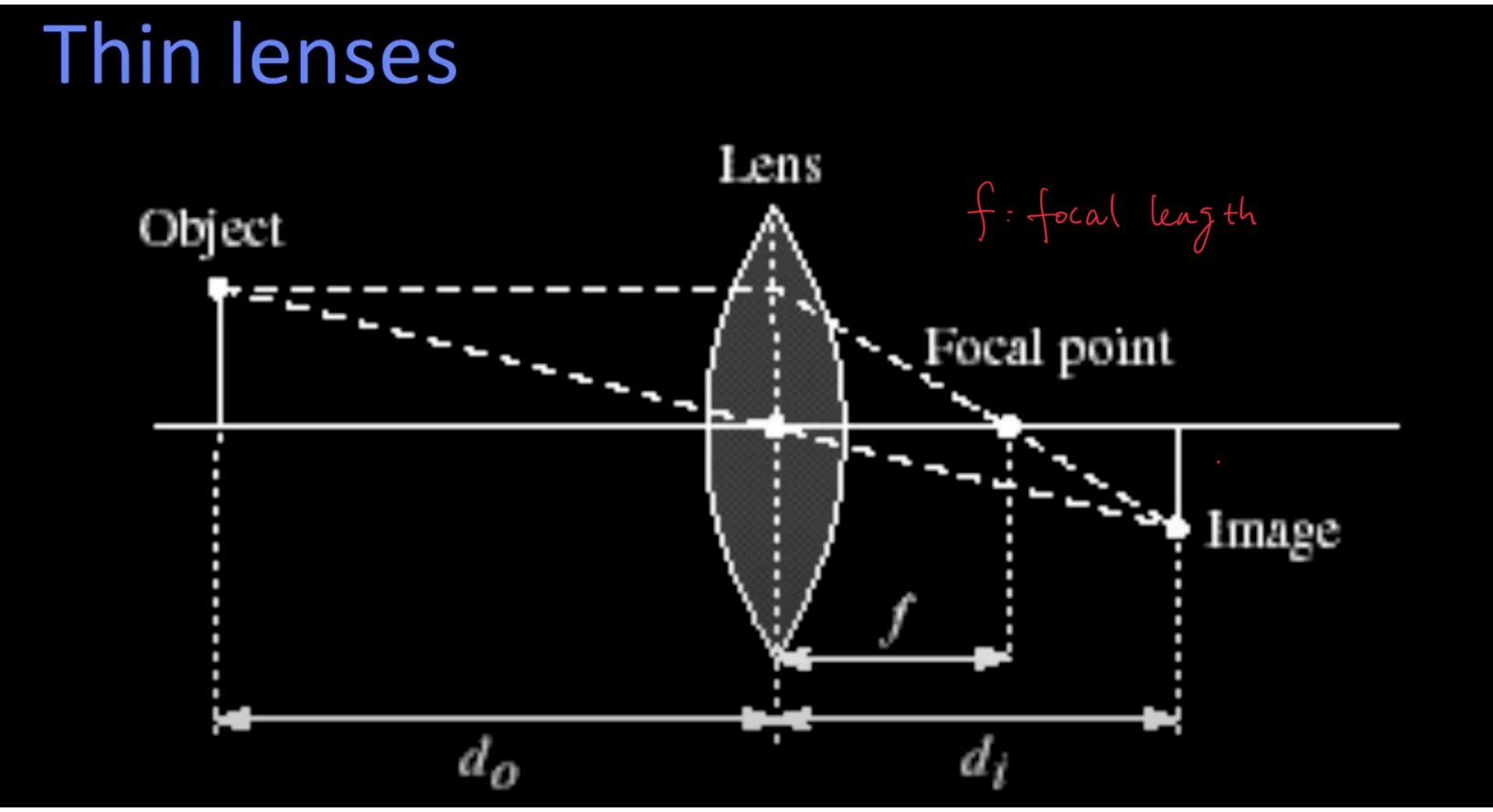
Adding a lens – and concept of focus



Lenses

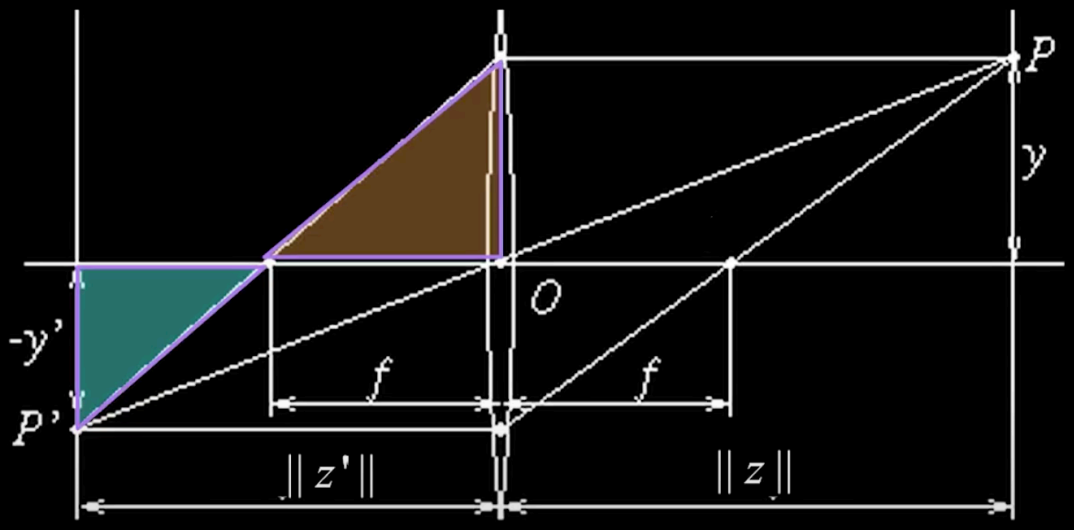


Thin lenses



The Thin Lens Equation

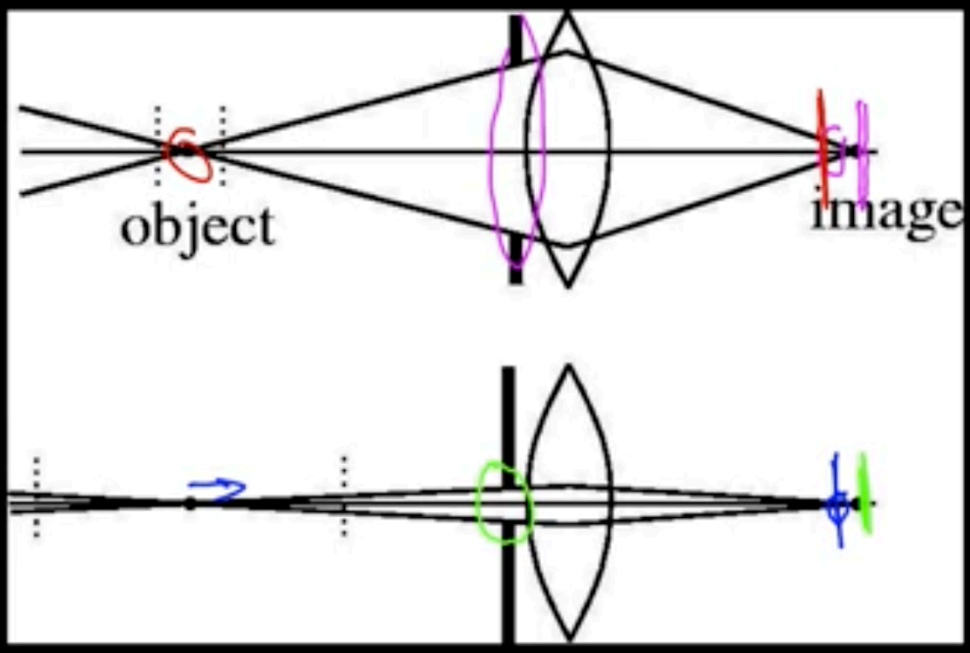
Full screen (f)



Any object point satisfying this equation is in focus.

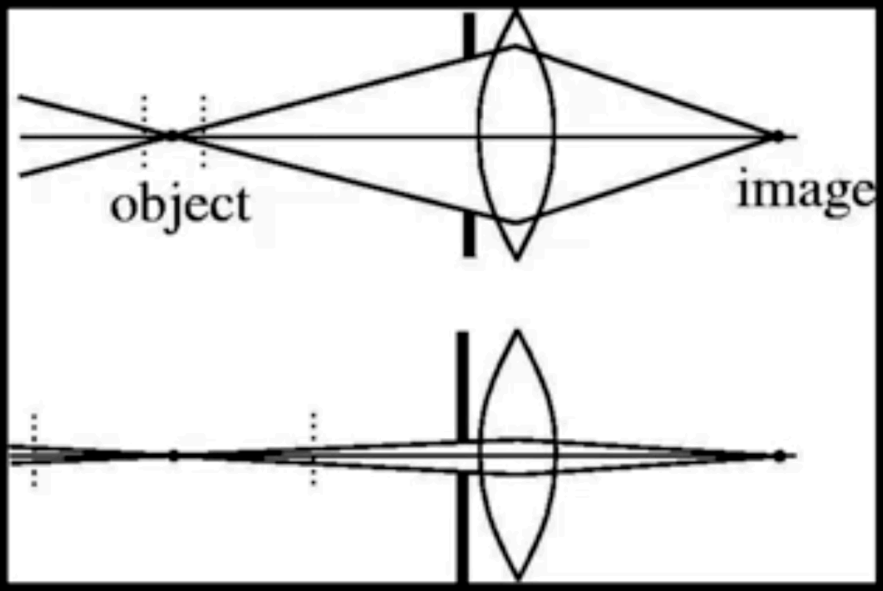
$$\rightarrow \frac{1}{\| z' \|} + \frac{1}{\| z \|} = \frac{1}{f}$$

Depth of field



Flower images from Wikipedia
http://en.wikipedia.org/wiki/Depth_of_field

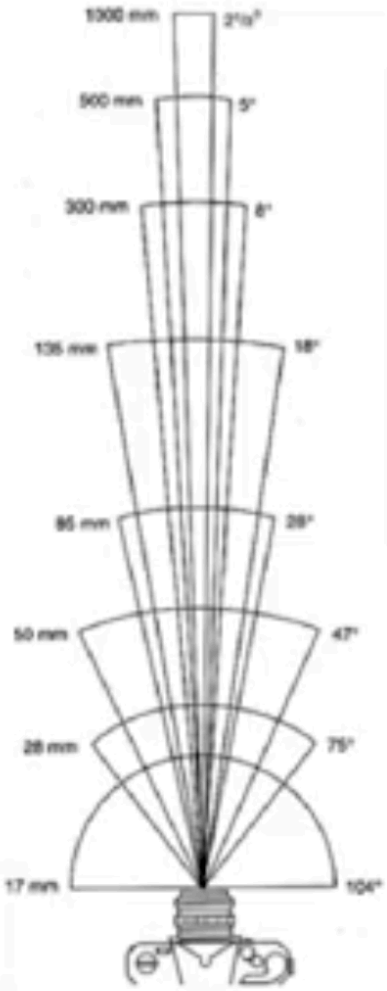
Depth of field



Flower images from Wikipedia
http://en.wikipedia.org/wiki/Depth_of_field

f / 5.6 = large aperture

f / 32 = small aperture



17mm

28mm

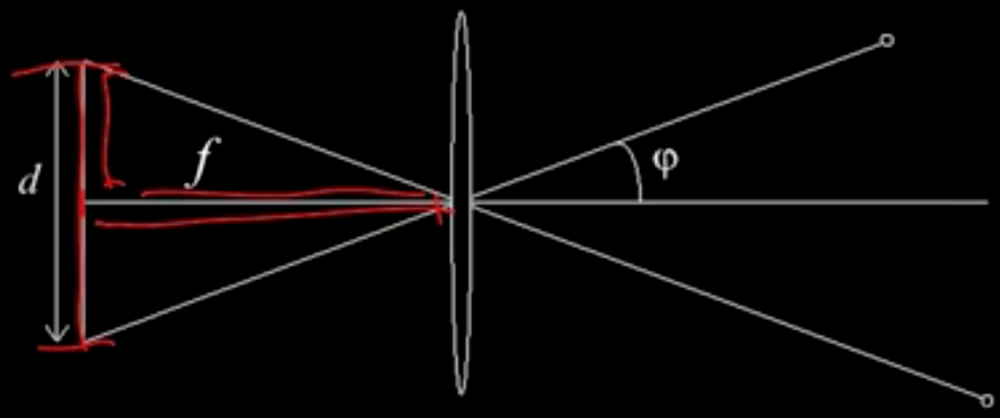
50mm

85mm

FOV depends on Focal Length

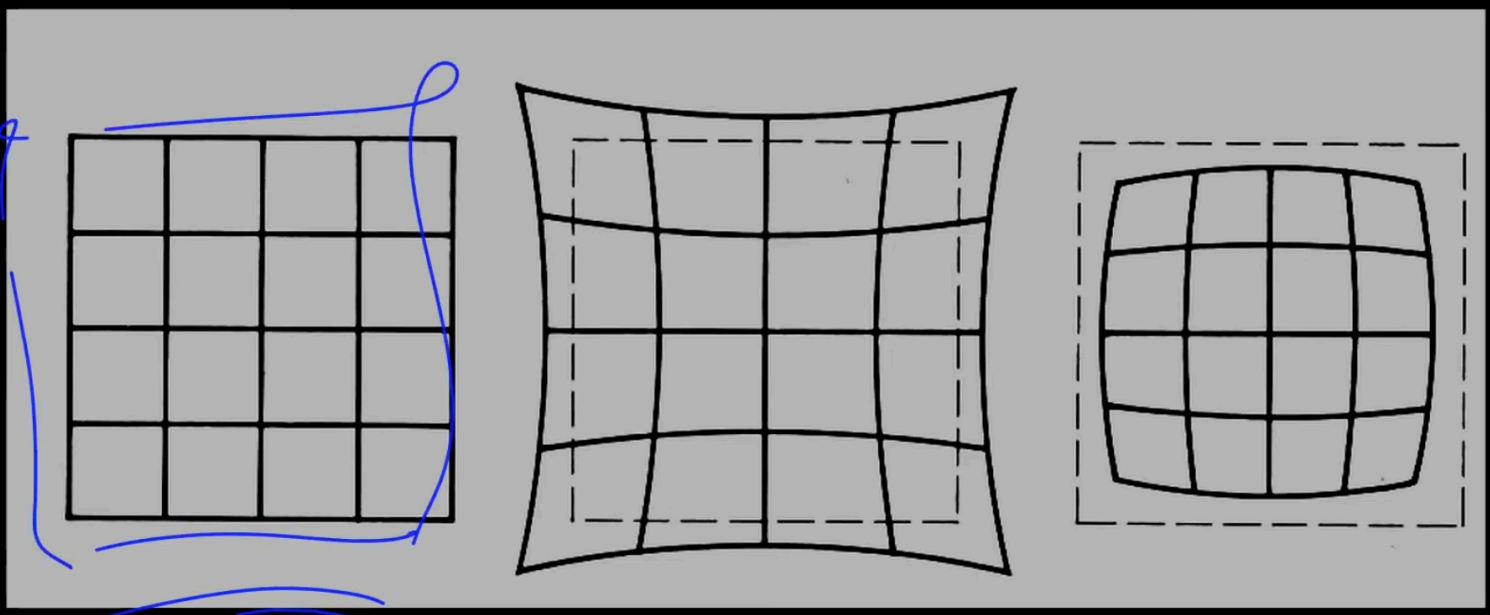
d is the "retina" or sensor size

$$\phi = \tan^{-1}\left(\frac{d/2}{f}\right)$$



Larger Focal Length => Smaller FOV

Geometric Distortion



No distortion

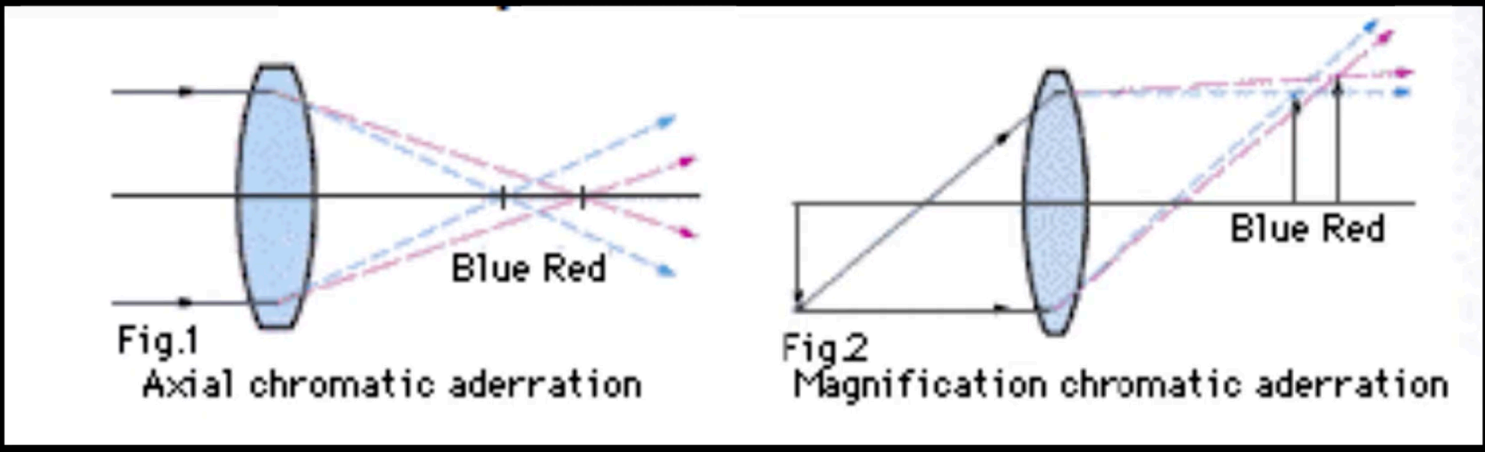
Pin cushion

Barrel

Correcting radial distortion

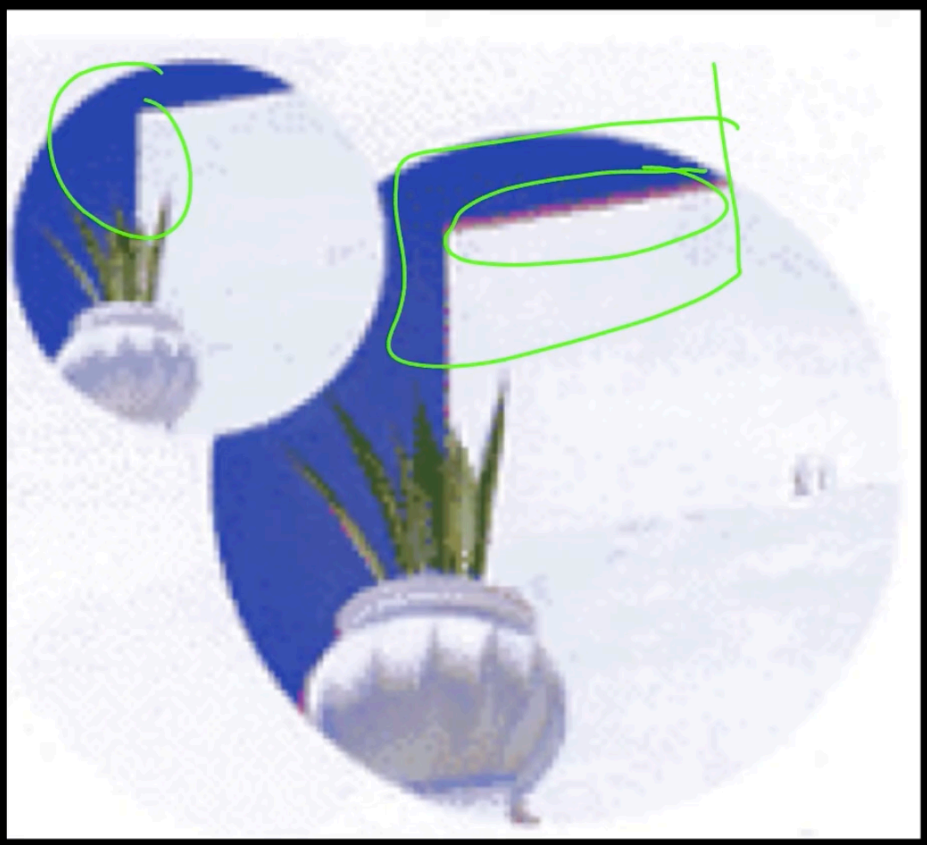
from Helmut Dersch

Chromatic Aberration

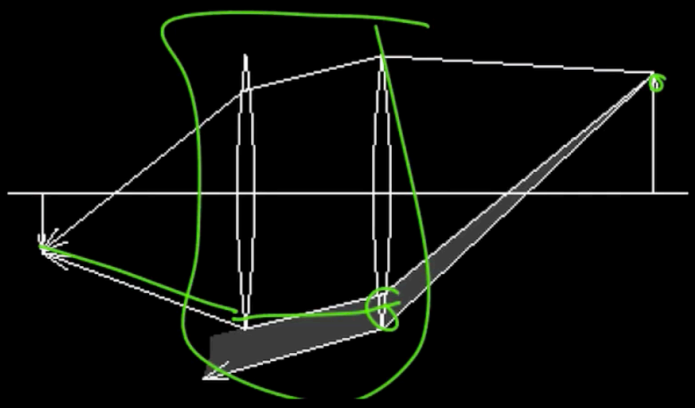


Rays of different wavelength focus in different planes

Chromatic Aberration



Vignetting



Lens Systems

Nikon 24-70mm zoom