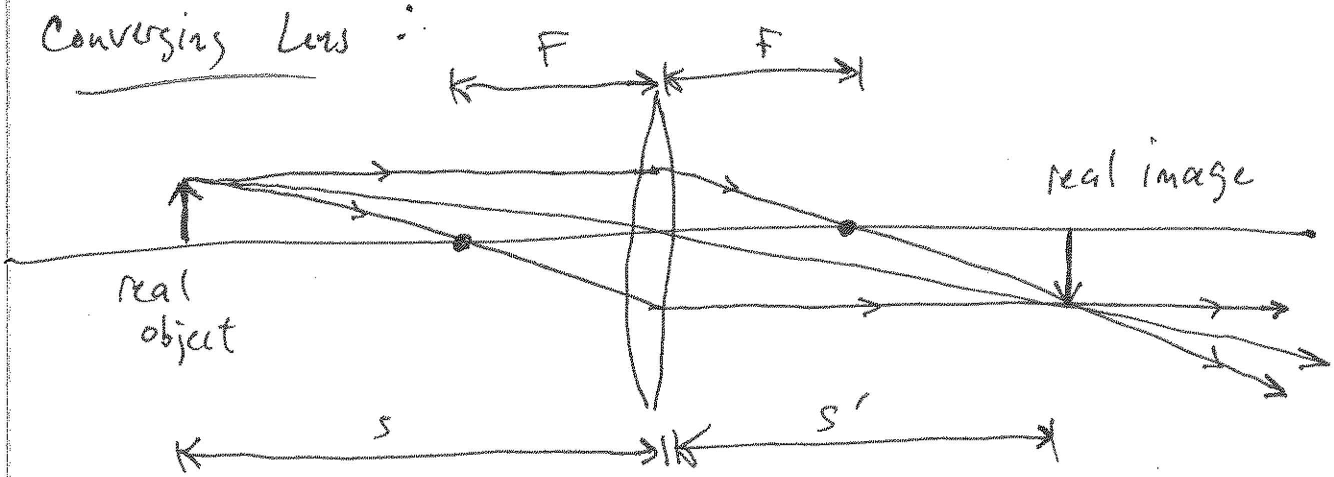
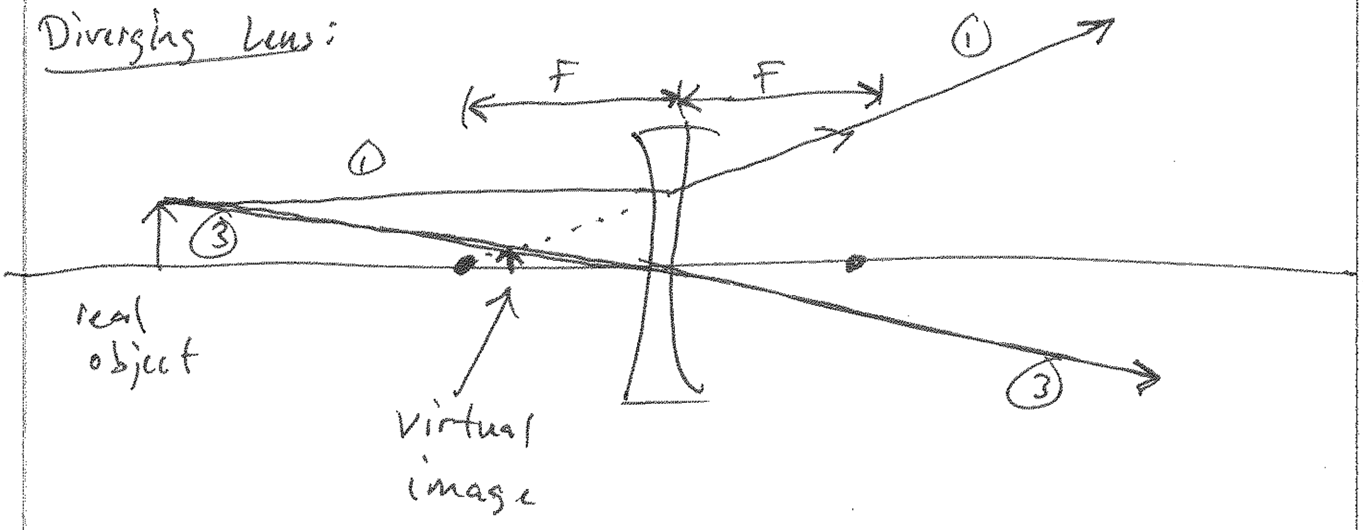
Imaging Recap:

Converging Lens:



Diverging Lens:



Lens Eq: $\frac{1}{s} + \frac{1}{s'} = \frac{1}{F}$

Converging Lens: $F > 0$.

Diverging Lens: $F < 0$

$s' > 0$: image on output side

$s' < 0$: image on input side.

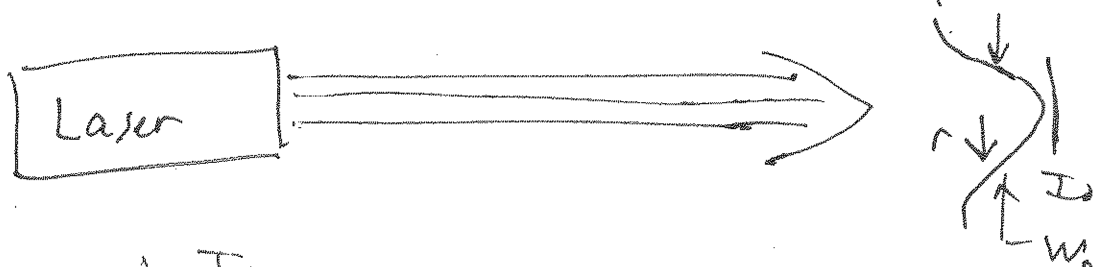
Gaussian Laser Beam

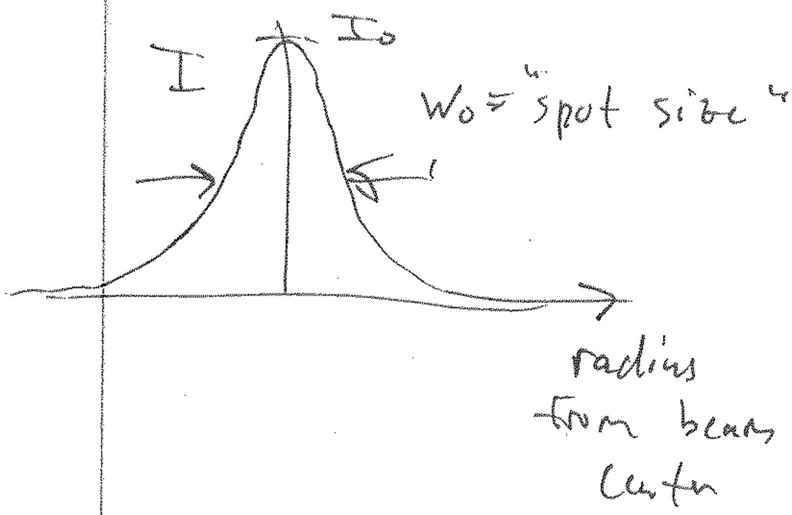
Beam intensity in the transverse direction is roughly Gaussian:

$$I(r) = I_0 e^{-2r^2/w_0^2}, \quad w_0 = \text{"spot size"}$$

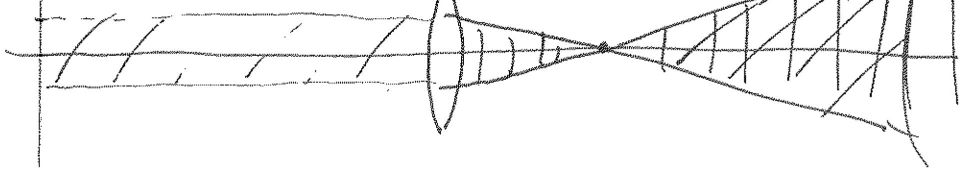
r = distance from beam center

I_0 = peak intensity:





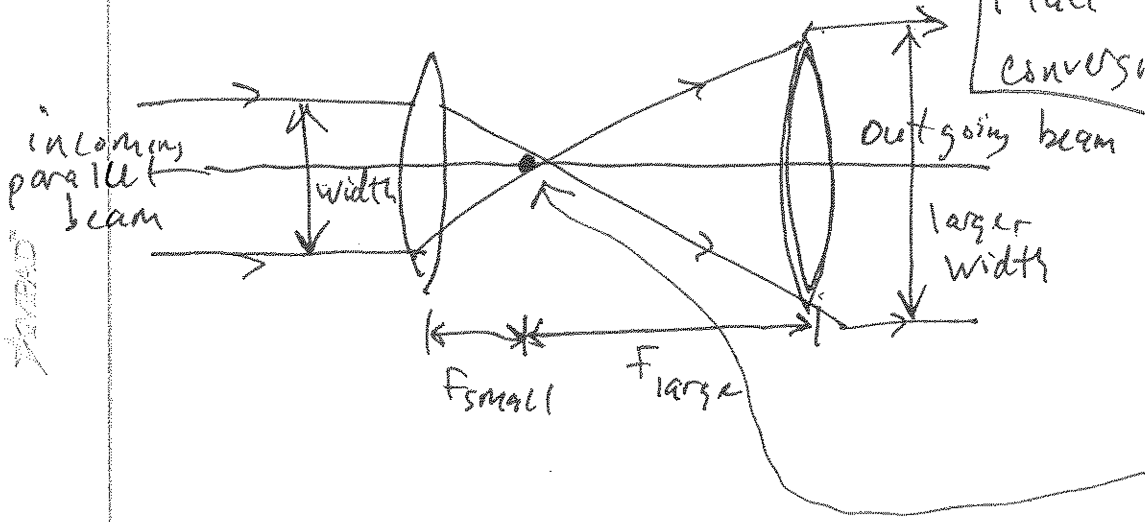
It is possible to measure the focal length of a lens by measuring the expansion or contraction of the beam width:



However there are some subtleties.

"<u>Beam Expander</u>" → <u>2 lens</u> to make the beam wider:

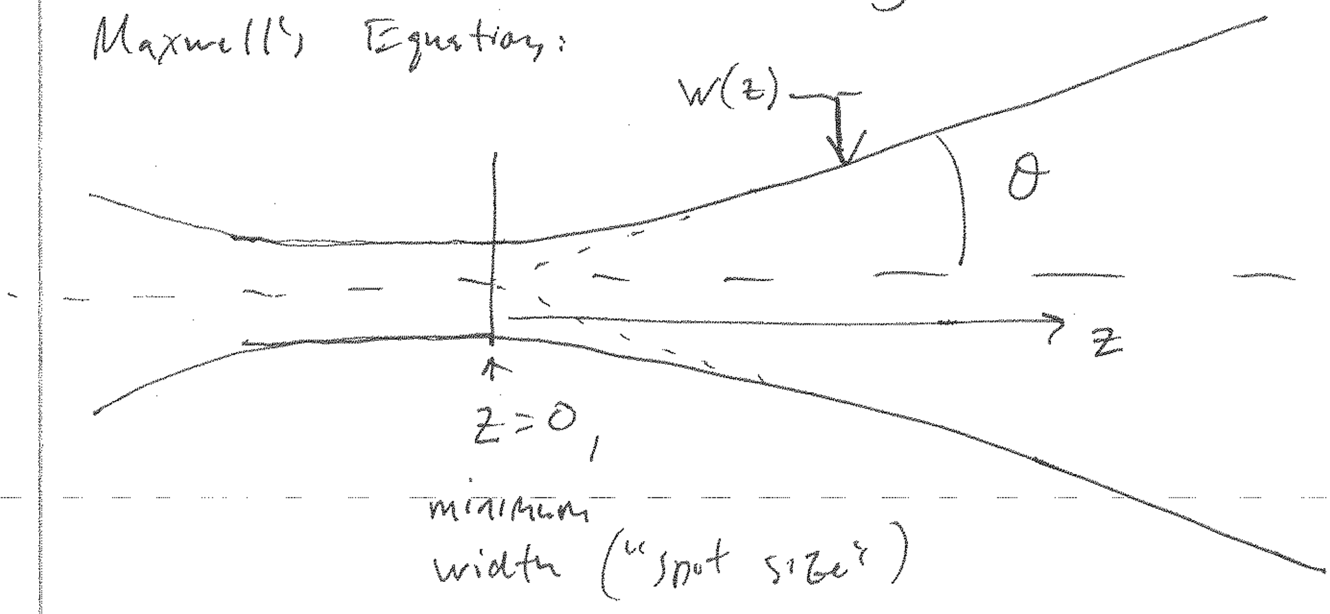
Place the two converging lenses so they have a focal point in common



It is easier to measure the width of the wider beam.

<u>Beam waist ("spot size") vs z:</u>

A laser beam cannot be perfectly parallel, it must diverge to some degree to satisfy Maxwell's Equations:



The functional form is

$$w(z) = w_0 \sqrt{1 + \left(\frac{z}{z_0}\right)^2}$$

where w_0 = minimum spot size, occurs at $z = \emptyset$.

z_0 = "Rayleigh Range" or "Rayleigh Length"

$$= \frac{\pi w_0^2}{\lambda}$$