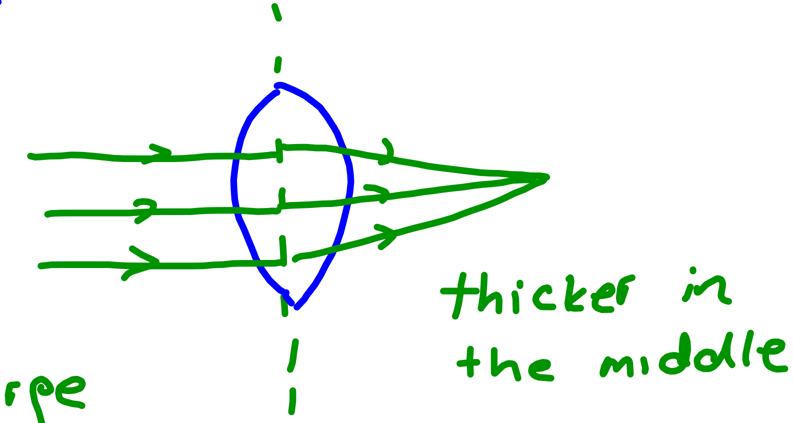
Lenses

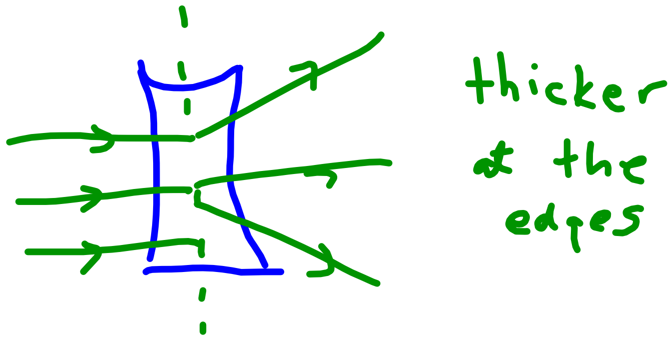
1) Converging lenses

- rays refract in a way that they converge



2) Diverging lenses

- rays refract in a way that they diverge



- thin lense so that all rays that fall on a lense are focused to a point FOCAL POINT

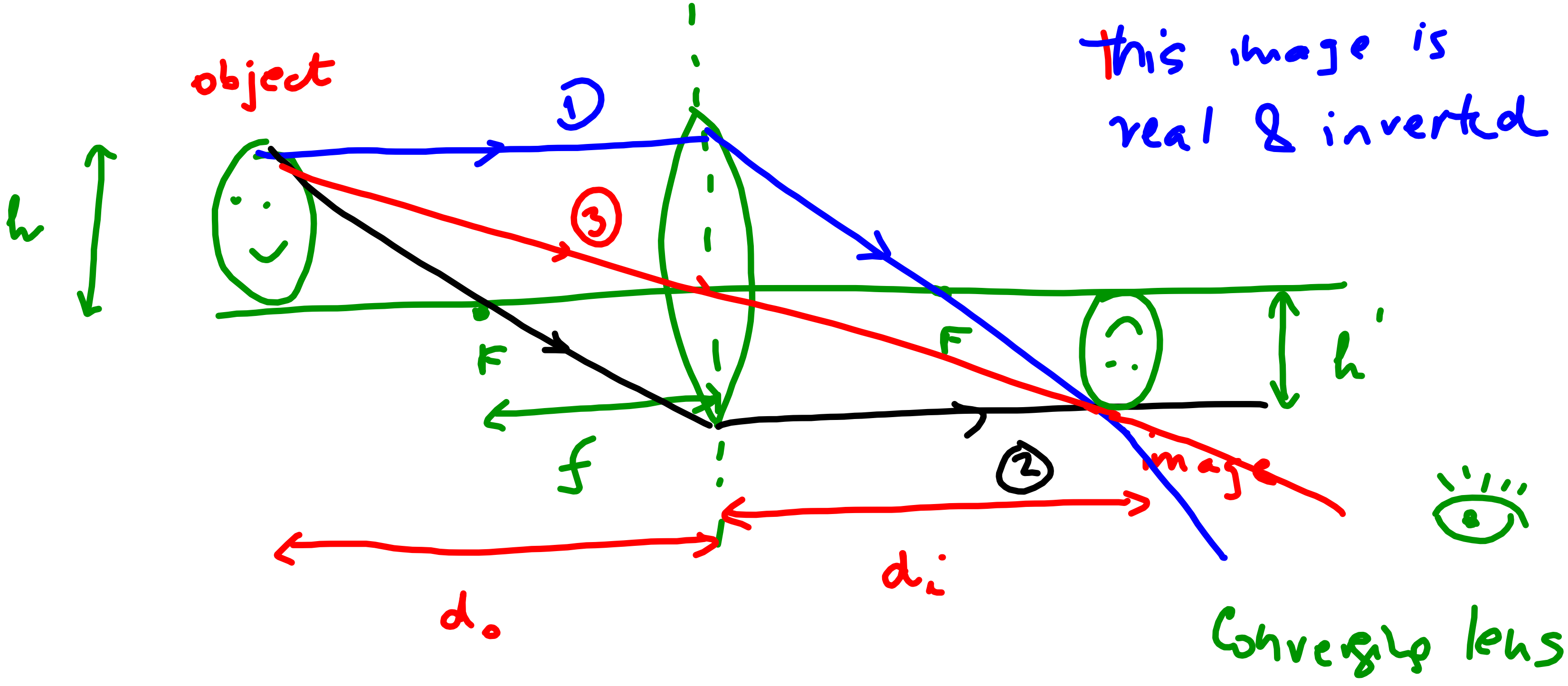
The distance of the focal point from the center of the lens is called focal length f [m]. f is the same on both sides.

Power of lense $P = \frac{1}{f}$ [m^{-1}] [D]

3 special rays will give us an image, they always start from the tip of an object

1. A ray parallel to the axis rafracts through the focal point behind the lens.
2. A ray that enters the lens through a focal point & refracts parallel to the axis.

3. (check) A ray through the center of the lens that does not bend.

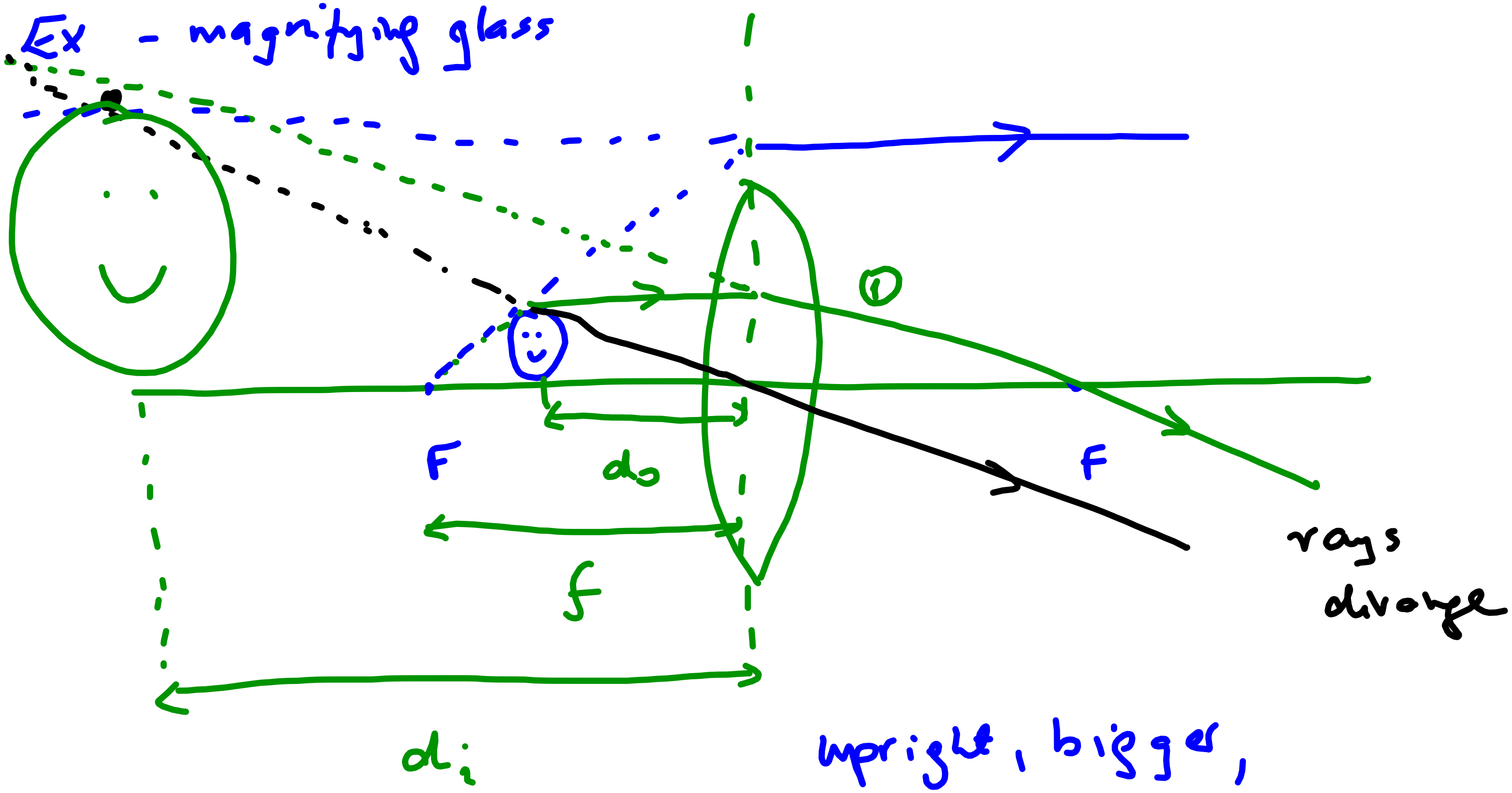


Real image – light passes through the image & it can be seen if we were to place white paper or screen at the position of the image

Virtual image - the image would not appear

Images can be: bigger, smaller
upright, inverted
real, virtual

Ex - magnifying glass



upright, bigger,
virtual

The thin lens eqn & magnification

h_o height of the  object

d_o distance between the object & lens center

f focal length

d_i length of the  image

h_i image height

Lens equation

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

For converging lenses f is positive $f > 0$

diverging f negative $f < 0$

$\left[P = \frac{1}{f} \right]$

d_o is positive if object is to the left of the lens

d_i is positive if image is on the other side

$h_i > 0$ if image is upright ↑ ☺

$h_i < 0$ inverted ↓ ☹

Lateral magnification

$$m = \frac{h_i}{h_o} = -\frac{d_i}{d_o}$$

if image is upright $m > 0$ => image is on the same side

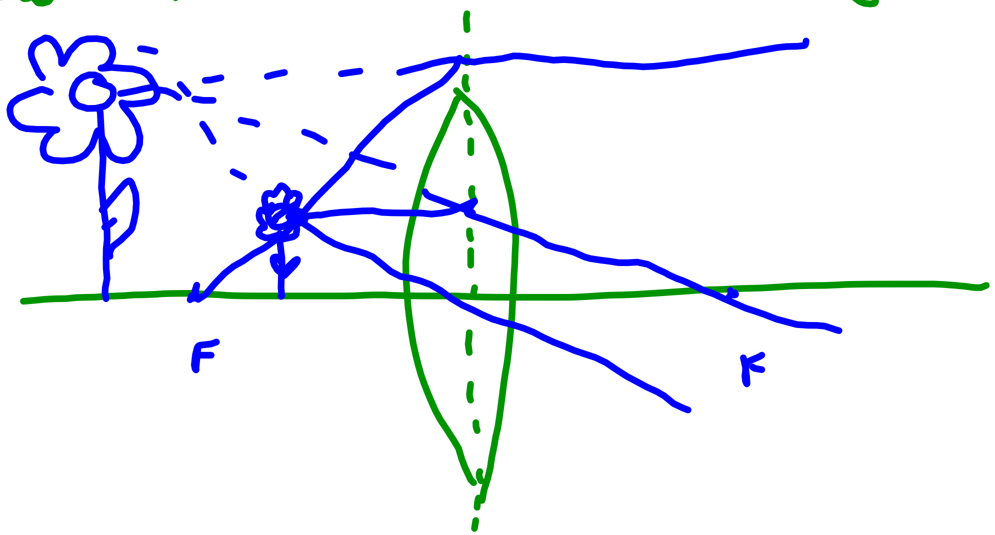
inverted $m < 0$ $(d_i < 0)$

Problem solving

1) draw a ray diagram
2) solve for unknowns in thin lens eqn
3) follow the sign convention (+, −)
4) check if your answer makes sense
   (compare with the picture)

Ex 1

To see a flower better, one holds a 6 cm focal length magnifying glass 4 cm from the flower. What is the magnification?



$f = 6\,cm$

$d_o = 4\,cm$

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} \qquad \frac{1}{6} = \frac{1}{4} + \frac{1}{d_i}$$

$$d_i = \left(1/6 - 1/4\right)^{-1} = {}^{-}12\,cm$$

$$m = \frac{-d_i}{d_o} = - \frac{-12}{4} = 3D$$

Ex 2 Demagnifying a flower

A divergent lens with f = -50 cm is placed 100 cm from a flower. Where is the image? What is its magnification?

f = -50cm

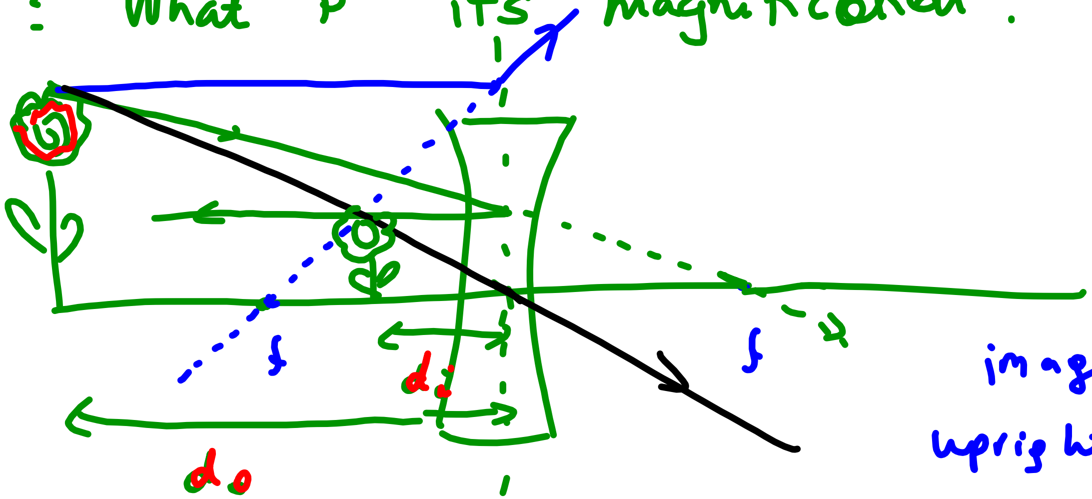


image is smaller upright & virtual

Divergent lenses always give virtual image.

$f = -50\,cm$

$d_o = 100\,cm$

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

$d_i \cong -33\,cm$

$m = -\frac{d_i}{d_o} = 0.33$