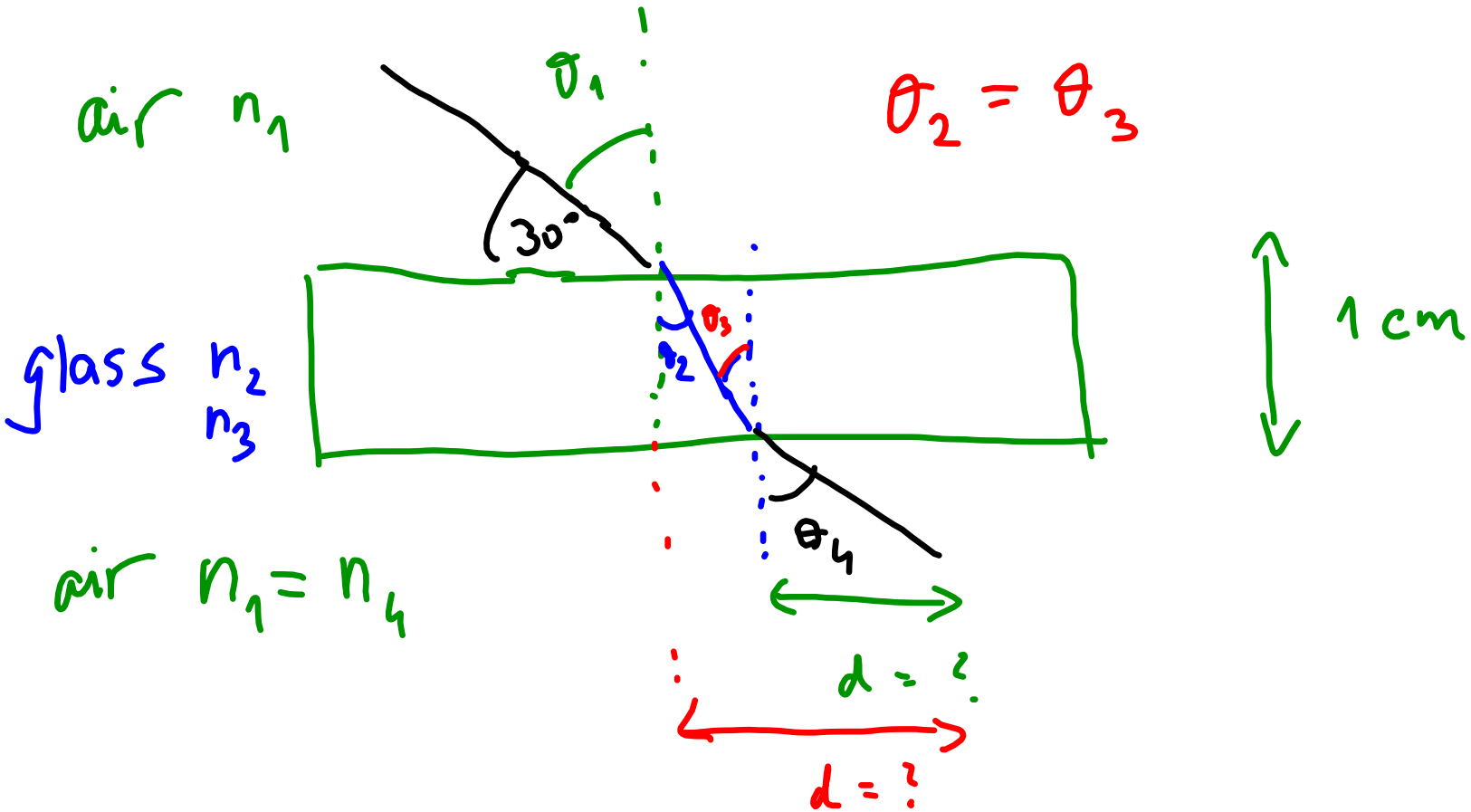
Laser beam is aimed at 1 cm thick sheet of glass at an angle 30° above the glass.

a) What is the laser beam's direction of travel in the glass?

b) What is its direction in the air on the other side?


air n_1
θ_1
$\theta_2 = \theta_3$
30°
glass n_2
n_3
θ_3
θ_2
1 cm
θ_4
air $n_1 = n_4$
d = ?
d = ?

a) $\theta_2 = ?$

$\theta_1 = 90^\circ - 30^\circ = 60^\circ$

$n_1 = 1$

$n_2 = 1.5$

$n_1 \sin\theta_1 = n_2 \sin\theta_2$

$\sin\theta_2 = \frac{n_1}{n_2} \sin\theta_1$

$\sin\theta_2 = \frac{1}{1.5} \sin 60^\circ \Rightarrow \theta_2 = 35.3^\circ$

b) $\theta_3 = \theta_2 = 35.3^\circ$

$n_3 \sin\theta_3 = n_4 \sin\theta_4$

$\theta_4 = 60^\circ$

or $n_1 \sin\theta_1 = n_2 \sin\theta_2$

$n_3 \sin\theta_3 = n_4 \sin\theta_4$

$1 \sin 60^\circ = 1.5 \sin\theta_2$

$1.5 \sin\theta_2 = 1 \sin\theta_4$

$\theta_4 = 60^\circ$

$\theta_2 = \theta_3$

$n_1 = n_4 = 1$

$n_2 = n_3 = 1.5$

$\theta_4 = ?$

Dispersion

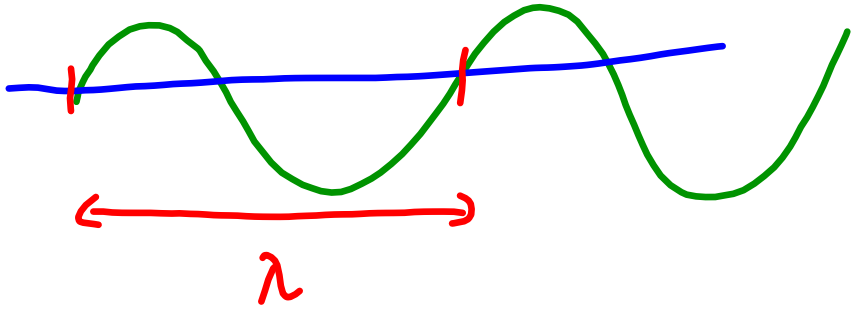
- phenomena in which v (wave speed) depends on λ wavelength

White light (from Sun) consists of colors & each color has its own wavelength λ

red λ max

purple λ min

$\lambda_{red} > \lambda_{purple}$



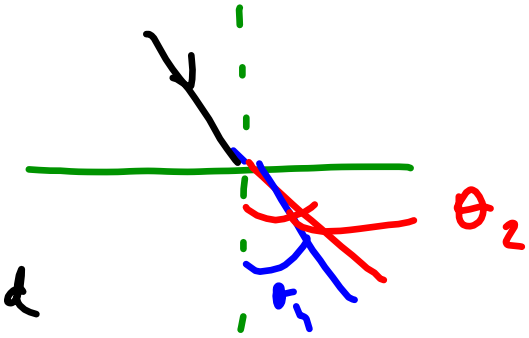
$v = \frac{\lambda}{T}$ $v_{red} > v_{purple}$ T period

$v = \frac{c}{n}$ $n_{red} < n_{purple}$

$$= \boxed{\begin{array}{l} n_1 \sin\theta_1 = n_{red} \sin\theta_2 \\ n_3 \sin\theta_3 = n_{purple} \sin\theta_4 \end{array}}$$

incident

refracted



$$n_{red} < n_{purple}$$

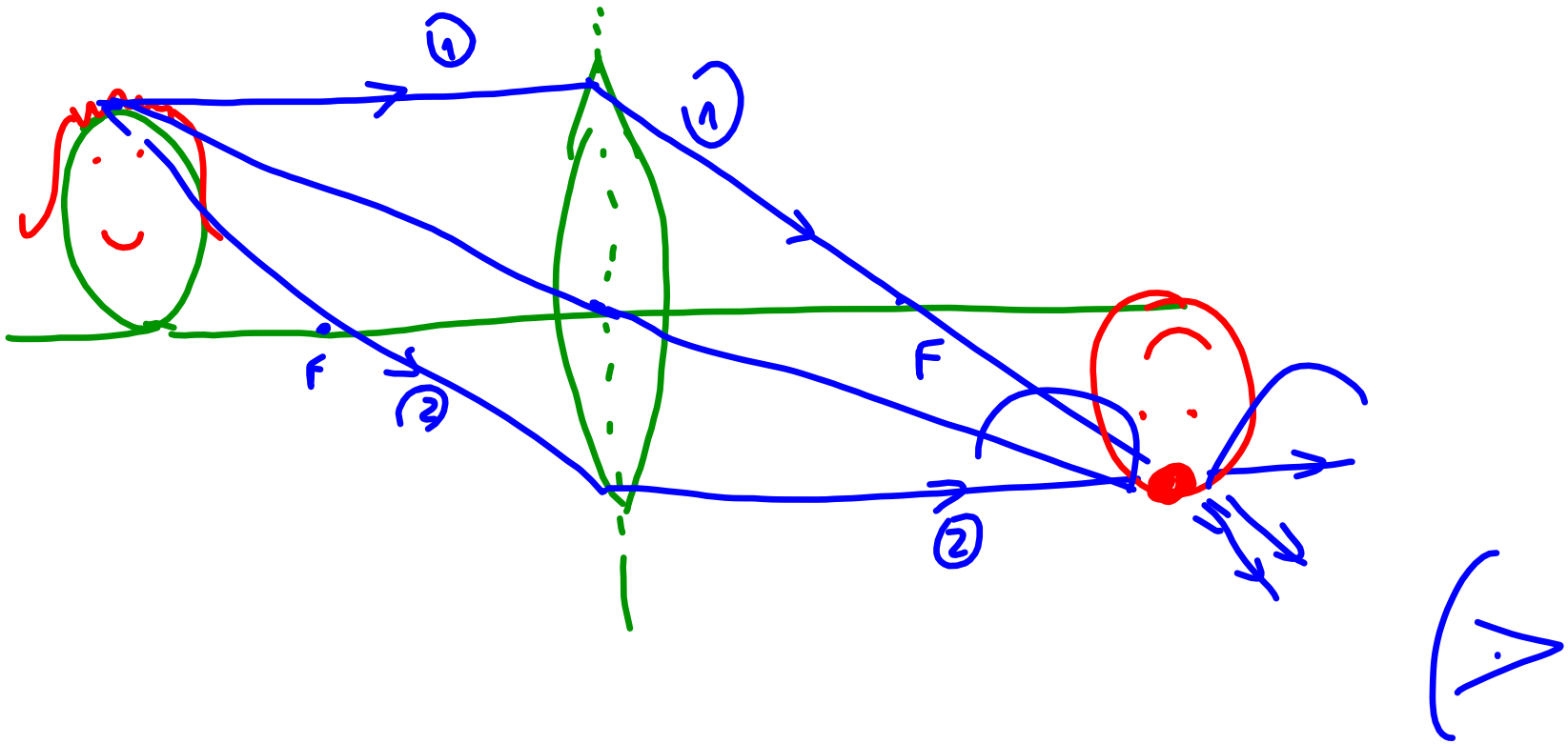
$$\theta_{red} > \theta_{purple}$$

Lenses

- transparent material that uses refraction at curved surfaces to form an image from light rays

  (magnifying glass, cameras, microscopes, telescopes, etc)

- Converging lenses
- Diverging lenses
- lenses have 2 focal points
- images that we get can be:
  - bigger / smaller
  - upright / inverted
  - real / virtual


1
1
F
2
F
2