- Light of wavelength 589 nm in vacuum passes through a piece of quartz (crystal of SiO_2) with n=1.458

(a) Speed of light in quartz:

$$v = \frac{c}{n} = \frac{3.0\times10^{8}}{1.458} = 2.06\times10^{8}\ \text{m/s}$$

(b) Wavelength of this light in quartz

$$\lambda = \frac{\lambda_0}{n} = \frac{589}{1.458} = 404\ \text{nm}$$

(c) Frequency: $f = \dfrac{c}{\lambda_0} = \dfrac{3.0\times10^{8}}{589\times10^{-9}} = 5.09\times10^{14}\ \text{Hz}$

Example $n_1\sin(\theta_1) = n_2\sin(\theta_2)$

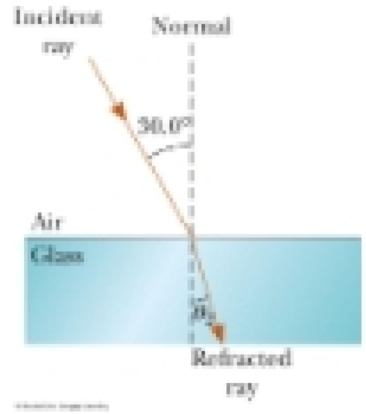
- Calculate refraction angle θ_2
- n=1.00, n2=1.52 for λ_0=589nm

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

$$\Rightarrow \sin(\theta_2) = \frac{n_1\sin(\theta_1)}{n_2}$$

$$\Rightarrow \sin(\theta_2) = \frac{1.00\times\sin(30^\circ)}{1.52} = 0.329$$

$$\Rightarrow \theta_2 = \sin^{-1}(0.329) = 19.2^\circ$$



Example $n_1\sin(\theta_1) = n_2\sin(\theta_2)$

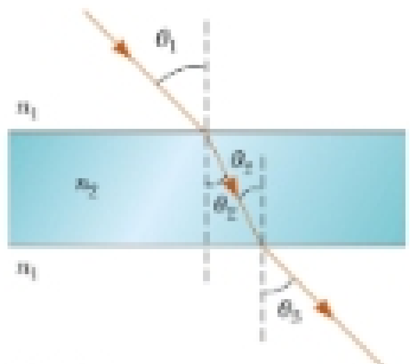
- What is the relation between θ_3 and θ_1 ?

(a) $n_1\sin(\theta_1) = n_2\sin(\theta_2)$

(b) $n_2\sin(\theta_2) = n_1\sin(\theta_3)$

Therefore,

$$\sin(\theta_3) = \sin(\theta_1)$$
$$\Rightarrow$$
$$\theta_3 = \theta_1$$



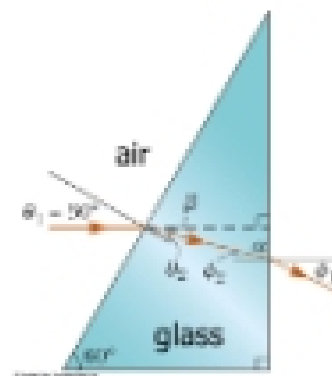
Example $n_2\sin(\theta_2) = n_1\sin(\theta_1)$

- The index of refraction of this glass is 1.8 for violet light and 1.5 for red light. Calculate the refraction angle ϕ_1 for both violet and red lights.

(a) Refraction angle θ_2 for violet light

$$\sin(\theta_2) = \frac{n_1\sin(\theta_1)}{n_2} = \frac{1.0\times\sin(30^\circ)}{1.8} = 0.278$$

$$\theta_2 = \sin^{-1}(0.278) = 16.1^\circ$$



(b) Incident angle ϕ_2

Observation: $\phi_2 = \beta$

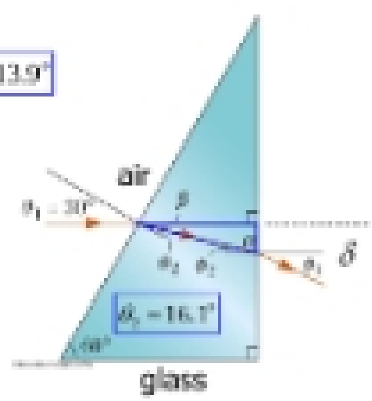
$$\begin{cases}\phi_2 - \alpha = 90^\circ \\ \beta + \alpha = 90^\circ\end{cases}$$

Since $\beta = 30^\circ - \theta_2 = 13.9^\circ$ $\quad$ $\boxed{\phi_2 = \beta = 13.9^\circ}$

(c) Calculate ϕ_1

$$\sin(\phi_1) = \frac{n_2\sin(\phi_2)}{n_1} = \frac{1.8\times\sin(13.9^\circ)}{1.0} = 0.432$$

$$\phi_1 = \sin^{-1}(0.432) = 25.6$$



In this case, φ_1 is the same as the derivation angle δ.
Please repeat the calculations for red light (n=1.5).

Example

Calculate angle θ_1 so that incident angle φ is the critical angle at the bottom surface.

Refraction at the n=1.6/1.4 interface: $1.6\times\sin(\theta_1) = 1.4\times\sin(\beta)$

Refraction at the n=1.4/1.2 interface: $1.4\times\sin(\beta) = 1.2\times\sin(\phi)$

Refraction at the n=1.2/1.0 interface: $1.2\times\sin(\phi) = 1.0\times\sin(90^\circ)$

Upon observation, we have

$$1.6\times\sin(\theta_1) = 1.0\times\sin(90^\circ) = 1$$

$$\theta_1 = \sin^{-1}\left(\frac{1.0}{1.6}\right) = 38.7^\circ$$

Find the energy of the following. Express your answers in units of electron volts, noting that 1 eV = 1.60 10-19 J.
(a) a photon having a frequency of 2.20e17 Hz
=________ eV

(b) a photon having a wavelength of 7.40e2 nm
=____________ eV

The expression for energy of photon

$$E = h\nu$$

Or

$$E = \frac{hc}{\lambda}$$

Here

h = Plank's constant
c = Speed of light
ν = Frequency of light
λ = Wavelength of light

$$1\text{eV} = 1.60\times10^{-19}\text{J}$$

a) The energy of a photon having a frequency of 2.20e17 Hz

$$E = h\nu = 6.626\times10^{-34}\times2.20\times10^{17}$$
$$E = 1.4577\times10^{-16}\ \text{J}$$

In eV

$$E = \frac{1.4577\times10^{-16}}{1.6\times10^{-19}}$$
$$E = 911.06\ \text{eV}$$

b) The energy of photon having wavelength of 7.40e2nm

$$E = \frac{hc}{\lambda} = \frac{6.626\times10^{-34}\times3\times10^{8}}{7.40\times10^{2}\times10^{-9}}$$
$$E = 2.686\times10^{-19}\ \text{J}$$

In eV

$$E = \frac{2.686\times10^{-19}}{1.6\times10^{-19}}$$
$$E = 1.678\ \text{eV}$$