Revision

Waves

I) Vibrations

Vibrations or oscillations are regular to-and-fro motions of an object between two extreme positions.

Characteristics of vibratory motion:

1- Period T: Is the time taken by one complete vibration.

The SI unit of T is second (s).

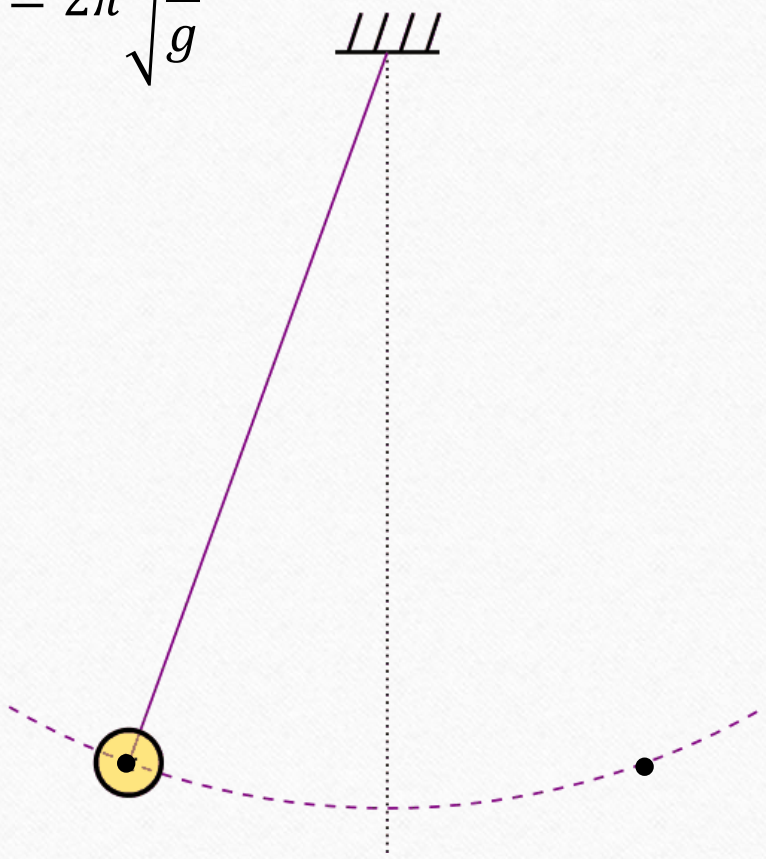
2- Frequency f: is the number of cycles per unit time (in SI per second).

$$f = \frac{1}{T}$$

The SI unit of f is Hertz (Hz) or (s^{-1}).

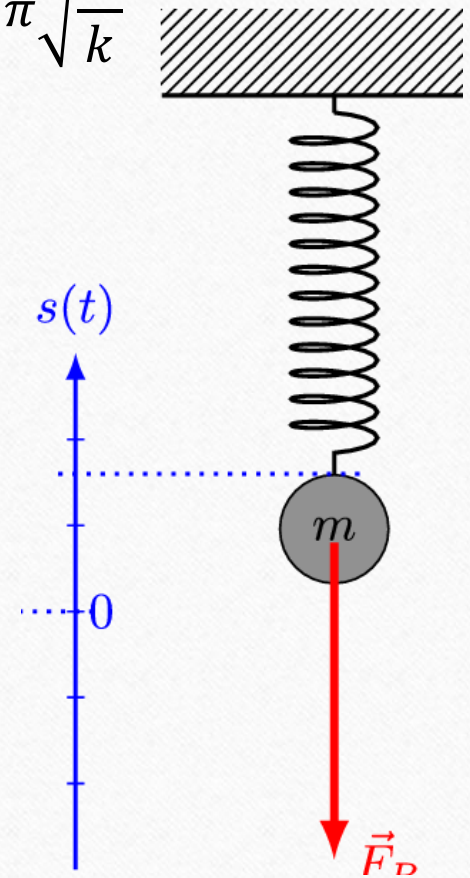
3- Amplitude: is the distance or angle between the equilibrium position and one of the extreme points.

$$T = 2\pi\sqrt{\frac{l}{g}}$$



Simple Pendulum

$$T = 2\pi\sqrt{\frac{m}{k}}$$



Elastic Pendulum

Experimentally:

T is calculated by measuring the time Δt taken by n oscillations, then:

$$\boldsymbol{T = \frac{\Delta t}{n}}$$

II) Waves:

- A propagating wave is produced by vibratory motion.
- A propagating wave carries energy but not matter.
- A non-damped motion, propagating in a given medium, is characterized by its amplitude $\boldsymbol{a}$, its wavelength $\boldsymbol{\lambda}$, and its frequency $\boldsymbol{f}$.
- **The characteristics of the wave (amplitude, period and frequency) are the same as those of the vibratory motion.**

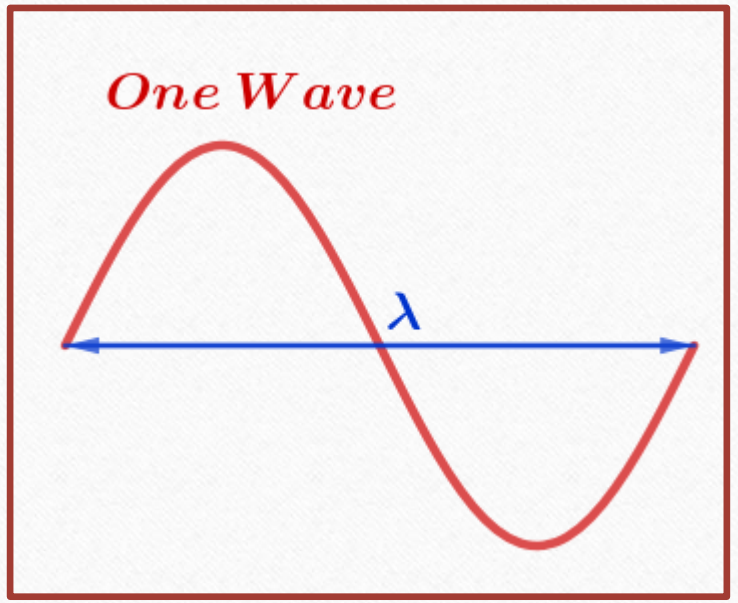
The motion of the wave in a homogeneous medium is uniform. (i.e: its speed is constant).

The distance $\boldsymbol{x}$ covered by the wave during time $\boldsymbol{t}$ is:

$$\boldsymbol{x = Vt} \qquad (x\ in\ m\ and\ t\ in\ s)$$

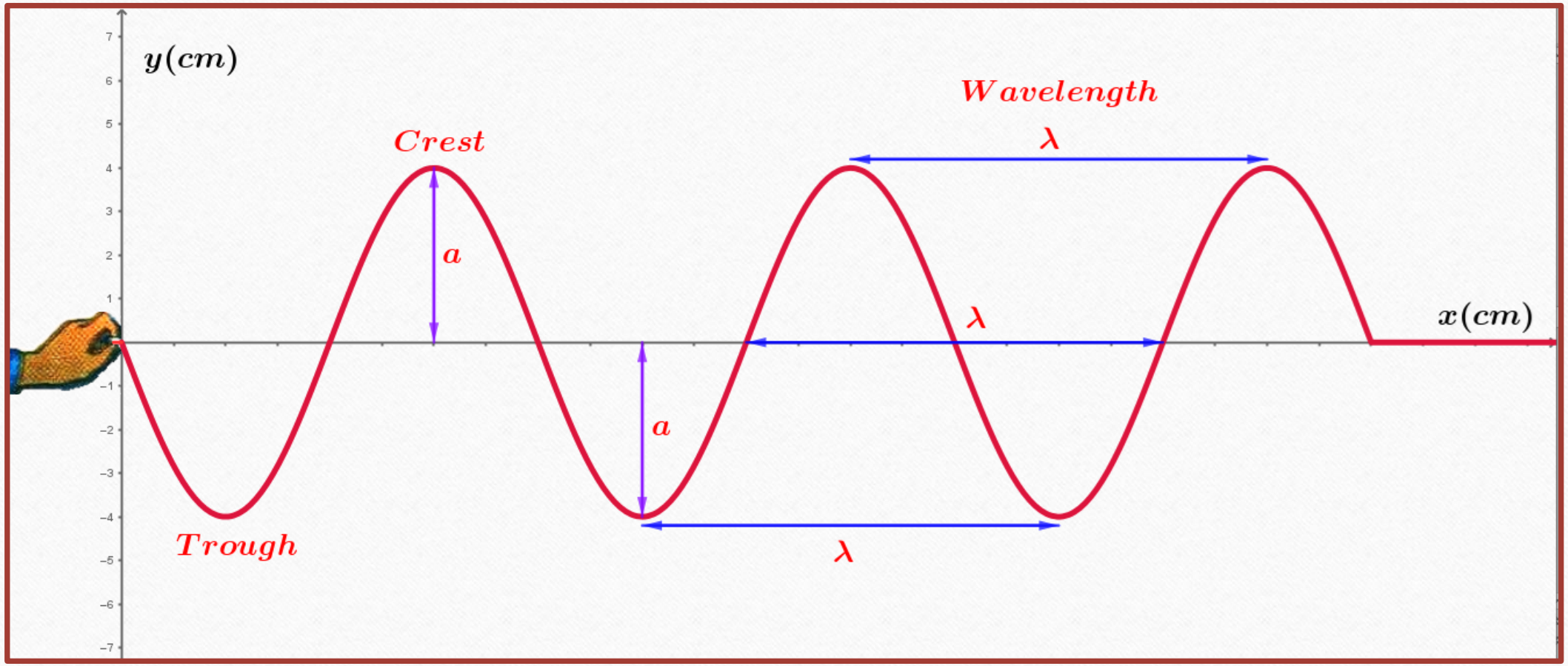
Where V is the speed of the wave in (m/s)

- The length of one wave is called the **wavelength $\boldsymbol{\lambda}$**. It is the distance from one point of a wave to an identical point on the next wave.
- The wavelength $\boldsymbol{\lambda}$ is the distance covered by the wave during a period $\boldsymbol{T}$.



Substitute in the above equation:

$$\Rightarrow \boldsymbol{\lambda = VT = \frac{V}{f}}$$

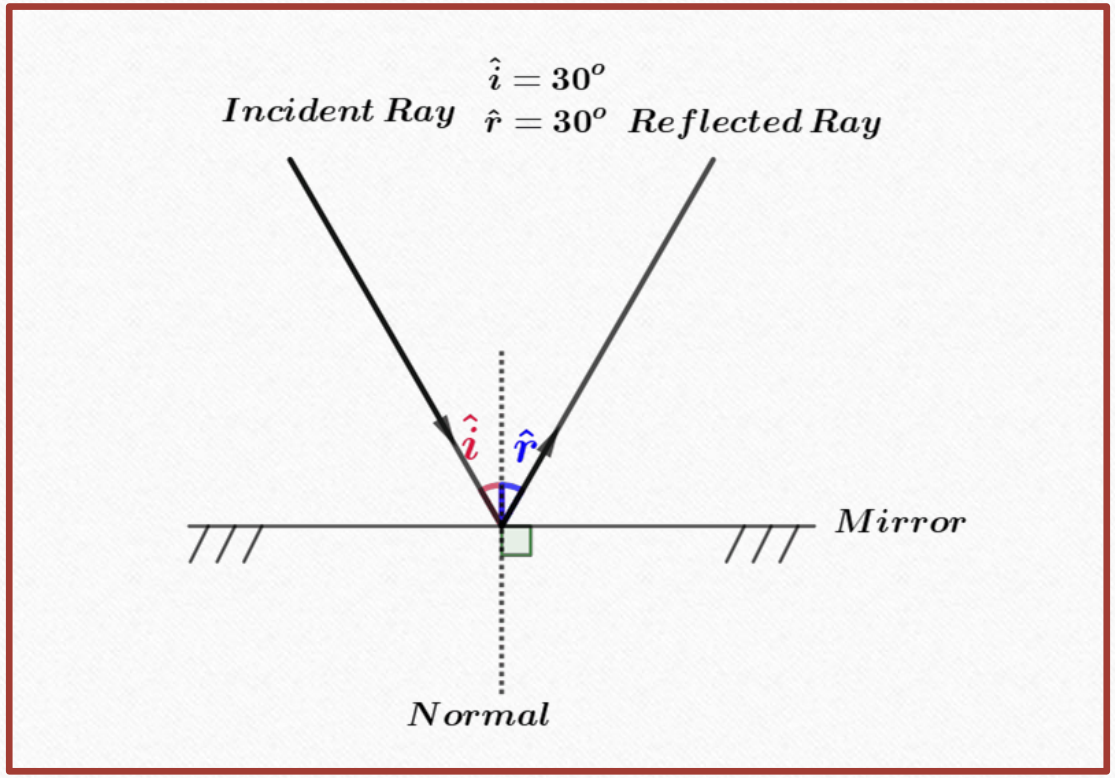

y(cm)
x(cm)
Crest
Trough
Wavelength
a
a
λ
λ
λ

III)Reflection of light:

Light undergoes reflection when it falls on a polished surface like mirrors

$\hat{i}$: angle of incidence

$\hat{r}$: angle of reflection



Law of reflection:

Angle of incidence = angle of reflection

$$\hat{i} = \hat{r}$$

IV) Index of refraction n:

The index of refraction n of a transparent medium, is the ratio of the speed of light c in vacuum to its speed V in the medium:

$$n = \frac{Speed\ of\ light\ in\ vacuum}{speed\ of\ light\ in\ the\ medium} = \frac{c}{V}$$

$$c = 3 \times 10^8 m/s$$

Since $V \leq c \Rightarrow n \geq 1$

Speed of light in air is: $V_{air} \cong c \Rightarrow n_{air} \cong 1$

Material	n
Vacuum	1
Air	1.000293
Water	4/3
Ice	1.31
Milk	1.35
Glass	1.5
Diamond	2.417
Benzene	1.501

V) Refraction of light:

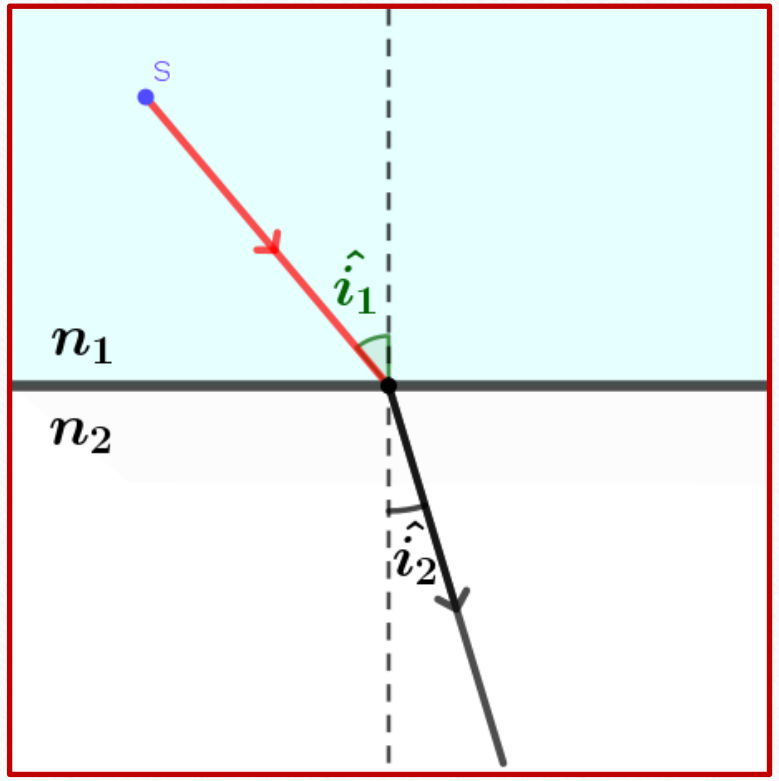
Light undergoes refraction when it passes from a transparent medium of index n_1 to another transparent medium of index n_2

Law of refraction (Snell's law):

$$n_1 \sin i_1 = n_2 \sin i_2$$

$\widehat{i_1}$: *is the angle of incidentce*

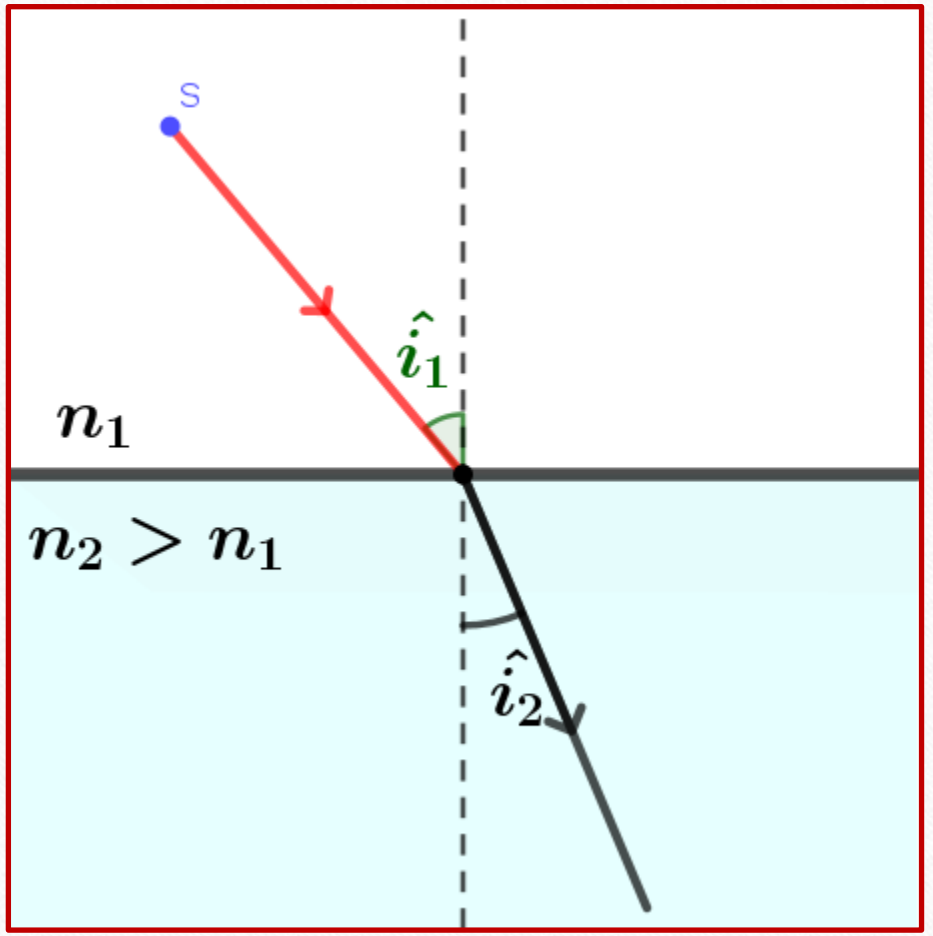
$\widehat{i_2}$: *angle of refraction*



1- if $n_2 > n_1$

$$\frac{\sin i_2}{\sin i_1} = \frac{n_1}{n_2} < 1$$

$$\Rightarrow \sin i_2 < \sin i_1 \Rightarrow i_2 < i_1$$

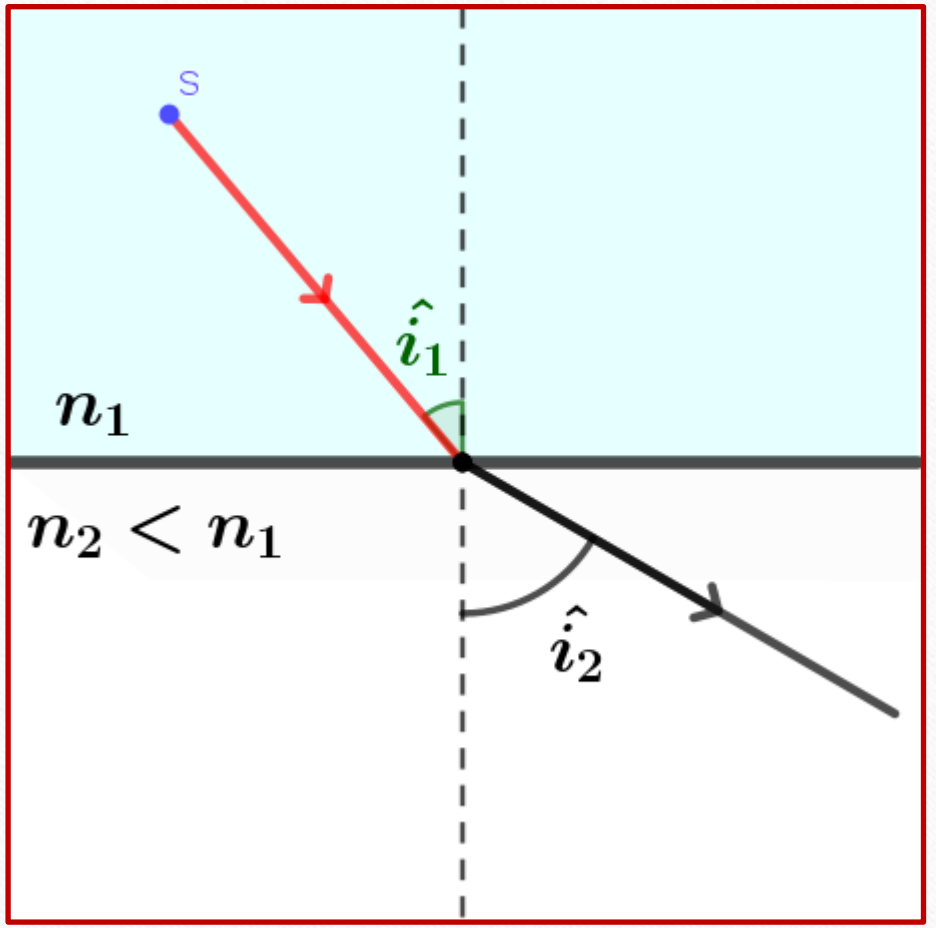


The ray refracts toward the normal (see figure)

2- if $n_2 < n_1$

$$\frac{\sin i_2}{\sin i_1} = \frac{n_1}{n_2} > 1$$

$$\Rightarrow \sin i_2 > \sin i_1 \Rightarrow i_2 > i_1$$



The ray refracts away the normal (see figure)

Limiting angle i_l:

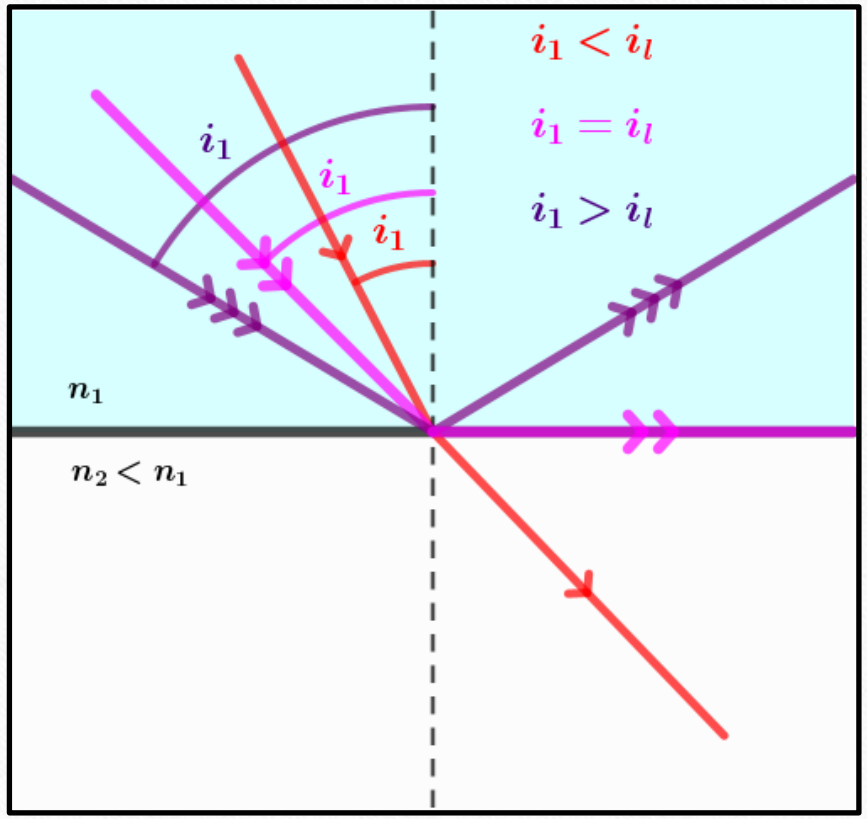
The limiting (or critical) angle i_l is a special value of i_1 for which $i_2 = 90^o$

$$\Rightarrow n_1 sin\, i_l = n_2 sin\, 90 \Rightarrow sin\, i_l = \frac{n_2}{n_1}$$

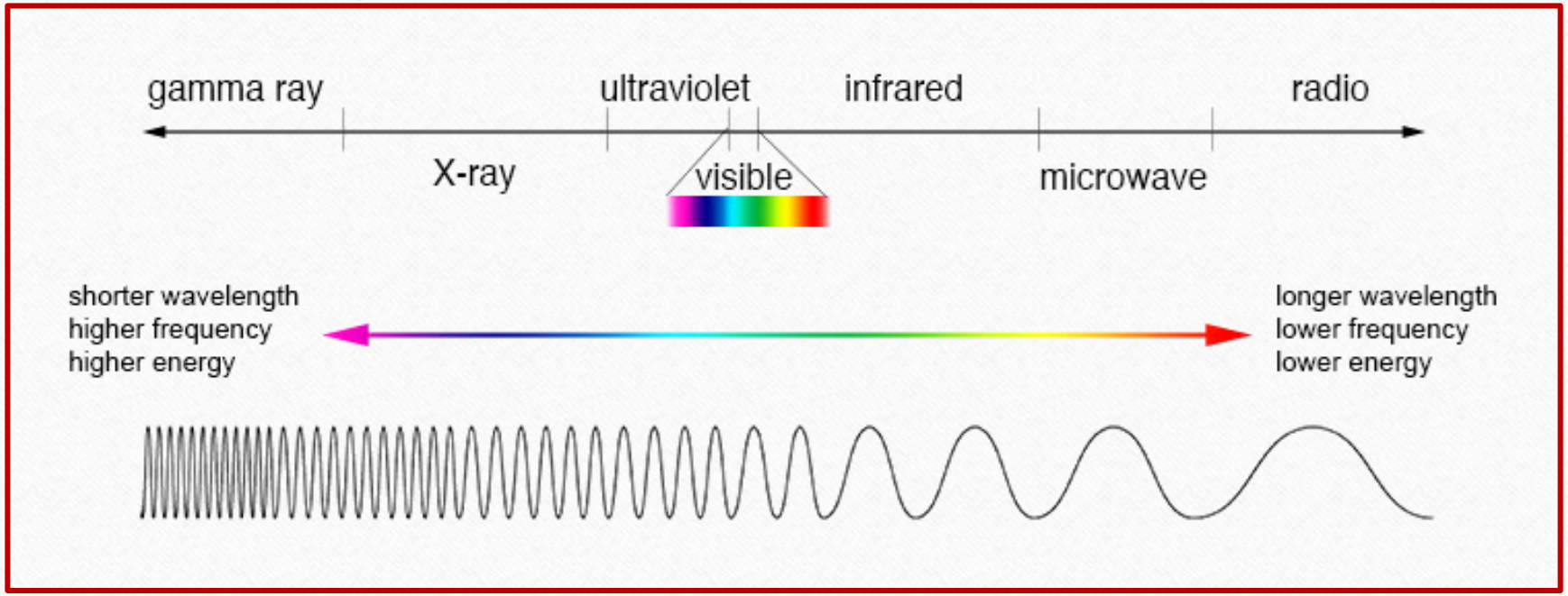
1- if $i_1 < i_l \Rightarrow$ the ray refracts to the second medium.

2- if $i_1 = i_l \Rightarrow$ the ray refracts with $i_2 = 90^o$, it grazes the surface.

3- if $i_1 > i_l \Rightarrow$ the ray undergoes total internal reflection



VI) Electromagnetic waves:



The entire range (electromagnetic spectrum) is given by:

Gamma rays, X-rays, ultra-violet (UV), visible light, , infrared (IR), microwaves and radio waves.

- When the above waves are arranged in the order of increasing λ (or decreasing f), the arrangement is called electromagnetic spectrum.
- The wavelength of the visible spectrum varies between $400nm$ (for violet) and $750nm$ (for red).

- If λ is slightly less than $400nm$, then this radiation is infrared (IR).
- If λ is slightly greater than $750nm$, then this radiation is ultraviolet (UV).
- Unlike mechanical waves (water wave, sound,….), electromagnetic waves can propagate in vacuum with the same speed $c = 3 \times 10^8 m/s$.