KEY

Snell's Law

1.) What is the speed of light in a clear plastic whose index of refraction is 1.40?

Answer – $n = \frac{c}{\vec{v}}$ $1.40 = \frac{3.0\times10^8}{\vec{v}}$ $\vec{v} = 2.14 \times 10^8 \frac{m}{s}$

2.) The speed of light in a clear liquid is $2.3 \times 10^8 \frac{m}{s}$. What is its index of refraction?

Answer – $n = \frac{c}{\vec{v}}$ $n = \frac{3.0\times10^8}{2.3\times10^8}$ $n = 1.30$

3.) A beam of light strikes the surface of a block of glass ($n = 1.50$) and produces a refracted angle of 10.0^o. What is the incident angle?

Answer – $n_i sin\theta_i = n_r sin\theta_r$ $(1.0003)(\sin\theta_i) = (1.50)(\sin 10)$ $\theta_i = 15.1°$

4.) What is the wavelength of light in water ($n = 1.33$) if its wavelength in air is $5.30 \times 10^{-7}\ m$?

Answer – the change in optical densities of the mediums is equal to the change in wavelength that will occur. So . . . the change in optical density is $\frac{1.0003}{1.33} = 0.754$ $0.754 \times 5.30 \times 10^{-7}$

$\lambda = 3.986 \times 10^{-7} m$ $\lambda = 3.99 \times 10^{-7} m$

5.) Monochromatic liquid (light of one color) has a wavelength of $6.0 \times 10^{-7}\ m$ in air and $5.0 \times 10^{-7}\ m$ in a clear liquid. What is the index of refraction of the clear liquid?

Answer – $\frac{6.0\times10^{-7}}{5.0\times10^{-7}} = 1.2$ 1.2×1.0003 $\lambda = 1.200$ $\lambda = 1.2$

6.) Monochromatic light has a wavelength of $5.75 \times 10^{-7} m$ in air and $4.32 \times 10^{-7} m$ in a clear liquid. If a ray of light enters this clear liquid at an angle of incidence of $25.0°$, what is the angle of refraction?

Answer – $\frac{5.75\times10^{-7}}{4.32\times10^{-7}} = 1.3310$ 1.3310×1.0003 $n = 1.3314$

$n_i sin\theta_i = n_r sin\theta_r$ $(1.0003)(\sin 25.0) = (1.3314)(\sin\theta_r)$

$\theta_r = 18.512°$ $\theta_r = 18.5°$

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7.) Monochromatic light has a wavelength of $5.20 \times 10^{-7} m$ in air and $3.91 \times 10^{-7} m$ in a clear liquid. What is the speed of light in the clear liquid?

Answer - $\frac{5.20\times10^{-7}}{3.91\times10^{-7}} = 1.32992$ 1.32992×1.0003 $n = 1.3303$

$n = \frac{c}{\vec{v}}$ $1.3310 = \frac{3.0\times10^{8}}{\vec{v}}$ $\vec{v} = 2.25509 \times 10^{8} \frac{m}{s}$ $\vec{v} = 2.26 \times 10^{8} \frac{m}{s}$

8.) What is the index of refraction of a substance if the angle of incidence of this substance is $53.0°$ and the angle of refraction in this substance is $41.0°$?

Answer - $n_i sin\theta_i = n_r sin\theta_r$ $(1.0003)(\sin 53) = (n_r)(\sin 41)$ $n_r = 1.21768$

$n_r = 1.22$

9.) A ray of light strikes the surface of water ($n = 1.33$) at an angle of $60.0°$ from the water surface. What is the angle of refraction? ***Don't forget to measure angle from the normal***

Answer - $n_i sin\theta_i = n_r sin\theta_r$ $(1.0003)(\sin 30) = (1.33)(\sin \theta_r)$ $\theta_r = 22.0893°$

$\theta_r = 22.1°$

10.) What is the critical angle for an air-glass interface if the index of refraction of glass is 1.50?

Answer - $n_i sin\theta_i = n_r sin\theta_r$ $(1.50)(\sin \theta_i) = (1.0003)(\sin 90)$ $\theta_i = 41.8257°$

$\theta_i = 41.8°$

11.) What is the critical angle for a water-lucite interface if the index of refraction of water is 1.33 and of Lucite is 1.51?

Answer - $n_i sin\theta_i = n_r sin\theta_r$ $(1.51)(\sin \theta_i) = (1.33)(\sin 90)$ $\theta_i = 61.738°$

$\theta_i = 61.7°$

12.) The critical angle for a certain liquid-air interface is $48.8°$. What is the index of refraction of the liquid?

Answer - $n_i sin\theta_i = n_r sin\theta_r$ $(n_i)(\sin 48.8) = (1.0003)(\sin 90)$ $n_i = 1.3333$

$n_i = 1.33$

13.) What is the critical angle of a substance whose index of refraction is 1.81?

Answer - $n_i sin\theta_i = n_r sin\theta_r$ $(1.81)(\sin \theta_i) = (1.0003)(\sin 90)$ $\theta_i = 33.5491°$

$\theta_i = 33.5°$

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14.) What is the index of refraction of a substance whose critical angle is $42.0°$?

Answer - $n_i sin\theta_i = n_r sin\theta_r$ $(n_i)(\sin 42.0) = (1.0003)(\sin 90)$ $n_i = 1.4949$

$n_i = 1.50$

15.) The speed of light in a clear liquid is three quarters the speed of light in air. What is the critical angle of the liquid?

Answer - $n = \frac{c}{\vec{v}}$ $1.003 = \frac{3.0\times10^8}{\vec{v}_{air}}$ $\vec{v}_{air} = 2.99910 \times 10^8 \frac{m}{s}$

$\vec{v}_{liquid} = 0.75 \times 2.99910 \times 10^8$ $\vec{v}_{liquid} = 2.2493 \times 10^8 \frac{m}{s}$

$\frac{2.99910\times10^8}{2.2493\times10^8} = 1.333333$

$n_i sin\theta_i = n_r sin\theta_r$ $(1.3333)(\sin\theta_i) = (1.0003)(\sin 90)$ $\theta_i = 48.6099°$

$\theta_i = 48.6°$

16.) A ray of light travels from air into water and then into glass ($n = 1.50$) as shown below. Find the angle of the refraction in the glass.

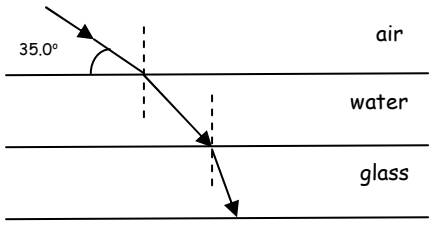

Diagram is not drawn to scale

Answer - $n_i sin\theta_i = n_r sin\theta_r$ $(1.0003)(\sin 55.0) = (1.33)(\sin\theta_r)$ $\theta_r = 38.03105°$

$n_i sin\theta_i = n_r sin\theta_r$ $(1.33)(\sin 38.03) = (1.50)(\sin\theta_r)$ $\theta_r = 33.11111°$

$\theta_i = 33.1°$

17.) A ray of light travels from glass ($n = 1.50$) into water and then into air as shown below. Find the angle that the light leaves the water-air interface.

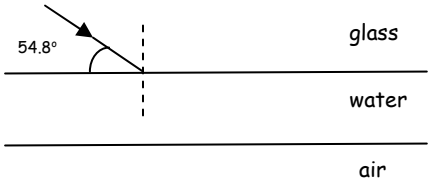

Diagram is not drawn to scale

Answer - $n_i sin\theta_i = n_r sin\theta_r$ $(1.50)(\sin 35.2) = (1.33)(\sin\theta_r)$ $\theta_r = 40.5500°$

$n_i sin\theta_i = n_r sin\theta_r$ $(1.33)(\sin 40.55) = (1.0003)(\sin\theta_r)$ $\theta_r = 59.8130°$

$\theta_i = 59.8°$

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18.) A ray of light strikes a side of an equilateral lucite prism ($n = 1.50$) at an angle of $36°$ as shown below. Find the angle that the light leaves the prism. *** triangle angles are $60°$***

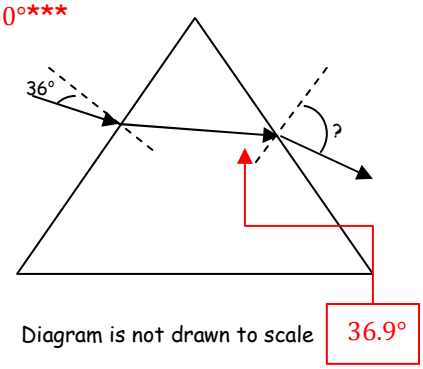

Diagram is not drawn to scale

Answer - $n_i sin\theta_i = n_r sin\theta_r$

$(1.0003)(\sin 36) = (1.50)(\sin\theta_r)$ $\theta_r = 23.0774°$

$n_i sin\theta_i = n_r sin\theta_r$

$(1.50)(\sin 36.9225) = (1.0003)(\sin\theta_r)$ $\theta_r = 64.26778°$

$\theta_i = 64°$

19.) A ray of light strikes a side of lucite ($n = 1.50$) prism at $40°$ as shown below. Find the angle that the light leaves the prism.

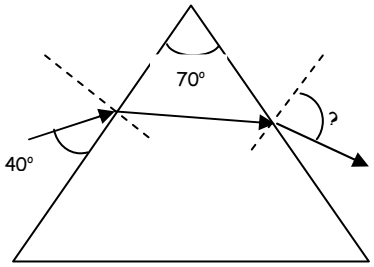

Diagram is not drawn to scale

Answer - $n_i sin\theta_i = n_r sin\theta_r$

$(1.0003)(\sin 50) = (1.50)(\sin\theta_r)$ $\theta_r = 30.72043°$

$n_i sin\theta_i = n_r sin\theta_r$

$(1.50)(\sin 39.2795) = (1.0003)(\sin\theta_r)$ $\theta_r = 71.69033°$

$\theta_i = 72°$

20.) A ray of light reflects from a mirror onto the surface of a clear liquid as shown in the diagram. Determine the index of refraction of the liquid.

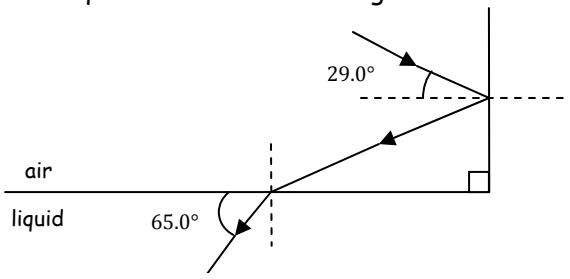

Diagram is not drawn to scale

Answer -

$n_i sin\theta_i = n_r sin\theta_r$ $(1.0003)(\sin 61.0) = (n_r)(\sin 25.0)$

$n_r = 2.07015$ $n_i = 2.07$

KEY

21.) A ray of light travels through a clear liquid into a clear plastic as shown in the diagram. Find the index of refraction of the plastic compared to the liquid.

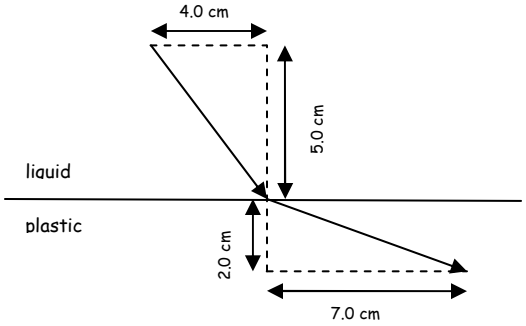

Diagram is not drawn to scale

Answer - $\tan\theta_1 = \frac{4}{5}$ $\theta_1 = 38.6598°$

$\tan\theta_2 = \frac{7}{2}$ $\theta_2 = 74.0546°$

$n_i sin\theta_i = n_r sin\theta_r$

$(n_i)(\sin 38.65) = (n_r)(\sin 74.05)$

$\frac{n_r}{n_i} = 0.649692$ $\frac{n_r}{n_i} = 0.65$

22.) What is the frequency of light in diamond ($n = 2.42$) if the frequency in air is $6.20 \times 10^{14}\ Hz$?

Answer - frequency never changes due to medium change. Therefore the frequency in diamond is the same as in air ($6.20 \times 10^{14}\ Hz$)?

23.) Monochromatic light of a wavelength of $6.22 \times 10^{2}\ nm$ enters lucite ($n = 1.51$). What is the frequency of the light in the Lucite? Change nm to metres. $6.22 \times 10^{2}\ nm \times \frac{1\ m}{1\ 000\ 000\ 000\ nm} = 6.22 \times 10^{-7}\ m$

Answer - $n = \frac{c}{\vec{v}}$ and $\vec{v} = \lambda f$ so . . . $n = \frac{c}{\lambda f}$ $1.51 = \frac{3.0\times10^{8}}{6.22\times10^{-7}\times f}$ $f = 3.1941 \times 10^{14} Hz$

$f = 3.19 \times 10^{14} Hz$

24.) Monochromatic light of a wavelength of $4.00 \times 10^{-7}\ m$ enters water. What is the period of the light in water?

Answer - $\frac{1.0003}{1.33} = 0.754$ $0.754 \times 4.00 \times 10^{-7}$ $\lambda = 3.016 \times 10^{-7} m$

$n = \frac{c}{\vec{v}}$ $1.33 = \frac{3.0\times10^{8}}{\vec{v}}$ $\vec{v} = 2.25564 \times 10^{8}\ \frac{m}{s}$

$\vec{v} = \frac{\lambda}{T}$ $2.25564 \times 10^{8} = \frac{3.016\times10^{-7}}{T}$ $T = 1.33709 \times 10^{-15}\ s$

$T = 1.34 \times 10^{-15} s$

25.) The period of a light wave in air is $1.70 \times 10^{-15}\ s$. What is its wavelength in water?

Answer - $\vec{v} = \frac{\lambda}{T}$ $3.0 \times 10^{8} = \frac{\lambda}{1.70\times10^{-15}}$ $\lambda = 5.10 \times 10^{-7} m$

$\frac{1.0003}{1.33} = 0.7521$ $0.7521 \times 5.10 \times 10^{-7}$ $\lambda = 3.8357 \times 10^{-7} m$

$\lambda = 3.84 \times 10^{-7} m$