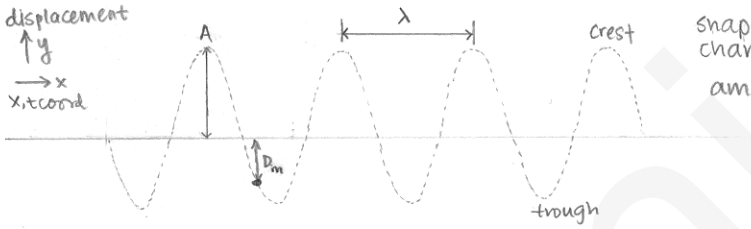
Physical Sciences 3

Lectures 13, 14 and 15 – April 2, 2008 – Induction, Waves, Ray Model of Light, and Polarization

Reading for Understanding: Chapter 28, Chapter 29, Chapter 15, Chapter 32

WAVE MOTION

Oscillations are the basis of wave motions - vibrations that propagate outward, continuously → sinusoidal wave



snapshot of wave characterized by amplitude & wavelength

A = amplitude, maximum vertical displacement

D_m = vertical displacement at a given point on the wave in time

λ = wavelength, distance between successive crests

f = frequency, number of crests that pass a given pt / unit time

$\frac{1}{f} = T$ = period, elapsed time between passage of two successive crests

v = wave velocity, velocity that crests move. $v = \lambda f$

general form of wave:

$D = D_m \sin\left(\frac{2\pi}{\lambda}(x - vt)\right)$

$D = D_m \sin\left(\frac{2\pi x}{\lambda} - \frac{2\pi t}{T}\right)$

$D = D_m \sin(kx - \omega t)$

k = wave # $= \frac{2\pi}{\lambda}$, $\omega = 2\pi f$, $v = \frac{\omega}{k} = \lambda f$

where convention is that the (-) sign refers to a wave traveling to the right ∴ a wave moving to the left means -v so

$D = D_m \sin\left(\frac{2\pi}{\lambda}(x + vt)\right)$

traveling waves: two waves with different speeds (relative)

ϕ = phase shift, if the sin wave doesn't start at x=0 but is moved "over" by some amt

$\phi = 2\pi\left(\frac{\text{shift in m}}{\lambda \text{ in m}}\right)$ radians

type of waves:

longitudinal — rarefaction / compression — ex sound waves

transverse — λ, A — ex. light waves

LIGHT WAVES

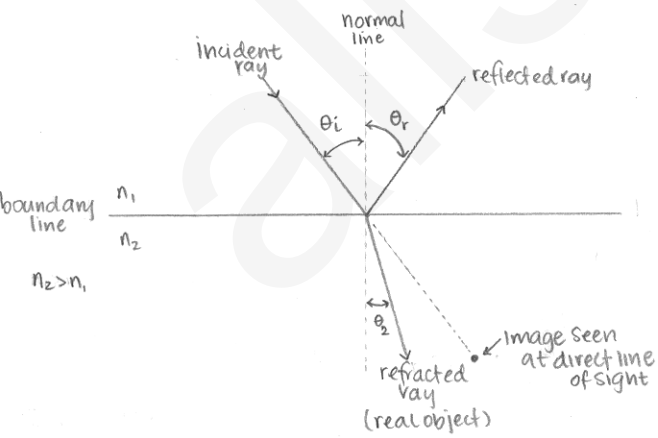
also as an electromagnetic wave $\vec{B} \perp \vec{E} \perp$ propagation

- light travels in straight lines except when it bounces off objects (reflection) OR when it moves into transparent objects (refraction)
- travels through a vacuum at 3×10^8 m/s $= 6.17\times10^8$ mph $= c$ except when moving through objects with index of refraction, $n > 1$.

$n = \frac{c}{v}$ (c = speed of light)

index of refraction is property of medium/object. air $n = 1.003$, water $n = 1.33$, glass $n = 1.52$

angle of incidence θ_i = angle of reflection θ_r



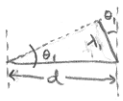
- **SNELL'S LAW**: speed of light decreases when $n > 1$

so $n_1 = \frac{c}{v_1}$ $n_2 > n_1$, $\uparrow n_2 = \frac{c}{v_2}\downarrow$ $v_2 < v_1$ $\lambda_2 < \lambda_1$ $\theta_1 > \theta_2$

general rule, the direction of light has to change when its speed changes upon entering a refractive substance.

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

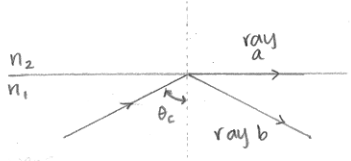
so $\frac{\sin\theta_1}{\sin\theta_2} = \frac{v_1}{v_2}$ $d\sin\theta_1 = \lambda_1$ where



Total internal reflection:

$n_1 > n_2$

θ_c = critical angle



if $\theta_i = \theta_c$, follow ray a

$n_1 \sin\theta_c = n_2 \sin 90°$

if $\theta_i > \theta_c$ follow ray b total internal reflection