Phys 5B: Light Waves II

by Kameron Gill

Date February 17, 2016

- Example

  Mirror Equation with a plane mirror!

  An object is d_0 in front of a mirrior. Where is the image?

  $\frac{1}{d_0}+\frac{1}{d_i}=\frac{1}{f}$ for plane mirrior $R=\infty$, therefore $f=\infty$

  $\frac{1}{d_0}+\frac{1}{d_i}=0\Rightarrow d_i=-d_0$

  Therefore, Image is d_0 behind the mirror!

  $m=\frac{-d_i}{d_0}\Rightarrow-\frac{-(-d_0)}{d_0}=1$ Image is same size as object

- Refraction for Light Waves

  - depends on velocity of light in medium

    $v=\frac{1}{\sqrt{\varepsilon\mu}}$

    The reduction factor $\frac{c}{v}=n$ which is the index of refraction

    $1\leq n<2.5$ frequency dependent

  - Refraction: same as for mechanical wave

  - Snell's Laws:

    $$n_1\sin\Theta_1=n_2\sin\Theta_2$$

    Moving into higher-n medium, light bends toward normal

    If Θ is too large, Snell's Law can't be satisfied. No refraction!

  - Max Θ_1?

    $\frac{n_{\text{water}}}{n_{\text{air}}}=\frac{\sin\Theta_2}{\sin\Theta_1}\Rightarrow\sin\Theta_1=\frac{\sin\Theta_2 n_{\text{air}}}{n_{\text{water}}}=\sin 90^0\,\frac{n_{\text{air}}}{n_{\text{water}}}$

    Max Angle: $\sin\Theta_1=\frac{n_{\text{air}}}{n_{\text{water}}}$

- Light pipe: Total Internal Refraction

  Light rays with $\Theta>\Theta_c$ experience TIR

- Air$\Rightarrow$glass

  at first surface $n_{\text{air}}\sin\Theta_1=n_{\text{glass}}\sin\Theta_A$

  at second surface, $n_{\text{glass}}\sin\Theta_A=n_{\text{air}}\sin\Theta'$

  $n_{\text{air}}\sin\Theta_i=n_{\text{air}}\sin\Theta'\Rightarrow\sin\Theta_i=\sin\Theta'\Rightarrow\Theta_i=\Theta'$

  $\frac{\text{Shift}}{t}=\tan\Theta_A$ if $\tan\Theta_A\approx\sin\Theta_A\approx\Theta_A$ (Θ_A is small enough) then $n_{\text{air}}\Theta_i \approx n_{\text{glass}}\Theta_A \Rightarrow n_{\text{glass}}\frac{\text{shift}}{t}$

$\frac{n_{\text{air}}}{n_{\text{glass}}}\Theta_i t = \text{shift}$

- Dispersion

  Index of refraction depeonds on frequency (or wavelength=$\frac{c}{f}$)