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OPTI 380A
Intermediate Optics Lab 5:
Wave Motion

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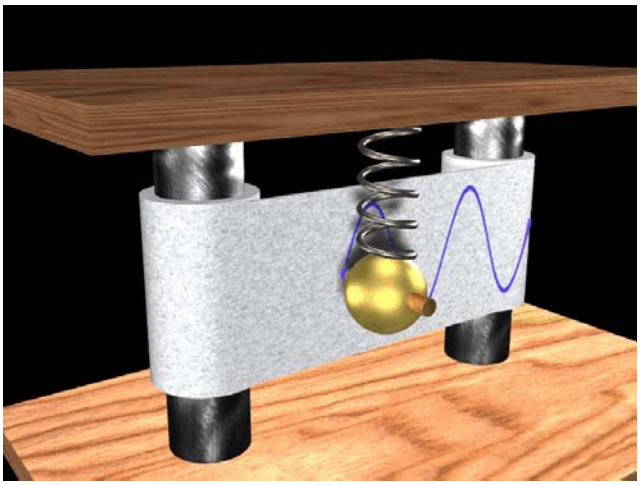
Pendulum



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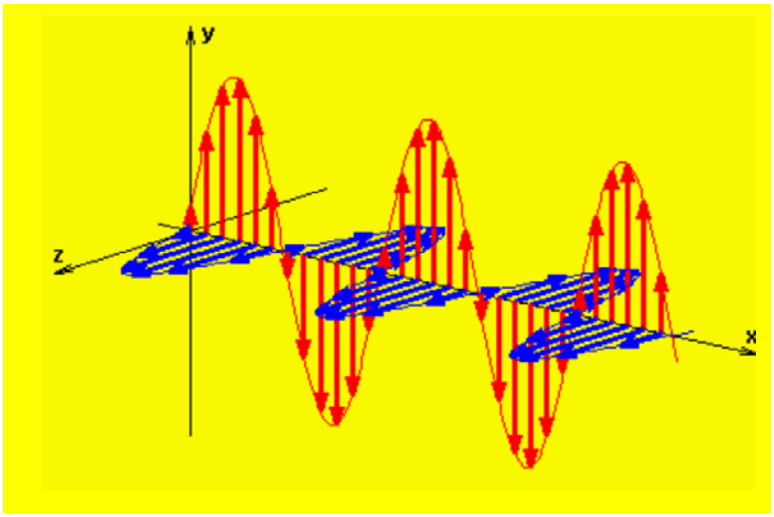
Electromagnetic Waves



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Simple Transverse Waves

One-dimensional wave equation:

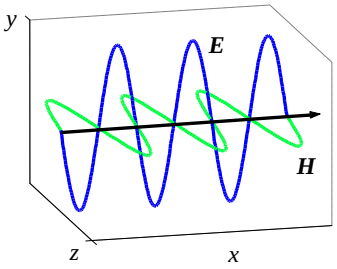
$$\frac{\partial^2 E_y}{\partial x^2} - \frac{1}{c^2}\frac{\partial^2 E_y}{\partial t^2} = 0$$

Solution for the real wave traveling in $+x$ direction:

$$E_y(x,t)\,\hat{\boldsymbol{y}} = A_0 \cos(kx - \omega t + \phi)\,\hat{\boldsymbol{y}}$$

if $k = \dfrac{\omega}{c}$.

The complete solution involves consideration of the magnetic field. If we take a snapshot in time of the EM wave it may look like:



$\boldsymbol{E} \perp \boldsymbol{H}$

$\boldsymbol{S} = \boldsymbol{E} \times \boldsymbol{H}$

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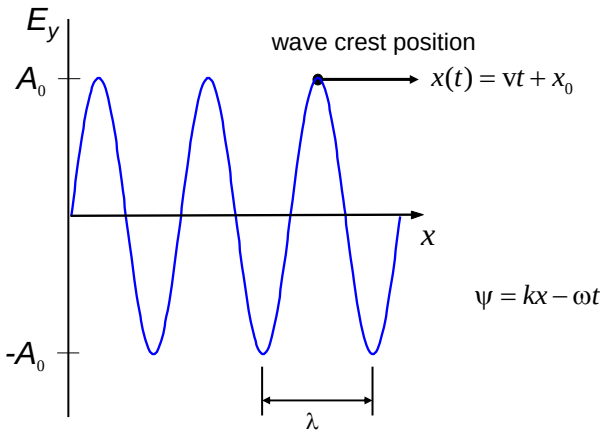
Simple Transverse Waves



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Standing Waves

(Waves traveling in opposite directions)

$$E_a(x,t) = A\cos(kx - \omega t + \phi_a)$$
$$E_b(x,t) = A\cos(kx + \omega t + \phi_b)$$

Addition of the two waves:

$$E(x,t) = 2A\cos\left(kx + \frac{\phi_\Sigma}{2}\right)\cos\left(-\omega t + \frac{\phi_\Delta}{2}\right)$$

Square magnitude and irradiance:

$$E^2(x,t) = A^2\left[1+\cos(2kx+\phi_\Sigma)\right]\left[1+\cos(-2\omega t+\phi_\Delta)\right]$$
$$I(x) = cn\varepsilon_0\left\langle E^2(x,t)\right\rangle = cn\varepsilon_0 A^2\left[1+\cos(2kx+\phi_\Sigma)\right]$$

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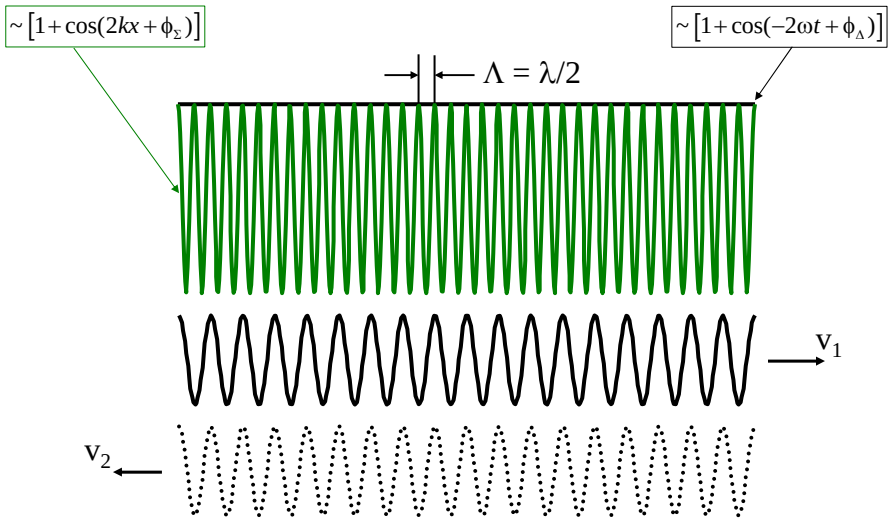
Standing Waves



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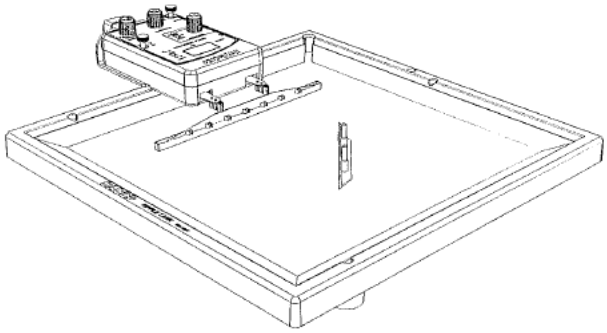
Ripple Tank



Position Paper Below Tank

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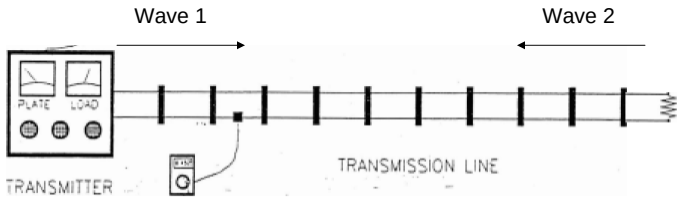
Transmission Line



Result is Standing EM Wave

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Internet Videos

- Speed of radio waves: http://www.youtube.com/watch?v=z-8lDHY_bWk&feature=fvw
- Reflection from Straight Barrier (Pulse): http://www.youtube.com/watch?v=r0088hYFuws&feature=related
- Circular wave reflection ripple tank: http://www.youtube.com/watch?v=-RBpOsgCdxo&feature=related
- Standing wave demo: http://www.youtube.com/watch?v=MT7EpS4OX3k&feature=related
- Waves on a bass instrument: http://www.videosift.com/video/Standing-waves-in-standup-bass-guitar-strings