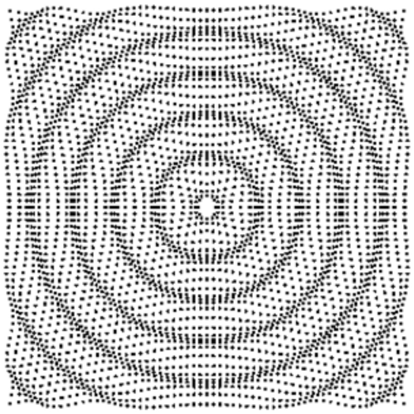
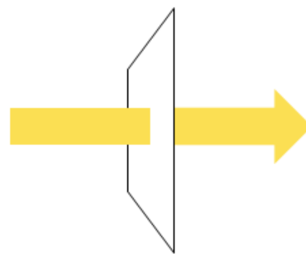
Radiation: Particles, Waves, Rays

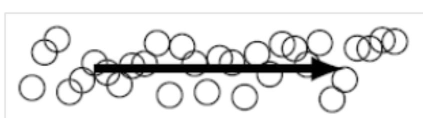
Energy flow and intensity is related to the amplitude and power of the driving source

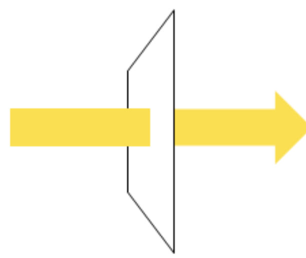




$$I = \frac{P}{4\pi r^2}$$

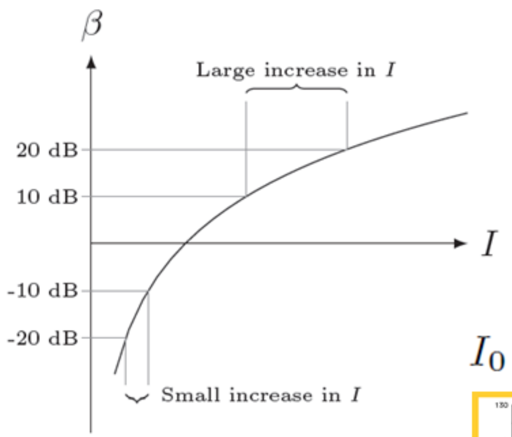
$$I = P/A$$



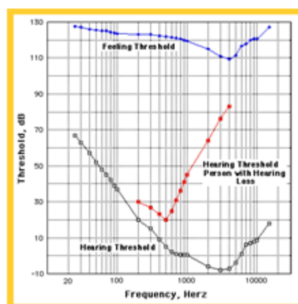


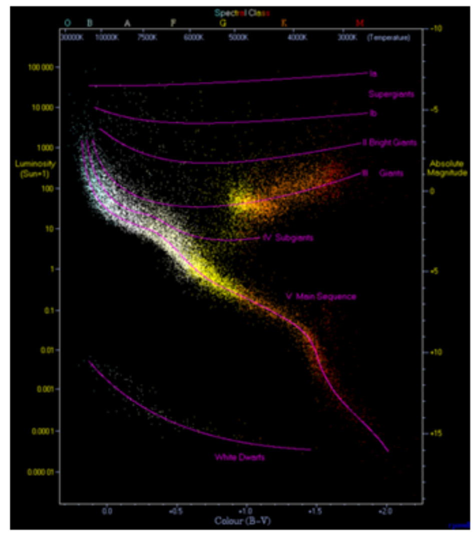
$$I = nE/t$$

"Intensity level" recalibrates the definition of intensity to our physiological sensation



$$I_0 = 1.0 \times 10^{-12}$$



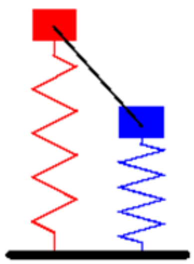


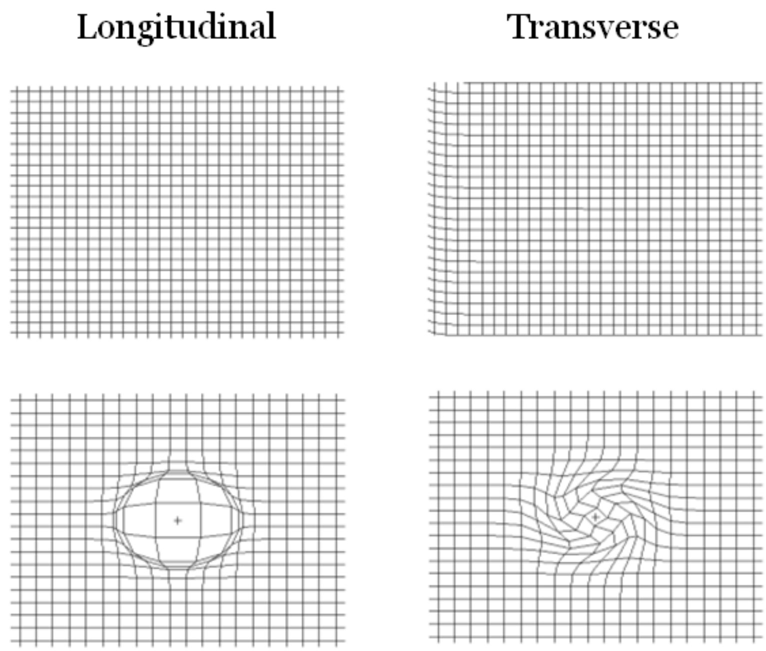
$$\beta = 10 \log_{10}(I/I_0)$$

$$I = 10^{(0.1\beta - 12)}$$

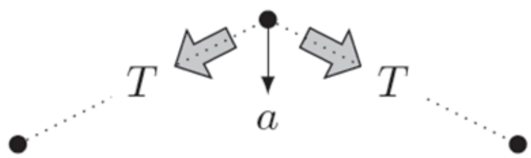
$$m = -2.5 \log_{10}(I/I_0)$$

Waves require a source and a medium made up of coupled oscillators near equilibrium





Any disturbance in the medium acts as a damped oscillator as energy radiates away



$$v = \sqrt{T/\mu}$$

Solid

$$v = \sqrt{Y/\rho}$$

Liquid

$$v = \sqrt{B/\rho}$$

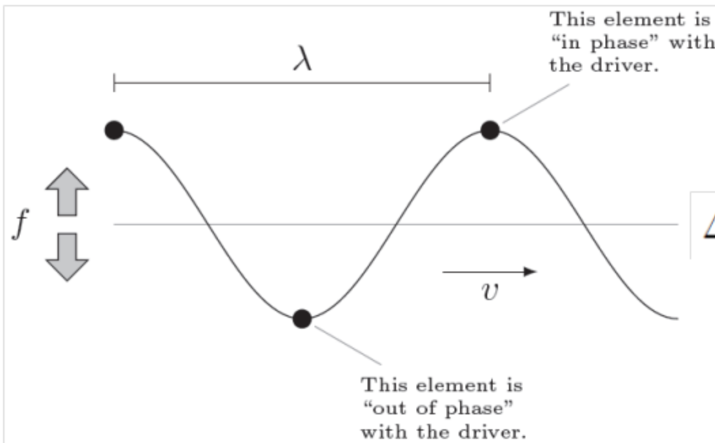
Gas

$$v = \sqrt{\gamma k T/M}$$

Air

$$v = 331 + 0.6 T_C$$

All the elements of the medium match the oscillation of the source with a phase shift



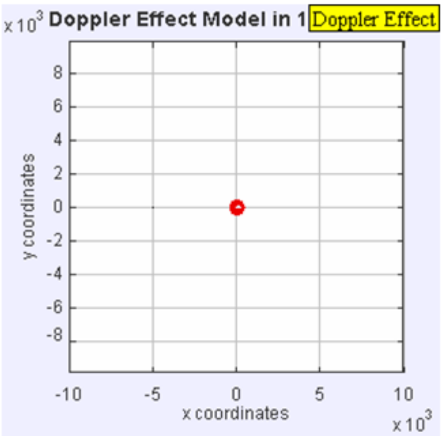
$$\Delta\phi = -(2\pi f/v)\Delta x$$

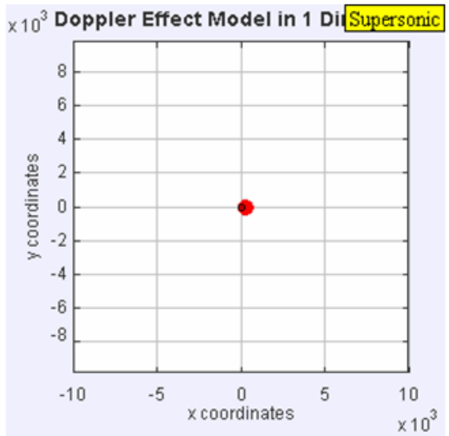
$$\psi = A\cos\left(2\pi f t - \frac{2\pi}{\lambda}x\right)$$

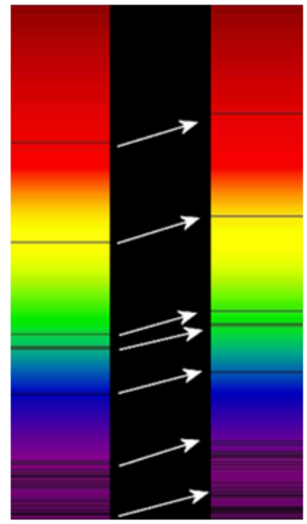
$$v = f\lambda$$

If the source is moving, the observed frequency suffers a Doppler shift

$$f\lambda = v_r \pm v_s$$







$$f_o = f\left(\frac{v_r}{v_r \pm v_s}\right)$$

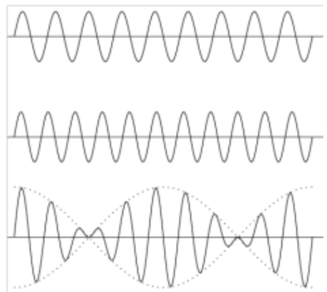
$$\sin\alpha = v_r/v_s$$

When the frequencies of two sources differ, non-sinusoidal beats result

$$\psi_1 = \cos(2\pi f_1 t)$$

$$\psi_2 = \cos(2\pi f_2 t)$$

$$\psi = \psi_1 + \psi_2$$

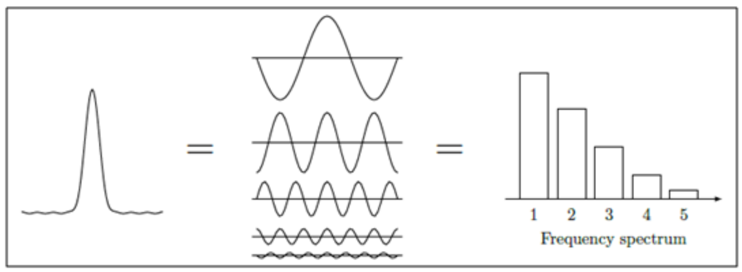


$$\psi(t) = A(t)\cos(2\pi f_{\text{avg}} t)$$

$$A(t) = 2\cos(\pi \Delta f t)$$

$$f_{\text{beat}} = \Delta f = f_1 - f_2$$

Fourier Analysis



Energy propagates along "rays" which move perpendicular to the overall wave fronts