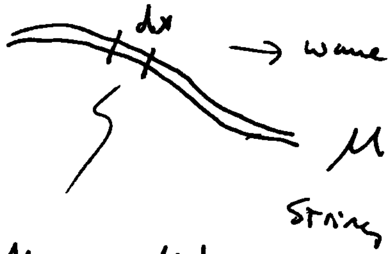
Waves carry energy

(move masses as they travel)

- → light waves carry energy from sun to us
- → earthquake waves can destroy buildings
- → sound waves can burst eardrums



μ = mass/length

Mass = $\mu\, dx$

Consider Harmonic wave — mass moves in SHM

has energy

$E = \frac{1}{2} k x^2$ where $x = A$ (Amplitude)

$k = m\omega^2$

$\omega^2 \equiv \frac{k}{m}$

dE in a dx of wave ↘

$\therefore$

$$dE = \frac{1}{2}\mu (dx)\,\omega^2 A^2$$

wave moves w/ $v = dx/dt$

Energy passing thru a point in time dt

$$dE = \frac{1}{2}\mu\omega^2 A^2 v\, dt$$

$$\frac{dE}{dt} = \frac{1}{2}\mu\omega^2 v A^2$$

Rate of energy transfer through a point

⇒ Power

Watts

More generally

$$\frac{dE}{dt} \propto A^2 v$$

Will see much more of this next semester

Intensity of wave $\equiv$ Power$/M^2$ = Watts$/M^2$

energy transported by wave per unit time across a unit area ⊥ to direction of flow

Intensity of Sound ·3 W/M^2

Useage ...

Reference intensity to some common reference

$$\beta \text{ (decibel) } = 10 \log \frac{I}{I_0}$$

dB

I_0: 1×10^{-12} W/M^2 Threshold intensity for hearing of Ave. person

	dB
Threshold of hearing	0
Whisper	~20
Street Traffic	~70
Siren @ 30 m	100
Rock Concert / Pain Threshold	~120
Jet engine at 30 m	~140

Example

Stereo advertisement

Flat response ±3 dB from 30 Hz to 18,000 Hz

What does this mean in relative intensity variation?

Ave intensity I_1, ∴ variation

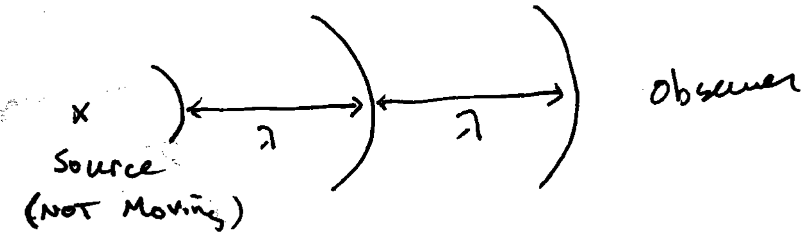
$I = I_1 + 3\,dB$

$$\beta - \beta_1 = 10 \log \frac{I}{I_0} - 10 \log \frac{I_1}{I_0}$$

$$3\,dB = 10 \log \frac{I}{I_1} \Rightarrow \frac{I}{I_1} = 2.0$$

variation in intensity is factor of two!

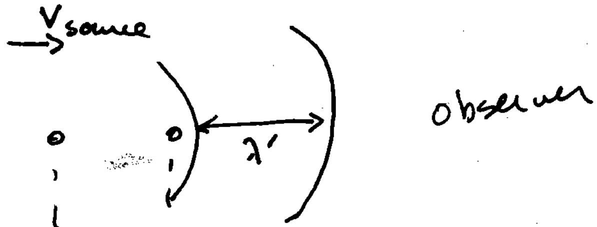
Doppler shift of Sound frequency



λ = Distance between wave crests

Suppose Source Moves!

Velocity of wave $\equiv V_w$ in Medium NOT affected by Source movement



$d = V_{source} T$ ~ period of wave

$T = \frac{1}{f}$ $\quad V_{wave} = \lambda f$

$$\lambda = d + \lambda'$$

$$\lambda' = \lambda - d = \lambda - V_s \frac{1}{f} = \lambda - V_s \frac{\lambda}{V_{wave}}$$

$$\lambda' = \lambda \left(1 - \frac{V_s}{V_w}\right)$$

or $\boxed{\Delta\lambda = \lambda \frac{V_s}{V_w}}$

what is usually "heard" or Measured is frequency

$$f' = \frac{V_w}{\lambda'} = \frac{V_w}{\lambda(1 - V_s/V_w)} = \frac{f}{\left(1 - \frac{V_s}{V_w}\right)}$$

Source Moving Toward STATIONARY observer

$$f' > f$$

Can derive for source moving away from observer

$$f' = \frac{f}{\left(1 + \frac{v_s}{V_w}\right)}$$

known as Doppler shift of frequency

- Train whistle
- Demos
- Similar thing for light
  ↳ receding galaxies.

Thermodynamics

Parts of this I will zip thru because I assume you've seen it in Chemistry. chapts 15-18

Temperature → What is it?

≡ Measure of the ~~amount of~~ thermal energy density of an object ... how hot or cold is it?

3 scales in common use

Temperature ↑			
— b.p. H_2O 1 ATM press	212°	100°	373.15°
— F.p. H_2O 1 ATM press	32°	0°	273.15°
	Farenheit	~~[illegible]~~ celsius	Kelvin