PHYS 107 - Week 15 - Monday

Question Review session

* Superposition and interference:

$y_1 = f_1(x,t)$ $\qquad$ $y_2 = f_2(x,t)$

(right-moving) $\qquad$ (left-moving)

↳ $x - vt$ $\qquad$ ↳ $x + vt$

→ $y = f_1(x,t) + f_2(x,t)$ = just the sum of two waves

* Beat notes: $y_1 = A\cos(2\pi f_1 t)$ at position $x=0$

$y_2 = A\cos(2\pi f_2 t)$ at position $x=0$

↳ $y = \underbrace{2A\cos(\pi f_B t)}_{\text{modulation}} \cos(2\pi f_{avg} t)$

with $f_B = |f_1 - f_2|$

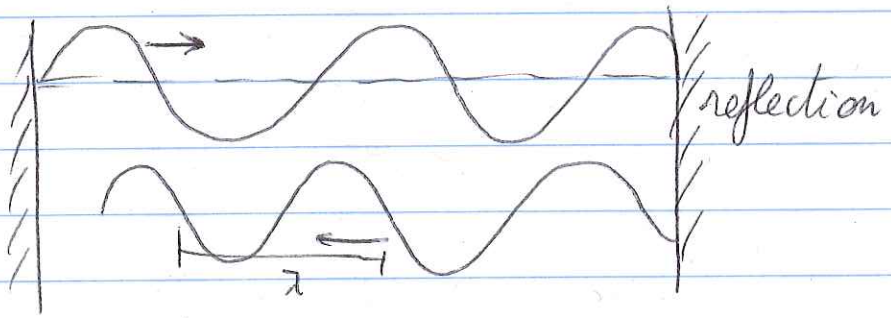
$f_{avg} = \frac{f_1 + f_2}{2}$

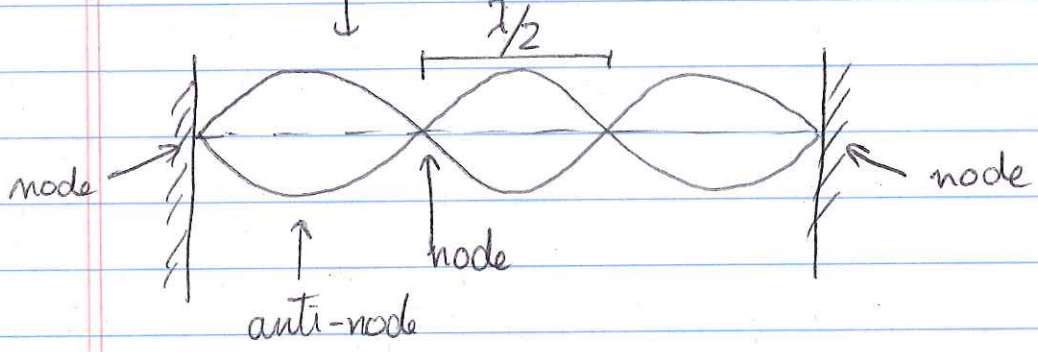
Example: $f_1 = 440\,Hz$, $f_2 = 442\,Hz$

↳ $f_B = 2\,Hz$

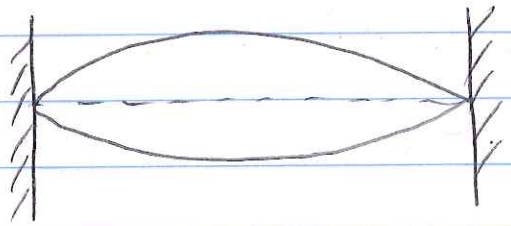
Demo beat notes

* Standing waves = interference of left-moving & right-moving



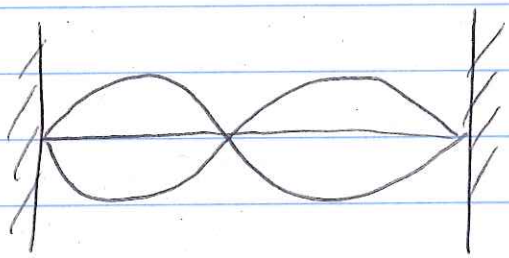


fundamental



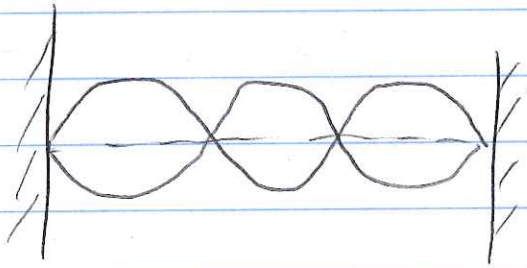
$L = 1\frac{\lambda}{2}$

1st harmonic



$L = 2\frac{\lambda}{2}$

2nd harmonic



$L = 3\frac{\lambda}{2}$

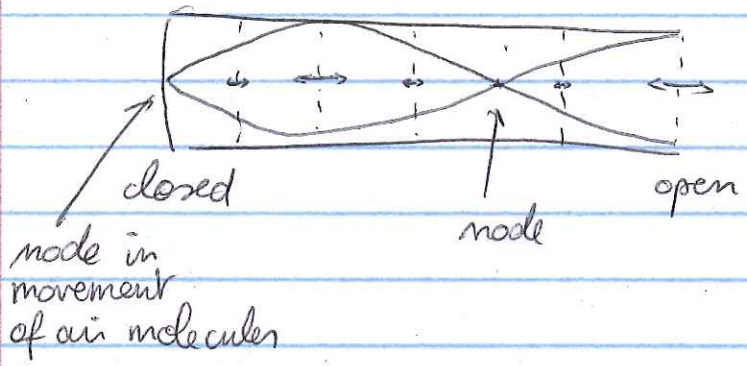
k^{th} harmonic, $n = k+1$ order $\longrightarrow$ $L = n\frac{\lambda}{2}$, $n = 1, 2, 3, \ldots$

or $\lambda = \frac{2L}{n}$

If v is constant $\rightarrow v = \lambda f \rightarrow f = \frac{v}{\lambda} = \frac{v n}{2L}$, $n = 1, 2, 3 \ldots$

Resonant frequencies: $f_n = \frac{v n}{2L}$

* Similar with sound: see later:

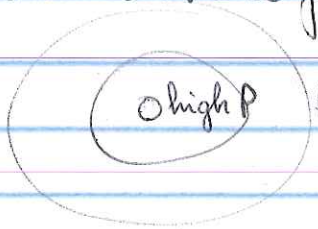


* Waves transport energy, energy $\propto$ (amplitude)^2
($E = \frac{1}{2} k A^2$ for SHM)

$E \propto A^2$

effects of waves (think earthquake) depend on

1) $E \propto A^2$
2) duration: all energy arrives in short time interval: Power $= \frac{\text{energy}}{\text{time}} = \frac{E}{\Delta t}$
3) spatial concentration:
effect of waves goes down as waves spread out with distance from the source



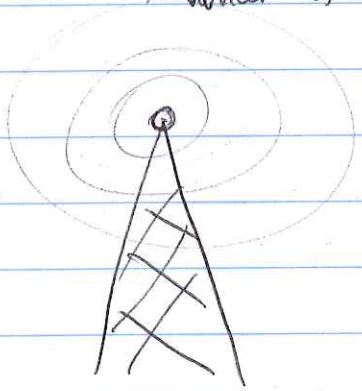
* Intensity $I = \frac{E/\Delta t}{A} = \frac{P}{A}$ in units $\frac{W}{m^2}$

$A \propto r^2 \rightarrow I \propto \frac{1}{r^2}$

$A_{circle} = \pi r^2$ (2D waves on water)
$A_{sphere} = 4\pi r^2$ (3D waves expanding)

Example: radio-transmitter emits in all directions with $P = 10\,kW$

1) What is intensity at 1 km? $\rightarrow A_{sphere} = 4\pi r^2$



$$I = \frac{P}{4\pi r^2} = \frac{10\,kW}{4\pi (1000m)^2}$$
$$= 8 \times 10^{-4} \frac{W}{m^2}$$

2) What is intensity at 10 km? $\rightarrow I = \frac{10\,kW}{4\pi (10000m)^2}$
$$= 8 \times 10^{-6} \frac{W}{m^2}$$

3) How much ~~energy~~ power does an antenna at 10km with an effective area of 10cm x 10cm receive?

$$P = I A = 4\pi (0.1m)^2 I = 1 \times 10^{-6} W$$
$$= 1\,\mu W$$