7)

$\beta_1 = 75\ dB$

$r_1 = 8\ m$

$\beta_2 = 85\ dB$

$r_2 = ?$

① $\beta = 10 \log\left(\frac{I}{I_0}\right)$

$I_1 = 3.16 \times 10^{-5}\ W/m^2$

② $I_1 = \frac{P}{4\pi r^2}$

$P = 0.025W$

③ $85 = 10 \log\left(\frac{I_2}{I_0}\right)$

$I_2 = 3.16 \times 10^{-4}$

④ $3.16 \times 10^{-4} = \frac{0.025}{4\pi r^2}$

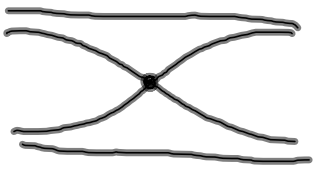
$r = 2.5\ m$

Harmonics

Open-Open:

l = length of pipe

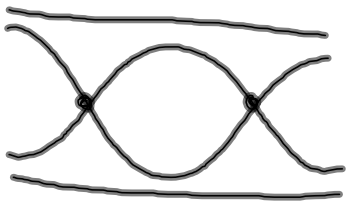
1st Harmonic



$\lambda_1 = 2l$

$f_1 = \frac{v}{2l}$

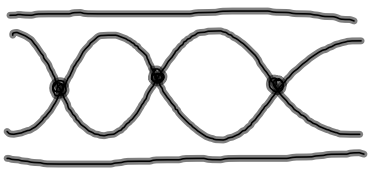
2nd Harmonic



$\lambda_2 = l$

$f_2 = \frac{v}{l} = 2f_1$

3rd Harmonic



$\lambda_3 = \frac{2}{3}l$

$f_3 = \frac{3v}{2l} = 3f_1$

n^{th} Harmonic:

$$\lambda_n = \frac{2l}{n}$$

$$f_n = \frac{nv}{2l}$$

Example 1

if the velocity of the sound is 340 m/s at a harmonic of $f_3 = 240$ Hz, what is the length of a pipe?

$$\ell = 2.12\text{ m}$$

$$v = f\lambda$$

$$\frac{340}{240} = \frac{240\lambda}{240}$$

$$\lambda = 1.417\text{ m}$$

$$\lambda_3 = \frac{2\ell}{3}$$

$$1.417 = \frac{2\ell}{3}$$

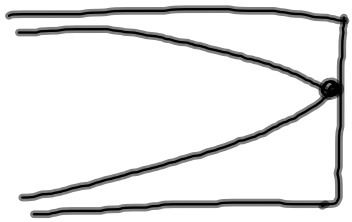
$$\ell = 2.12\text{ m}$$

Open-Closed:

1st Harmonic

$\lambda_1 = 4\ell$

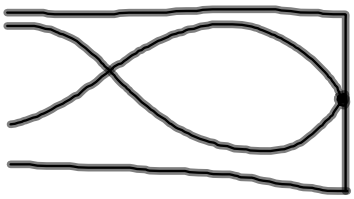
$f_1 = \frac{v}{4\ell}$



3rd Harmonic

$\lambda_3 = \frac{4\ell}{3}$

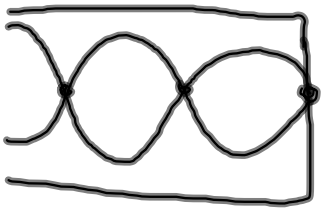
$f_3 = \frac{3v}{4\ell} = 3f_1$



5th Harmonic

$\lambda_5 = \frac{4\ell}{5}$

$f_5 = \frac{5v}{4\ell} = 5f_1$



Example 2:

A 2.45 m long pipe is OPEN at both ends. Find the first 3 harmonics when $v = 345$ m/s.
(frequencies)

$$f_1 = \frac{v}{2\ell} = \frac{345}{2(2.45)} = 70.4 \text{ Hz}$$

$$f_2 = \frac{v}{\ell} = \frac{345}{2.45} = 140.8 \text{ Hz}$$

$$f_3 = \frac{3v}{2\ell} = \frac{3(345)}{2(2.45)} = 211.2 \text{ Hz}$$

Example 3:

$\ell = 2.45\ m$ open-closed pipe

$v = 345\ m/s$

$f_1 = 352\ Hz$

$f_3 = 105.6\ Hz$

$f_5 = 176\ Hz$

BeatZ

$$f_{beat} = |f_1 - f_2|$$

Ex: Tuning fork 1 → $f = 293\,Hz$

" " 2 → $f = 300\,Hz$

What is the frequency of the beat?

$$f_{beat} = |293 - 300|$$

$$= 7\,Hz$$

What is the time period of the bEatZ?

$$T = \frac{1}{f} = \frac{1}{7} = 0.143\,s$$

Ex:

A 400 Hz tuning fork when struck with another tuning fork creates a beat of 5 Hz. What is the frequency of the other tuning fork?

$f_2 = 395$ Hz or 405 Hz