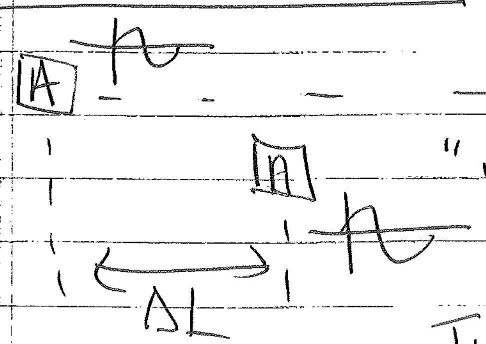
These are NOT notes. They are a visual aid(20%) for a verbal explanation(80%)

4 1

Already seen $f_1 = \frac{v}{4L}$

here, we have $L = 7\frac{\lambda}{4}$ $\therefore \lambda = \frac{4L}{7}$ | $f = \frac{v}{\lambda} = 7\frac{v}{4L} = 7f_1$

7th harmonic



Two Stereo speakers emit identical 1000 Hz waves.

What is their minimum separation that produces a *minimum in the sound heard by the observer?

* Destructive Interference

$V_{sound} = 340 \, m/s$

$\lambda * f = v$

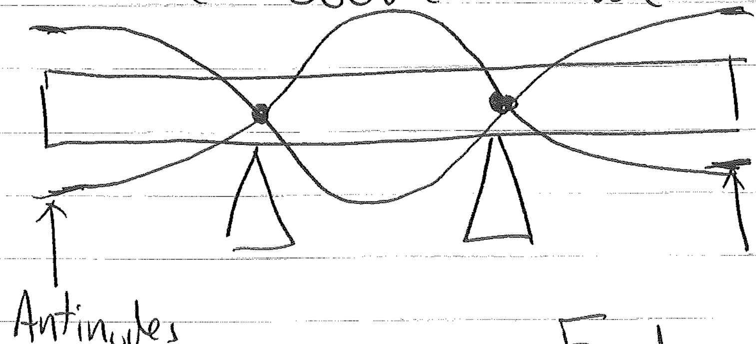
$\therefore \lambda = \frac{v}{f} = \frac{340}{1000} = 0.340$ meters

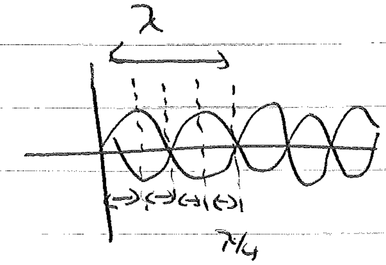
$\Delta L = \frac{\lambda}{2}, \frac{3\lambda}{2}, \frac{5\lambda}{2}, \ldots$

$\Delta L = \frac{\lambda}{2} = \frac{0.34}{2} = 0.17$ meters

(In posted H.O.) Ch. 18, pg 540, #63

For the wooden bar:





4 boundary conditions !!

$L_{bar} = 0.4$ meters

Fundamental (1st harmonic) $f_1 = 87\,Hz$ (given)

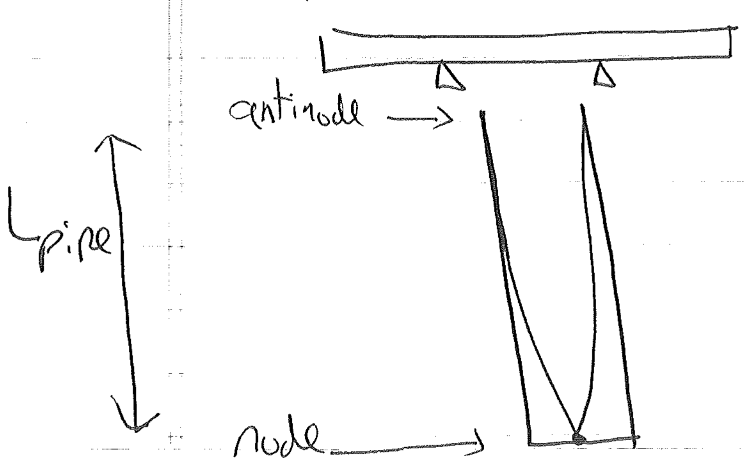
Find the speed of the waves travelling in the bar.

$$\lambda_1 f_1 = v$$ ☆

$$L_{bar} = 4\left(\frac{\lambda}{4}\right) = \lambda$$ ☺

$$\therefore v = 0.4 * 87 = 34.8\ m/s$$

b.) Install a resonant pipe and match its 1st harmonic to that of the bar.



$$L_{pipe} = \frac{\lambda}{4}$$

$$\therefore \lambda = 4 L_{pipe}$$

$$f_1 = \frac{v_{sound}}{\lambda} = \frac{343\ m/s}{4 L_{pipe}} = 87\,Hz$$

$\therefore L_{pipe} = 0.99$ meters

$\lambda_1 f_1 = v_1$

WAVE

material 1

$\lambda_2 f_1 = v_2$

material 2

I18.3 "Beats" (Interference of waves w/ similar frequencies)

$$\text{Intensity} = \frac{\text{Power}}{\text{Area}} \quad \Big\| \quad \frac{\text{watts}}{m^2}$$

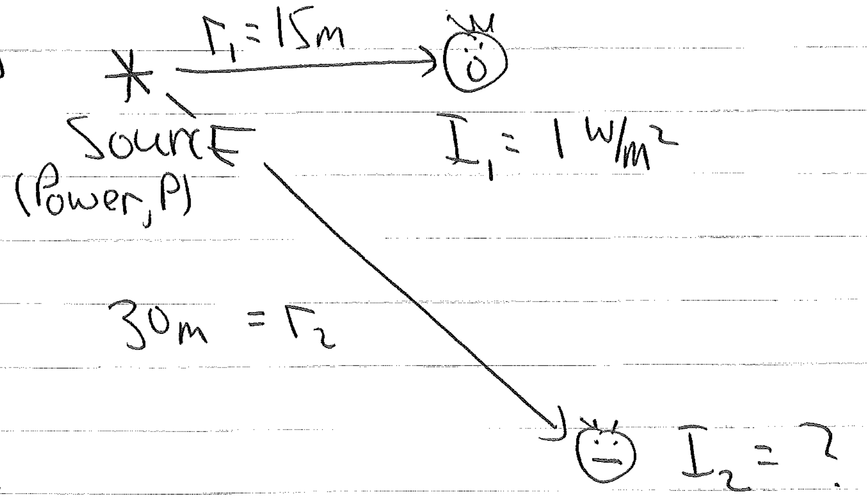
[Power carried by wave per unit area]

surface area Spherical ($4\pi r^2$)

EX.] A speaker produces a sound wave with a power of 75 watts (in the wave). Assuming the wave is spherical, what is the intensity 10 meters from the speaker?

$$I = \frac{75\,W}{4\pi(10)^2} = 0.06\ W/m^2$$

EX)



Assumed spherical WAVES

$$I_1 = \frac{P}{4\pi r_1^2} \quad \therefore P = 4\pi r_1^2 * I_1$$

$$I_2 = \frac{P}{4\pi r_2^2} \quad \therefore P = 4\pi r_2^2 * I_2$$

$$\therefore \frac{I_1}{I_2} = \frac{r_2^2}{r_1^2}$$

☆ Formula Sheet ☺

$$\frac{1}{I_2} = \frac{(30)^2}{(15)^2}$$

$$\therefore I_2 = \underline{0.25\ W/m^2}$$

Problem: The ear does not respond linearly. Response depends on Intensity $\boxed{\text{AND}}$ Frequency.

Ear responds logarithmically ☺

Rules for Logarithms

If $x = a^y$ then $y = \log_a(x)$

$\log_a(xy) = \log_a(x) + \log_a(y)$

$\log_a(x/y) = \log_a(x) - \log_a(y)$

$\log_a(x^n) = n \log_a(x)$

"loudness"

THE DECIBEL SCALE (reports intensity *level*, perceived by human ear, in dB)

Where $I_o = 1.0 * 10^{-12}$ W/m^2

$\beta = 10 \log(I/I_o)$

↑ # of decibels

threshold of human hearing @1000 Hz

Q: What does OSHA regulate, Intensity (watts/sq. meter) or Intensity Level (decibels) ?

Ex: What is the intensity of sound from a vacuum cleaner (70dB)?

$70 = 10 \log(I/I_o)$

$70/10 = \log(I/I_o)$

$\boxed{7 = \log(I/I_o)}$

$10^7 = I/I_o$

$I = I_o * 10^7$

$I = 1 * 10^{-5}$ W/m^2

120 dB → 1 W/m^2
Pain threshold

=

0 dB → 1×10^{-12} W/m^2

EX] A machine on a factory floor produces 100 dB of noise in the work environment. Owner want's to add 9 more machines for a total of 10.

What is the noise level ("loudness") in the work environment?

1^{st} step is to find I:

$$100 = 10 \log\left(\frac{I}{1\times10^{-12}}\right)$$

$$10 = \log\left(\frac{I}{1\times10^{-12}}\right)$$

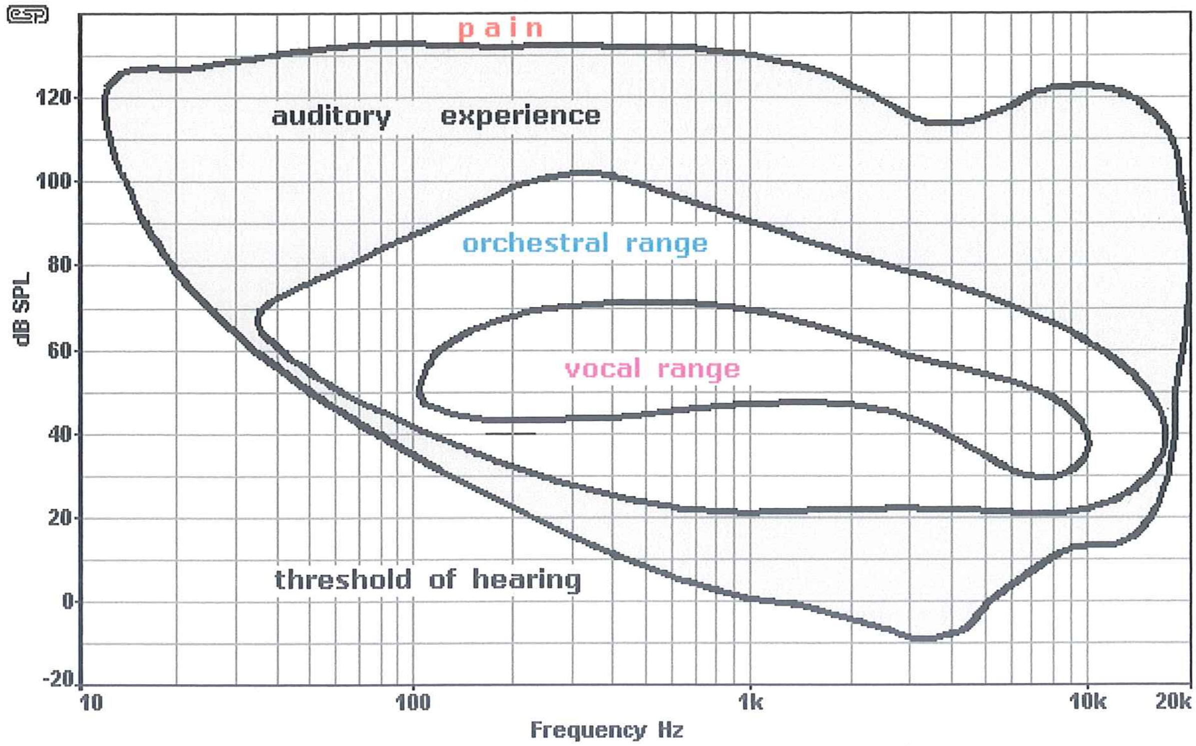
$$10^{10} = \frac{I}{1\times10^{-12}}$$

$$\therefore I = 10^{10} * 10^{-12} = 10^{-2} = \underline{\underline{0.01}}$$

ONE MACHINE

$$\therefore I_{\substack{10 \\ \text{machines}}} = 10 * (0.01) = \underline{\underline{0.1}} \ W/m^2$$

$$\Rightarrow \#dB_{\substack{10 \\ \text{machines}}} = 10 \log\left(\frac{0.1}{1\times10^{-12}}\right) = \underline{\underline{110 \, dB}}$$



pain
auditory experience
orchestral range
vocal range
threshold of hearing
dB SPL
120
100
80
60
40
20
0
-20
10
100
1k
10k
20k
Frequency Hz

E18.4 Doppler Effect

E18.1 Creating sound w/ Harmonics