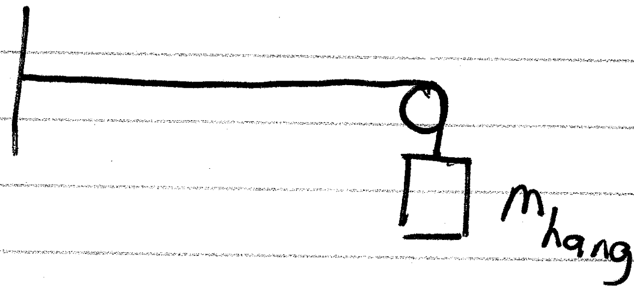
① Phys 2426 2014-11-10



Waves on the string. $v = \sqrt{F_T / \mu}$

$F_T = m_{hang}\, g$

$\mu = m_{string} / L$

For repeating waves $v = f \lambda$

$\lambda = \dfrac{2L}{i}$

L = Length of oscillating portion.

Sound Waves

- Oscillations of pressure in air

$$p = p_{max} \sin\left(\frac{2\pi}{\lambda} x - 2\pi f t\right)$$

wave repeats when x increases by λ

repeats when t increases by $1/f$

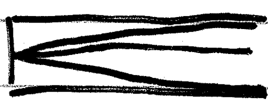
- Frequency - corresponds to pitch

Ex: 500 Hz is a low-pitch whistle

$v = v_{sound} = 340$ m/s

$v = f\lambda \Rightarrow \lambda = 0.68$ m

For a cavity that is open-closed:



$\lambda = \frac{4L}{i}$ i = odd

$L = \frac{\lambda}{4} = 0.17$ m $= 17$ cm

Intensity - for most waves, intensity is proportional to amplitude squared.

$$\text{Intensity} = \frac{\text{Power}}{\text{Area}} = \frac{\text{Energy}}{\text{Time} \cdot \text{Area}}$$

Point Source - energy spreads out equally in all directions.

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

Our ears hear on a log scale.

Decibels describe energy ratios between different signals.

☆ 10 dB → factor of 10

20 dB → factor of $100 = 10^2$

35 dB → factor of $10^{3.5}$

☆ Add x dB → increase by $10^{x/10}$

β = # of dB

$$\text{factor} = 10^{\beta/10}$$

Absolute vs. relative values.

relative: Add or subtract dB
"15 dB higher"

Absolute: Need a reference level.

Sound $I_0 = 10^{-12}\ W/m^2$

0 dB → $I = 10^{-12}\ W/m^2$

-10 dB → $I = 10^{-13}\ W/m^2$

10 dB → $10^{-11}\ W/m^2$

Pain ~120 dB → $1\ W/m^2$

Ex: 5 m from a source, SPL = 70 dB.
What is the SPL @ 10 m?

- New sound is quieter
- Intensity is 4 X less.

$$0.25 = 10^{\beta/10}$$

$$\log_{10}(0.25) = \beta/10$$

$$-0.6 = \beta/10$$

$$\beta = -6\ dB$$

Sub 6 dB ↓

SPL = 64 dB

(I)

Quick dB values

3dB	2 times
5dB	3 times
7dB	5 times
10dB	10 times

$47\,dB = 40\,dB + 7\,dB$

factor of $10^4 \cdot 5 = 50{,}000$

Generally, as energy moves from oscillation to wave & back, the frequency stays constant.

Exception: Doppler Effect

$$\frac{\Delta f}{f} = \frac{V_{rel}}{V_{wave}}$$

f = original frequency

Δf = doppler shift

V_{rel} = relative speed (toward or away)

V_{wave} = wave speed

Works when

$$\frac{V_{rel}}{V_{wave}} < 10\%$$

Ex: Doppler Radar

Transmitted : 5 GHz radio waves

$V_{wave} = C = 3\times10^8$ m/s

$V_{rel} = 30$ m/s (65 mph)

Shift :

$$\frac{\Delta f}{f} = \frac{V_{rel}}{V_{wave}} = \frac{30 \text{ m/s}}{3\times10^8 \text{ m/s}} = 10^{-7}$$

$$\Delta f = 10^{-7}(5\text{ GHz}) = 500 \text{ Hz}$$

Received by moving object :

$f = 5,000,000,500$ Hz

This is also the reflected freq.

The same doppler shift happens again.

The radar gun hears 5,000,001,000 Hz

$$\Delta f = 1000 \text{ Hz}$$