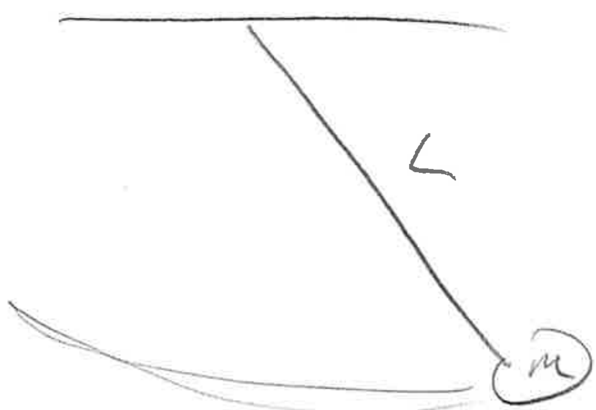
Warm Up Problem

1.



$T = 1s$

$g = 9.8 m/s$

$$T = 2\pi \sqrt{\frac{L}{g}}$$

$$\frac{T}{2\pi} = \sqrt{\frac{L}{g}}$$

$$\frac{T^2}{4\pi^2} = \frac{L}{g}$$

$$L = g\frac{T^2}{4\pi^2}$$

$$\boxed{L = 0.248 m}$$

2. $L \propto g$

$g_2 = 0.38 g_1$

$$\frac{L_2}{L_1} = \frac{g_2}{g_1}$$

$$L_2 = \frac{L_1 (0.38 g_1)}{g_1}$$

$$L_2 = 0.38 L_1$$

$$L_1 = 0.248 \text{ m}$$

$$\boxed{L_2 = 0.0942 \text{ m}}$$

Speed of Sound

- sound is a wave, has wavelength, frequency, and speed.

$$v = f \lambda$$

v - speed of sound, determined by medium (m/s.)

f - frequency, pitch of sound (Hz or 1/s).

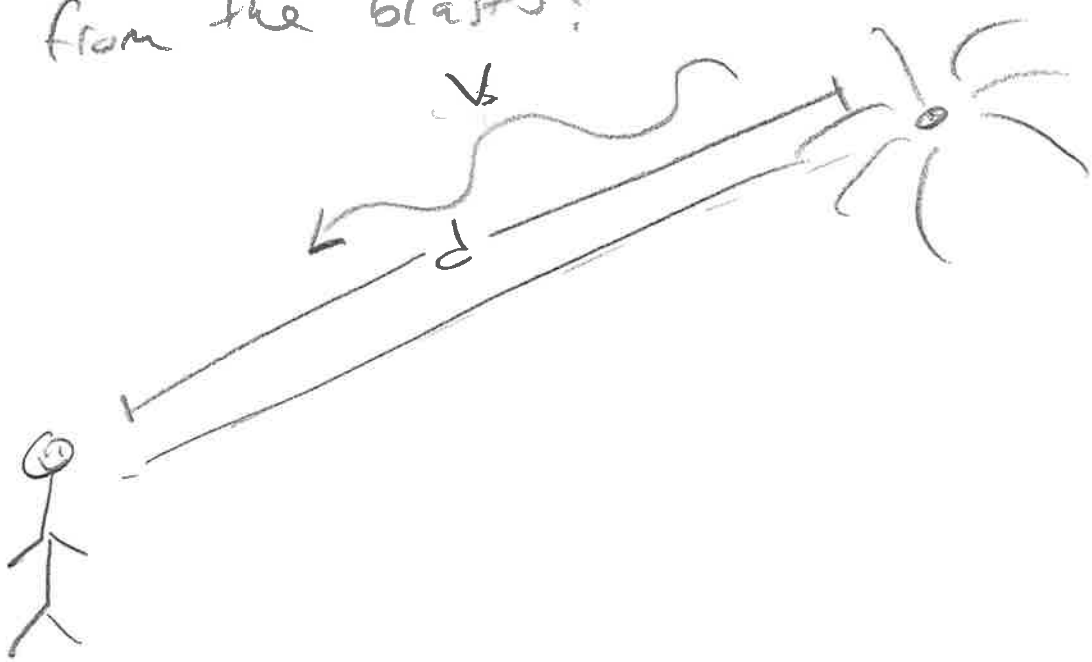
λ - wavelength (m).

- speed of sound depends on medium.

Air: $v = 343$ m/s.

Sound problem.

You are watching a fireworks show when you notice there is a considerable delay between the flash of the fireworks and the sound of the explosion. You time this delay to be 4s. Assuming the speed of light is significantly larger than the speed of sound, and the speed of sound is 343 m/s, how far are you from the blasts?



$$d = vt$$

$$d = 343(4)$$

$$\boxed{d = 1372 m}$$

Sound and Intensity

$$I = \frac{P}{A}$$

I - Intensity (W/m^2)

P - Power (J/s or W)

A - Area (m^2)

Sound waves, light are distributed spherically.

$A = 4\pi r^2$ a distance r from source.

Decibels - Measure of Intensity

$$dB = 10 \log_{10}\left(\frac{I}{I_0}\right)$$

dB - Intensity level (dB)

I - Perceived Intensity (W/m^2)

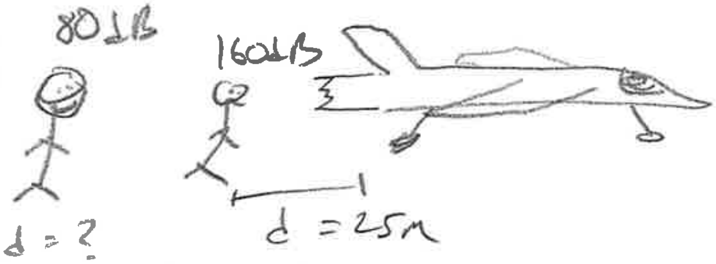
I_0 - Reference Intensity ($10^{-12} W/m^2$)

A jet taking off a distance of 25m has a sound intensity of 160 dB — enough to rupture your eardrums. At what distance will the take off be the much more pleasant 80 dB? Start by subtracting the two dBs.

$$dB = 10 \log\left(\frac{I}{I_0}\right) \qquad I_0 = 10^{-12}\ W/m^2$$

$$dB_2 = 160\ dB$$

$$dB_1 = 80\ dB$$



$$dB_2 - dB_1 = 160 - (80)$$

$$10 \log\left(\frac{I_2}{I_0}\right) - 10 \log\left(\frac{I_1}{I_0}\right) = 80$$

$$\cancel{10}\left[\log\left(\frac{I_2}{I_0}\right) - \log\left(\frac{I_1}{I_0}\right)\right] = 8\cancel{0}$$

$$\log\left(\frac{I_2}{I_0}\right) - \log\left(\frac{I_1}{I_0}\right) = 8$$

$$\log\left(\frac{I_2}{\cancel{I_0}} \cdot \frac{\cancel{I_0}}{I_1}\right) = 8$$

$$10^{\log\left(\frac{I_2}{I_1}\right)} = 10^{8}$$

$$\frac{I_2}{I_1} = 10^8$$

Now use scaling relations

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

$$\frac{I_2}{I_1} = 10^8$$

$$\frac{I_2}{I_1} = \left(\frac{r_1}{r_2}\right)^2$$

$$\sqrt{10^8} = \sqrt{\left(\frac{r_1}{r_2}\right)^2}$$

$$10^4 = \frac{r_1}{r_2}$$

$$r_1 = r_2 \cdot 10^4$$

$$r_2 = 25\,m$$

$$\boxed{r_1 = 250{,}000\,m}$$

Doppler Effect

- The pitch (ie. frequency) of a sound is altered is either the source or observer are moving with respect to each other. (Either towards or away).

Moving emitter

$$f_o = f_e \left(\frac{c}{c \pm v_e} \right)$$

f_o - frequency observed (Hz)
f_e - frequency emitted (Hz)
c - speed of sound (m/s)
v_e - speed of emitter (m/s)

+ - away
− - towards

Moving observer

$$f_o = f_e \left(\frac{c \pm v_o}{c} \right)$$

v_o - speed of observer

+ - towards
− - away

Doppler Effect Problem

A car is blaring its horn as it approaches and eventually passes you. The car horn emits sound at a rest frequency of 500Hz. The car is moving at a constant velocity $v = 40$ km/h, and the speed of sound in air is 343m/s. Calculate:

a) The observed frequency as the car approaches you.

b) The observed frequency as the car passes you.

c) The observed frequency when the car is moving away from you.

$$\frac{40km}{h} \times \frac{1000m}{1km} \times \frac{1hr}{60min} \times \frac{1min}{60s}$$

$$= 11.1 m/s$$

a)

$V_e = -11.1 m/s$ (towards

$f_e = 500 Hz$

$c = 343 m/s$

$$f_o = f_e \left(\frac{c}{c - v_e} \right)$$

$$\boxed{f_o = 516.7 Hz}$$

1b)

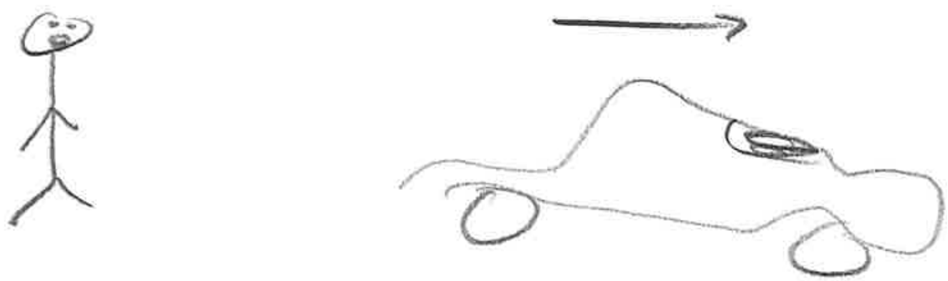
The velocity is neither towards or away, $v_e = 0$

$$f_o = f_e$$

$$\boxed{f_o = 500\text{Hz}}$$

c)

$v_e = +11.1\text{m/s}$



$$f_o = f_e\left(\frac{c}{c+v_e}\right)$$

$$\boxed{f_o = 484.3\text{ Hz}}$$