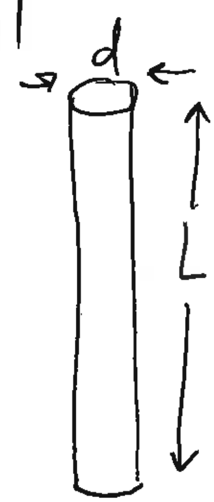
1) For a string fixed at both ends,

$$f_n = \frac{n}{2L}\sqrt{\frac{F}{\mu}}$$

We want to find tension, F. Get f_1 from an app (such as Spectrum Viewer for iOS). Use $n=1$. May Need to make assumptions about μ (linear mass density, kg/m) – if bought the strings yourself this info may be on the package. Otherwise assume a cylindrical string, measure diameter, get Volume. "Plastic" strings are usually acrylic, "metal" usually steel. Look up density ρ & find mass & μ. Solve for F.



2) Measure length of flute (e.g., $L = 29.5$ cm)

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

speed of sound @ sea level $v = 343$ m/s, but in Laramie use $v = 330$ m/s. Use $n=1$ for fundamental.

Cover all holes & blow. Use an app to find f_1 (e.g. $f_1 = 564.94$ Hz) for checking

calculated: $f_1 = \dfrac{1 \cdot 330}{2 \cdot 0.295} = 559.32$ Hz

These are in sufficient agreement.

15.27

$I_1 = 0.026\,W/m^2$ $\qquad$ $I_2 = ?$

$r_1 = 4.3m$ $\qquad$ $r_2 = 3.1m$

a) $I = \frac{P}{A} \rightarrow P = IA \rightarrow I_1 A_1 = I_2 A_2$

$$I_1 \cdot \cancel{4\pi} r_1^2 = I_2 \cancel{4\pi} r_2^2$$

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

$$= 0.026 \cdot \left(\frac{4.3}{3.1}\right)^2$$

$$= \boxed{0.0500\ W/m^2}$$

b) $P = \frac{W}{t} \rightarrow W = P \cdot t$

$$W = I_1 A_1 t$$

$$= I_1 4\pi r_1^2 t$$

$$= 0.026 \cdot 4\pi \cdot 4.3^2 \cdot 3600s$$

$$= 21{,}748 = \boxed{2.2 \times 10^4 J}$$

$\boxed{15.28}$

$$y = 2.30\text{mm} \cos[(6.98\,\text{rad/m})x + (742\,\text{rad/s})t]$$

$$y = A \cos(kx - \omega t)$$

+x direction

a) $\boxed{A = 2.30\text{mm}}$

b) $\omega = 742\,\text{rad/s} = 2\pi f$

$f = 742/2\pi = \boxed{118\text{Hz}}$

c) $k = \frac{2\pi}{\lambda} = 6.98 \rightarrow \lambda = \frac{2\pi}{6.98} = \boxed{0.900\,\text{m}}$

d) $v = f\lambda$ (or $v = \omega/k$)

$= 118 \cdot 0.900 = 106.2 = \boxed{106\,\text{m/s}}$

e) a − sign infront of t term is +x, so this is $\boxed{-x}$

f) $v = \sqrt{\frac{F}{\mu}} \rightarrow F = v^2\mu$ $\quad \mu = \frac{m}{L} = 2.5037\times10^{-3}\,\frac{\text{kg}}{\text{m}}$

$= \frac{v^2 m}{L}$

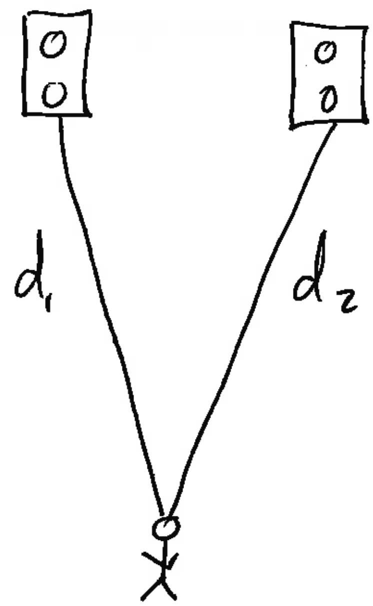
$= \frac{106.2^2 \cdot 0.00338}{1.35} = 28.237 = \boxed{28.2N}$

g) $P_{avg} = \frac{1}{2}\sqrt{\mu F}\,\omega^2 A^2$

$= \frac{1}{2}\sqrt{2.5037E{-3} \cdot 28.237} \cdot 742^2 \cdot (2.30E{-3})^2$

$= 0.38720 = \boxed{0.39\,W}$

$\boxed{16.33}$ In general:



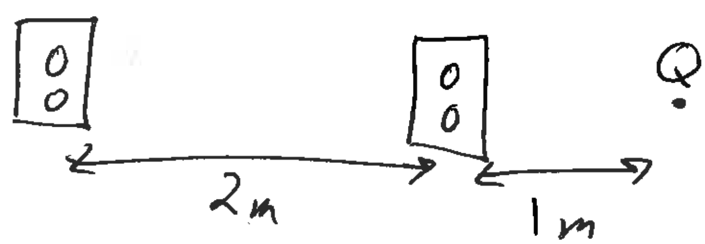
For Constructive,

$d_2 - d_1 = n\lambda$

Destructive

$d_2 - d_1 = n\lambda/2$

In our case,



$d_2 - d_1 = 2m$

$n = 1$

a) Const: $\lambda = 2 \rightarrow v = f\lambda \rightarrow f = \frac{v}{\lambda} = \frac{343}{2} = \boxed{172\,Hz}$

b) Dest: $\frac{\lambda}{2} = 2$ $\quad f = \frac{343}{4} = \boxed{86\,Hz}$

$\lambda = 4$

16.50

Doppler formula $\quad f_L = \dfrac{V + V_L}{V + V_s} f_s$

f_L = freq. Listener hears = ?

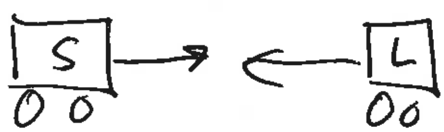
f_s = freq Source emits = 262 Hz

V = sound speed = 343 m/s

see below

V_L = Listener speed = $\pm$18.0 m/s

V_s = Source speed = $\pm$ 30.0 m/s

a) 

when things move towards each other, I know the freq goes up. so $f_L > f_s$, so want $\left(\dfrac{V+V_L}{V+V_s}\right)$ top to be bigger so +18.0 m/s

and bottom to be smaller so −30.0 m/s

$$f_L = \left(\frac{343+18}{343-30}\right)262 = \boxed{302\text{ Hz}}$$

b) 

Now want to get lower pitched, so freq is smaller, so want top $V+V_L$ to be smaller so $-18.0\,m/s$, and bottom $V+V_s$ to get bigger so $+30.0\,m/s$:

$$f_L = \left(\frac{343-18}{343+30}\right)262 = \boxed{228\,Hz}$$

3) $\lambda_s = 656.3\,nm$

$V_L = 0$

$V_s = \pm 50.5\,m/s$ (read off graph:

$V = C = 3.00\times10^8\,m/s$

a) $\lambda_L = ?$

$$f_s = \frac{V + V_L}{V + V_s} f_L$$

$$f_s = \frac{C}{C + V_s} f_L \qquad V = f\lambda \rightarrow c = f\lambda \rightarrow f = \frac{c}{\lambda}$$

$$\frac{\cancel{c}}{\lambda_s} = \frac{c}{c+V_s} \cdot \frac{\cancel{c}}{\lambda_L}$$

take reciprocal of both sides

$$\lambda_s = \frac{C+V_s}{c} \lambda_L$$

$$\lambda_L = \frac{c}{C+V_s} \lambda_s$$

$$= \frac{3E8}{3E8 \pm 50.5} 656.3\,nm = \boxed{\begin{matrix} 656.2999\,nm \\ 656.3001\,nm \end{matrix}}$$

3b) From the Discussion on Gravity/orbits/Periodic Motion, we used $F = \frac{GMm}{r^2}$, $F = \frac{mv^2}{r}$, and

$V_{circ} = \text{Circumf}/t$ to find:

$$M = \frac{4\pi^2 r^3}{Gt^2}$$

M = star Mass = $1.1 \times M_{\odot}$ =

$1.1 \times 1.988E30 = 2.19 \times 10^{30}$ kg

r = orbit radius

t = period

$G = 6.67 \times 10^{-11}$

$$t = \frac{4.2d}{} \Big| \frac{24h}{1 day} \Big| \frac{3600s}{h} = 362{,}880\ s$$

$$r^3 = \frac{MGt^2}{4\pi^2}$$

$$r = \left(\frac{GMt^2}{4\pi^2}\right)^{1/3} = 7.86886 \times 10^9 m$$

$$= \boxed{7.87 \times 10^9 m}$$

c) $V_{orbit} = \sqrt{\frac{GM}{r}}$ or $V = \frac{\text{Circumf}}{t}$

$$= \frac{2\pi r}{t} = \frac{2 \cdot \pi \cdot 7.86886E9}{362{,}880 s}$$

$$= 136{,}248\ m/s$$

$$= \boxed{136\ km/s}$$

d) momentum $p = mv$

$$M_* V_* = m_p V_p$$

$$m_p = M_* \frac{V_*}{V_p}$$

$$= 2.19 \times 10^{30}\,kg \cdot \frac{50.5\,m/s}{136{,}248\,m/s}$$

$$= 8.117 \times 10^{26}\,kg$$

$$= \boxed{8.1 \times 10^{26}\,kg}$$

All these agree well with accepted values, yay! :)