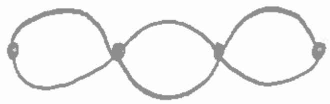
Standing Waves (Practice Problems)

① $L = 1.5 m$ * 3 antinodes
$f = 85 Hz$ *string

(a) 

(b) in phase ⇒ antinodes
out of phase ⇒ nodes
(phase difference of 180°
or π radians)

(c) $\lambda = \frac{2L}{n} = \frac{2(1.5 m)}{(3)} = \underline{1.0 m}$

$v = \lambda f = (1.0 m)(85 Hz) = \underline{85 ms^{-1}}$

② $L = 400 mm = .4 m$ * closed at one end
$f_1 = 215 Hz$

$L = \frac{1}{4}\lambda$
$\therefore \lambda = 4L$

(a) $v = \lambda f = (4L) f = (4)(.4 m)(215 Hz) = \underline{344 ms^{-1}}$

(b) 3rd harmonic ⇒ $f_3 = 3f_1 = 3(215 Hz) = \underline{645 Hz}$

③ $L_{min} = 30 mm = .03 m$ * open pipe
$L_{max} = 4.0 m$
$v = 340 ms^{-1}$

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

$f_{max} = \frac{(1)(340 ms^{-1})}{2(.03 m)} = 5666.\overline{6} Hz$

$\lambda_1 = 2L = \underline{.06 m}$

$f_{min} = \frac{(1)(340 ms^{-1})}{2(4.0 m)} = 42.5 Hz$

$\underline{43 Hz \text{ to } 5700 Hz}$

(4) * closed at one end

$f = 342\ Hz$

$L_1 = 245\ mm = .245 m$

$L_3 = 735\ mm = .735 m$

$L_1 = \frac{\lambda}{4} \quad L_3 = \frac{3\lambda}{4}$

$L_3 - L_1 = \frac{\lambda}{2} = .490 m$

$\lambda = .980 m$

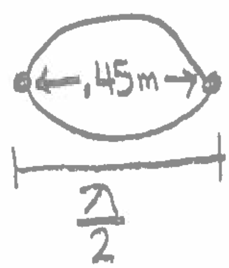
$V = \lambda f = (.980 m)(342 Hz)$

$\underline{V = 335\ ms^{-1}}$

(5) $f = 438\ Hz$

* wire (string)

* nodes 45 cm apart (.45 m)



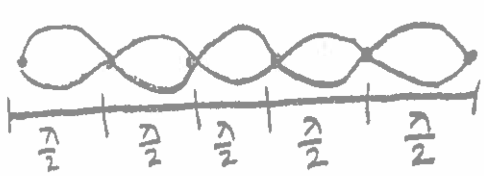
$.45 m = \frac{\lambda}{2}$

$\underline{\lambda = .90 m}$

$V = \lambda f = (.90 m)(438 Hz) = 394.2 = \underline{390\ ms^{-1}}$

(6) $L = 120\ cm$

$= 1.20 m$



$L = \frac{5\lambda}{2}$

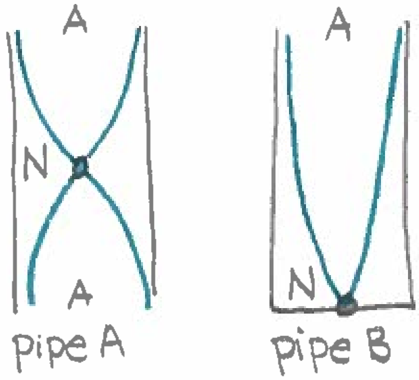
$\therefore \lambda = \frac{2L}{5}$

(a) $\lambda = \frac{2(1.20 m)}{5} = \underline{.48 m}$

(b) $f = 250 Hz$

$V = \lambda f = (.48 m)(250 Hz) = \underline{120\ ms^{-1}}$

(7) (a)



(b) $f = 512\ Hz$

$V = 325\ ms^{-1}$

(i) $V = \lambda f \quad L = \frac{\lambda}{2}$

$\therefore L = \frac{V}{2f} = \frac{325\ ms^{-1}}{2(512\ Hz)} = .3174$

$L = .317\ m$

(ii) open pipe — Closed at one end

$f_n = \frac{nV}{2L} \qquad f_n = \frac{nV}{4L}$

$(f_n)_{\text{closed at one end}} = \frac{(f_n)_{open}}{2}$

Doppler Effect (Practice Problems)

(8) $f = 1600\,Hz$

(a) $f' = f\left(\frac{V}{V-V_s}\right) = (1600\,Hz)\left(\frac{340\,ms^{-1}}{340\,ms^{-1} - 25\,ms^{-1}}\right) = 1726.98$

$\underline{f' = 1727\,Hz}$

(b) $f' = f\left(\frac{V}{V+V_s}\right) = 1600\,Hz\left(\frac{340\,ms^{-1}}{340 + 25\,ms^{-1}}\right) = 1490.41$

$\underline{f' = 1490\,Hz}$

(9) $f = 75\,Hz$

$f' = f\left(\frac{V}{V-V_s}\right) = (75\,Hz)\left(\frac{340\,ms^{-1}}{340 - 10\,ms^{-1}}\right) = 77.27\,Hz$

beat frequency $= |f' - f| = |77.27 - 75| = \underline{2.3\,Hz}$

(10) $f = 277\,Hz$

$f' = f\left(\frac{V}{V-V_s}\right) = 277\left(\frac{340}{340 - 11.11}\right) = 286.36$

$V_s = \frac{40\,Km}{h} \left| \frac{1000\,m}{1\,Km} \right| \frac{1\,h}{3600\,s} = 11.11\,ms^{-1}$

beat frequency $= |f' - f| = |286.36 - 277| = \underline{9.36\,Hz}$

(11) beat frequency $= |f' - f| = f\left(\frac{V}{V-V_s}\right) - f = 5.5\,Hz$

$f\left[\left(\frac{V}{V-V_s}\right) - 1\right] = 5.5$

$f = \frac{5.5}{\left[\frac{(340)}{(350-15)} - 1\right]} = \frac{5.5}{.04615} = 119.1\overline{6}$

$\underline{f = 120\,Hz}$

(12) $f = 2\,KHz = 2000\ Hz,\ v = 15\,ms^{-1}$

$f_s' = \left(\frac{340}{340-15}\right)(2000) = \underline{2092\ Hz}$ (moving source)

$f_0' = \left(\frac{340+15}{340}\right)(2000) = \underline{2088\ Hz}$ (moving observer)

$v = 150\,ms^{-1}$

$f_s' = \left(\frac{340}{340-150}\right)(2000) = \underline{3579\ Hz}$ (moving source)

$f_0' = \left(\frac{340+150}{340}\right)(2000) = \underline{2882\ Hz}$ (moving observer)

$V = 300\,ms^{-1}$

$f_s' = \left(\frac{340}{340-300}\right)(2000) = \underline{17000\ Hz}$ (moving source)

$f_0' = \left(\frac{340+300}{340}\right)(2000) = \underline{3765\,Hz}$ (moving observer)

- at relatively small values of V_s or u_0 f_s' and f_0' are close in value
- at relatively large values of V_s or u_0

$f_s' \gg f_0'$

(13) $V = \lambda f \Rightarrow \lambda = V/f \Rightarrow \boxed{\lambda = c/f}$ (a)

$V_s = c + V$ (b)

(14) $f = 440\,Hz$

$V = 330\,ms^{-1}$

(a) (i) $\lambda = \frac{V}{f} = \frac{330\,ms^{-1}}{440\,Hz} = \underline{.75\,m}$

(ii) $f = 440\,Hz$ (car and observer are at rest)

(b) $V_s = 330 + V \quad ms^{-1}$

(c) $V_{car} = 8.00\,ms^{-1}$

(i)

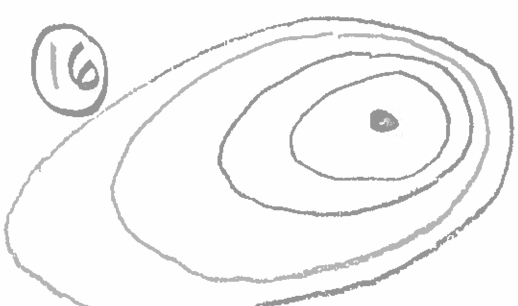
$\lambda = \frac{V}{f} = \frac{330}{451} = \underline{.73\,m}$

(ii) $f' = f\left(\frac{V}{V - V_s}\right) \quad f' = 440\left(\frac{330}{330-8}\right) = \underline{451\,Hz}$

(15) $\Delta f = f\frac{V}{c} = (6.0\times10^{14}\,Hz)\frac{(3.0\times10\,ms^{-1})}{(3.0\times10^{8}\,ms^{-1})}$

$\underline{\Delta f = 6.0\times10^{7}\,Hz}$

(16)



(a)

$\Delta\lambda = .004\,nm$

$\underline{\Delta\lambda = 4\times10^{-12}\,m}$

$\lambda = 600.00\,nm$

$\underline{\lambda = 6.00\times10^{-7}\,m}$

$f = \frac{V}{\lambda}$

$\Delta f = \frac{V}{\Delta\lambda}$

(b)

$\underline{V = 4.5\times10^{13}\,ms^{-1}}$

$\frac{V}{\Delta\lambda} = \frac{V}{\lambda}\,\frac{V}{c} = \frac{V^2}{\lambda c}$

$V\lambda c = \Delta\lambda V^2$

$\lambda c = \Delta\lambda V$

$\therefore V = \lambda c/\Delta\lambda = \frac{(6\times10^{-7})(3\times10^{8})}{(4\times10^{-12})} = 4.5\times10^{13}$