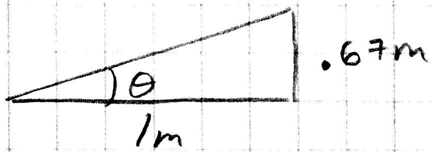
Wave Phenomena

(1) $\theta = \frac{\lambda}{b} = \frac{500 \times 10^{-9} m}{1.5 \times 10^{-6} m} = 0.333 \text{ rad} \times 2 = \underline{0.667 \text{ rad}}$

(2)



$\theta = \tan^{-1}\left(\frac{.67}{1}\right) = .59 \text{ rad.}$

$\theta = \frac{\lambda}{b}$

$b = \frac{\lambda}{\theta} = \frac{2.8 \times 10^{-2} m}{.59} = \underline{0.047 m}$

(3) $s = \frac{\lambda D}{d} = \frac{(680 \times 10^{-9} m)(1.5 m)}{0.1 \times 10^{-3} m} = \underline{0.010 m}$

(4) $n\lambda = d \sin\theta$

$\lambda = \frac{d \sin\theta}{n} = \frac{(1.67 \times 10^{-3} m) \sin 15}{1}$

$d = \frac{1}{600 \times 10^{3}} = 1.67 \times 10^{-6} m$

$\underline{\lambda = 4.3 \times 10^{-7} m}$

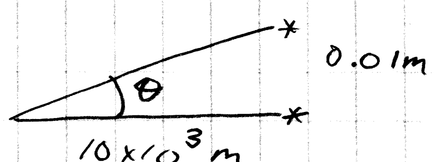
(5) constructive interference

$2dn = (m + \frac{1}{2})\lambda$ minimum: $m = 0$

$d = \frac{\frac{1}{2}\lambda}{2n}$

$= \frac{\frac{1}{2}(650 \times 10^{-9} m)}{2(1.582)} = \underline{1.0 \times 10^{-7} m}$

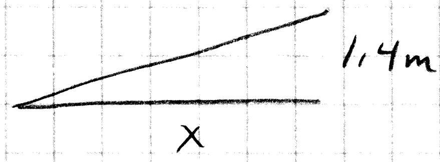
(6) $\theta = 1.22 \frac{\lambda}{b} = \frac{1.22(600 \times 10^{-9} m)}{.20 m} = 3.66 \times 10^{-6} \text{ rad}$



$\theta \approx \frac{.01}{10 \times 10^{3}} = 1 \times 10^{-6} \text{ rad}$

no, they will not be resolved.

(7) $\theta = 1.22\dfrac{\lambda}{b} = \dfrac{1.22(500\times10^{-9}m)}{.05m} = 1.22\times10^{-5}\ rad.$



$\theta \simeq \dfrac{1.4m}{x}$

$x \simeq \dfrac{1.4m}{\theta} = \dfrac{1.4m}{1.22\times10^{-5}rad} = \underline{1\times10^{5}m}$

(8) $f' = f\left(\dfrac{v}{v-u_s}\right) = 500Hz\left(\dfrac{343ms^{-1}}{343ms^{-1}-40ms^{-1}}\right) = \underline{570\ Hz}$

(9) $f' = f\left(\dfrac{v}{v+u_s}\right) = 480Hz\left(\dfrac{343ms^{-1}}{343ms^{-1}+32ms^{-1}}\right) = \underline{440\ Hz}$

(10) $f' = f\left(\dfrac{v-u_o}{v}\right) = 512Hz\left(\dfrac{343ms^{-1}-12ms^{-1}}{343ms^{-1}}\right) = \underline{490\ Hz}$

(11) $f' = f\left(\dfrac{v+u_o}{v}\right) = 628Hz\left(\dfrac{343ms^{-1}+25ms^{-1}}{343ms^{-1}}\right) = \underline{670\ Hz}$

(12) source to observer | observer to source

$f' = f_s\left(\dfrac{v}{v-u_s}\right)$ | $f' = f\left(\dfrac{v+u_o}{v}\right)$

$f' = f_s\left(\dfrac{v}{v-u_s}\right)\left(\dfrac{v+u_o}{v}\right)$ $\quad u_o = u_s = u$

$f' = f_s\left(\dfrac{\cancel{v}}{v-u}\right)\left(\dfrac{v+u}{\cancel{v}}\right)$

$f'(v-u) = f_s(v+u)$

$f'v - f'u = f_s v + f_s u$

$f'v - f_s v = f'u + f_s u$

$u = v\dfrac{(f'-f_s)}{(f'+f_s)} = 343ms^{-1}\left(\dfrac{512Hz-500Hz}{512Hz+500Hz}\right) = \underline{4.1ms^{-1}}$

(13) $f_n = \frac{nv}{4L}$ $\quad L = \frac{nv}{4f_n}$

$n=1$ $\quad L = \frac{(1)\,330\,ms^{-1}}{4(306\,Hz)} = 0.27\,m$

$n=3$ $\quad L = \frac{(3)\,330\,ms^{-1}}{4(306\,Hz)} = \underline{0.81\,m}$

$n=5$ $\quad 5L \quad = \underline{1.35\,m}$

$n=7$ $\quad 7L \quad = 1.89\,m$

(14)

(a) $f_n = \frac{nv}{2L}$ $\quad f_{n+1} = \frac{(n+1)v}{2L}$

$300\,Hz = \frac{n(330\,ms^{-1})}{2L}$ $\quad 360\,Hz = \frac{(n+1)(330\,ms^{-1})}{2L}$

$n = 1.818L$ $\quad 360 = \frac{(1.818L+1)\,330}{2L}$

$720L = 599.94L + 330$

$120.06\,L = 330$

$\underline{L = 2.7\,m}$

(b) $n = 1.818L = 1.818(2.7) = 5$

harmonics = 5th + 6th

(15) $f_3 = \frac{3v}{2L}$ $\quad f = \frac{v}{\lambda}$ $\quad \frac{v}{\lambda} = \frac{3v}{2L}$

$\lambda = \frac{2L}{3} = \frac{2(6.0\,m)}{3} = \underline{4.0\,m}$