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Physics 913 Fall 2013

Assignment 9

35-1, 3, 11, 19, 49

36-1, 5, 15, 19, 39

35-1 a) To hear reinforced sound (constructed) the path length difference should be an integer # of wavelengths

$$n\,0.34 = 1.5 - x$$

$$x = 1.5 - 0.34n$$

$$= 1.50, 1.16, 0.82, 0.48,$$

$$n = 1, 2, 3, 4$$

b) cancelled (destructive) path difference is $\frac{1}{2}\lambda, \frac{3}{2}\lambda, \ldots$

$$\left(\frac{1}{2}, \frac{3}{2}, \frac{5}{2}, \ldots\right) 0.34 = 1.5 - x$$

$$x = 1.33, 0.99, 0.65, 0.31,$$

2.11

35-3 $v = 340\ m/s$

$300 < f < 600\ Hz$

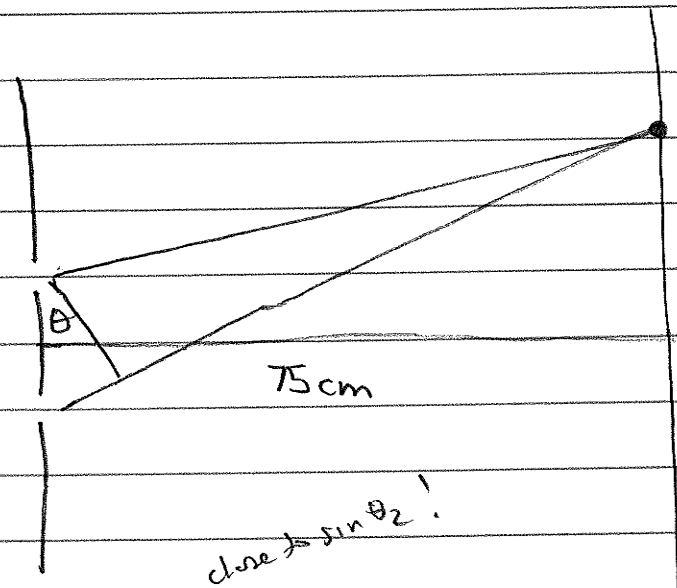
a) If you hear minimum intensity you must be $\lambda/2, 3\lambda/2, \ldots$ closer to one speaker than another

b) If speaker motion of 39.8 cm results in maximum intensity, 39.8 cm must be $\lambda/2, 3\lambda/2, \ldots$ to convert distance difference to an integer number of wavelengths

$\lambda = 2(39.8) \rightarrow f = v/\lambda = 427\ Hz$

c) Must be moved full $\lambda = .796\ m$

35-11



$d = .45\ mm$

$\lambda = 500\ nm$

dark lines

$d \sin\theta = \frac{\lambda}{2}(1, 3, 5, \ldots$

$n = 1, 2, 3$

$\sin\theta_2 = \frac{3\lambda}{2d} = \frac{3 \cdot 5 \cdot 10^{-7}}{2 \cdot 4.5 \cdot 10^{-4}}$

$\sin\theta_3 = 5\lambda/2d = \frac{5 \cdot 5 \cdot 10^{-7}}{2 \cdot 4.5 \cdot 10^{-4}}$

close to $\sin\theta_2$

$y_2 = 75 \tan\theta_2 = 75(1.67 \cdot 10^{-3}) =$

$y_3 = 75 \tan\theta_3 = 75(2.78 \cdot 10^{-3}) =$

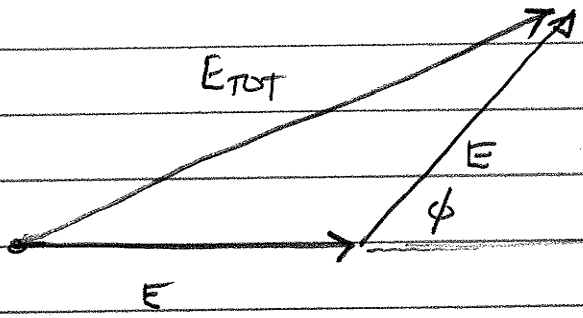
close to $\sin\theta_3$

$y_3 - y_2 = 0.083\ cm$

3/1

35-19

a)



$\phi = 0$:

$I_{max} = (E+E)^2$

$= 4E^2$

law of cosines: $E_{TOT}^2 = E^2 + E^2 + 2EE\cos\phi$

$= 2E^2(1+\cos\phi)$

$I_{TOT} = E_{TOT}^2 = \frac{I_{max}}{2}(1+\cos\phi)$

$= \frac{I_{max}}{2}(1+\cos 60) = \frac{3}{4} I_{max}$

$\uparrow$ $\frac{1}{2}$

b) $\phi = \frac{2\pi}{\lambda}(r_2 - r_1)$

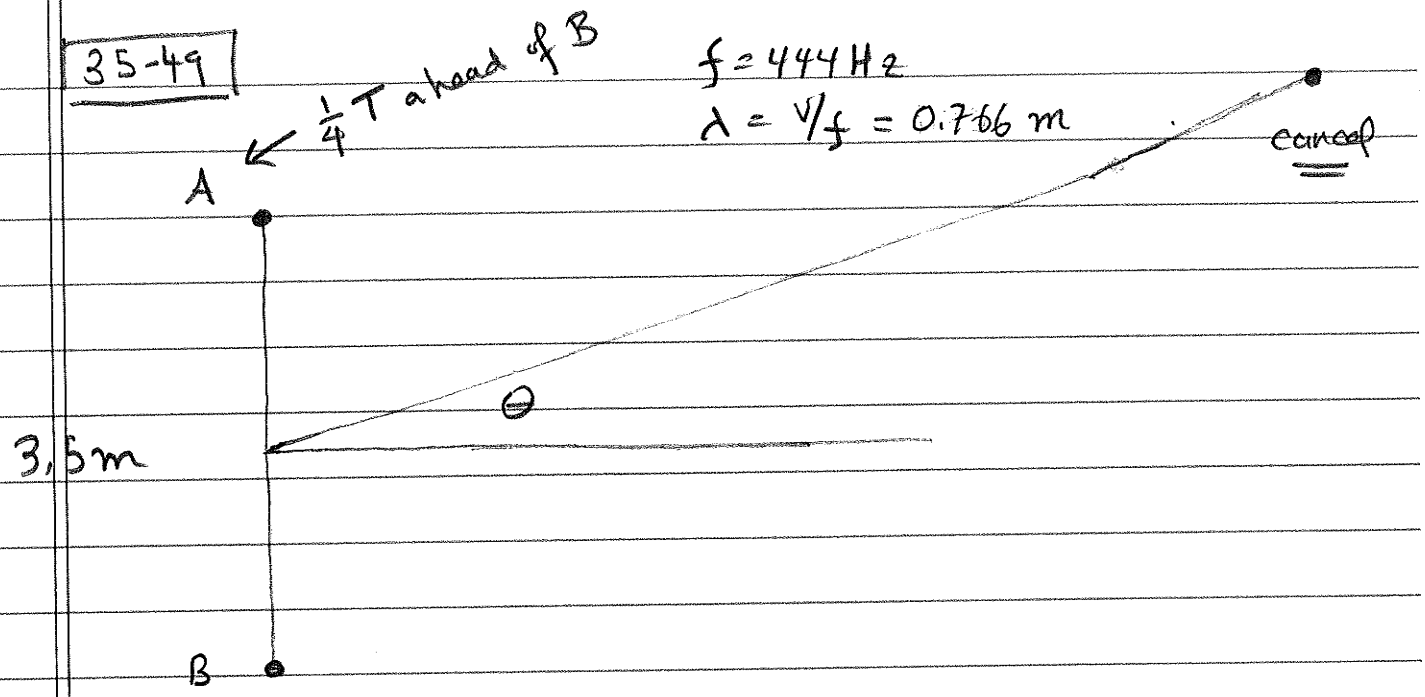
$60\,\frac{2\pi}{360} = \frac{2\pi}{480}(r_2 - r_1)$

deg $\rightarrow$ radian

$r_2 - r_1 = 480\left(\frac{1}{6}\right) = 80$ nm

4/1

35-49



Need $d \sin\theta = n(\lambda/2, 3\lambda/2, 5\lambda/2 \ldots)$ for usual inphase case

but now speakers are already ¼ T out of phase so

$d \sin\theta = \frac{\lambda}{4}, \frac{5\lambda}{4}, \frac{9\lambda}{4}, \ldots$ so that added $\lambda/4$ gives usual $\lambda/2, 3\lambda/2, \ldots$

(on other side $d\sin\theta = \frac{-3\lambda}{4}, \frac{-7\lambda}{4}, \ldots$)

$d = 3.5$ m $\quad \lambda = 0.766$ m

$\sin\theta = 0.766/4(3.5) \qquad \theta = 3.14°$

$\sin\theta = -3(0.766)/4(3.5) \qquad \theta = -9.45°$

6.11

36-15 $a = .24 \cdot 10^{-3}\ m$

$\lambda = 5.4 \cdot 10^{-7}\ m$

$d = 3\ m$

$I_{max} = 6 \cdot 10^{-6}\ w/m^2$

First min at $\sin\theta = \lambda/a = 5.10^{-7} / .24 \cdot 10^{-3} = .0021$

For this $\sin\theta \sim \tan\theta \sim \theta$; $y = d\tan\theta = 3(.0021) = .0063\ m$

$$I = I_{max} \left\{ \frac{\sin \pi a \sin\theta/\lambda}{\pi a \sin\theta/\lambda} \right\}^2$$

Half way in between $\sin\theta = .0021/2 = .00105$

$$\frac{\sin \pi a \sin\theta/\lambda}{\pi a \sin\theta/\lambda} = \frac{\sin \pi (.24 \cdot 10^{-3})(.00105)/5.4 \cdot 10^{-7}}{(\pi a (.00105)/5.4 \cdot 10^{-7})}$$

1.466 $= .678$

$I = I_{max}(.678)^2 = 2.76 \cdot 10^{-6}\ w/m^2$

5/11

36-1 Dark fringes are at $\sin\theta = m\lambda/a$

First minimum $\Rightarrow$ $m = 1$

$\lambda = a\sin\theta = (0.75\cdot10^{-3})(0.675\cdot10^{-3}) = 5.06\cdot10^{-7}\,m$

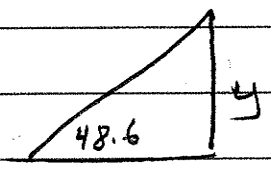
$\tan\theta = \frac{1.35\cdot10^{-3}}{2} = 0.675\cdot10^{-3}$ ← for this small value $\sin\theta = \tan\theta$ is a very good approximation

36-5 $\lambda = .09\,m$

$a = .12\,m$

Zero intensity when $\sin\theta = m\lambda/a = m(.09/.12) = 3m/4$

$\theta = \sin^{-1}3/4 = 48.6^\circ$



$y = 8\tan\theta = 9.07\,m$

7/1

36-19 $\lambda = c/f = 3.108/88.9.10^6 = 3.37\ m$

$a = 15\ m$

a) $\sin\theta = m\lambda/a = m\ 3.37/15$

$\sin\theta = .225\ (m=1) \rightarrow \theta = 13.00°$

$.449\ (m=2) \rightarrow \theta = 26.7°$

$.675\ (m=3) \rightarrow \theta = 42.4°$

b) $\dfrac{\sin(\pi a \sin\theta/\lambda)}{\pi a \sin\theta/\lambda} = .770$

$I = 3.5/.770)^2 = 2.08\ \frac{W}{m^2}$

$\pi \dfrac{15}{3.37} \sin 5° = 1.218$

36-39 $\lambda = .085\ nm$

$m = 2$ at $\theta = 21.5°$

$2d\sin\theta = m\lambda$

$2d \sin 21.5 = 2(.085 \cdot 10^{-9})$

$d = .232 \cdot 10^{-9}\ m$