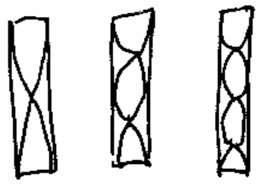
Phys 101 Part II Solutions

1 a)



$L = \frac{\lambda}{2}$ $\quad L = 2\left(\frac{\lambda}{2}\right)$ $\quad L = 3\frac{\lambda}{2}$ ...

$\Rightarrow \lambda = 2L \quad \lambda = L \quad \lambda = \frac{3L}{2}$ ...

since $V = f\lambda$

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

$\Rightarrow f_0 = \frac{V}{2L} \quad f_1 = \frac{V}{L} \quad f_2 = 3\frac{V}{2L} \quad f_3 = \frac{2V}{L}$

$\Rightarrow \quad f_1 = 2f_0 \quad f_2 = 3f_0 \quad f_3 = 4f_0$

$\Rightarrow$ if $f_0 = 440 \Rightarrow f_1 = \quad Hz \quad f_2 = 880\ Hz \quad f_3 = 1100\ Hz$

b) $v = 343$

$f_0 = 220$

$\Rightarrow$ since $f_0 = \frac{V}{2L}$, $L = \frac{V}{2f_0} = \frac{343}{2(220)} = 0.78\ m$

PHYS 101 PART II

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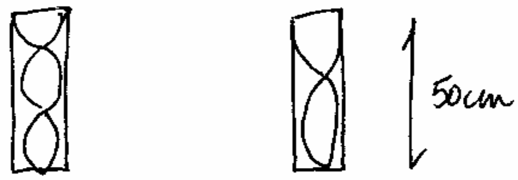


2nd overtone 1st overtone

$L_1 = \frac{5\lambda_1}{4}$ $L_2 = \frac{3\lambda_2}{4}$

$\lambda_1 = \frac{4L_1}{5}$ $\lambda_2 = \frac{4L_2}{3}$

$v_1 = f_1 \lambda_1$ $v_2 = f_2 \lambda_2$

but $v_1 = v_2 = 343$ and $f_1 = f_2$

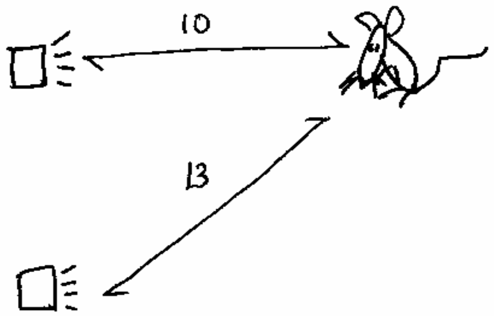
$\Rightarrow \lambda_1 = \lambda_2$

$\Rightarrow \frac{4L_1}{5} = \frac{4L_2}{3}$

$\Rightarrow L_1 = \frac{5L_2}{3} = \frac{5(50)}{3} = 83\text{ cm}$

PHYS 101 Part II ③

③



a) Sources $\underline{\underline{in}}$ phase and we want $\underline{\underline{destructive}}$ interference.

$\Rightarrow pd = (n+\frac{1}{2})\lambda \quad n = 0,1,2,3\ldots$

$pd = 3 \quad \lambda = v/f = 343/f$

$\Rightarrow 3 = (n+\frac{1}{2})\cdot\frac{343}{f}$

$\Rightarrow f = (n+\frac{1}{2})\cdot\frac{343}{3} \quad n = 0,1,2\ldots$

b) if $n=0$ $f_0 = 57\,Hz \Rightarrow$ within range.

if $f = 50{,}000 \Rightarrow 50{,}000 = (n+\frac{1}{2})\cdot\frac{343}{3}$

$\Rightarrow n = 436.8 \Rightarrow n = 436$ is the last possible integer value of n.

$\Rightarrow$ Total frequencies $\Rightarrow \boxed{437}$

c) just use $pd = n\lambda$ where $n = 0,1,2\ldots$

[You'll need to end up discarding the solution $f=0$ obviously]

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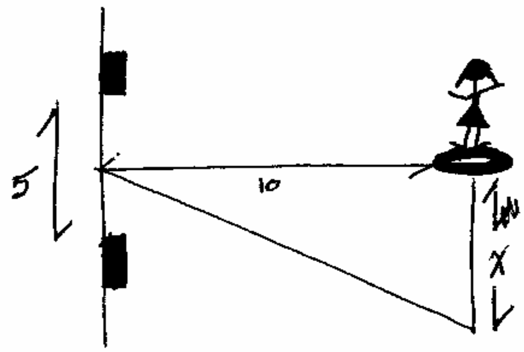
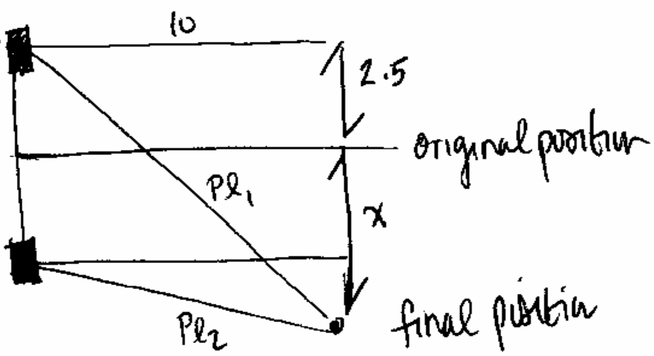


We want a break from the waves ⇒ destructive interference of sources in phase

$\Rightarrow pd = (n+\frac{1}{2})\lambda \quad , \quad \lambda = \frac{v}{f}$



$(2.5+x)^2 + 100 = Pl_1^{\,2}$

$(x-2.5)^2 + 100 = Pl_2^{\,2}$

$\Rightarrow Pl_1 = [(x+2.5)^2+100]^{1/2}$

$\Rightarrow Pl_2 = [(x-2.5)^2+100]^{1/2}$

$\Rightarrow pd = [(x+2.5)^2+100]^{1/2} - [(x-2.5)^2+100]^{2}$

$\Rightarrow [(x+2.5)^2+100]^{1/2} - [(x-2.5)^2+100]^{\frac{1}{2}} = (n+\frac{1}{2})\left(\frac{5}{2}\right)$

let $n=0$ for first solution

$$\Rightarrow \boxed{[(x+2.5)^2+100]^{1/2} - [(x-2.5)^2+100]^{1/2} = \frac{5}{4}}$$

The solution turns out to be

$x \cong 2.66$

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5 When the train is moving and Priscilla is still

$$f' = f_0 \left(\frac{1 \pm v_0/v}{1 \pm v_s/v} \right)$$

$v_0 = 0$
$v_s = 3$
$v = 343$
$f' = 600$

$$\Rightarrow 600 = f_0 \left(\frac{1 + 0}{1 + 3/343} \right)$$

$$\Rightarrow f_0 = 605.24$$

When Priscilla <u>and</u> the train are moving:

$$f' = f_0 \left(\frac{1 \pm v_0/v}{1 \pm v_s/v} \right)$$

$v_0 = ?$
$v_s = 10$
$v = 343$
$f_0 = 605.24$
$f' = 598$

$$\Rightarrow 598 = 605.24 \left(\frac{1 + v_0/343}{1 + 10/343} \right)$$

$$\Rightarrow \boxed{v_0 = 5.8 \text{ m/s}}$$

Phys 101 Part II

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STEP 1:

6 Dracula = Source Victim = observer

$f_0 = 40{,}000$ Hz $\quad V_0 = u = $ unknown

$V_s = 13$ m/s

$V = 343$

$$f' = f_0 \left(\frac{1 \pm V_0/V}{1 \pm V_s/V} \right)$$

$$\Rightarrow f' = 40{,}000 \left(\frac{1 - u/343}{1 - 13/343} \right)$$

STEP 2:

Dracula = observer Victim = source

$$f'' = f' \left(\frac{1 \pm V_0/V}{1 \pm V_s/V} \right)$$

$V_0 = 13$

$V_s = u = $ unknown

$f'' = 39530$

$$39530 = 40{,}000 \left(\frac{1 - u/343}{1 - 13/343} \right) \left(\frac{1 + 13/343}{1 + u/343} \right)$$

Solving for u

$$\Rightarrow \boxed{u = 15.0 \text{ m/s}}$$

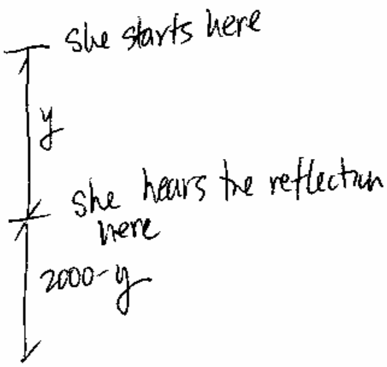
$\Rightarrow$ NO LUNCH!

Phys 101 Part II

(7)

(7)

First we must determine how long it takes for her to hear the reflected sound:



Distance travelled by sound $= 2000 + 2000 - y$

$= 4000 - y$

$t = d/v = \dfrac{4000-y}{343}$ (I)

But ... there is another expression for this time:

$d = v_0 t + \frac{1}{2}at^2$

$y = 10t + \frac{1}{2}(9.8)t^2$ (II)

Plugging (II) into (I) gives

$$t = \frac{4000 - \left(10t + \frac{1}{2}(9.8)t^2\right)}{343}$$

$\Rightarrow 343t = 4000 - 10t - 4.9t^2$

$\Rightarrow 4.9t^2 + 353t - 4000 = 0$

Solving for t gives

$t = 9.95s$

And this means we can determine her final speed.

$v_f = v_0 + at$

$v_f = 10 + (9.8)(9.95)$

$v_f = 107.5$ m/s.

So initially Krista is the source and the ground is the "observer".

$\Rightarrow f' = f_0 \left(\dfrac{1 \pm v_0/v}{1 \pm v_s/v}\right)$

$\Rightarrow f' = 1000 \left(\dfrac{1}{1 - 10/343}\right) = 1030$ Hz

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Now when the sound reflects the ground is the source and Krista is the observer:

$$f'' = f' \left(\frac{1 \pm V_o/V}{1 \pm V_s/V} \right)$$

$$f'' = 1030 \left(\frac{1 + 107.5/343}{1} \right)$$

$$\boxed{f'' = 1352\ Hz}$$

8 a) Energy Available $= mgh$

$$= (0.2 \times 10^{-3})(9.8)(2.0)$$

$$= 0.00392\ J$$

E converted to Sound $= 0.00392 \cdot \frac{0.05}{100} = 1.96 \times 10^{-6}\ J$

$$P = \frac{\Delta E}{\Delta t} = \frac{1.96 \times 10^{-6}}{0.5} = 3.92 \times 10^{-6}\ W.$$

$$I = \frac{P}{4\pi r^2}$$

$$\Rightarrow r = \left[\frac{P}{4\pi I}\right]^{1/2} = \left[\frac{3.92 \times 10^{-6}}{4\pi \times 10^{-12}}\right]^{1/2} = \boxed{559\ m}$$

(9)

Phys 101 Part II

(8) b) 20 dB ⇒ must convert to intensity

$$\beta = \log\left(\frac{I}{I_0}\right)$$

$$\Rightarrow \frac{\beta}{10} = \log\left(\frac{I}{I_0}\right)$$

$$\Rightarrow I = I_0\, 10^{\beta/10}$$

$$\Rightarrow I = 10^{-12}\, 10^{20/10}$$

$$\Rightarrow I = 10^{-10}\ \text{W/m}^2$$

Now $I = \dfrac{P}{4\pi r^2}$ $\quad P = \dfrac{\Delta E \cdot n}{\Delta t}$ where n = # of pebbles

Since I = 100 fold the Intensity due to a single pebble in our case, then we'll need $\boxed{\text{100 pebbles}}$ to get $I = 10^{-10}\ \text{W/m}^2$

(9) $\beta_1 = 10\log\left(\frac{I_1}{I_0}\right)$ $\quad \beta_2 = 10\log\left(\frac{I_2}{I_0}\right)$ $\quad \beta_1 = 90$ $r_1 = 2$, $\beta_2 = ?$ $r_2 = 4$

a)

$$\Rightarrow \beta_2 - \beta_1 = 10\log\left(\frac{I_2}{I_0}\right) - 10\log\left(\frac{I_1}{I_0}\right)$$

$$\Rightarrow \beta_2 - \beta_1 = 10\log\left(I_2/I_1\right)$$

$$\rightarrow \beta_2 - \beta_1 = 10\log\left(\frac{P/4\pi r_2^2}{P/4\pi r_1^2}\right)$$

$$\Rightarrow \beta_2 - \beta_1 = 10\log\left(\frac{r_1^2}{r_2^2}\right)$$

$$\Rightarrow \beta_2 - 90 = 10\log\left(\frac{4}{16}\right)$$

$$\Rightarrow \boxed{\beta_2 = 84\ \text{dB}}$$

b) if $\beta_2 = 45$

$$\Rightarrow (45 - 90) = 10\log\left(\frac{4}{r_2^2}\right)$$

$$\Rightarrow \frac{4}{r_2^2} = 10^{-4.5}$$

$$\Rightarrow \boxed{r_2 = 356\text{m}}$$

Phys 102 Part II

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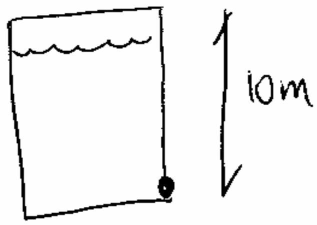
a)



$y_2 = 10$

$y_1 = 0$

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2$$

$P_1 = P_2 = 1\text{ atm}$

$y_1 = 0$

$$\Rightarrow \frac{1}{2}\rho v_1^2 = \frac{1}{2}\rho v_2^2 + \rho g y_2$$

$$\Rightarrow \frac{1}{2} v_1^2 = \frac{1}{2} v_2^2 + g y_2$$

but $v_2 \approx 0$

$$\Rightarrow v_1 = \sqrt{2 g y_2} = \sqrt{2(9.8)\cdot 10} = \sqrt{196}\,\text{m/s} = 14\,\text{m/s}$$

b) we cannot make the approx. that $v_2 = 0$

$\Rightarrow$ from $\frac{1}{2} v_1^2 = \frac{1}{2} v_2^2 + g y_2$ and apply $A_1 v_1 = A_2 v_2$

$$\Rightarrow \pi r_1^2 v_1 = \pi r_2^2 v_2$$

$$\Rightarrow r_1^2 v_1 = r_2^2 v_2$$

$$\Rightarrow v_1 = \frac{r_2^2}{r_1^2} v_2$$

$$\Rightarrow \frac{1}{2}\left[\frac{r_2^2}{r_1^2} v_2\right]^2 = \frac{1}{2} v_2^2 + g y_2$$

$$\Rightarrow \left[\frac{1}{2}\frac{r_2^4}{r_1^4} - \frac{1}{2}\right] v_2^2 = g y_2$$

$$\Rightarrow v_2 = \left[g y_2 \Big/ \left(\frac{1}{2}\frac{r_2^4}{r_1^4} - \frac{1}{2}\right)\right]^{1/2} = \left[(9.8)(10) \Big/ \frac{1}{2}\left(\frac{5^4}{2^4} - 1\right)\right]^{1/2} = \boxed{2.27\,\text{m/s}}$$

(11)

Phys 101 Part II

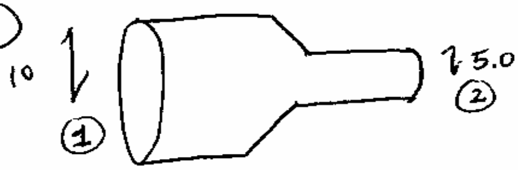
$A_1 V_1 = A_2 V_2$

$\Rightarrow r_1^2 V_1 = r_2^2 V_2$

$\Rightarrow V_1 = \frac{5^2}{2^2}(2.27)$

$\Rightarrow \boxed{V_1 = 14.18 \text{ m/s}}$

(11)



$P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2$

$P_1 - P_2 = -\frac{1}{2}\rho v_1^2 + \frac{1}{2}\rho v_2^2 - \rho g y_1 + \rho g y_2$

but $y_1 = y_2$

$\Rightarrow \Delta P = \frac{1}{2}\rho (v_2^2 - v_1^2)$

but $\pi r_1^2 v_1 = \pi r_2^2 v_2$

$\Rightarrow v_1 = \frac{r_2^2 v_2}{r_1^2}$

$\Rightarrow \Delta P = \frac{1}{2}\rho \left(v_2^2 - \frac{r_2^4}{r_1^4} v_2^2\right)$

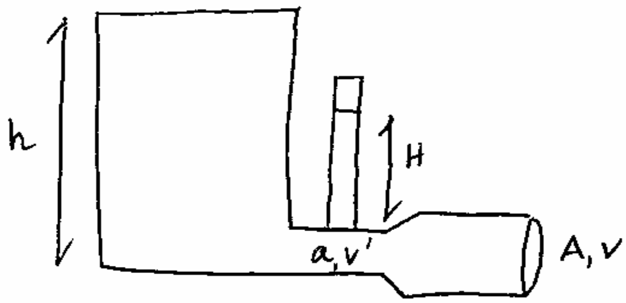
$\Rightarrow \Delta P = \frac{1}{2}\rho v_2^2 \left(1 - \frac{r_2^4}{r_1^4}\right)$

$\Rightarrow v_2 = \left[\frac{2\Delta P}{\rho} \cdot \frac{1}{\left(1 - \frac{r_2^4}{r_1^4}\right)}\right]^{1/2} = \left[\frac{2\Delta P}{\rho}\left(\frac{r_1^4}{r_1^4 - r_2^4}\right)\right]^{1/2} = \left[\frac{2(10)}{1000}\left(\frac{10^4}{10^4 - 5^4}\right)\right]^{1/2}$

$= 0.146 \text{ m/s}$

Phys 101 Part II (12).

(12)



a) $V = \sqrt{2gh}$ as shown in Q 10.

$V = \sqrt{2 \cdot 9.8} = \boxed{4.43\ m/s}$

b) $a\,v' = Av$

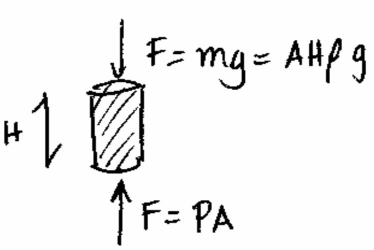
$\Rightarrow (1.0)(v') = (2.0)(4.43)$

$\Rightarrow v' = \boxed{8.86\ m/s}$

e) $P_1 + \frac{1}{2}\rho v_1^2 + \cancel{\rho g y_1} = P_2 + \frac{1}{2}\rho v_2^2 + \cancel{\rho g y_2}$ $\quad y_1 = y_2$

$\Rightarrow P_1 + \frac{1}{2}(1000)(8.86)^2 = 101300 + \frac{1}{2}(1000)(4.43)^2$

$\Rightarrow P_1 = 71863\ Pa$ ⊳ This is the pressure supporting the column of water.



$PA = AH\rho g \Rightarrow P = \rho g H \Rightarrow H = \dfrac{P}{\rho g} = \dfrac{71863}{(1000)(9.8)} = \boxed{7.33\ m}$