PHYSICS 101 PART I SOLUTIONS

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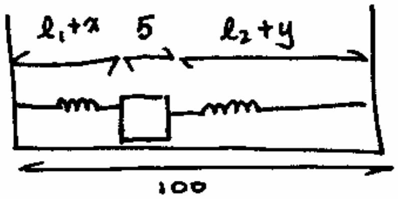
1// a)



$l_1+x+5+l_2+y=100 \quad l_1=20 \quad l_2=15$

$3.0x = 2.2y$ ballances forces

$\Rightarrow$ solve for x and y

$\Rightarrow x = 25.3$ cm $\quad y = 34.6$ cm

$\Rightarrow$ The left end of the block is 45.3 cm from the left end of the box.

b) $F_{net} = -k_1 x - k_2 x$

$F_{net} = -(k_1+k_2)x \Rightarrow k_{eff} = 5.2$ N/m

c) $x = A\cos(\omega t+\phi) \qquad \omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{5.2}{5\times10^{-3}}} = 32.2s^{-1}$

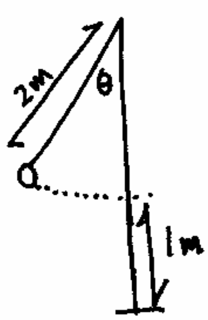
$x = 3\cos(32.2t+\phi)$

$x(0) = -3 \Rightarrow \cos\phi = -1$

$\Rightarrow \phi = \pi$

$\Rightarrow x = 3\cos(32.2t+\pi)$

2//



$\theta = \theta_0\cos(\omega t+\phi) \quad \omega = \sqrt{g/l}$

$\theta = 7\cos(2.21t+\phi) \quad \omega = \sqrt{\frac{9.8}{2}}$

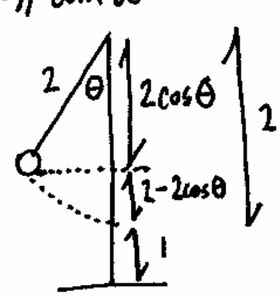
$\theta(0) = 7^\circ$

$\Rightarrow \phi = 0 \qquad \omega = 2.21s^{-1}$

$\Rightarrow \theta = 7\cos(2.21t)$ deg

$\Rightarrow \theta = \frac{7}{180}\pi\cos(2.21t)$ rad

2// cont'd



$h = (2-2\cos\theta)+1$

$h = 2\left(1-\cos\left(\frac{7\pi}{180}\cos(2.21t)\right)\right)+1$

b) $x = r\theta$

$\frac{dx}{dt} = r\frac{d\theta}{dt} \qquad \frac{dx}{dt} = 2\left(\frac{7\pi}{180}\right)\left[-\sin(2.21t)\cdot 2.21\right]$

$\Rightarrow \left.\frac{dx}{dt}\right|_{max} = 0.54$ m/s

c) $h = 2(1-\cos\theta)+1$

if $\theta = 7^\circ \Rightarrow h = 1.01490$

if $\theta = 4^\circ \Rightarrow h = 1.04872$

$\Rightarrow \Delta h = 0.01003$

$\Rightarrow \Delta E = mg\Delta h$

$\Delta E = (0.800)(9.8)(0.01003)$

$\Delta E = 0.0786J$

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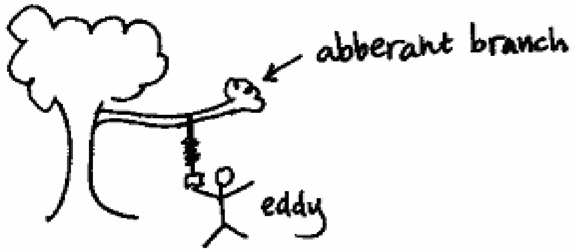
3// a)



The mass drops twice as far as the distance to its equilibrium position

$\Rightarrow$ At equilibrium $mg = kA$

$$A = \frac{mg}{k} = \frac{50\times10^{-3}\cdot 9.8}{30}$$

$$A = 0.0163 \text{ m}$$

$$\Rightarrow \text{Ans} = 2A = 0.033 \text{ m}$$

b) Back to where it was let go!

c) $x = A\cos(\omega t + \phi)$ $\quad \omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{30}{50\times10^{-3}}} = 24.5\,s^{-1}$

$x = 0.0163(24.5t + \phi)$

$x(0) = +0.0163 \Rightarrow \phi = 0$

$\Rightarrow x = 0.0163(24.5t + \phi)$

d) $V_{max} = \omega A = 0.4$ m/s

4// a) $\omega T = 2\pi \quad \omega = \sqrt{\frac{k}{m}}$

$$\Rightarrow T = \frac{2\pi}{\sqrt{k/m}} = \frac{2\pi}{\sqrt{60/2}} = 1.15s$$

b) $f = \frac{1}{T} = 0.872\ s^{-1}$

c) $V_{max} = A\omega = (0.15)(\sqrt{30})$
$= 0.82$ m/s

d) $x = A\cos(\omega t + \phi)$

$x = 0.15\cos(\sqrt{30}t + \phi)$

$x(0.2) = 0.06$

$\Rightarrow 0.06 = 0.15\cos(\sqrt{30}\cdot 0.2 + \phi)$

$\Rightarrow 0.4 = \cos(1.0954 + \phi)$

$\Rightarrow 1.0954 + \phi = \pm 1.1593$

$\Rightarrow \phi = 0.0639, -2.255$

but which is correct? $\Rightarrow$ the one that assures that $\frac{dx}{dt} > 0$ when $t = 0.2s$!

$$\frac{dx}{dt} = 0.15\left(-\sin(\sqrt{30}t - 2.255)\right)(\sqrt{30})$$

comes out > 0 when $t = 0.2s$

$\Rightarrow \phi = -2.255.$

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5// a) $y(2.7, 0.63) = 0.3\cos(0.75 \cdot 2.7 + 12 \cdot 0.63)$
$= -0.296$ m

b) as explained in lecture

c) $y_2 = 0.3\cos(0.75x - 12t)$

$y_1 + y_2 = A\cos(kx + \omega t) + A\cos(kx - \omega t)$

$y_1 + y_2 = A(\cos kx \cos\omega t - \sin kx \sin\omega t)$
$+ A(\cos kx \cos\omega t + \sin kx \sin\omega t)$

$y_1 + y_2 = 2A\cos kx \cos\omega t$

$y_1 + y_2 = 0.6\cos(0.75x)\cos(12t)$

d) just plug in $x = 2.7$ $t = 0.63$

6// a) to the left

b) $k\lambda = 2\pi$

$\Rightarrow \lambda = \frac{2\pi}{2} = \pi$ m

c) $V = \frac{\omega}{k} = \frac{10}{2} = 5$ m/s

d) $\frac{dy}{dt} = -40\sin(2x + 10t)$

$\frac{d^2y}{dt^2} = -400\cos(2x + 10t)$

$\left.\frac{d^2y}{dt^2}\right|_{max} = 400$ m/s^2

e) $\frac{\Delta\phi}{\Delta x} = \frac{2\pi}{\lambda}$

$\frac{\pi/6}{\Delta x} = \frac{2\pi}{\pi}$

$\Delta x = 0.26$m

7// The two possible perceived frequencies of the moving train are 123 Hz (moving away) and 127 Hz (moving towards)

$f' = f_0\left(\frac{1 \pm V_0/V}{1 \pm V_s/V}\right)$ $V_s = V_{source} = ?$
$V_0 = V_{obs.} = 0$
$V = 343$

$123 = 125\left(\frac{1}{1 + V_s/343}\right)$

or $127 = 125\left(\frac{1}{1 - V_s/343}\right)$

$\Rightarrow V_s = 5.6$ m/s or 5.40 m/s
(away) (toward)

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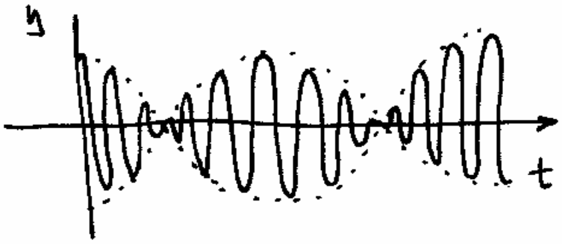
8 a) 509 Hz or 515 Hz

b) $y_1 = A\cos((\omega+\varepsilon)t)$

$y_2 = A\cos(\omega t)$

$$y_1+y_2 = A\left[\cos\left(\frac{(2\omega+\varepsilon)t}{2}\right)\cos\left(-\frac{\varepsilon t}{2}\right)\right]$$

$$\cong A\cos(\omega t)\cos\left(\frac{\varepsilon t}{2}\right)$$



9 a) $v = \sqrt{\frac{T}{\mu}}$; when the string is fingered 1/3 of the way down its length T= same μ = same so v is also constant. We'll need this...

$v = f\lambda \qquad \frac{\lambda}{2} = L$

$\Rightarrow v = f(2L)$

$\Rightarrow v = 196(2\cdot 0.5)$

$\Rightarrow v = 196$ m/s regardless of where the string is fingered

b) $v = f\lambda = f(2L)$

but v= constant = 196

$L = \frac{2}{3}(0.5)$

$f = ?$

$\Rightarrow f = \frac{v}{2L} = \frac{196}{2\left(\frac{2}{3}\right)(0.5)} = 294$ m/s

c) $T = \mu v^2$

$T = \frac{m}{\ell}v^2$

$T = \frac{40\times10^{-3}}{0.5}\cdot(196)^2$

$T = 3070$ N.

d)  $L = \frac{\lambda}{2}$ $f = 196$

$v = f\lambda$

$343 = 196(2L)$

$L = 0.875$ m

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10 a) $f = \frac{100}{0.8} = 125\ Hz$

b) $V = \sqrt{\frac{T}{\mu}}$ $V = f\lambda$ $\lambda = 2L$

$\Rightarrow V = 2Lf$

$2Lf = \sqrt{\frac{T}{\mu}}$

$\mu 4L^2f^2 = T$

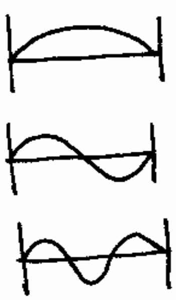
$\left(\frac{0.025}{3}\right)(4)(3)^2(125)^2 = T$

$T = 46.87\ N$

c) $f \propto \sqrt{T}$

$\Rightarrow T \rightarrow 4T$ $f \rightarrow 2f$

d)



11// $f \propto \sqrt{T}$ as per question 10.

if $T \rightarrow 1.03T$

$f \rightarrow 1.0149f$

$\Rightarrow f' = 1.0149(321)$

$f' = 325.77$

$f_{beat} = |f' - f_0| =$ 4.8 beats/s

12// $V = 2Lf$ as per q10.

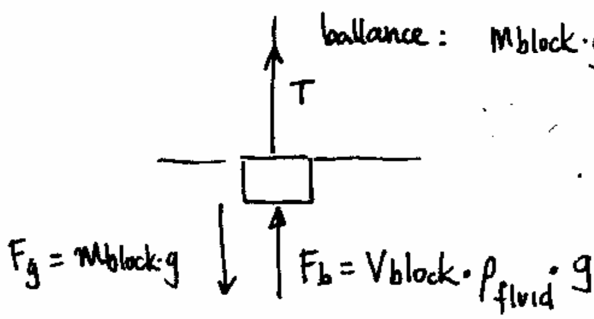
a) $V = \sqrt{T/\mu}$ $T = mg$

$\Rightarrow f = \frac{1}{2L}\sqrt{\frac{T}{\mu}} = \frac{1}{2(2.3)}\sqrt{\frac{(25)(9.8)}{(4.6\times10^{-3})/(2.3)}}$

$= 24\ Hz$

b) $f_1' = 2f_0' = 24\ Hz \Rightarrow f_0' = 12\ Hz$

ballance: $M_{block} \cdot g = T' + V_{block} \cdot \rho_{fluid}\, g$



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Now we know that the new fundamental is $f_0' = 12\ \text{Hz}$

We also know that for the fundamental

$f_0' = \frac{1}{2L}\sqrt{\frac{T'}{\mu}}$ L has not Δ'd
μ has not Δ'd

$\Rightarrow\ T' = \mu 4L^2 f_0'^2$

$\Rightarrow\ m_{block}\cdot g = \mu \cdot 4L^2 f_0'^2 + V_{block}\cdot g \cdot \rho_{fluid}$

$\Rightarrow\ (25)(9.8) = \left(\frac{46\times10^{-3}}{(2.3)}\right)\cdot 4(2.3)^2\cdot(12)^2 + \left(\frac{25}{3000}\right)(9.8)\,\rho_{fluid}$

$\rho_{fluid} = 2254\ \text{kg/m}^3$