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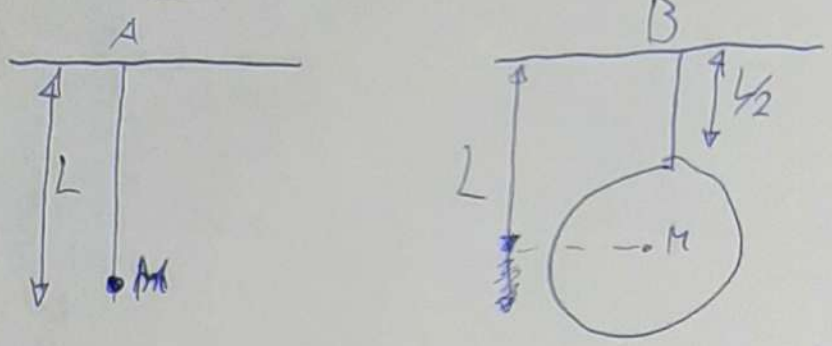
PHY 250

Homework 3:

1).



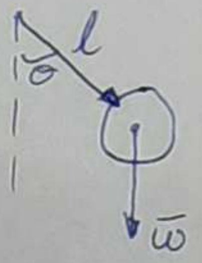
Pendulum A:

Since the volume is so small we can assume that:

$$\omega_A = \sqrt{\frac{g}{L}}$$

$$T_A = \frac{2\pi}{\omega_A} \rightarrow T_A = \frac{2\pi}{\sqrt{g/L}}$$

Pendulum B:



$$\text{Torque} = l \cdot \vec{\text{Weight}} \cdot \sin\theta$$

$$= -l \cdot M \cdot g \cdot \sin\theta$$

$$= -L \cdot M \cdot g \cdot \sin\theta$$

$$-L \cdot M \cdot g \cdot \sin\theta = I \cdot \ddot{\theta} \qquad I = \tfrac{2}{5} M \cdot R^2 + M \cdot L^2$$

$$-L \cdot M \cdot g \cdot \sin\theta = \tfrac{2}{5} \cdot M \left(\tfrac{L}{2}\right)^2 + M \cdot L^2 \cdot \ddot{\theta} \qquad \theta = \text{small}$$

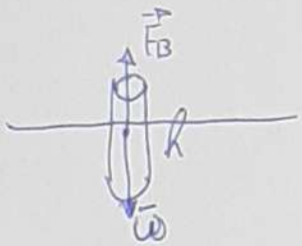
$$\frac{2L}{20} + L\ddot{\theta} + g \cdot \theta = 0$$

$$\tfrac{2}{20} + \ddot{\theta} + \boxed{g/L}\ \theta = 0 \rightarrow \omega_B = g/L \rightarrow T_B = \frac{2\pi}{g/L}$$

B). $\sqrt{g/L} < g/L \rightarrow \dfrac{2\pi}{\sqrt{g/L}} > \dfrac{2\pi}{g/L} \rightarrow T_A > T_B$

The pendulum A takes more time

2).



M, ρ, A, h

a). Since we have that the object is in equilibrium

$$\sum F = 0 \rightarrow F_B - W = 0$$
$$\rho \cdot V \cdot g - M \cdot g = 0$$
$$\rho \cdot A \cdot h - M = 0 \rightarrow h = \frac{M}{\rho \cdot A}$$

b). Applying a new forge generates a new equilibrium;

$$\sum F = 0 \rightarrow F_B - W - F = 0$$
$$\rho \cdot V \cdot g - M \cdot g - F = 0$$
$$\rho \cdot A \cdot h \cdot g - M \cdot g - F = 0$$
$$h = \frac{F + M \cdot g}{\rho \cdot A \cdot g}$$

c). $F = k \cdot \Delta l \rightarrow \Delta l = \dfrac{F}{\rho \cdot A \cdot g}$ $k = \rho \cdot A \cdot g$

$\omega = \sqrt{\dfrac{k}{M}} \rightarrow \omega = \sqrt{\dfrac{\rho \cdot A \cdot g}{M}}$

$T = \dfrac{2\pi}{\omega} \rightarrow T = \dfrac{2\pi}{\sqrt{\dfrac{\rho \cdot A \cdot g}{M}}}$

3). $f = 40.0\,Hz$, $A = 0{,}03\,m$, $\mu = 0{,}05\,kg/m$, $F_T = 5.00\,N$

a). Velocity?

$V = \sqrt{\dfrac{F_T}{\mu}} = \sqrt{\dfrac{5}{0{,}05}} = 10\,m/s$

b). λ?

$V = \lambda \cdot f \rightarrow \lambda = \dfrac{V}{f} \rightarrow \lambda = \dfrac{10}{40} \rightarrow \lambda = 0{,}25\,m$

c). $y(x,t)$?

$f = \dfrac{\omega}{2\pi}$

$\omega = 2\pi f =$

$y(x,t) = A \cdot \sin(kx - \omega t + \phi)$

$y(0,0) = A \rightarrow \sin(\phi) = 1 \rightarrow \phi$

$y(x,t) = 0{,}03 \cdot \sin(kx - 80\pi t + \pi/2)$

3). d). $a(x,t)$?

$a(x,t) = -A\cancel{\omega}\cdot \cos(kx - \omega t + \phi)$

$a(x,t) = -0{,}03 \cdot k \cdot \cos(kx - 80\pi t + \pi/2)$

$a_{max} \rightarrow \cos(\cdot\cdot) = 1 \rightarrow kx - 80\pi t + \pi/2 = 0 \quad x = 0$

$t = \frac{\pi}{2 \cdot 80\pi} \rightarrow t = 1/2 \cdot 80$

$a_{max} = -0{,}03 \cdot k$

e). Yes, it is a reasonable approach since the mass of the rope is negligible.

4). $y(x,t) = A\cos(kx + \omega t)$ Since this goes back when reaching the end, we get something like this:

$y(x,t) = A\cos(kx + \omega t) + A\cos(kx - \omega t)$

$y(x,t) = A\cos(kx)\cos(\omega t) - \cancel{A\sin(kx)\sin(\omega t)} + A\cdot\cos(kx)\cdot\cos(\omega t) + \cancel{A\sin(kx)\sin(\omega t)}$

$y(x,t) = 2A\cos(\omega t)\cdot\cos(kx)$

b). Amplitude at each point $= 2A\cdot\cos(kx)$

$x = 0 \quad \cos(kx) = 1 \quad A_{abx} = 2A$ At the end of the rope we have the maximum amplitude, this means that at $x = 0$ there is an antinode.

c). ~~As seen before we get~~

~~Tog~~ To get the maximum displacement we use:

$y(x,t) = 2 \cdot A \cdot \cos(\omega t) \cdot \cos(kx)$

$y_{max}(x,t)$ for $\omega t =$ [illegible] and $kx =$ [illegible]

To get the maximum velocity we use:

$V(x,t) = 2 \cdot A \cdot \omega \cdot \sin(\omega t) \cdot \cos(kx)$

$V(x,t) = V_{max}$ for $\omega t = \pi/2$ and $kx = 0$

To get the maximum acceleration we use:

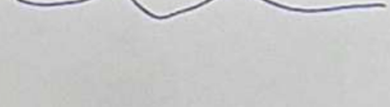
$a(x,t) = -2 \cdot A \cdot \omega^2 \cdot \cos(\omega t) \cdot \cos(kx)$

a_{max} for $\omega t = 0$ and $kx = 0$

d). Since the system has one end fixed and the other loose, the resonance frequencies will be:

$L = \frac{1}{4}\lambda$ $\underline{f}$

$L = \frac{3}{4}\lambda$ $\underline{3f}$



$L = \frac{5}{4}\lambda$ $\underline{5f}$