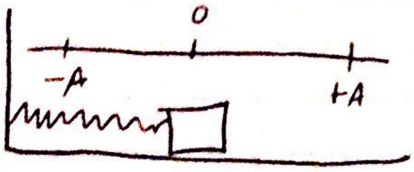
PH202 Recitation 8: SHM and Pendulum Solutions

[redacted]

Discussion Questions 1,2,3,4:



1: [redacted] mass at $+A$ what is instantaneous velocity?

at end points we know the velocity is 0 since it will change direction.

So answer C

2: [redacted] mass at 0 what is instantaneous velocity?

At $x=0$ we know that $F=0$ and $a=0$

and [redacted] that $U=0$. If $U=0 \Rightarrow K_E$ is max

$\Rightarrow$ max velocity

$\Rightarrow$ can be either positive or negative since it can go from $-A$ to A or A to $-A$

So answer A

3: [redacted] instantaneous acceleration at $+A$?

$F=-kx$ and at $+A$ Force is to the left $\Rightarrow$ negative

x is max at $+A \Rightarrow$ Force is max

$\Rightarrow$ negative max force

$\Rightarrow$ answer B

4: [redacted] instantaneous acceleration at 0?

at center $\Rightarrow$ equilibrium

$\Rightarrow F=-kx=0 \Rightarrow a=0$

$\Rightarrow$ answer C

[redacted]

Problem 1: cuckoo clock with mass on a spring
K? for $0.500\,s$ T and $0.450\,kg$ mass?

well, $T = 2\pi\sqrt{\frac{m}{k}}$

$$\Rightarrow \frac{T}{2\pi} = \sqrt{\frac{m}{k}}$$

$$\Rightarrow \frac{T^2}{4\pi^2} = \frac{m}{k}$$

$$\Rightarrow k = \frac{4\pi^2 m}{T^2}$$

$$\Rightarrow k = \frac{4\pi^2 \cdot 0.0450\,kg}{(0.500\,s)^2} = 2.37\,\frac{kg}{s^2} = \frac{N}{m}$$

b) if spring constant doubled, how does mass change in order for frequency to be same?

well we know $k = \frac{4\pi^2 m}{T^2}$

and $T = \frac{1}{f} \Rightarrow T^2 = \frac{1}{f^2}$

$\Rightarrow k = 4\pi^2 m f^2$

if $k \to 2k$ and f is constant

$\Rightarrow m \to 2m$

Problem 2: .500kg mass suspended from spring oscillates with period $T = 1.50s$.
mass added to change period to 2s ?

$$T = 2\pi\sqrt{\frac{m}{k}}$$

$$\Rightarrow \quad \frac{T}{2\pi} = \sqrt{\frac{m}{k}}$$

$$\Rightarrow \quad \frac{T^2}{4\pi^2} = \frac{m}{k}$$

$$\Rightarrow \quad k = \frac{4\pi^2 m}{T^2}$$

$$\Rightarrow \quad k = \frac{4\pi^2 \cdot 0.500\text{kg}}{(1.50s)^2} = 8.77\frac{N}{m}$$

now $T = 2.0s$, $k = 8.77\frac{N}{m}$, $m = 0.500\text{kg}$

$$T = 2\pi\sqrt{\frac{m}{k}}$$

$$\Rightarrow \quad \frac{T^2}{4\pi^2} = \frac{m}{k}$$

$$\Rightarrow \quad m = \frac{T^2 k}{4\pi^2}$$

$$\Rightarrow \quad m = \frac{(2.0s)^2 \cdot 8.77\frac{N}{m}}{4\pi^2}$$

$$\Rightarrow m = .89m$$

$\Rightarrow \quad .89 - .5 = .39m$ needed to add

[redacted]

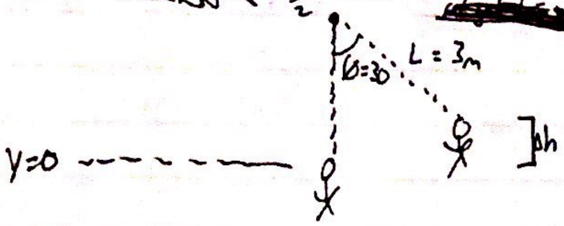
Problem [redacted] 3: A man is swinging on a rope [redacted]

What is the tension at the bottom of the string?

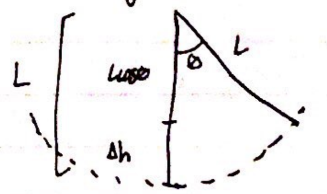
[redacted] rope length = 3m angle max = 30° mass = 80kg [redacted]

[redacted]

Picture:



We know that at the top of swing we have only potential energy U^g and at the bottom we only have kinetic energy K^E.



So $U^g_{max} = K^E_{max}$

$\Rightarrow mg\Delta h = \frac{1}{2}mv^2$

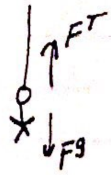
$\Rightarrow 2g\Delta h = v^2$

$\Rightarrow v^2 = 2gL(1-\cos\theta_{max})$

$\Delta h = L - L\cos\theta$
$= L(1-\cos\theta)$

we know v^2, how does that help with tension?

Well, we are in circular motion $\Rightarrow a = \frac{v^2}{r}$



$\Sigma F_{net_y} = ma_y$

$\Rightarrow F^T - F_g = ma_y$

$\Rightarrow F^T = ma_y + mg$

$\Rightarrow F^T = m(a_y + g)$

$\Rightarrow F^T = m(\frac{v^2}{r} + g)$

$\Rightarrow F^T = m\left(\frac{2gL(1-\cos\theta)_{max}}{L} + g\right)$

$\Rightarrow F^T = m(2g(1-\cos\theta_{max}) + g)$

[redacted]

note it doesn't depend on the length since the velocity term and acceleration cancel eachother out.

So $F^T = 80kg\,(2(9.8m/s^2)(1-\cos(30)) + 9.8m/s^2)$

$\Rightarrow F^T = 994\,N$

$mg = 784N$ so $F^T > F^g$ which it should.