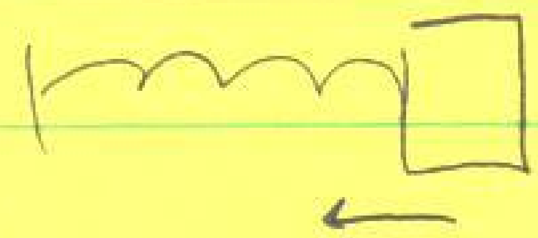
G

Last Time

Oscillations:



$$-kx = ma$$

$$-kx = m\frac{d^2x}{dt^2}$$

$$x = A\cos(\omega_0 t + \phi)$$

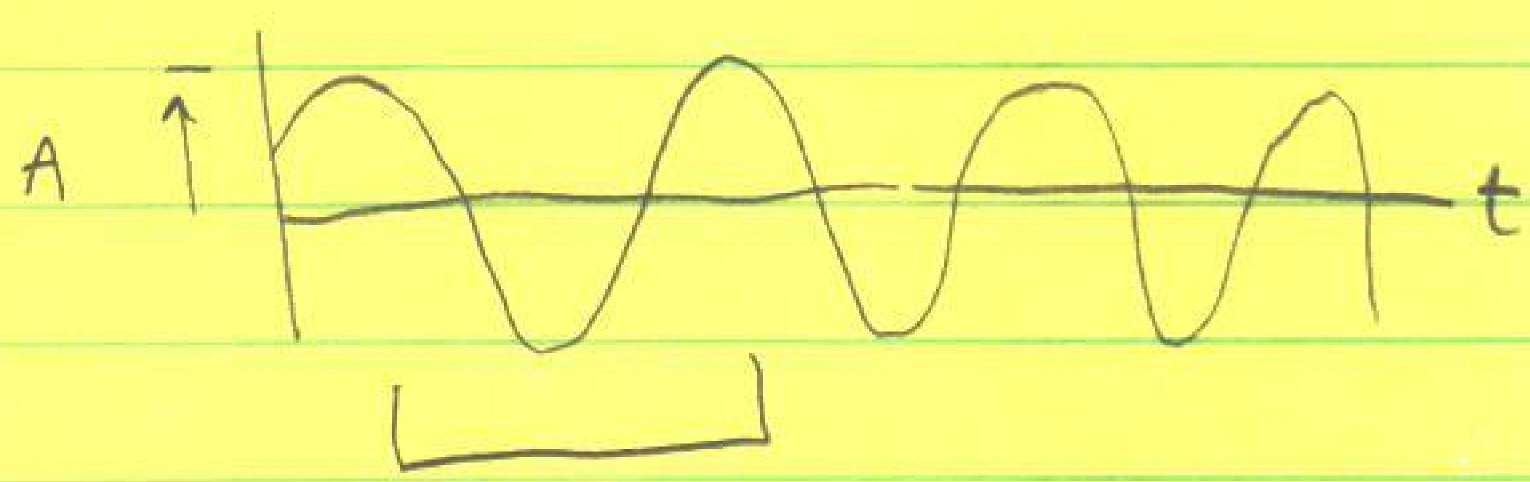
$$-\omega_0^2 x = \frac{d^2x}{dt^2}$$

assumes radians!

$$\omega_0^2 = \frac{k}{m} = \frac{1}{s}$$

ω_0 = Angular Freq

A = Amplitude



$$T = \frac{2\pi}{\omega_0}$$

$$f = \frac{1}{T}$$

Vertical Spring:

- Everything still applies around the Equilibrium position

(2)

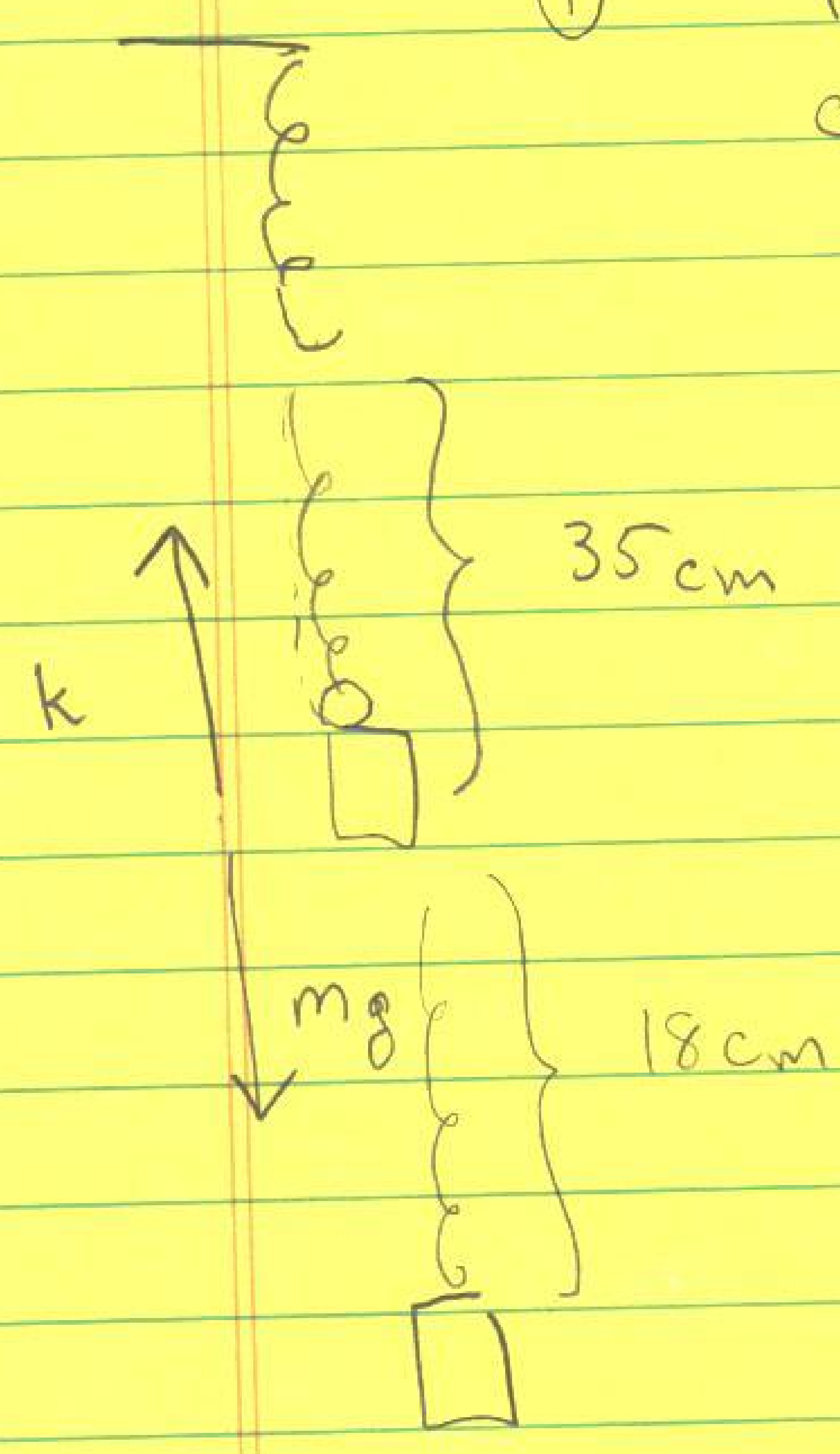
A hanging spring stetches 35.0 cm when an object of 450g is hung on it at rest. The Object is pulled down on an additional 18cm

(1) What is position 84.4s later?

(2) When does it reach the top of its arc?

Solution

(1) First determine the spring constant.



$$kx_0 - mg = 0$$

$$k = \frac{mg}{x_0} = \frac{(0.45\ kg)(9.8\ m}{0.35\ m}$$

$$k = 12.6\ \frac{N}{m}$$

Next determine the angular frequency:

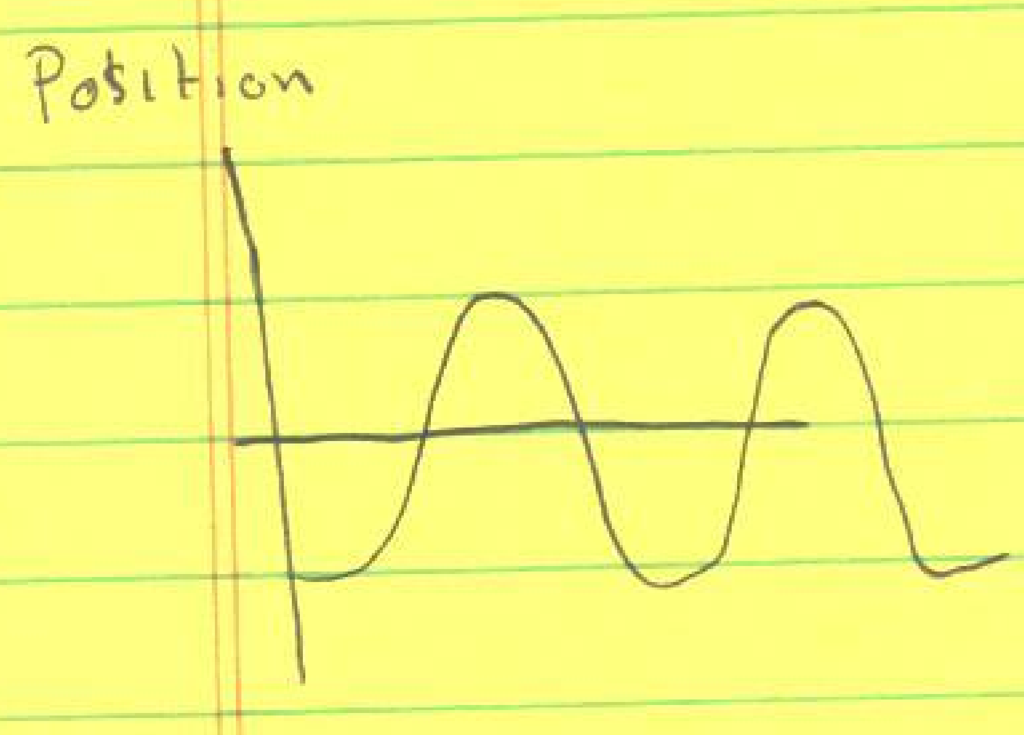
$$\omega_0 = \sqrt{\frac{k}{m}} = 5.29\ \frac{1}{s} \qquad T = \frac{2\pi}{\omega_0} = 1.19$$

3

Then

$$x(t) = A\cos(\omega_0 t + \phi)$$

$$V(t) = -A\omega_0 \sin(\omega_0 t + \phi)$$



Need IC $\quad x(t=0) = -18\ cm = A\cos\phi$

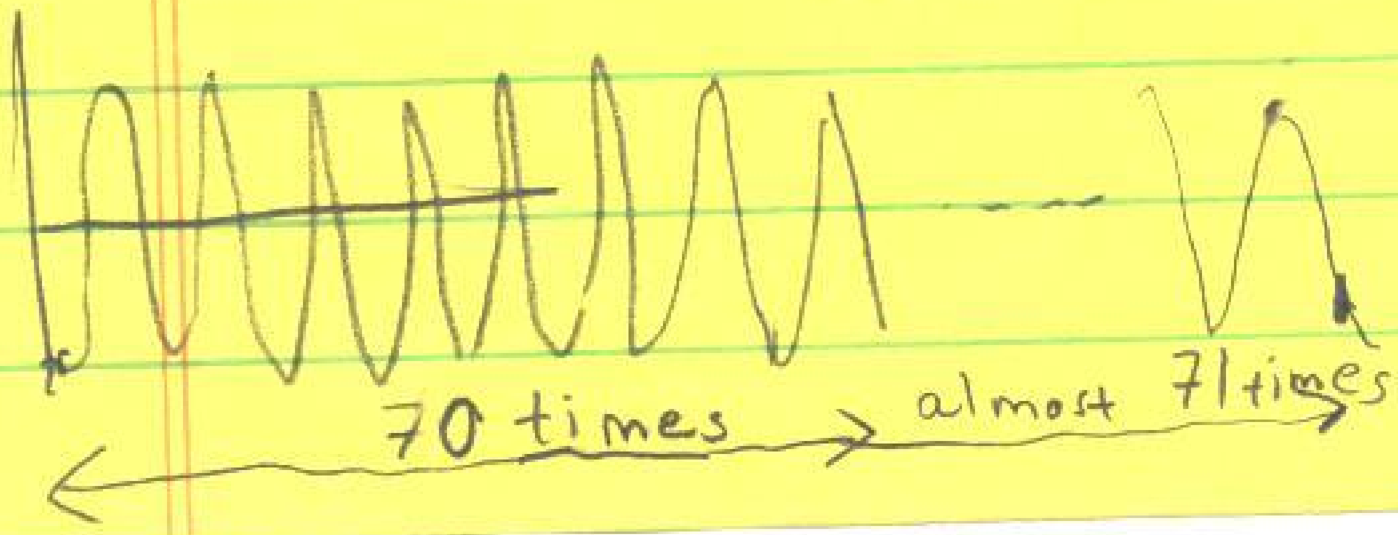
$$v(t=0) = 0 = -A\omega_0 \sin\phi$$

$$\phi = 0 \qquad A = -0.18m$$

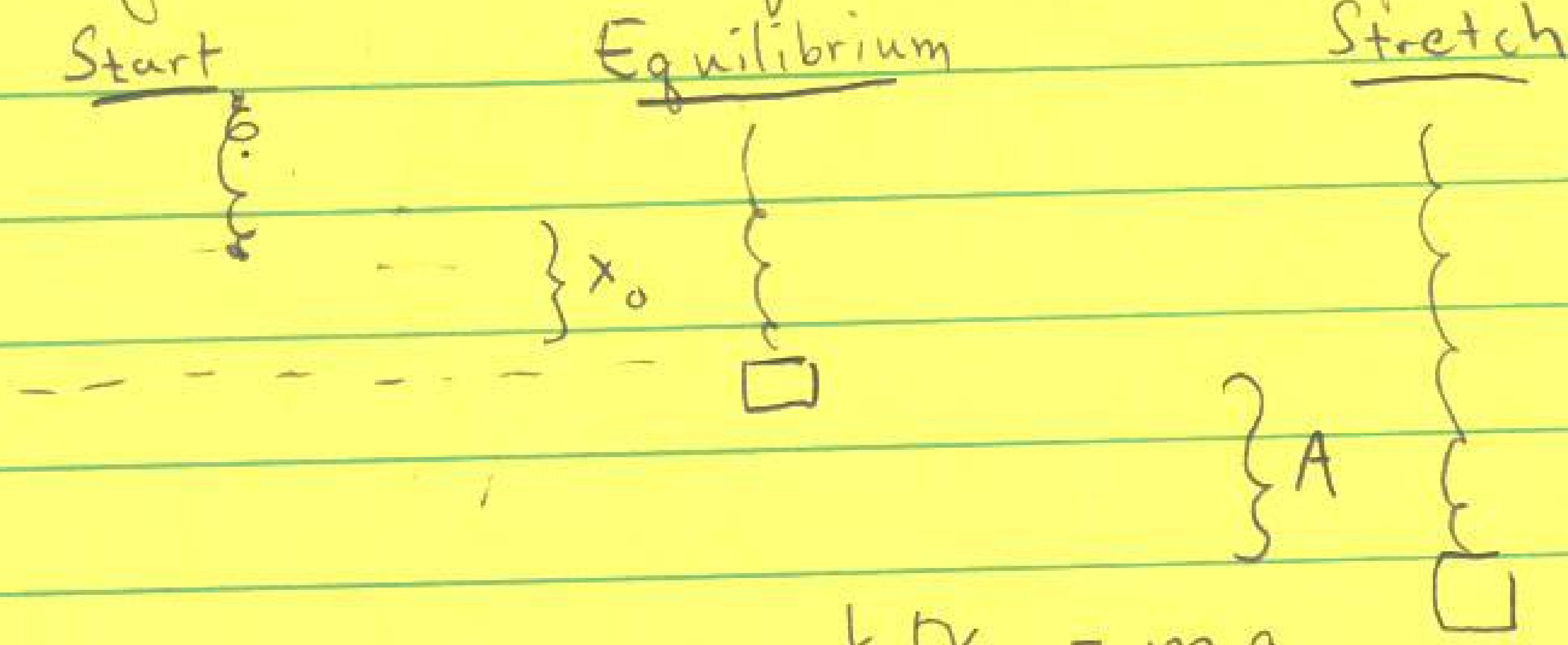
$$x(t) = (-0.18m)\cos\Big(\underbrace{5.29\tfrac{1}{s}}_{\text{be sure to use radians}} \cdot t\Big)$$

$$x(t=84.4s) = -16.8s$$

$$\#\ \text{periods} = \frac{84.4s}{1.19s} = 70.9$$



What is the speed as the block passes through the equilibrium position



Solution: $PE_g = 0$

Use Energy Consv:

$kx_0 = mg$

$$\cancel{KE_i}^{\,0} + PE_i = KE_f + PE_f$$

$$\frac{1}{2}k(x_0 + A)^2 - mgA = \frac{1}{2}mV_f^2 + \frac{1}{2}kx_0^2$$

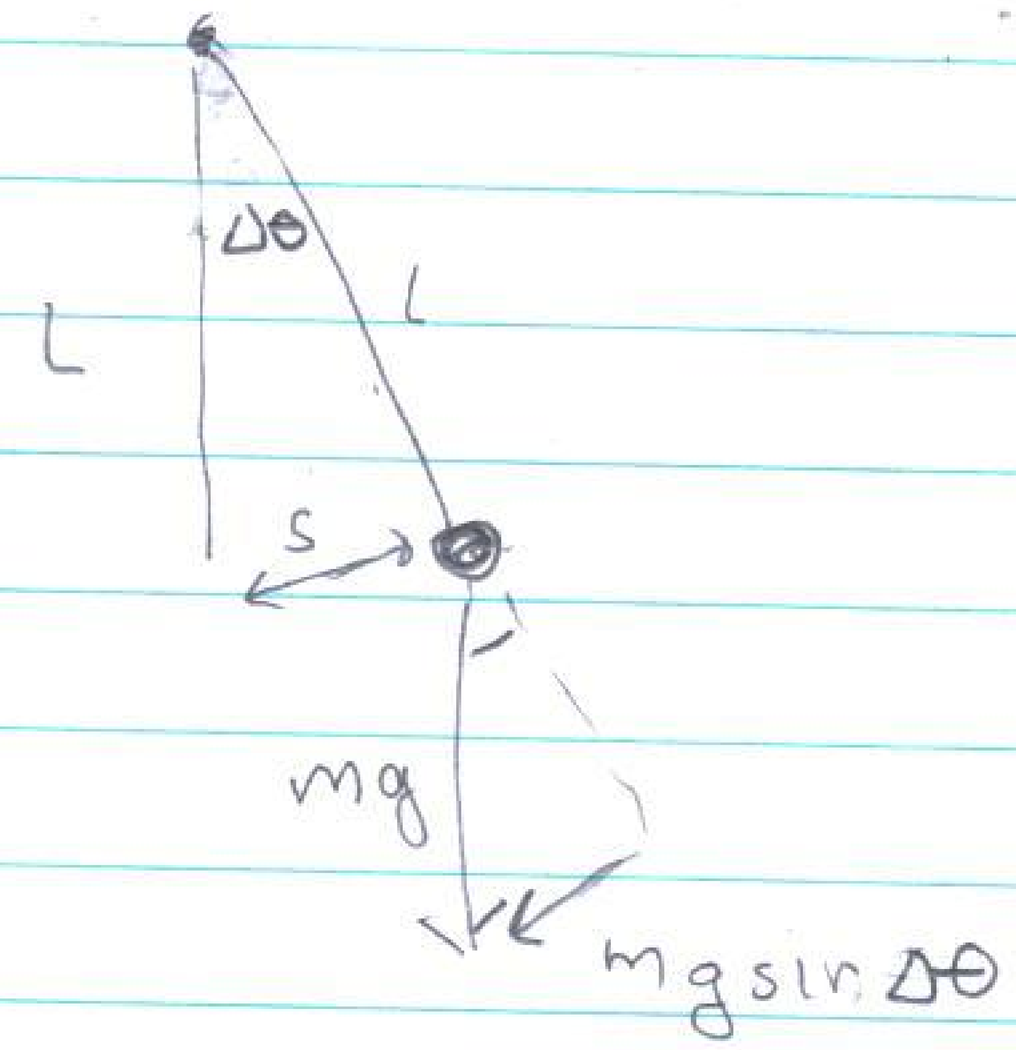
$$\frac{1}{2}kx_0^2 + 2\frac{1}{2}kx_0A + \frac{1}{2}kA^2 - mgA = \frac{1}{2}mv^2 + \frac{1}{2}kx_0^2$$

$kx_0 = mg$

$$\frac{1}{2}kA^2 = \frac{1}{2}mV^2$$ ← just like horizontal

$\frac{1}{2}(12.6)$

P'endulum Pendulum



$$s \simeq L\,\Delta\theta$$

$$F = ma$$

$$-mg\sin\Delta\theta = m\frac{d^2s}{dt^2} = mL\frac{d^2(\Delta\theta)}{dt^2}$$

$$\sin\Delta\theta \simeq \Delta\theta$$

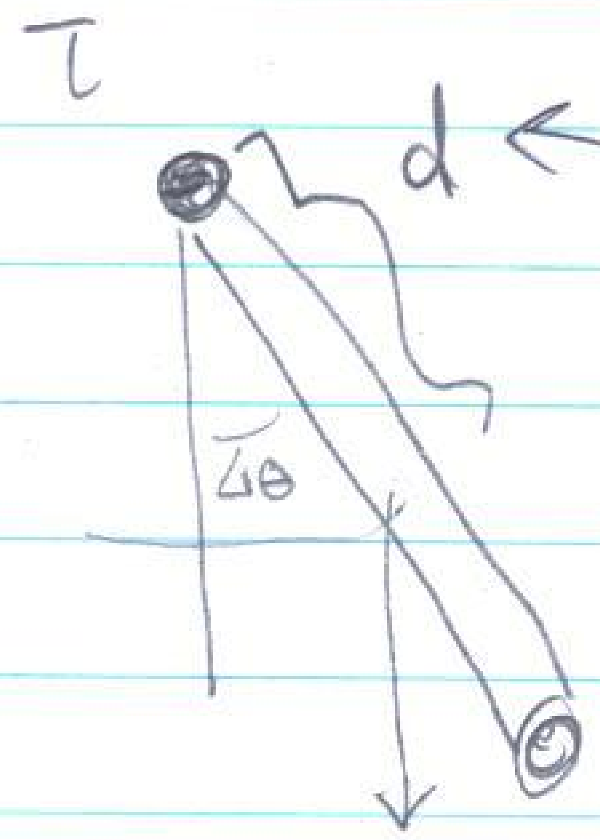
$$-\cancel{m}g\,\Delta\theta = \cancel{m}L\frac{d^2(\Delta\theta)}{dt^2}$$

$$-\left(\frac{g}{L}\right)\theta = \frac{d^2(\Delta\theta)}{dt^2} \qquad \frac{d^2x}{dt^2} = -\left(\frac{k}{m}\right)x$$

$$\theta = A\cos(\omega_0 t + \phi) \qquad T = \frac{2\pi}{\omega} \quad \text{etc}$$

$$\omega_0 = \sqrt{\frac{g}{L}}$$

Another Example



distance from pivot to cm

$$\tau = I\alpha$$

$$-mgd\sin\theta = I\frac{d^2\theta}{dt^2}$$

$$-mgd\Delta\theta = I\frac{d^2(\Delta\theta)}{dt^2}$$

$$-\left(\frac{mgd}{I}\right)\Delta\theta = \frac{d^2}{dt^2}\left(\Delta\theta\right) \qquad \frac{d^2x}{dt^2} = -\omega^2 x$$

$$\omega = \sqrt{\frac{mgd}{I}} \qquad T = \frac{2\pi}{\omega} \text{ etc}$$

Last Time

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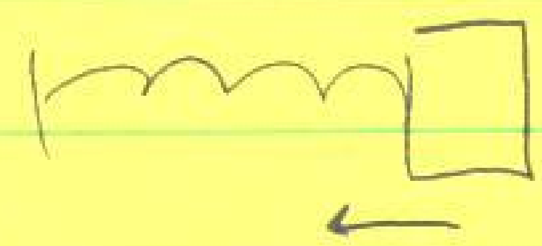

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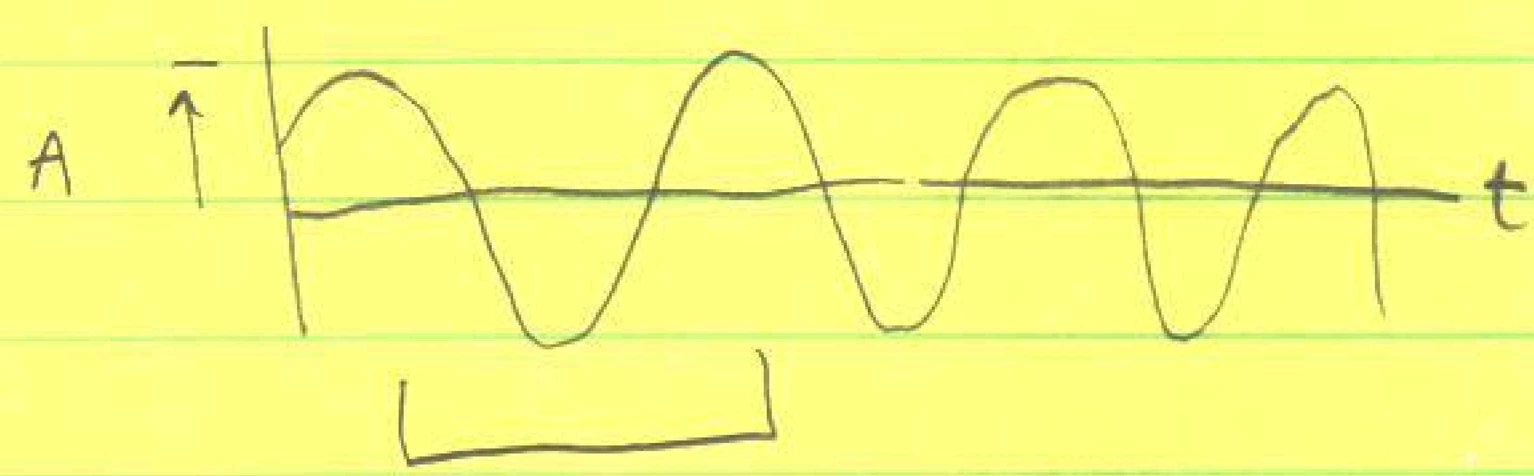

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Vertical Spring:

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