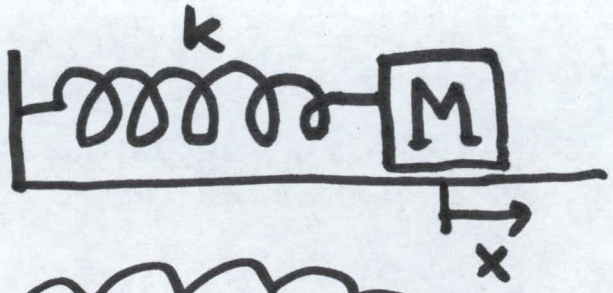
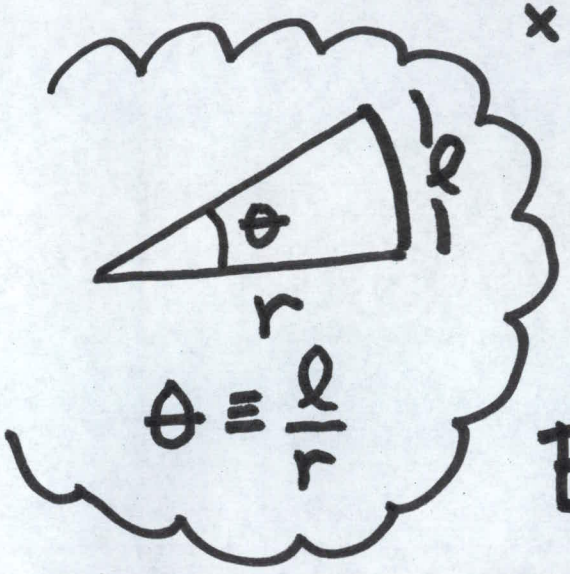


$$K = \frac{1}{2}mv^2 \qquad U = \frac{1}{2}kx^2$$

$$x = \underbrace{A\cos(\omega t + \phi)}_{\text{const.}}$$

$$v = \frac{dx}{dt} = -\omega A \sin(\omega t + \phi)$$



$$E = \frac{1}{2}mv^2 + \frac{1}{2}kx^2$$

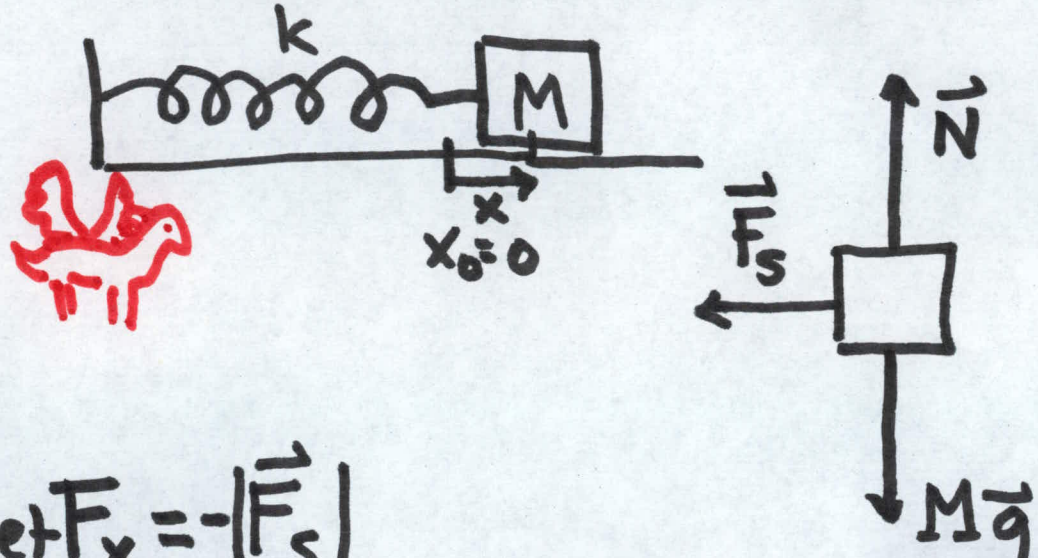
$$E = \frac{1}{2}m\omega^2A^2\sin^2(\omega t+\phi) + \frac{1}{2}kA^2\cos^2(\omega t+\phi)$$

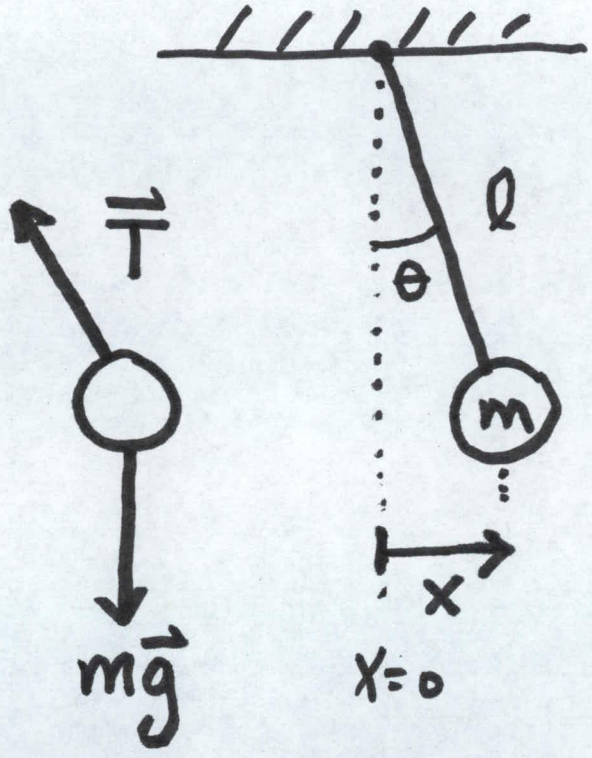
$$E = \text{☺}\sin^2(\omega t+\phi) + \text{☺}\cos^2(\omega t+\phi)$$

$E =$ ☺ conservation of energy!

$$\text{☺} = \frac{1}{2}m\omega^2A^2 = \frac{1}{2}kA^2 \quad \text{) true only if} \quad \omega = \sqrt{\frac{k}{m}}$$

Differential Equation:





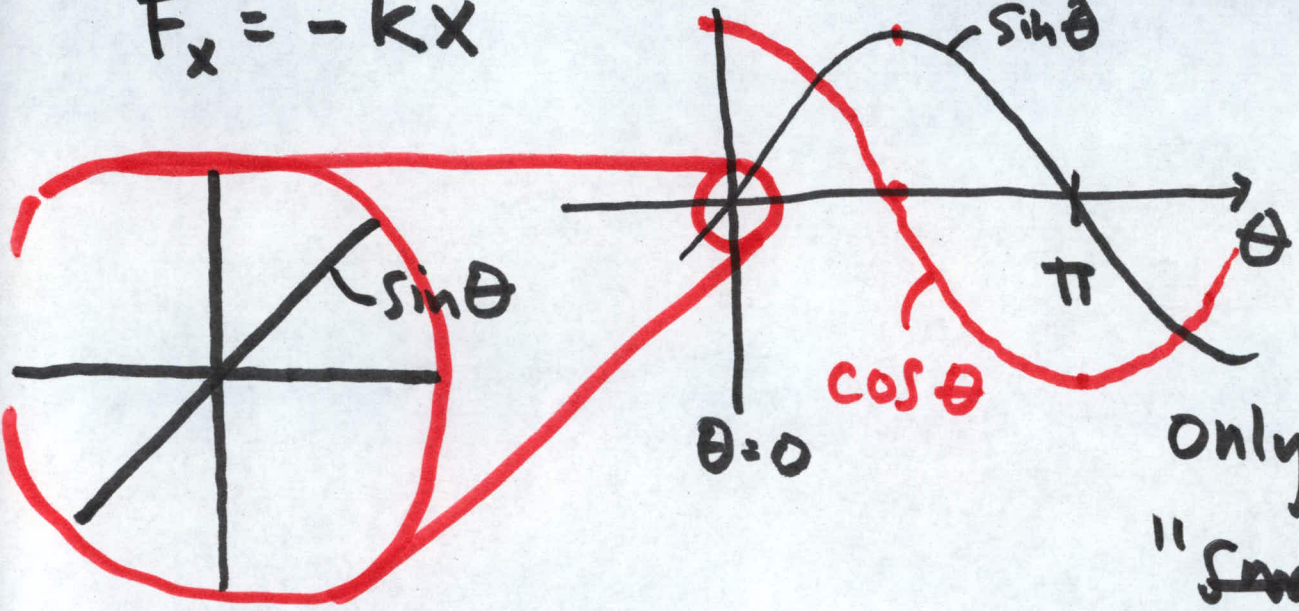
$\text{net } F_x = -|\vec{F}_s|$

$F_x = -kx$

$\text{net } F_x = -|\text{horizontal comp of } \vec{T}|$

$= -|\vec{T}| \cdot \sin\theta$

$= -|T \sin\theta|$



only allow $\theta \ll 1$

"~~small~~ oscillations"

small

θ	$\sin\theta$
0.01	0.00999998
0.001	0.000999999998...
0.02	0.0199998[illegible]...
	...

$$\sin\theta = \theta - \frac{\theta^3}{3!} + \frac{\theta^5}{5!} - \frac{\theta^7}{7!} + \dots$$

$$\cos\theta = 1 - \frac{\theta^2}{2!} + \frac{\theta^4}{4!} - \frac{\theta^6}{6!} + \dots$$

$$e^x = \dots$$

$$e^{i\theta} = \dots$$

$$F_x = -kx$$

$$\Downarrow$$

$$ma_x = -kx$$

$$\Downarrow$$

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

differential equation

- Solve:

guess + check

$$F_x = -T\theta \quad \text{approx} \quad (\theta \ll 1)$$

$$F_x = -T\frac{x}{\ell}$$

$$ma_x = -\frac{T}{\ell}x$$

$$m\frac{d^2x}{dt^2} = -\frac{T}{\ell}x \quad \text{approx}$$

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