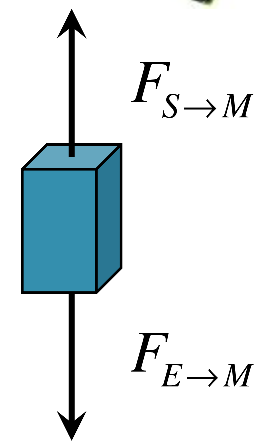
- **Theme Music:** **Elvis Presley**

  All Shook Up

  Cartoon: **Scott & Borgman**

  Zits

Summary with Equations: Mass on a spring



$$a = \frac{1}{m} F^{net} \qquad F^{net} = -kx$$

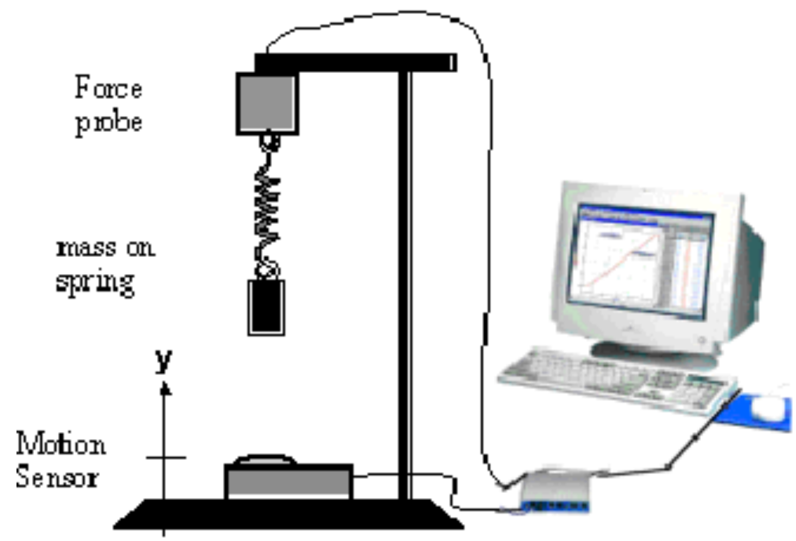
Measured from where?

$$a = -\omega_0^2 x \qquad \omega_0^2 = \frac{k}{m}$$

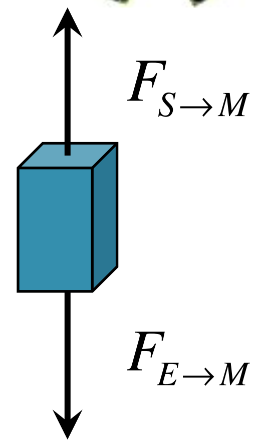
$$x(t) = A\cos(\omega_0 t + \phi)$$

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

Interpret!



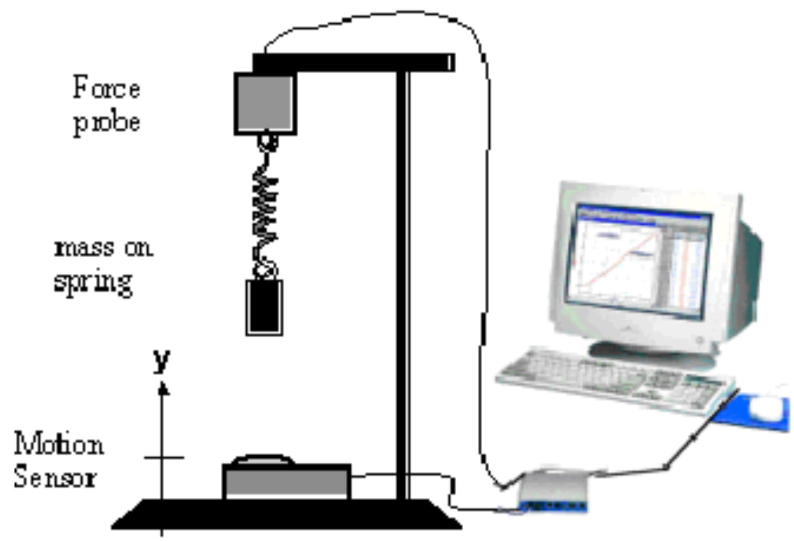
Summary with Equations: Mass on a spring (Energy)



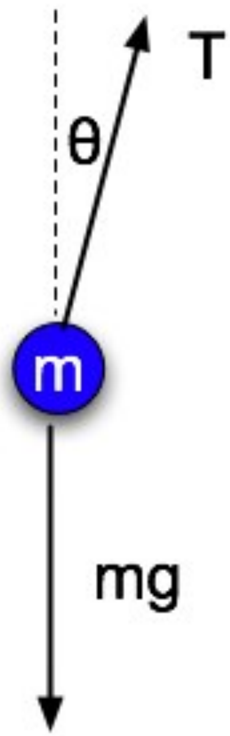
Measured from where?

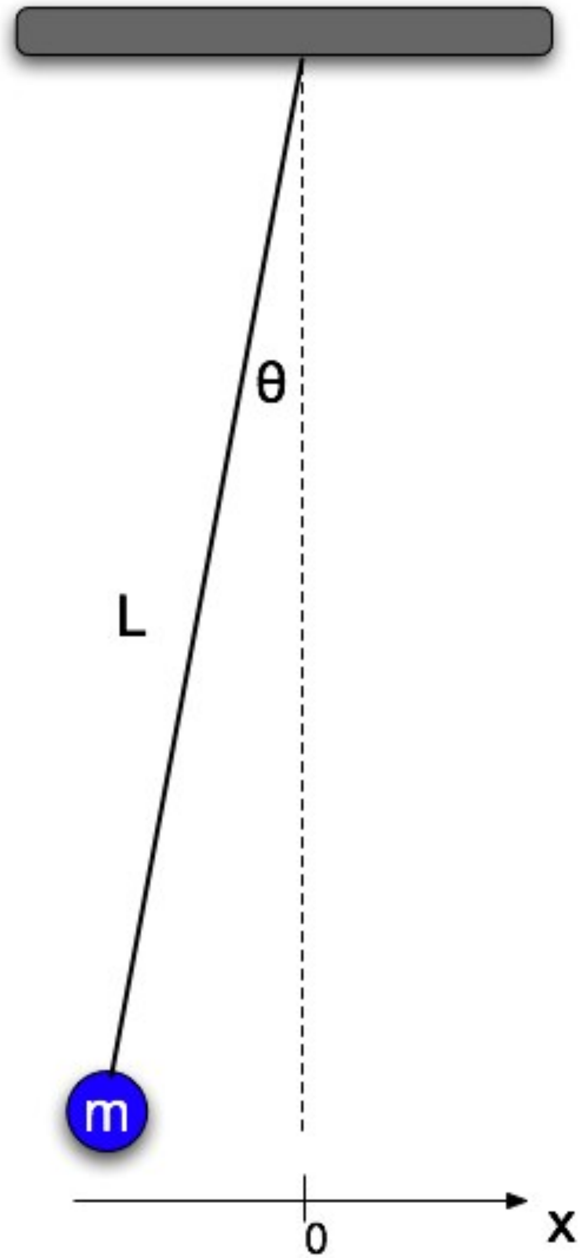
$$E = \tfrac{1}{2}mv^2 + mgh + \tfrac{1}{2}k(\Delta l)^2$$

$$E_i = E_f$$



The Long Pendulum





Pendulum motion energy

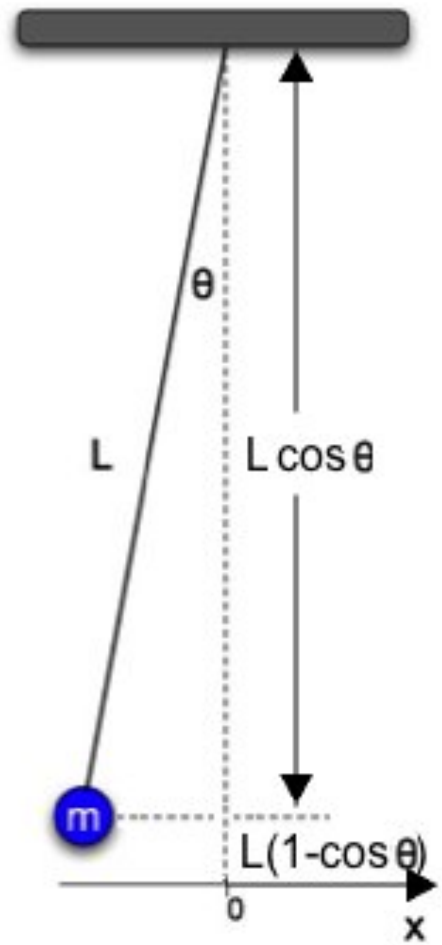
$$E_0 = \tfrac{1}{2}mv^2 + mgh = \tfrac{1}{2}mv^2 + mgL(1-\cos\theta)$$

$$\cos\theta \approx 1 - \tfrac{1}{2}\theta^2$$

$$E_0 \approx \tfrac{1}{2}mv^2 + \tfrac{1}{2}[mgL]\theta^2$$

$$\theta \approx \sin\theta = \frac{x}{L}$$

$$E_0 \approx \tfrac{1}{2}mv^2 + \tfrac{1}{2}kx^2 \qquad k = \frac{mg}{L}$$



Same as mass on a spring!

Just with a different $\omega_0^2 = k/m = g/L$

What's the period? Why doesn't it depend on m?

Foothold ideas: Damped oscillator 1

- Amplitude of an oscillator tends to decrease. Simplest model is viscous drag.

$$ma = -kx - bv$$

$$\frac{d^2x}{dt^2} + \gamma \frac{dx}{dt} + \omega_0^2 x = 0 \qquad \gamma = \frac{b}{m} \quad \omega_0 = \sqrt{\frac{k}{m}}$$

- Solution:

$$x(t) = A_0 e^{-\gamma t/2} \cos\left(\omega_1 t + \phi\right)$$

$$\omega_1 = \sqrt{\omega_0^2 - \frac{\gamma^2}{4}}$$

Foothold ideas: Damped oscillator 2

- Competing time constants:

$$\frac{\gamma}{2} = \frac{1}{\tau} \qquad \frac{\omega_0}{2\pi} = \frac{1}{T} \qquad Q = \frac{\omega_0}{\gamma} = \pi\frac{\tau}{T}$$

Decay time (τ)

Period (T)

Tells which force dominates: restoring or damping. (Q)

- If:

$\omega_0 > \gamma/2$ underdamped: oscillates

$\omega_0 = \gamma/2$ critically damped: no oscillation, fastest decay

$\omega_0 < \gamma/2$ over damped: no oscillation, slower decay

Foothold ideas: Driven oscillator

- Adding an oscillating force.
- When the extra oscillating force (driver) matches the natural frequency of the oscillator you get a big displacement (**resonance**). Otherwise, not much.