April 1, 2013 Physics 132 Prof. E. F. Redish

- **<u>Theme Music:</u> Elvis Presley**

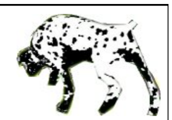
All Shook Up

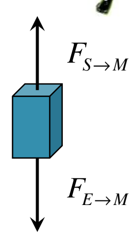
<u>Cartoon:</u> Scott & Borgman

Zits

4/1/13 Physics 132 **1**

Summary with Equations: Mass on a spring





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

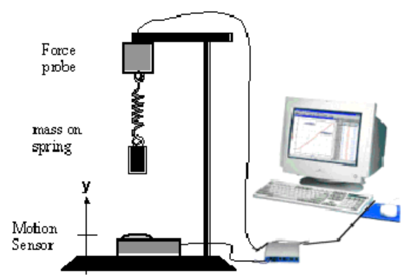
Measured from where?

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

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

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

Interpret!



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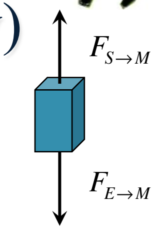
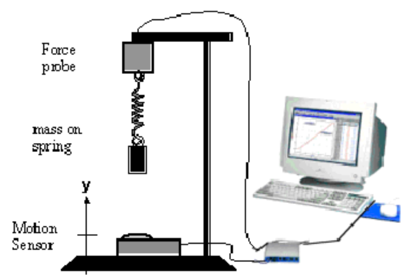
Summary with Equations: Mass on a spring (Energy)



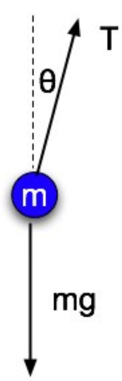
Measured from where?

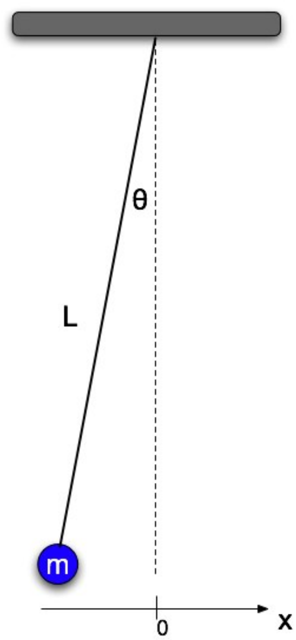
$$E = \tfrac{1}{2}mv^2 + mgh + \tfrac{1}{2}k(\Delta l)^2$$

$$E_i = E_f$$



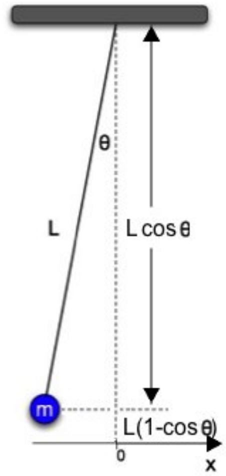
The Long Pendulum





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?

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

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

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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 *Period* *Tells which force dominates: restoring or damping.*

- 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

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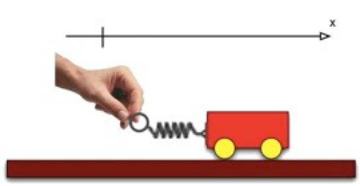
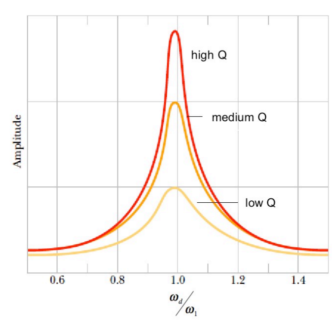
Foothold ideas: Driven oscillator

- 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.





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