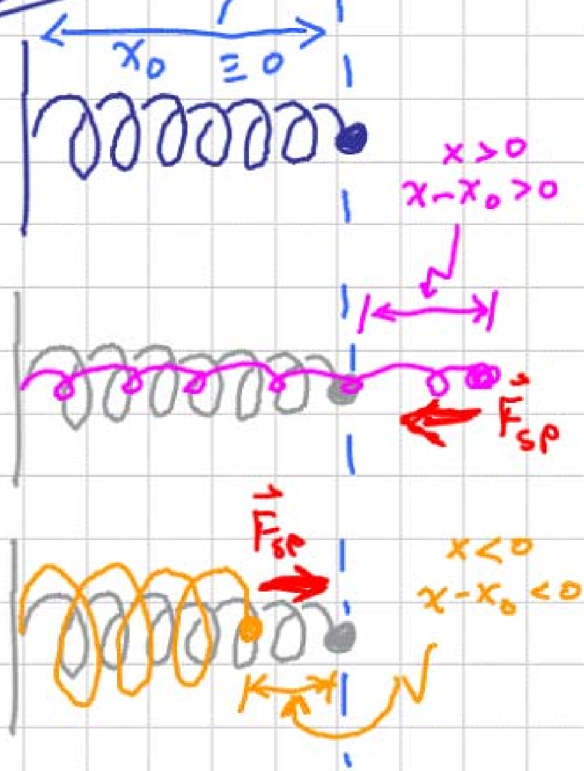
Physics 113 - October 17, 2013

Last Time

natural length (uncompressed and unstretched)

x_0 often take $x=0$ when $x=x_0$



$$\vec{F}_{sp} = -k(\vec{x-x_0}) = -k\vec{x}$$

Spring CONSTANT, size depends on spring

Restoring force

$$|\vec{F}_{sp}| = kx = k|x-x_0|$$

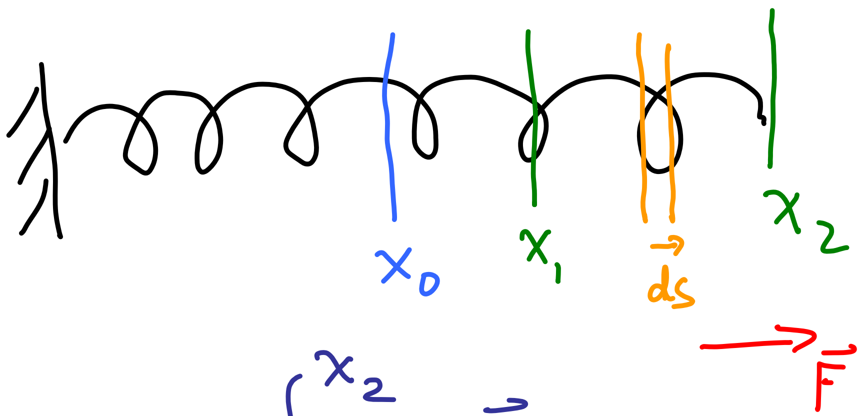
If springs ain't your things, suck it up

Simple harmonic motion

Waves

"attractive potentials", Bonds

Energy in Springs



Stretch spring from x_1 to x_2

Work done on spring to move it from $x_1 \to x_2$

$$W = \int_{x_1}^{x_2} \vec{F} \cdot \underbrace{\vec{ds}}_{dx} = \int_{x_1}^{x_2} F\,ds = \int_{x_1}^{x_2} F\,dx = \int_{x_1}^{x_2} k(x-x_0)\,dx$$

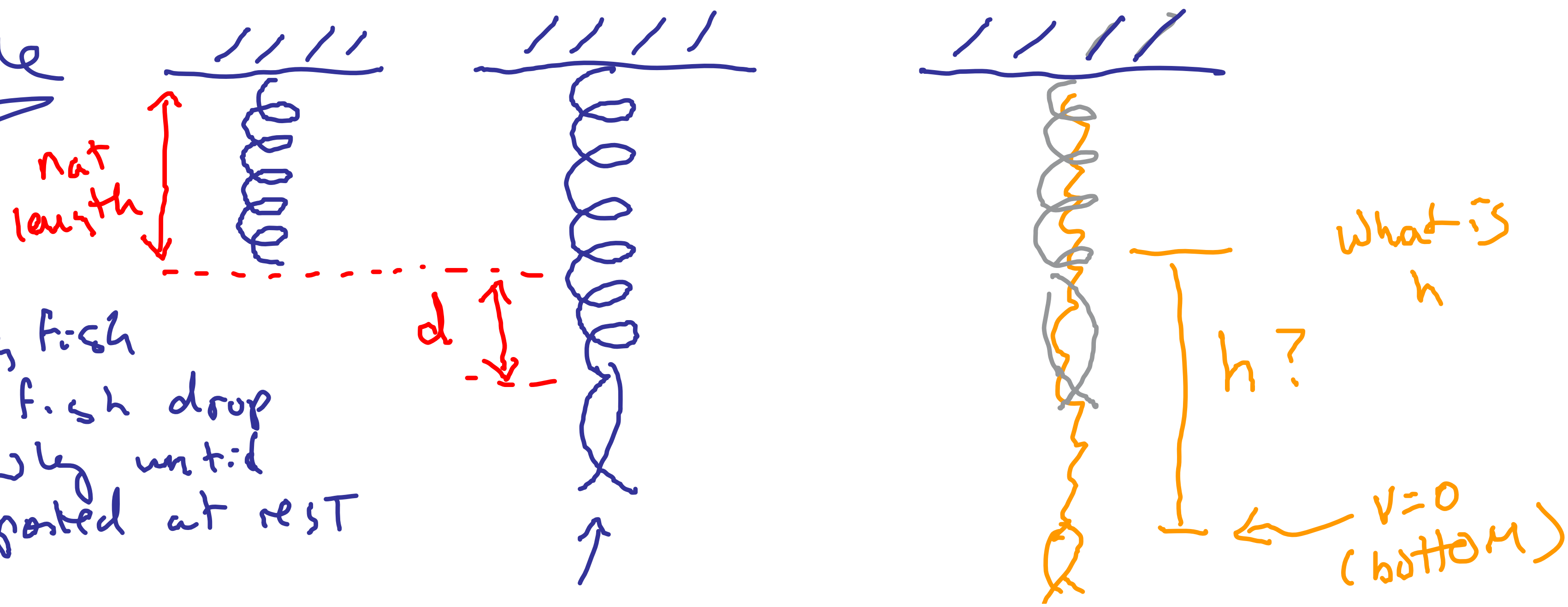
$\overset{\longleftarrow}{k(x-x_0)}$ $\overset{\longrightarrow}{-}$ $F_{exerted}$

let $x_0 = 0$ $\quad \int_{x_1}^{x_2} kx\,dx = \frac{1}{2}k(x_2^2 - x_1^2)$

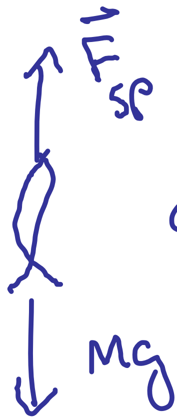
define PE stored in Spring as $\frac{1}{2}kx^2$

$$\Delta PE_{x_1 \to x_2} = \Delta\left(\tfrac{1}{2}kx^2\right) = \tfrac{1}{2}kx_2^2 - \tfrac{1}{2}kx_1^2$$

Example



hang fish
let fish drop
slowly until
supported at rest



$a = 0$

$\Sigma F = 0 = Mg - F_{sp} = mg - Kd$

$Mg = Kd$

$K = \frac{mg}{d}$ Newtons / m

$F = Kx$

units of K are N/m

For 2ND part
can't use constant accel eqns because
F_{sp} Δ'es
a changes

$\uparrow F_{sp}$

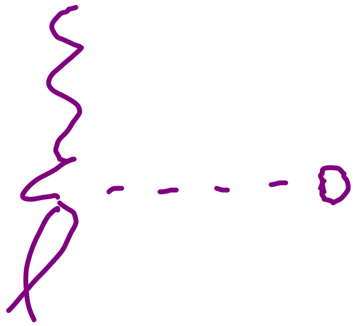
$\downarrow mg$

Use Energy Conservation

$E_{start} = E_{end}$

(top) (bottom)

Start



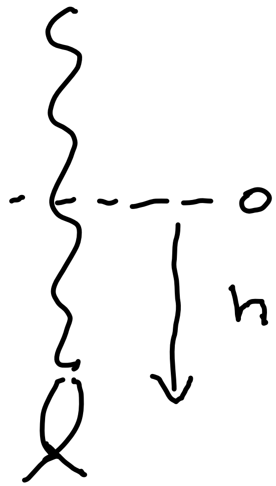
$$E_{start} = \cancel{PE_{grav}} + \cancel{PE_{spring}} + \cancel{KE}$$

0   mg(height) $\equiv 0$

0   $= \frac{1}{2}kx^2$

0 not moving

energy cons



$$E_{end} = PE_{grav} + PE_{spring} + \cancel{KE}$$

$= 0$

$-mgh$

$\frac{1}{2}kx^2$

$\frac{1}{2}kh^2$

0

$E_{start} = Mgh$

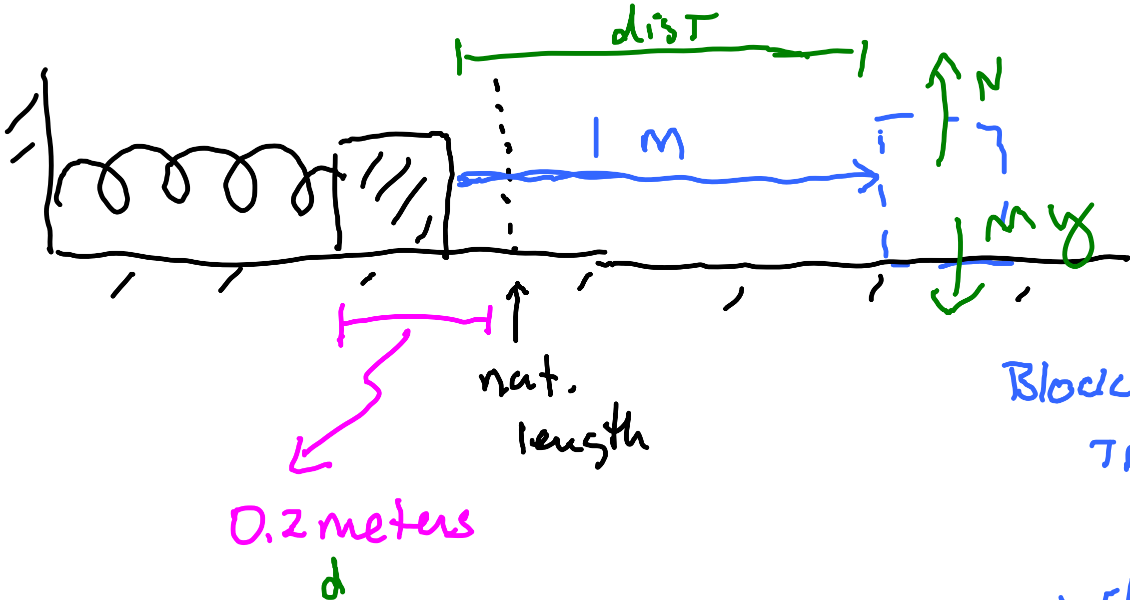
$mgh = \frac{1}{2}kh^2$

bottom $PE_{grav} = 0$ $PE_{sp} = \frac{1}{2}kh^2$

$\boxed{h = \frac{2mg}{k}}$

$mgh \longrightarrow \frac{1}{2}kh^2$

$$\boxed{h = \frac{2mgd}{mg} = 2d}$$



$K_{spring} = 100\ N/m$

$M_{block} = 0.5\ kg$

Block released + travels 1 m before coming to rest.

What is μ_k

Energy Start

$\frac{1}{2}kd^2$

End

$PE_{sp} = 0$ $\quad KE = 0 \quad$ E lost to Fr

$mg\mu_k(\text{dist})$

$\overset{100}{\frac{1}{2}k}\ \underset{.2}{d}^2 = \overset{.5}{m}g\ \underset{?}{\mu_k}\ \underset{1\text{ m}}{(\text{dist})}$

$$\text{Power} = \frac{\Delta W}{\Delta t} = \frac{\Delta \text{ in Energy}}{\text{Time}}$$

rate of Energy flow

$$\boxed{\text{Power} = \frac{dW}{dt} = \frac{\text{Joule}}{\text{sec}} \equiv \text{Watt}}$$

Joule = unit of work or Energy in MKS

Potential Energy + Force

$$W = Fd$$

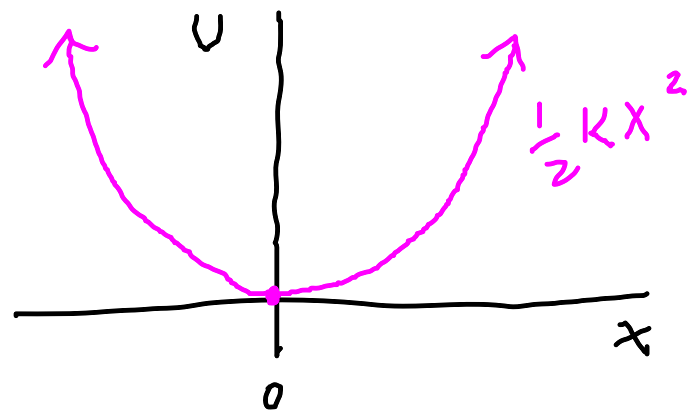
$$dW = F\,dx$$

$$dU = F\,dx$$

potential
Energy function

$$\frac{dU}{dx} \sim F_x$$

Spring $PE = \frac{1}{2}kx^2$



$$\frac{dU}{dx} = kx$$

if "−" and vector $\rightarrow F$

$$\boxed{F_s = -\frac{dU}{ds}}$$