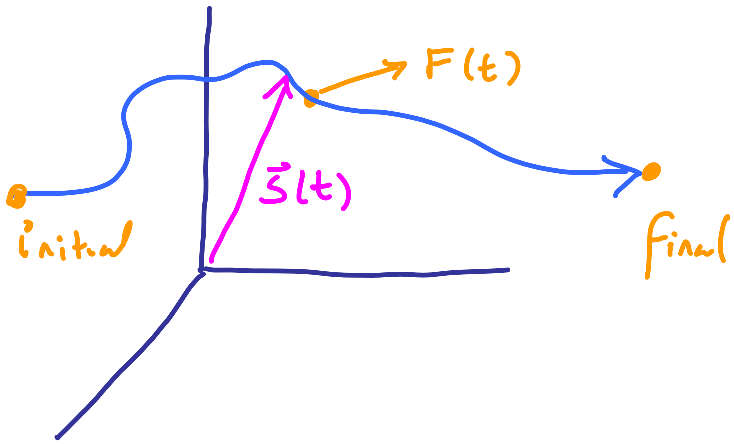
Physics 113 - October 4, 2012

- Time early for exam return is 1 week
- P.S. 4 issue
- Next week's workshop cycle

Last time



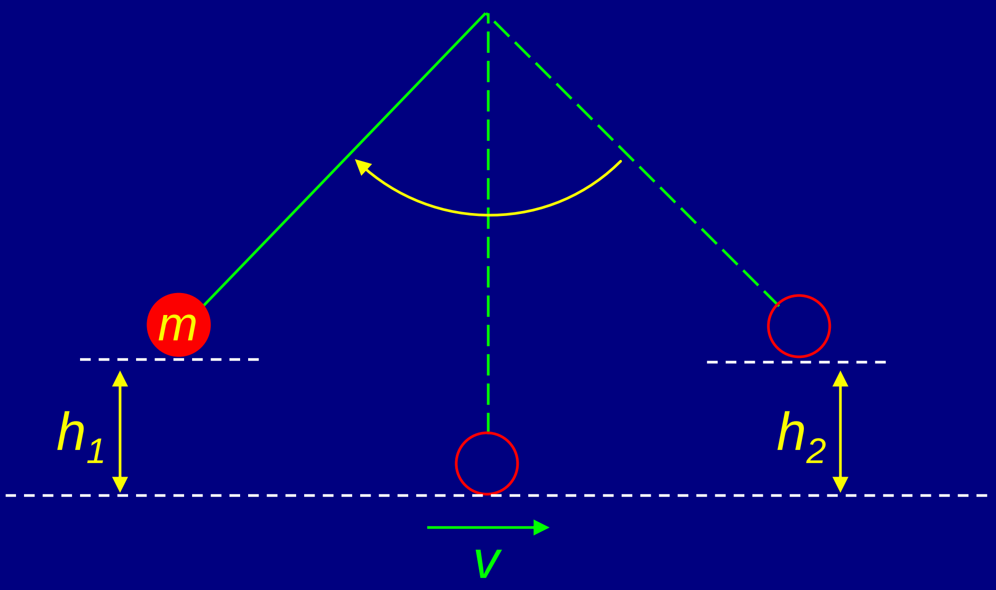
$$W = \int_{\text{initial}}^{\text{final}} \vec{F} \cdot d\vec{s}$$

Potential energy – Potential to do work

Kinetic energy – energy of motion $= \frac{1}{2} m v^2$

Example: The simple pendulum

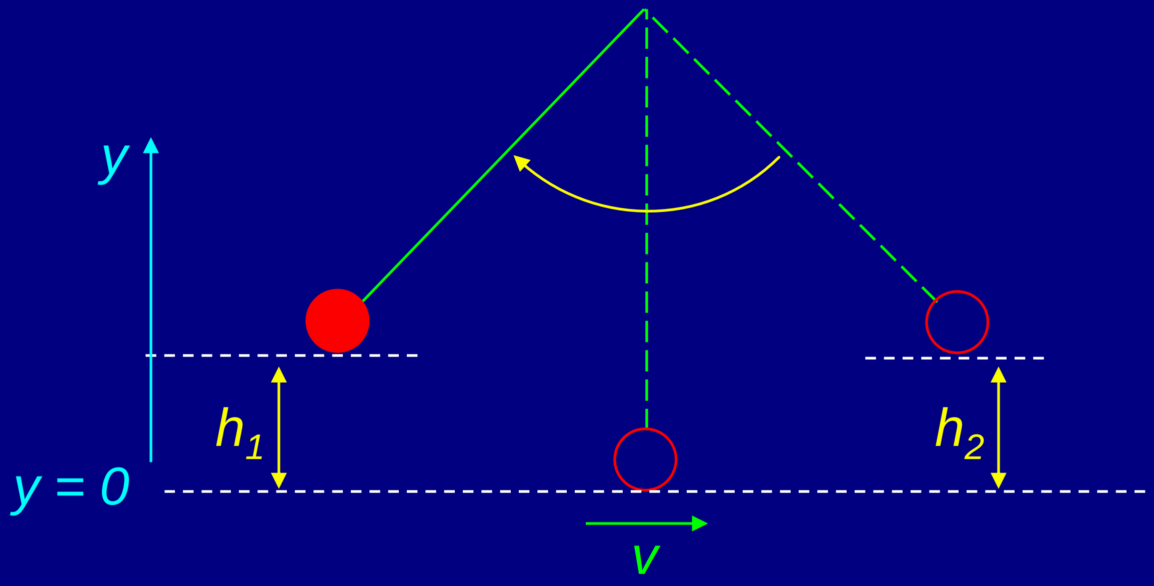
- Suppose we release a mass m from rest a distance h_1 above its lowest possible point.
  - What is the maximum speed of the mass and where does this happen?
  - To what height h_2 does it rise on the other side?



Example: The simple pendulum

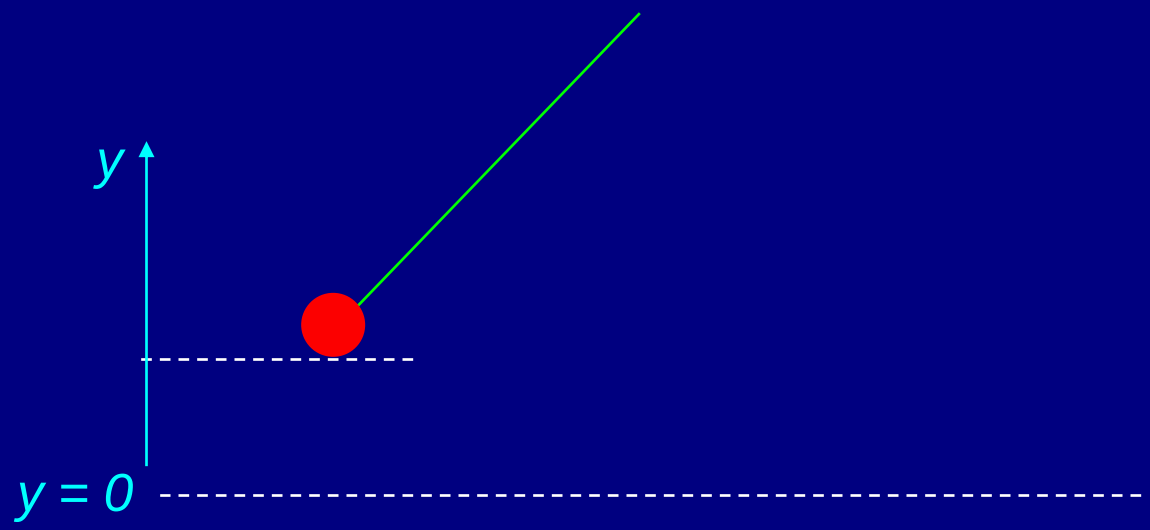
- Kinetic+potential energy is conserved since gravity is a conservative force ($E = K + U$ is constant)
- Choose $y = 0$ at the bottom of the swing, and $U = 0$ at $y = 0$ (arbitrary choice)

$$E = {}^1/_2 mv^2 + mgy$$



Example: The simple pendulum

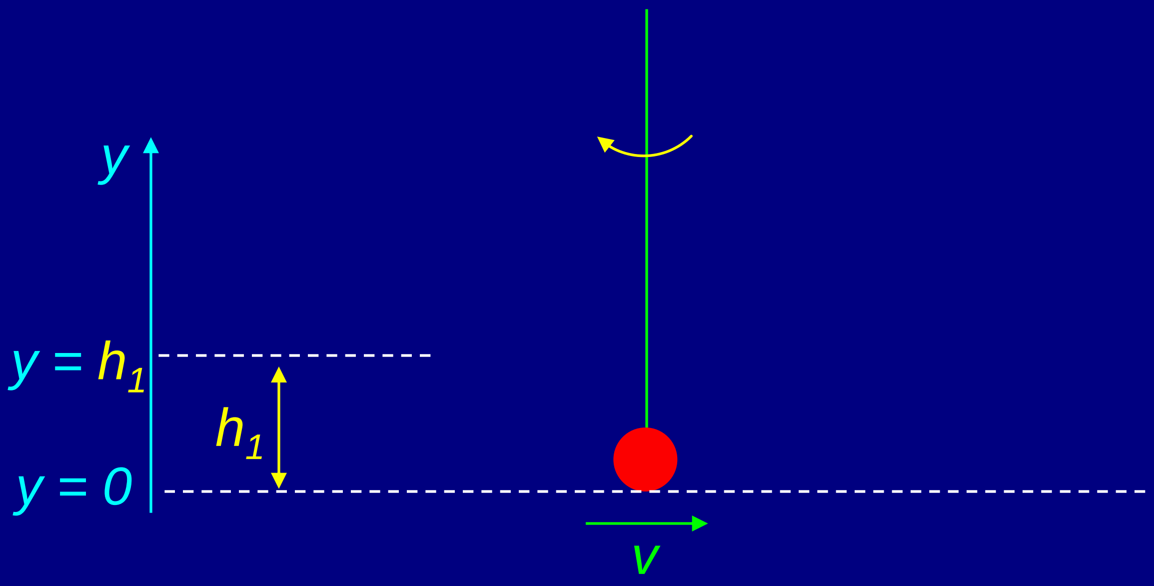
- $E = {}^1/_2 mv^2 + mgy$.
  - Initially, $y = h_1$ and $v = 0$, so $E = mgh_1$.
  - Since $E = mgh_1$ initially, $E = mgh_1$ always since energy is conserved.



Example: The simple pendulum

- $^1/_2 mv^2$ will be maximum at the bottom of the swing.
- So at $y = 0$ ⇨ $^1/_2 mv^2 = mgh_1$ ⇨ $v^2 = 2gh_1$

$$\boxed{v = \sqrt{2gh_1}}$$



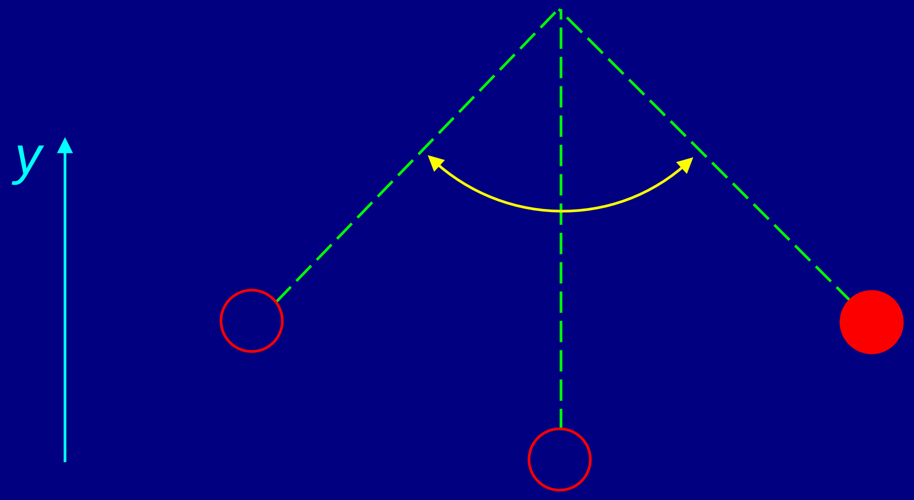
Example: The simple pendulum

- Since $E = mgh_1 = {}^1/_2mv^2 + mgy$ it is clear that the maximum height on the other side will be at $y = h_1 = h_2$ and $v = 0$.
- The ball returns to its original height.

Example: The simple pendulum

- The ball will oscillate back and forth. The limits on its height and speed are a consequence of the sharing of energy between K and U.

  $E = {}^1/_2 mv^2 + mgy = K + U = constant$.



Generalized Work/Energy Theorem:

$$W_{NC} = \Delta K + \Delta U = \Delta E_{mechanical}$$

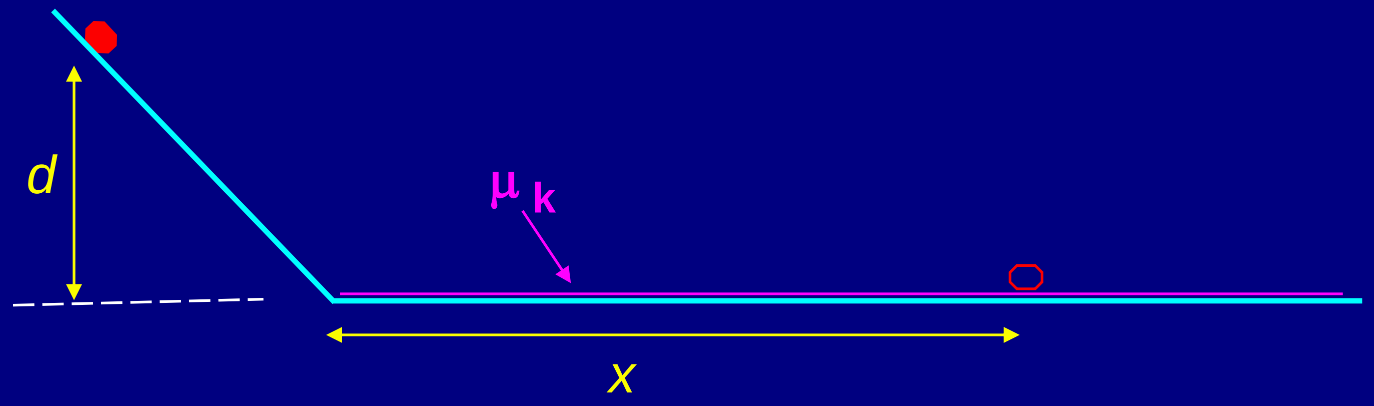
- The change in kinetic+potential energy of a system is equal to the work done on it by non-conservative forces. $E_{mechanical}$ =K+U of system not conserved!

⇐If all the forces are conservative, we know that K+U energy is conserved: $\Delta K + \Delta U = \Delta E_{mechanical} = 0$ which says that $W_{NC} = 0$.

⇐If some non-conservative force (like friction) does work, K+U energy will not be conserved and $W_{NC} = \Delta E$.

Problem: Block Sliding with Friction

- A block slides down a frictionless ramp. Suppose the horizontal (bottom) portion of the track is rough, such that the coefficient of kinetic friction between the block and the track is μ_k.
  - How far, *x*, does the block go along the bottom portion of the track before stopping?

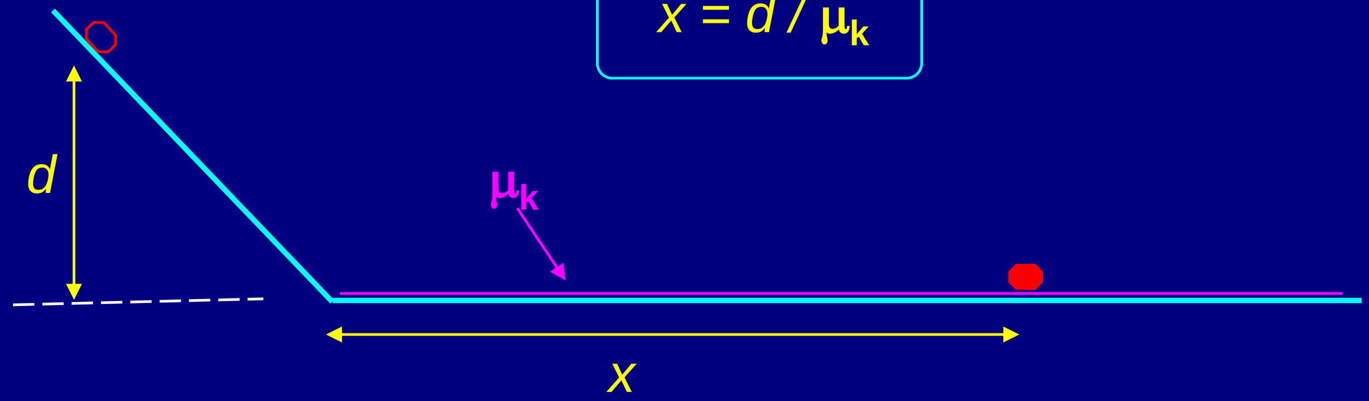


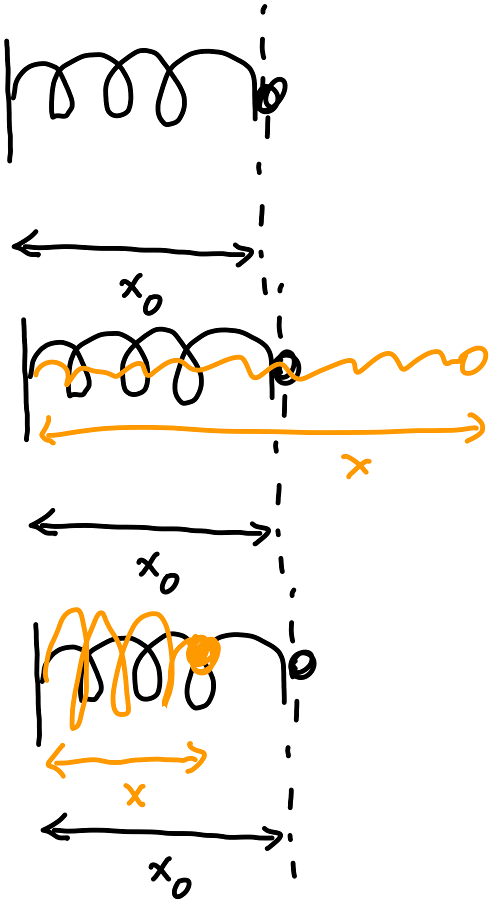
Problem: Block Sliding with Friction...

- Using $W_{NC} = \Delta K + \Delta U$
- As before, $\Delta U = -mgd$
- W_{NC} = work done by friction $= -\mu_k mgx$.
- $\Delta K = 0$ since the block starts out and ends up at rest.
- $W_{NC} = \Delta U \quad \Rightarrow \quad -\mu_k mgx = -mgd$

$$\Downarrow$$

$$\boxed{x = d / \mu_k}$$





Springs

$F \propto |x - x_0|$

$x_0 \equiv$ natural length

$|F| = k|x - x_0|$

$k \equiv$ spring constant

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

Hooke's Law

restoring force

$F = k|x - x_0|$ magnitude form - use common sense

$F = kx$ (define $x_0 = 0$)

We'll come back to springs shortly ...

Energy is conserved

$$\underline{\sum E_{initial}} = \sum E_{Final}$$

$\sum$ KE and PE

U = Potential energy

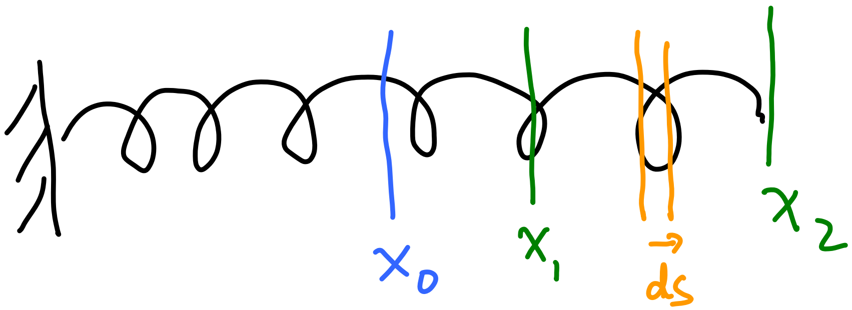
$$W_{done} = \Delta KE + \Delta PE$$

(nonconservative)

friction

$$= \Delta K + \Delta U$$

Energy in Springs



Stretch spring from x_1 to x_2

Work done on spring to move it from

$$x_1 \to x_2$$

$\vec{F}$

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

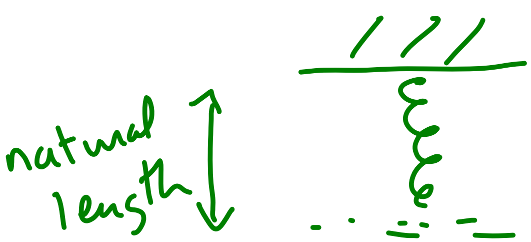
$\longleftarrow k(x - x_0)$ $\longrightarrow F_{exerted}$

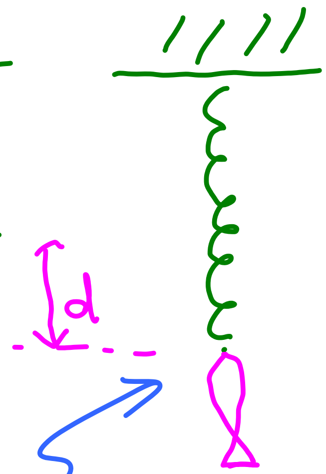
let $x_0 = 0$ $$\int_{x_1}^{x_2} kx\,dx = \frac{1}{2}k(x_2^2 - x_1^2)$$

$$W = PE_{end} - PE_{start}$$

$$PE_{spring} = \frac{1}{2} k x^2$$

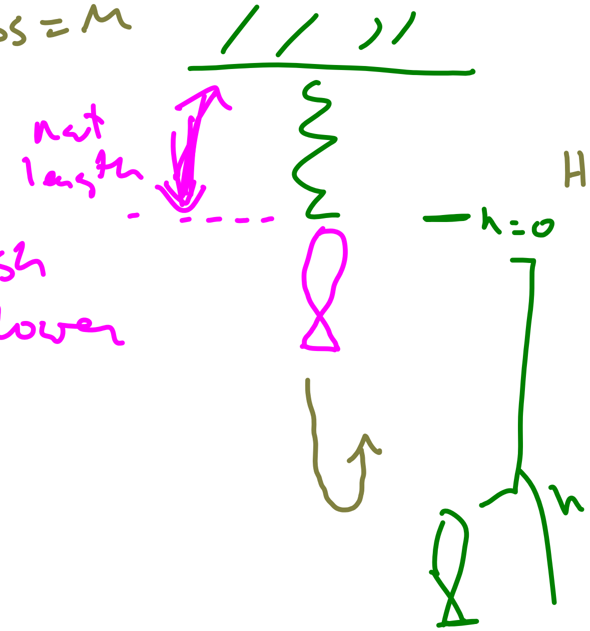
dist from nat. lengths





Fish mass = m

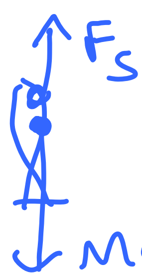
Attach fish
Slowly lower



How low does fish go when let go

$\sum F_y = 0$

$F_s = mg$



$kd = mg$

$$\boxed{k = \frac{mg}{d}}$$

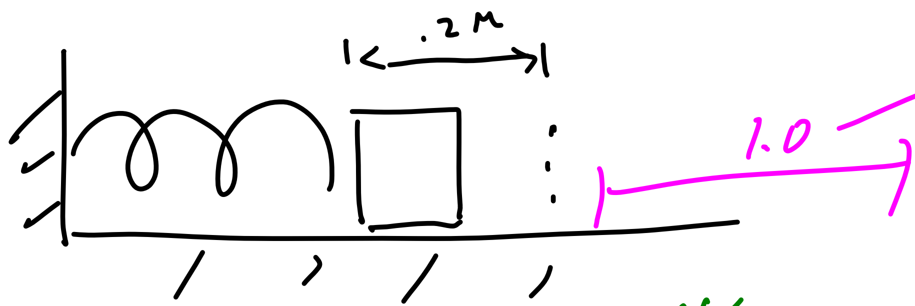
$mgh = \frac{1}{2} k h^2$

$\Delta PE_{grav} = mgh$

$\Delta PE_{spring} = \frac{1}{2} k h^2$

$$\cancel{mg}\,\cancel{h} = \frac{1}{2}\,\frac{\cancel{mg}}{d}\,h^{\cancel{2}}$$

$$h = 2d$$



$K_{spring} = 100$ N/m

Block has mass 0.5 Kg

Spring compressed 0.2 m

release block

moves 1.0 m

before comes to rest

what is μ_k

$PE_{spring\ initial} \rightarrow W_{done\ by\ friction}$

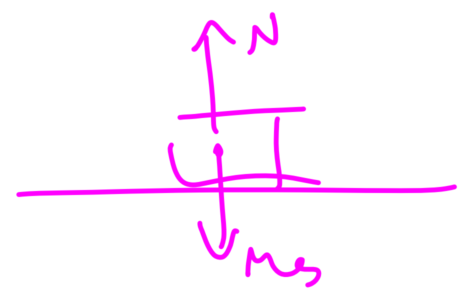
$$\frac{1}{2} k x^2 = \mu_k N d$$

100

.2 m

mg

1.0 m



$$\mu_k = \frac{kx^2}{2Mgd} \qquad \mu_k = 0.41$$

$$\text{Power} = \frac{\Delta W}{\Delta t}$$

$$P = \frac{dW}{dt} = \frac{\text{Joules}}{s} \equiv \text{Watt}$$

Potential Energy + Force

$$W = Fd$$

$$\underline{\underline{dW}} = F\,dx$$

$$dU = F\,dx$$

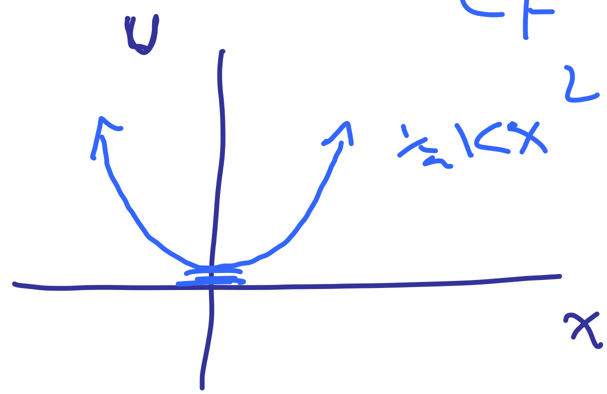
Pot. Energy

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

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

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

↳ F



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