Phy 4A 10/26

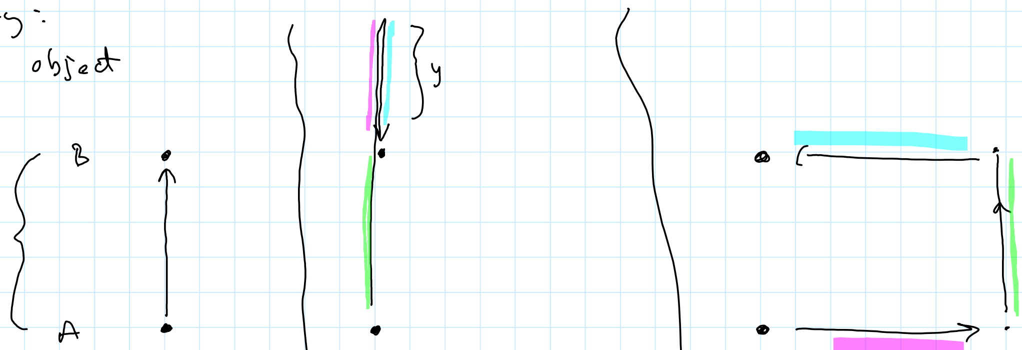
Wednesday, October 26, 2016 10:00 AM

Goals for the Lecture:

1) Use the Work – Kinetic Energy Theorem to solve problems
2) Understand how defining your system can affect the work done on the system or by the system
3) Calculate kinetic and potential energy

Conservative and Non-conservative Forces

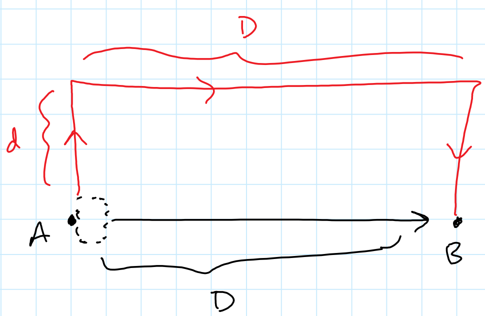
Force of gravity:
Lift an object



$W = -mgh$ | $W = -mgh - mgy + mgy = -mgh$ | $W = 0 - mgh + 0 = -mgh$

So, gravity is a conservative force
(W does not depend on path taken)

Friction:



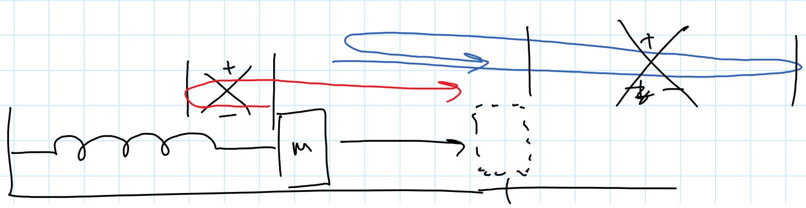
$W_{friction} = -f_k D = -\mu_k mgD$

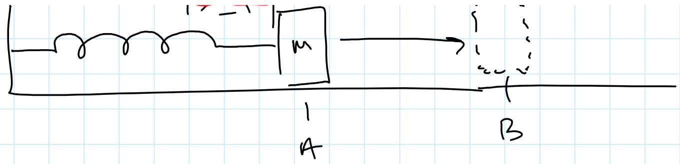
$W_{friction} = -\mu_k mgd - \mu_k mgD - \mu_k mgd$

Not the Same

So, Non-conservative force
(Work does depend on path taken)

Spring:





Spring force is a conservative force

Any conservative force $\longrightarrow$ Potential Energy

$$W_{A\to B} = \int \vec{F}\cdot d\vec{x} \quad \text{in general}$$

$$= \vec{F}\cdot \Delta\vec{x} \quad \text{for gravity}$$

$$= -(mgy_f - mgy_i) = -\Delta U_g$$

U_g define gravitational Potential Energy, $U_g = mgy$

$\left.\begin{matrix} U_{sp} \\ U_E \end{matrix}\right\}$ for a spring

Spring:

$$W = \int \vec{F}\cdot d\vec{x}$$

$$= \int -k\vec{x}\cdot d\vec{x}$$

$$= -\tfrac{1}{2}kx_f^2 + \tfrac{1}{2}kx_i^2$$

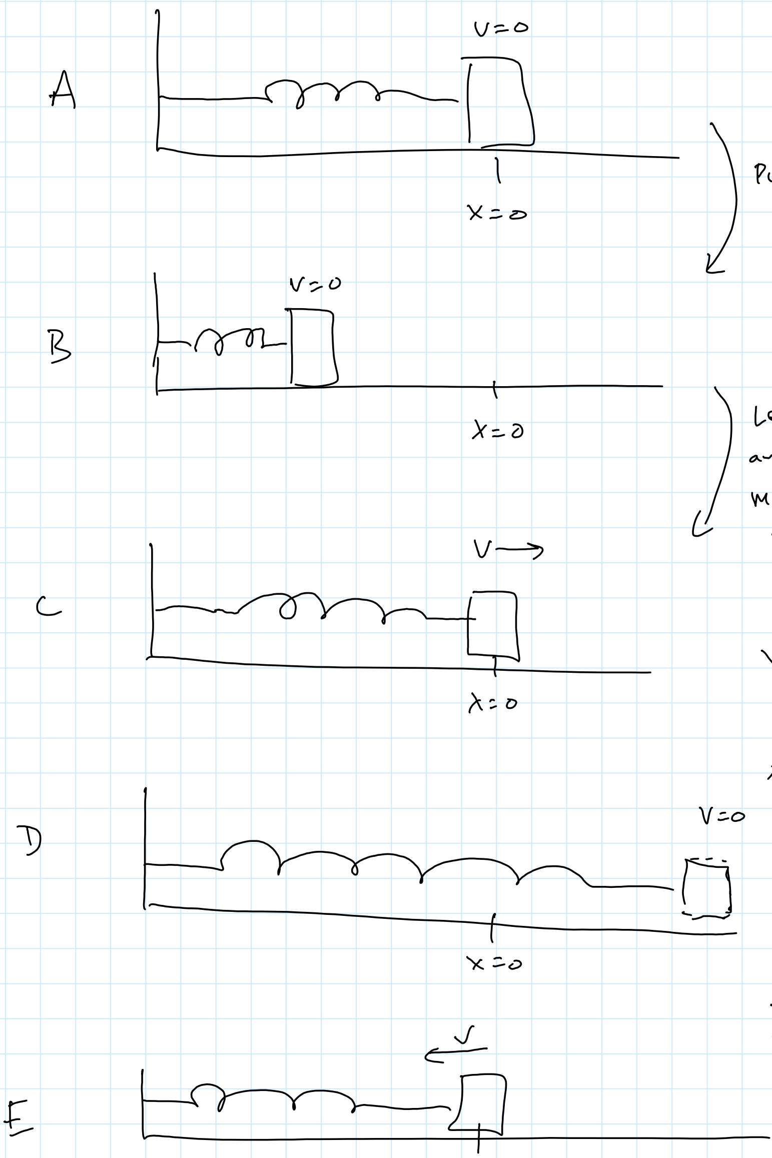
$$= -\Big(\underbrace{\tfrac{1}{2}kx_f^2}_{U_{sp}} - \tfrac{1}{2}kx_i^2\Big)$$

$$= -\Delta U_{sp}$$

$U_{sp} = \frac{1}{2}kx^2$ Potential energy in a spring (always positive)

$W_{sp} = \pm \frac{1}{2} k x^2$ can be + or −

Work done by Spring on box



A → B: Push box and compress Spring — $W_{A\to B} < 0$

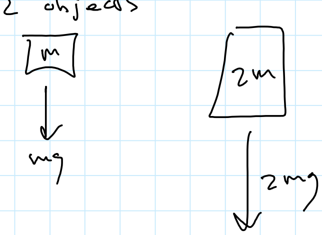
B → C: Let go and box moves to Right — $W_{B\to C} > 0$

C → D: box come to Rest — $W_{C\to D} < 0$

D → E: Box moves to the left — $W_{D\to E} > 0$

$F = ma \Rightarrow a = \frac{F}{m}$

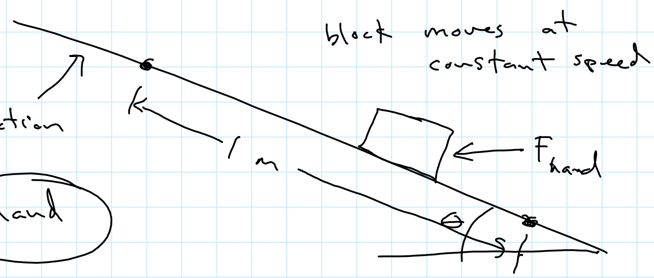
Drop 2 objects



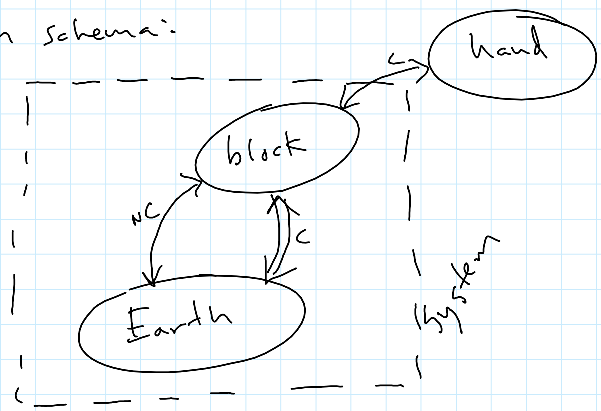
$a = \frac{mg}{m} = g$ $a = \frac{2mg}{2m} = g$

$a = \frac{mg}{m} = g$ $\quad a = \frac{2mg}{2m} = g$

Potential Energy (Interaction energy)

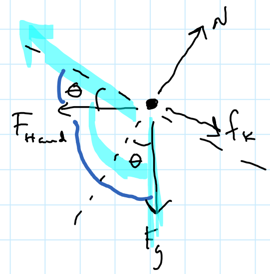


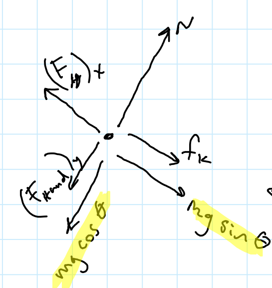
1) System schema:



2) Free body diagram: block

$W_{F_g} = (\Delta x)\, mg \cos(90+\theta)$





$W_{f_k} = (\Delta x)(f_k)_x \cos 180°$

$(F_{Hand})_y = F_{Hand} \sin\theta$

$(F_{Hand})_x = F_{Hand} \cos\theta$

3) given:

$\Delta x = 1$ m

$m = 10$ kg

$\theta = 30°$

$F_{Hand} = 100$ N

use $g = 10\ \frac{m}{s^2}$

Find: $\mu_k = ?$

Plan: $W_{net} = \underbrace{\Delta K}_{0}$ since v is constant

Force | Work done on box

Find N:

$\Sigma F_y = 0$

$N = F_H \sin\theta + mg\cos\theta$

$= 50 + 87$

$= 137$ N

Force	Work done on box
N	$W_N = N(\Delta x)\cos 90° = 0$
f_k	$W_{f_k} = f_k(\Delta x)\cos 180° = -137\,\mu_k$
F_g	$W_g = mg(\Delta x)\cos(90+\theta) = -50$ J
F_H	$W_H = F_H\,\Delta x\,\cos\theta = +87$ J

$-(\Delta x)mg\sin\theta$ or $(\Delta x)(mg)\cos(90+\theta)$

$$W_{net} = 0 = 0 - 137\mu_k - 50 + 87$$

$$137\mu_k = 37$$

$$\mu_k = 0.27$$

Mechanical Energy: $E \rightarrow K, U_g, U_{sp}$

we want to say:

$$E_i = E_f$$

energy can enter or leave our system:

$$E_i + W_{ext} = E_f$$

friction can change the total mechanical energy:

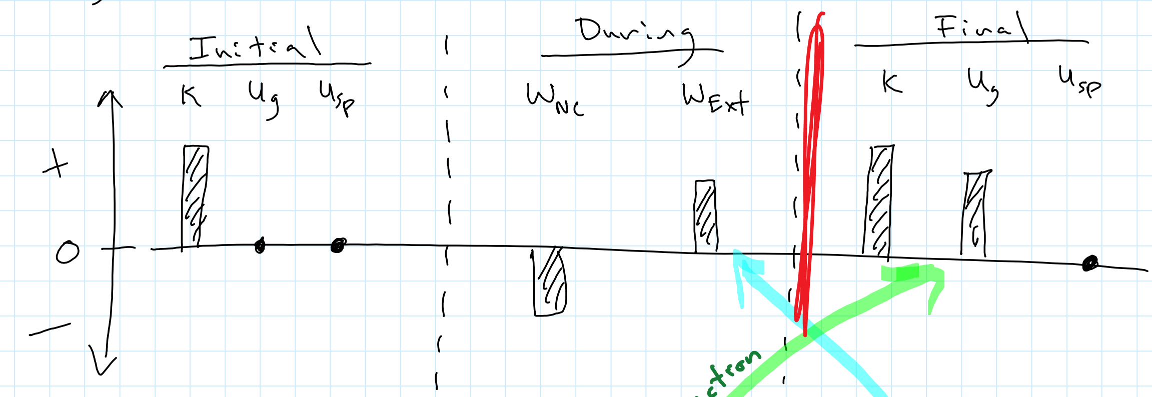
$$E_i + W_{NC} + W_{ext} = E_f$$

W_{NC} ↑ Non-conservative (like friction)

Why + ? Because W_{NC} is negative

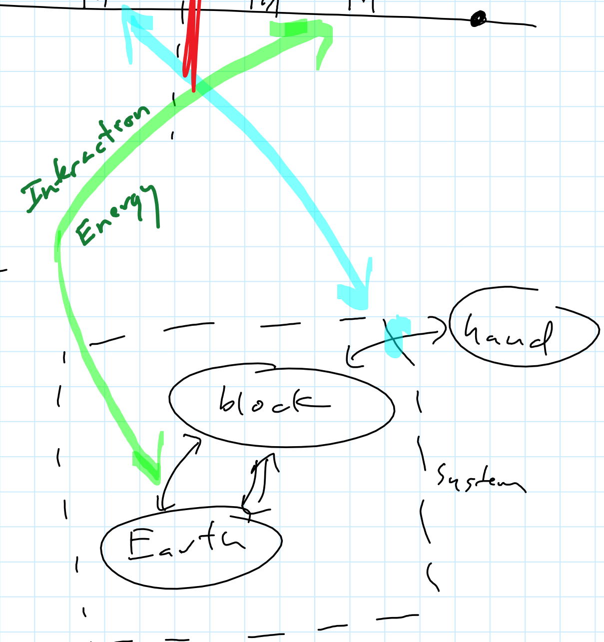
Energy Bar Chart

Energy Bar Chart



Why did we get this bar chart ↗

Because of our choice of the system

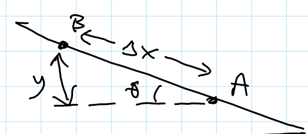


Equation (from bar chart):

$$K_i + (U_g)_i + (U_{sp})_i + W_{NC} + W_{ext} = K_f + (U_g)_f + (U_{sp})_f$$

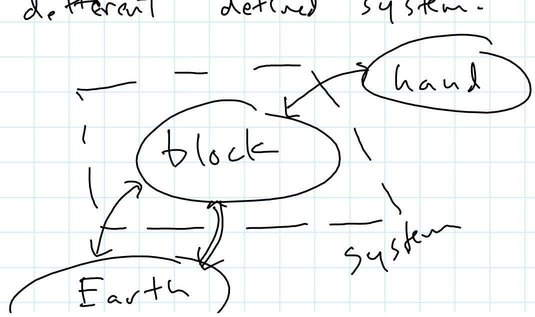
$$\frac{1}{2}mv_i^2 + 0 + 0 - f_k \Delta x + F_H \cos\theta \, \Delta x = \frac{1}{2}mv_f^2 + mgy + 0$$

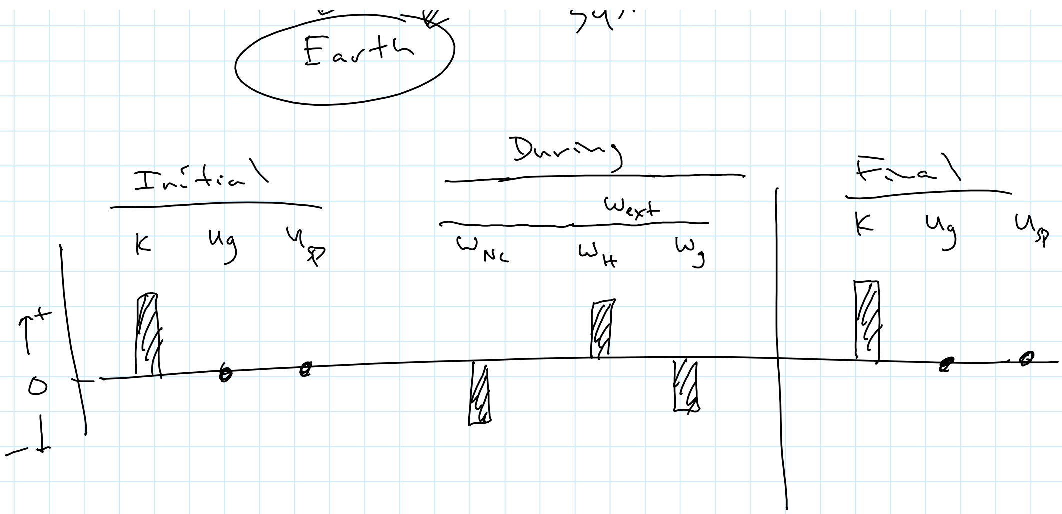
$v_i = v_f$



$y = \Delta x \sin\theta$

Again, with a different defined system:




Earth
Initial
K
U_g
U_{sp}
During
W_{ext}
W_{NC}
W_H
W_g
Final
K
U_g
U_{sp}
+
0
−