

HW 9 is due today, 3/31, Monday.

New schedule for Physics Learning Center (401 Tiernan):  
<http://web.njit.edu/~kenahn/08spring/phy105.htm>

## Work and Energy

Kinetic energy in 1D, 2D, 3D

Work in 1D

Work-Energy Theorem

Work in 2D, 3D & Dot product

Work by multiple forces

Last class...

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Conservative vs. Non-conservative forces

Today...

Gravitational Potential Energy

Conservation of Mechanical Energy

Work by Non-conservative force

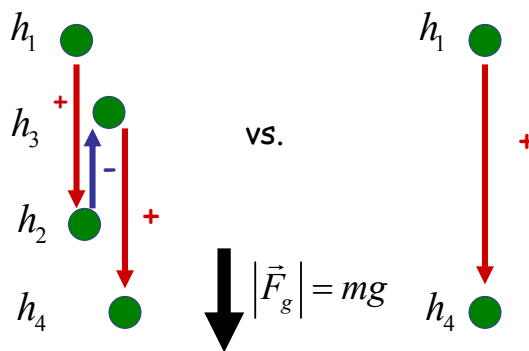
### Motivation

Why do we learn about potential energy and conservation of mechanical energy?



### Conservative force

Work done by a gravity force

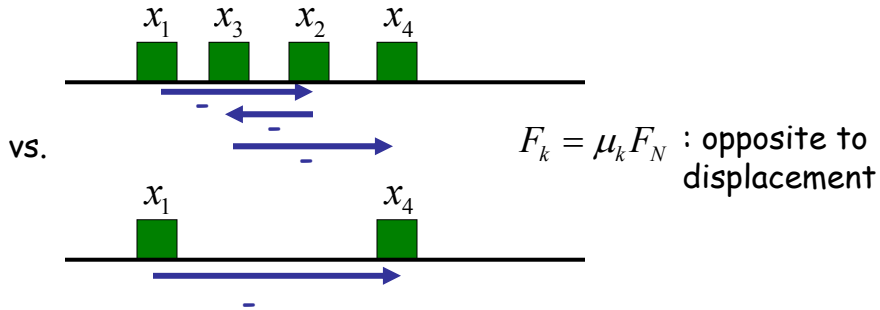


$$(\text{Work along } h_1 \rightarrow h_2 \rightarrow h_3 \rightarrow h_4) = (\text{Work along } h_1 \rightarrow h_4) = mg(h_1 - h_4)$$

Work done by a conservative force depends only on the initial and final positions.

## Non-Conservative force

Work done by a friction force



(Work along  $x_1 \rightarrow x_2 \rightarrow x_3 \rightarrow x_4$ )  $\neq$  (Work along  $x_1 \rightarrow x_4$ )


Work done by a non-conservative force depends on the path from initial to final position.

Conservative forces in Phys 105:  
Gravity, Spring force

Let's consider spring force later...

Non-Conservative forces in Phys 105:  
Friction, Normal force, Tension, Other applied forces

## Gravitational Potential Energy

  $F_g = mg$

$h_i$  ● (Work done by gravity on object with mass  $m$ )

$$= W_g = mg(h_i - h_f)$$
$$= mgh_i - mgh_f$$

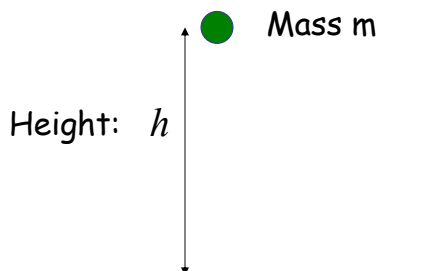
$h_f$  ●  $= U_{g,i} - U_{g,f}$

$U_g = mgh$  → Gravitational Potential Energy

$$W_g = U_{g,i} - U_{g,f} = -(U_{g,f} - U_{g,i}) = -\Delta U_g$$

→ Work done by gravity is negative of gravity P.E. change

## Gravitational Potential Energy

 ● Mass  $m$

Height:  $h$

Gravitational Potential Energy:

$$U_g = mgh$$

(Note: Height,  $h$ , should be measured along vertical direction.)

The higher and the heavier an object is,  
the greater the gravitational potential energy is.

### Quick Quiz

Which one has a larger gravitational potential energy?

Bowling ball on the top shelf of a bookcase ←

vs.

Tennis ball on the top shelf of a bookcase

Baseball on the bottom shelf of a bookcase

vs.

Baseball on the top shelf of a bookcase ←

### Conservation of Mechanical Energy

Work-Energy Theorem:  $K_f - K_i = W_{net}$

If  $W_{net} = W_g$

$$K_f - K_i = W_{net} = W_g = U_{g,i} - U_{g,f}$$

$$\rightarrow \underline{K_f + U_{g,f} = K_i + U_{g,i}}$$

$$\rightarrow \underline{E_{mech,f} = E_{mech,i}}$$

Mechanical energy,  $E_{mech} \equiv K + U_g$

is conserved, if gravity is the only force that does work.

Example1: Ice on a frictionless surface

Example2: Tarzan

### Mechanical Energy and Non-conservative force

If both non-conservative and conservative forces do work,  
for example, friction and gravity,

$$W_{net} = W_{nc} + W_c = W_{nc} + W_g \quad (\text{nc}=\text{non-conservative})$$

$$\rightarrow \underline{K_f - K_i} = W_{net} = W_{nc} + W_g = \underline{W_{nc} + U_{g,i} - U_{g,f}}$$

$$\rightarrow K_f + U_{g,f} = W_{nc} + K_i + U_{g,i}$$

$$\rightarrow E_{mech,f} = W_{nc} + E_{mech,i}$$

$$\rightarrow \underline{E_{mech,f} - E_{mech,i}} = \Delta E_{mech} = W_{nc}$$

(Work by non-conservative force) = (Change in mech. E.)

Example3: Box sliding on partly rough surface I