Spring 2014

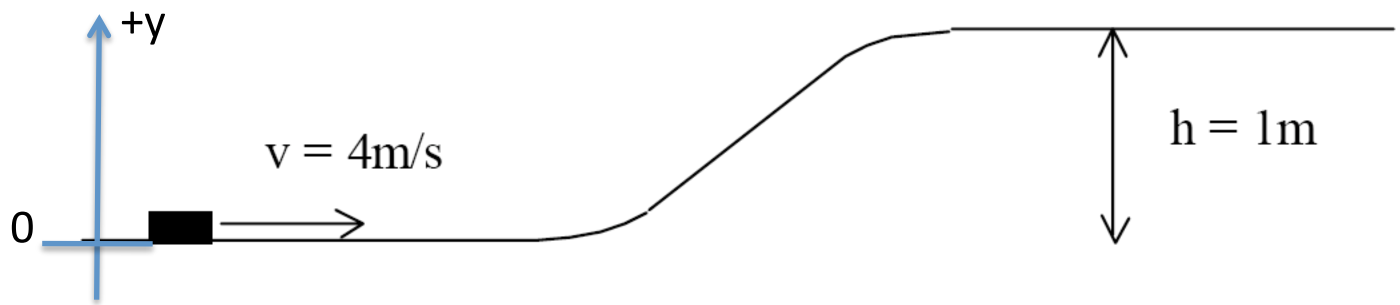
PHYS-2010

Lecture 26

Clicker Question

Room Frequency BA

A hockey puck slides **without friction** along a frozen lake toward an ice ramp and plateau as shown. The speed of the puck is 4 m/s and the height of the plateau is 1 meter.



Will the puck make it all the way up the ramp?

A) Yes B) No C) Depends on the puck mass

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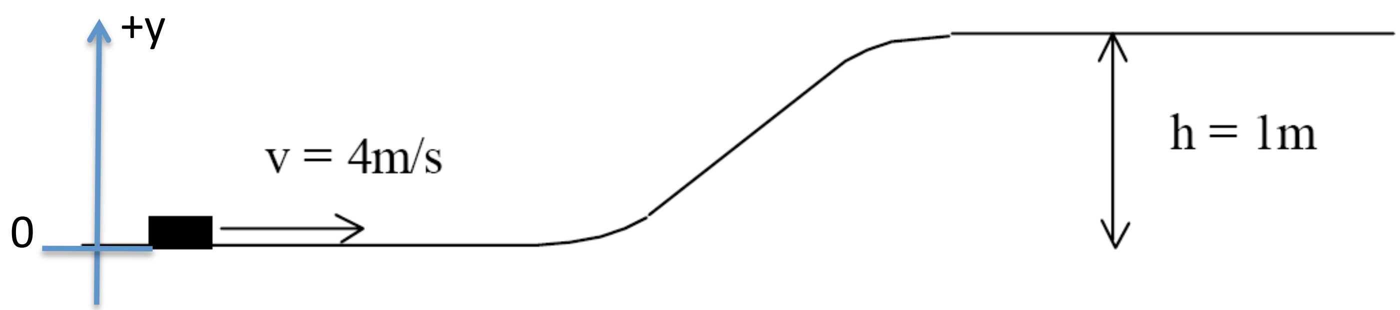


Will the puck make it all the way up the ramp?

A) Yes

B) No

C) Depends on the puck mass

ME(initial) = $KE_i + PE_i = ½\, mv^2 + 0$ = (8 x mass) Joules

ME(on the plateau) = $KE_p + PE_p = ½\, mv_p^2 + mgh$

>= (9.8 x mass) Joules

Not enough energy to get up the ramp!

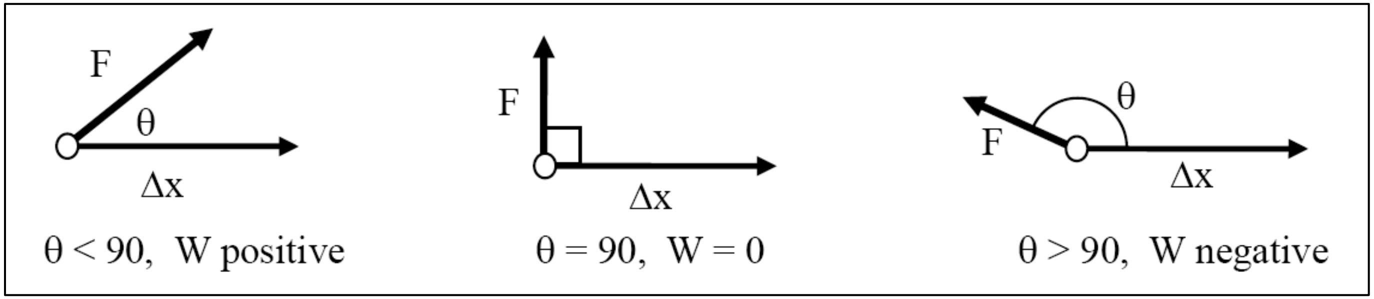
Announcements

- Read Giancoli **Chapter 6**.
- **Written homework** due today at 4 pm.
- CAPA # 9 due next Tuesday.
- I will be **out of town next week**; lectures will be given by Prof. Pollock.

1. Work:

$$W_F \equiv F_x \cdot d = F\cos\theta\, d = F_{||}\, d$$

Component of "specific" force along displacement x displacement:



2. Kinetic Energy:

$$KE = \frac{1}{2}mv^2$$

3. Work – Energy Principle:

$$W_{net} = W_{Fnet} = \Delta KE = KE_f - KE_i$$

4. Potential energy:

PE is the amount of work done on a system by an external force when KE does not change and no heat flows (no friction):

$$\Delta PE = W_{ext} \quad \text{when } \Delta KE = 0$$

Example: $PE_{grav} = mgy$

5. Conservation of "Mechanical Energy":

$$E_{mechanical} = KE + PE = \text{constant}$$

(isolated system, no dissipation)

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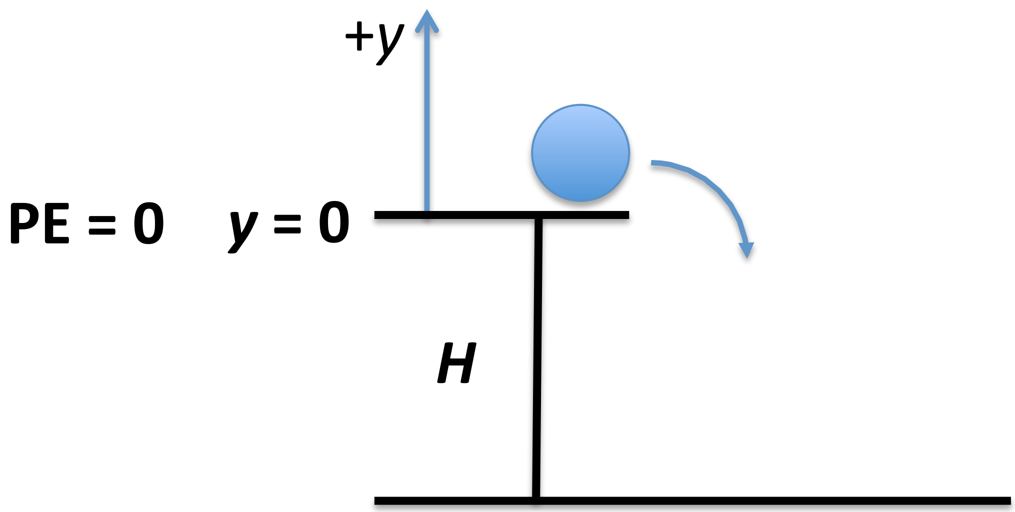
A ball, initially at rest at the edge of a table, drops to the floor. What is the ***mechanical energy*** of the ball just before it hits the floor?

We choose the potential energy to be zero at the level of the table top.
+y
Neglect air resistance.



A) Positive

B) Zero

C) mhg

ME = KE + PE is conserved:

$ME_f = ME_i = KE_i + PE_i = 0$

$KE_f > 0$ but $PE_f = -mgH < 0$

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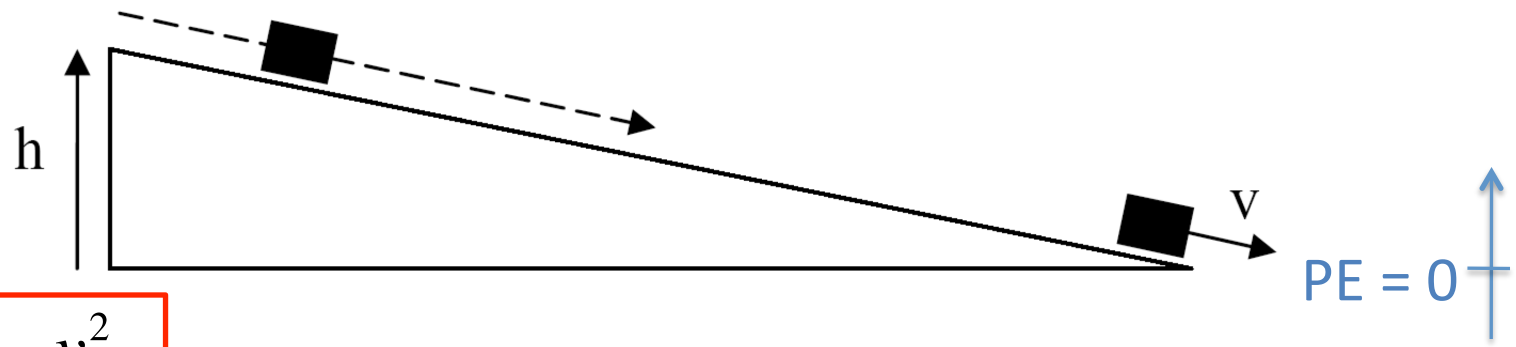
A block initially at rest is allowed to slide down a frictionless ramp and attains a speed **v** at the bottom.

How is the initial height **h** related to the speed at the bottom of the ramp?



A) $h = \dfrac{v^2}{2g}$

B) $h = \sqrt{2gv}$

C) $h = \sqrt{g / v}$

D) $h = \dfrac{v^2}{g}$

$$E_i = E_f$$

$$KE_i + PE_i = KE_f + PE_f$$

$$0 + mgh = \frac{1}{2}mv^2 + 0$$

$$h = \frac{v^2}{2g}$$

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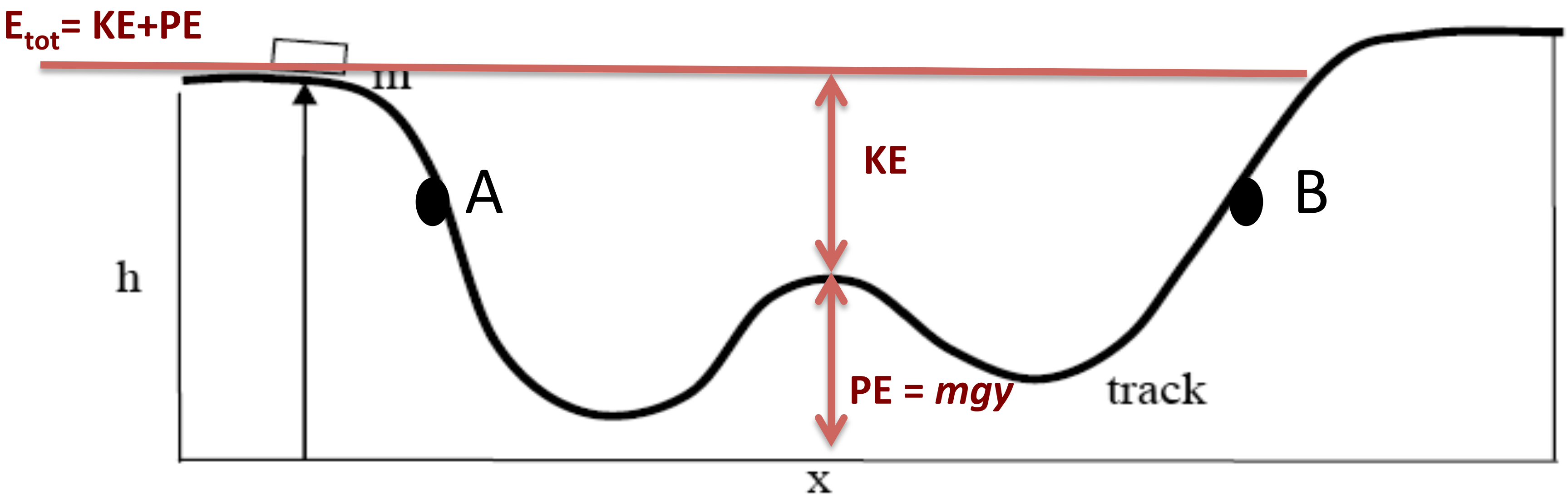
Roller Coaster Problem



Assume an isolated system (no external work).
Assume no dissipation from friction (i.e. thermal energy generation)

Which of the following is true:

A) Speed at position A = Speed at position B
B) Speed at position A > Speed at position B
C) Speed at position A < Speed at position B

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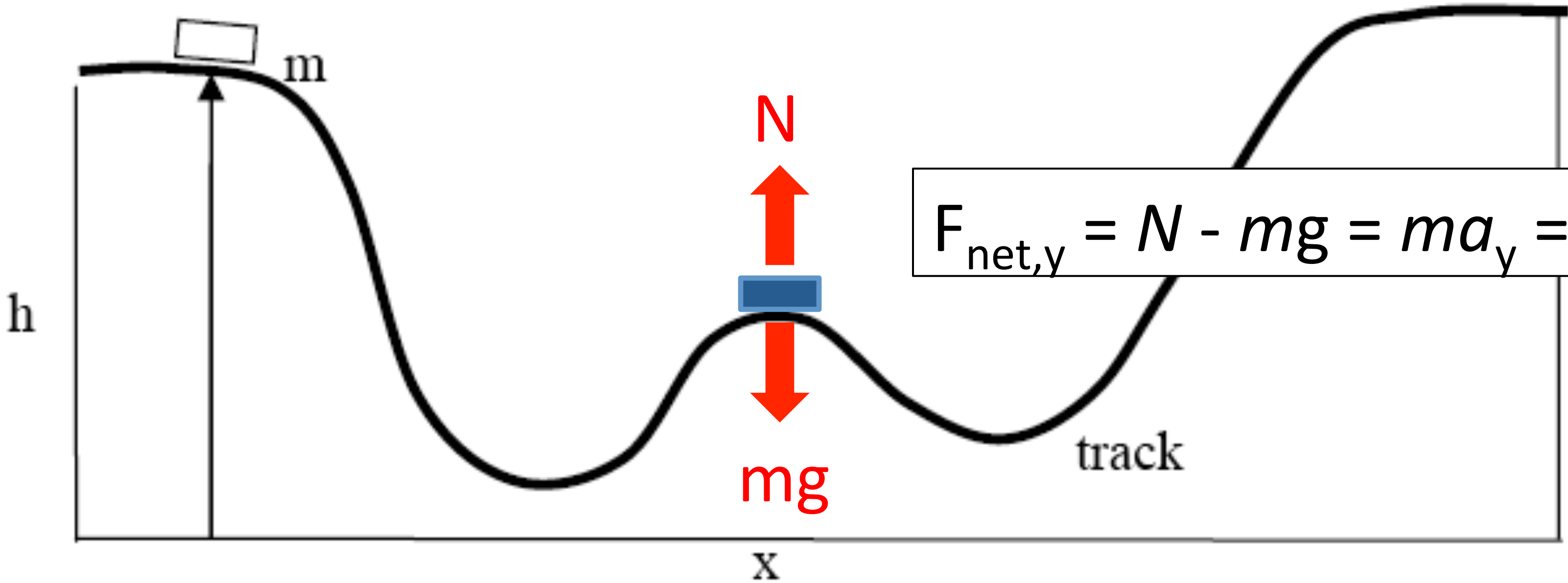
Roller Coaster Problem



$F_{net,y} = N - mg = ma_y = 0$

If the car is just sitting at the top of this hill:

A) The net force on the car is upward.

B) The net force on the car is downward

C) The net force on the car is zero

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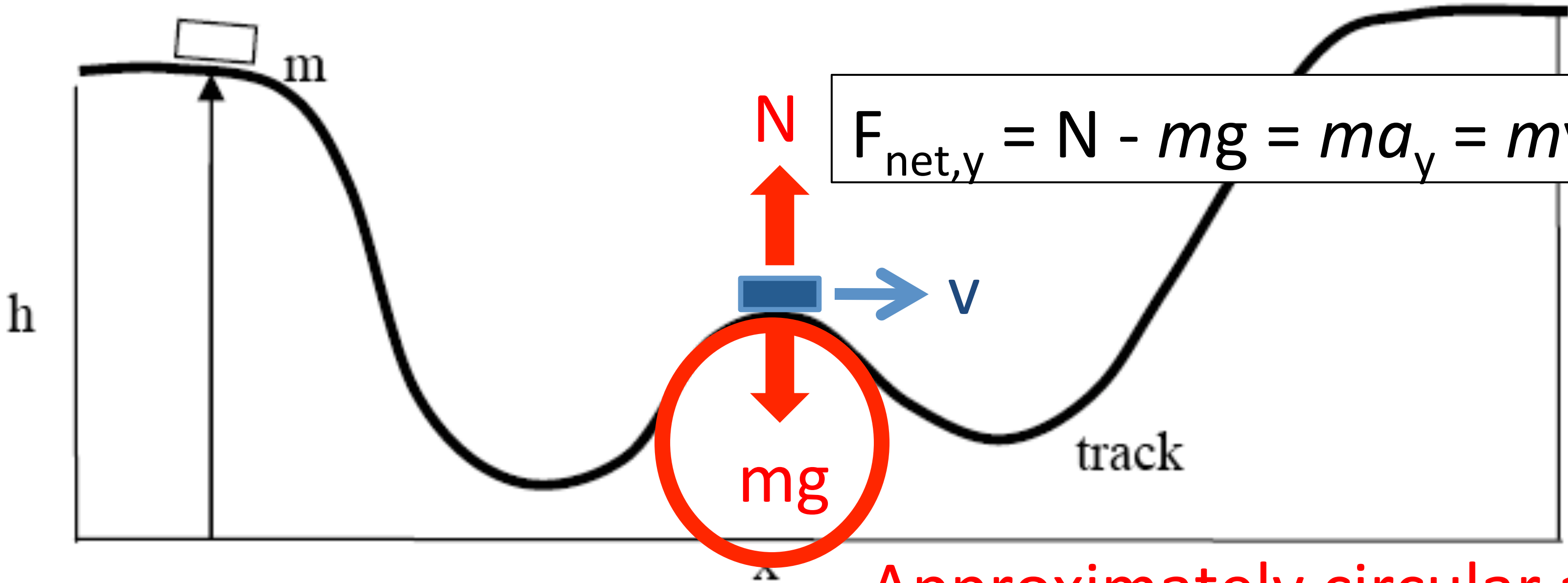
Roller Coaster Problem



$F_{net,y} = N - mg = ma_y = mv^2/r$

Approximately circular arc

If the car moving rightward at the top of this hill:

A) The net force on the car is upward.

B) The net force on the car is downward

C) The net force on the car is zero

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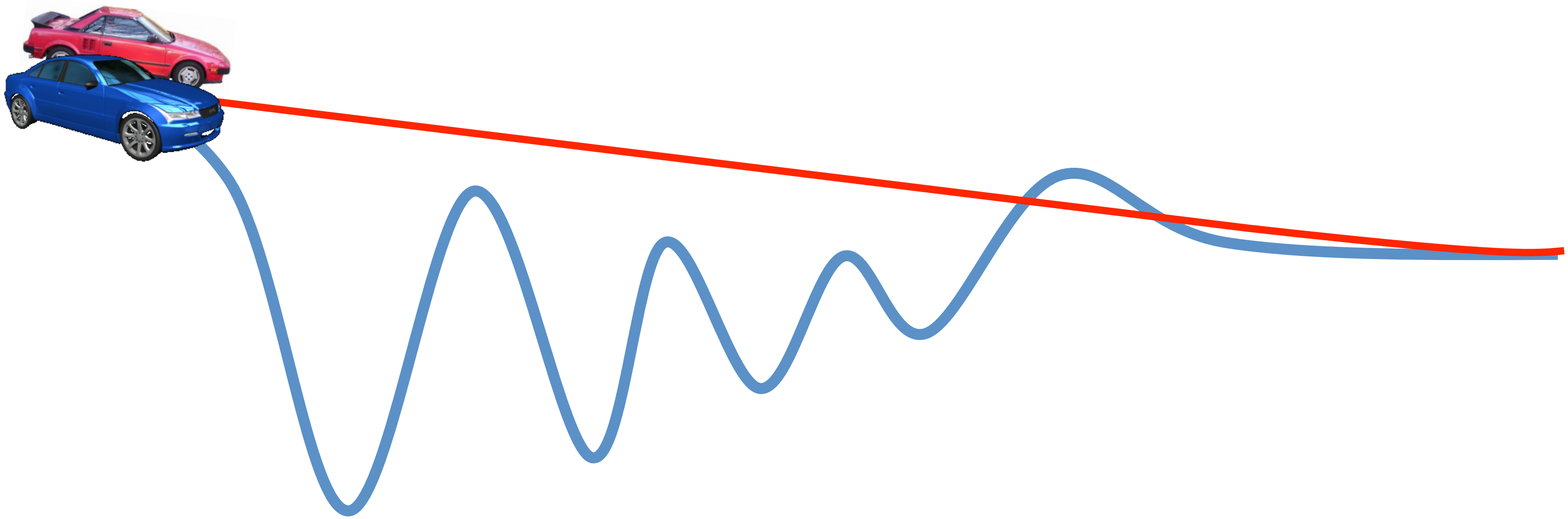

A blue car coasts in neutral (no stepping on the gas or brakes) down the blue path.

A red car coasts in neutral (no stepping on the gas or brakes) down the red path.

If only gravity is acting (no friction!), then:

A) The red car ends up with a larger velocity;

B) The blue car ends up with a larger velocity;

C) The two velocities are equal at the end.

Conservation of Energy with Friction

$$\Delta E_{mechanical} + \Delta E_{thermal} = W_{external}$$

$E_{mechanical} = KE + PE$

$\Delta E_{thermal}$ = thermal energy generated = $- W_{friction} > 0$

$W_{frict} = - F_{friction}\, \Delta x = - \mu_k\, N\, \Delta x < 0$

$W_{external}$ = external work done on the system

$W_{external}$

Can change total energy of the system

System

Energy can transform between PE and KE and $E_{thermal}$

General Statement of Conservation of Energy

$$\Delta E_{mechanical} + \Delta E_{thermal} = W_{external}$$

or

$$KE_i + PE_i + W_{frict} + W_{external} = KE_f + PE_f$$

$W_{external} > 0$ if external work is done on the system

$W_{external} < 0$ if external work is done by the system

$W_{external} = 0$ if no external work is done on or by the system

$W_{frict} < 0$ if there is friction

$W_{frict} = 0$ if there is no friction

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$$KE_i + PE_i + W_{frict} + W_{external} = KE_f + PE_f$$

Under what condition will the final mechanical energy be greater than the initial mechanical energy?

A) $W_{external} > |W_{friction}|$

B) $W_{external} < |W_{friction}|$

C) $W_{external} = |W_{friction}|$

D) It will never be greater than the initial mechanical energy

E) It will always be greater than the initial mechanical energy

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$$KE_i + PE_i + W_{frict} + W_{external} = KE_f + PE_f$$

Under what condition will $W_{external}$ be negative?

A) If the external work is done on the system.

B) If the external work is done by the system.

C) It will never be negative.

D) It will always be negative.

If there is work done by the system, the system loses energy to the surroundings that it does work on.

One has to be careful about the definition of the "system"

System = everything in the box

Friction between hippo and rug converts mechanical energy to thermal energy.

However, no external work. All energy remains within the system (isolated).

System = the hippo

Friction between hippo and rug converts mechanical energy to thermal energy.

Friction force of rug on the hippo is now an external force. Thus energy leaves the system.

Conservative Forces

The effect of some forces is expressed as a Potential Energy:
e.g., gravity, elastic forces produced by springs (later).

These forces are said to be **Conservative**.

For conservative forces, the work done depends only on the starting and ending points, not the path taken while the force is being applied.

The work done by some other forces depends on the path taken:
e.g., friction. Under the action of these forces, mechanical energy is not conserved.

The friction force is **Non-Conservative**.

Its effect cannot be expressed as a Potential Energy.