Ch7: ~~Moron~~ More on Energy

When a conservative force does work on an object w/in a system, that force transfers Energy between the Kinetic Energy of the object and the Potential Energy of the system.

Ex:
Consider a system of objects:
{ Ball + ___?___ }

Drop the ball from point A and let it fall to point B.

$W = \Delta K$

And recall for a conservative force;

$W = -\Delta U$, so equate $W = W$ to get

$\Delta K = -\Delta U$

or $\Delta K + \Delta U = 0$

$(K_f - K_o) + (U_f - U_o) = 0$

$(K_f + U_f) - (K_o + U_o) = 0$

$E_f \quad - \quad E_o \quad = \; 0$, where

"E" is the Total Mechanic Energy; $E = K + U$

so $\Delta E = 0$ or $E_o = E_f$

This is the Law of Conservation of Mechanical Energy.

As the ball falls to Earth, the work done by gravity is converted into kinetic energy (at the expense of reducing the ball's potential energy).

So the total mechanic energy E of the ball (really the ball-Earth system) remains unchanged. K↑ while U↓ .

Law of Conservation of Mechanical Energy

* it holds only when conservatives force act (no fingers, strings, wind,…)

*conservative forces (gravity, spring…) lead to conservation principles.

Here's another way of looking at the falling ball problem:

Analysis:

Ch2	Ch6	Ch7
Kinematic Eq's of motion	Work-Energy Th^m	Conservation of Energy

When applying $E_o = E_f$, you will need to pick a reference point for U.

Rule of  : Let U = zero at some convenient place.
A good choice is to pick U = 0 at the lowest position that the object will/can be.

Projectile Launcher:

If the spring (k = 3 N/cm) is compressed 10cm by a 25-g ball, find the ball's exit speed if:

a) it is fired horizontally. (ignore friction in the barrel) we can apply $E_o = E_f$ to the ball-spring system.

$U_{spring} = K_f$

$\frac{1}{2}kx^2 = \frac{1}{2}mv^2 \quad \rightarrow \quad v = \sqrt{\frac{k\,x^2}{m}}$

B) what if it is fired vertically?

$E_o = E_f$

$\frac{1}{2}kx^2 = \frac{1}{2}mv^2 + mgx$

so now $v = \sqrt{\frac{k\,x^2}{m} - 2gx}$

What was the spring constant k for your launcher?

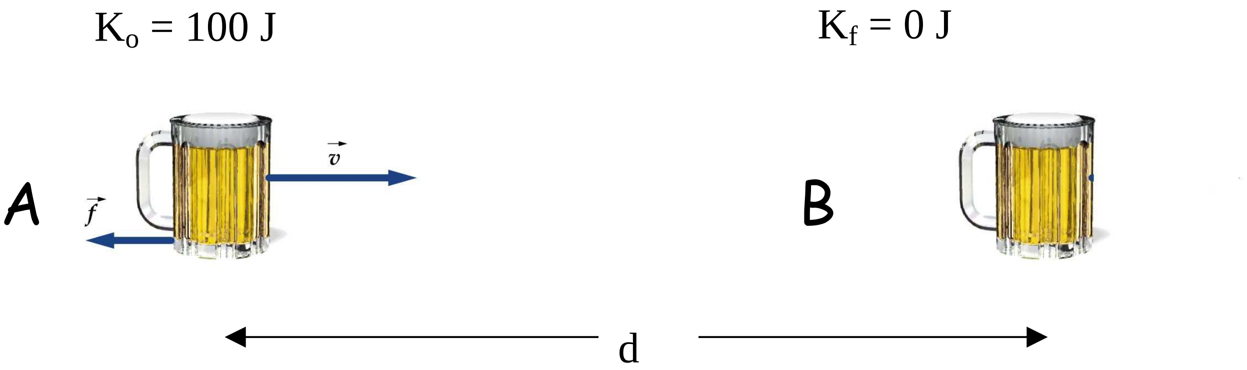
(ignoring the mass of the spring) we can apply $E_o = E_f$

$\frac{1}{2}kx^2 = \frac{1}{2}mv^2 \rightarrow k = mv^2/x^2$

(m ~ 9.66grams, and x ~ 5.5cm)

so $k \approx 65$ N/m (for v ~ 4.5 m/s)

Accounting for Nonconservative Forces



100 Joules of mechanical energy were dissipated by f_k.
Where did it go?

Do you think the Work done by friction is independent of the path?

The thermal energy (or internal energy) produced is not a mechanical potential energy.

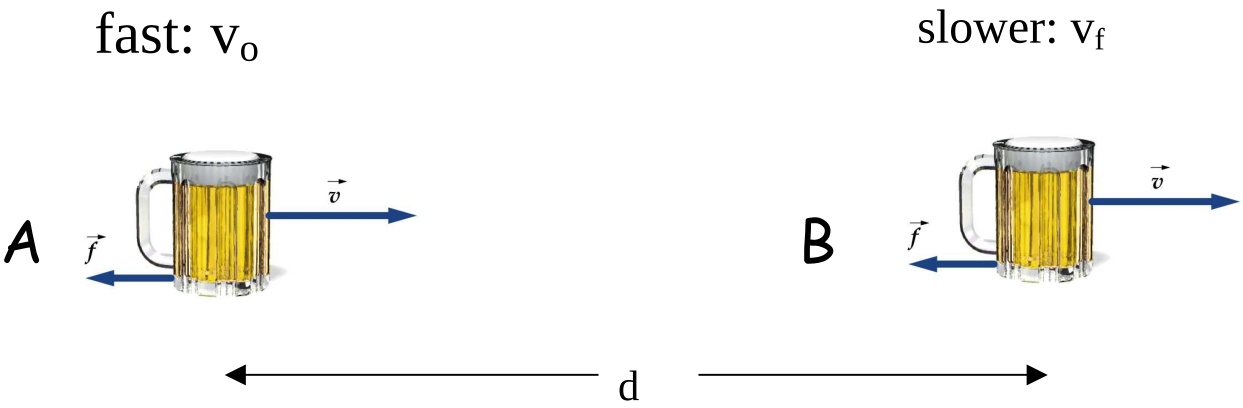
It's not a reversible process.
Thus, f_k is a nonconservative force.

f_k has no associated potential energy function (since the work done by f_k is not stored as a potential energy).

We have $\Delta K = -100$ J.

For the sliding mug, what parameters does ΔK depend on?

$\Delta K = \Delta K(?, ?,?)$



$\Delta K = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_o^2$

$\Delta K = \frac{1}{2}m\,(v_f^2 - v_o^2)$

But $v_f^2 = v_o^2 + 2ad$, so $v_f^2 - v_o^2 = 2ad$

gives $\Delta K = \frac{1}{2}m(2ad) = mad$

Applying $\Sigma F = ma$ to the sliding mug:

$- f_k = ma$, gives $\Delta K = (- f_k)d$

so we find that

$$\Delta K = -f_k d$$

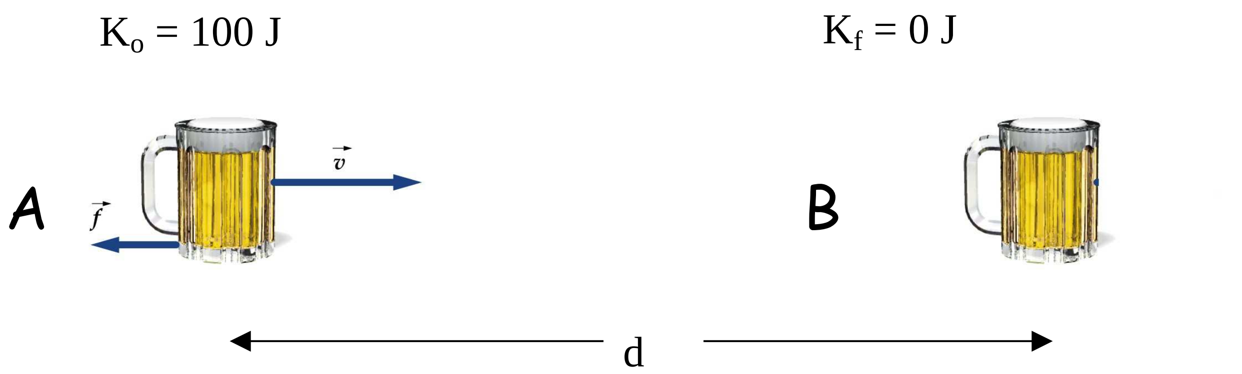
or

$$\Delta K_{NC} = -f_k d$$

$\therefore$ the kinetic energy dissipated by the kinetic friction force depends on:

* the roughness of the surfaces in contact
* the distance it slides

Lets' revisit the sliding mug…



Here ΔK_{NC} = -100 J.

It is tempting to say:

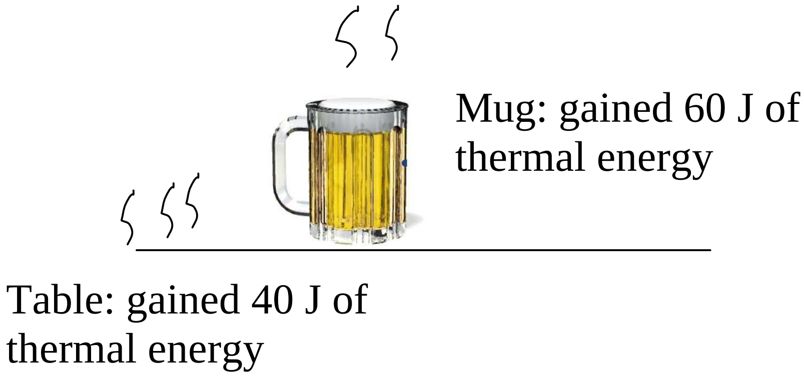
"The Work done by friction is

$W_{fk} = f_k\ d\ \cos 180^\circ = -f_k d$."

No!

W_{fk} = only the mechanical energy that 'leaves;' the mug.

Perhaps we find that:



∴ W_{fk} = - 40J, since only 40J of mechanical energy 'left' the mug.

W_{fk} is usually not easily measured or known, ∴ we don't even mention it.

All we *can* say is

ΔE = -100 J,

or more descriptively, ΔK_{NC} = -100 J.

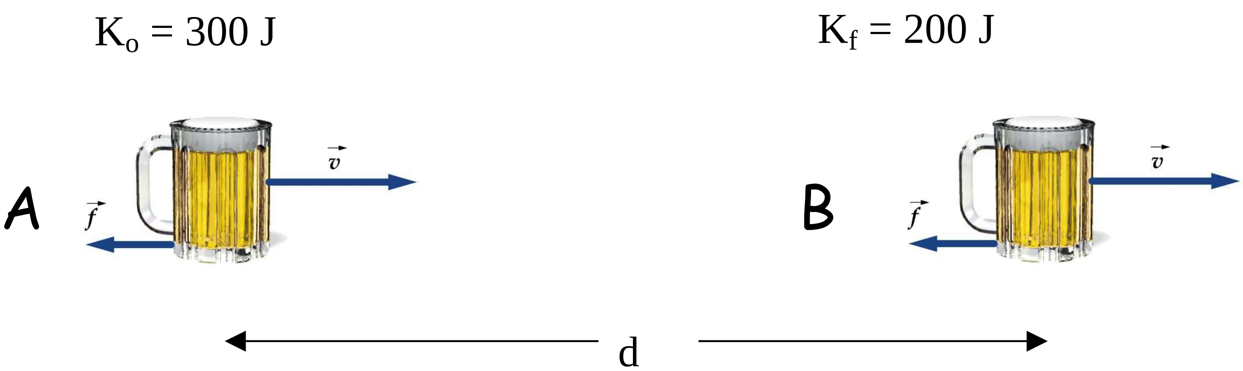
Now we can modify our $E_f = E_o$ expression to include:

a) losses due to the nonconservative force f_k

b) other external forces that may be doing work (ex: fingers, ropes…)

Accounting 101:
We will be using the concept of ENERGY as a bookkeeping tool.

Let's say:



Is $E^{200J}{}_f = E^{300J}{}_o$?

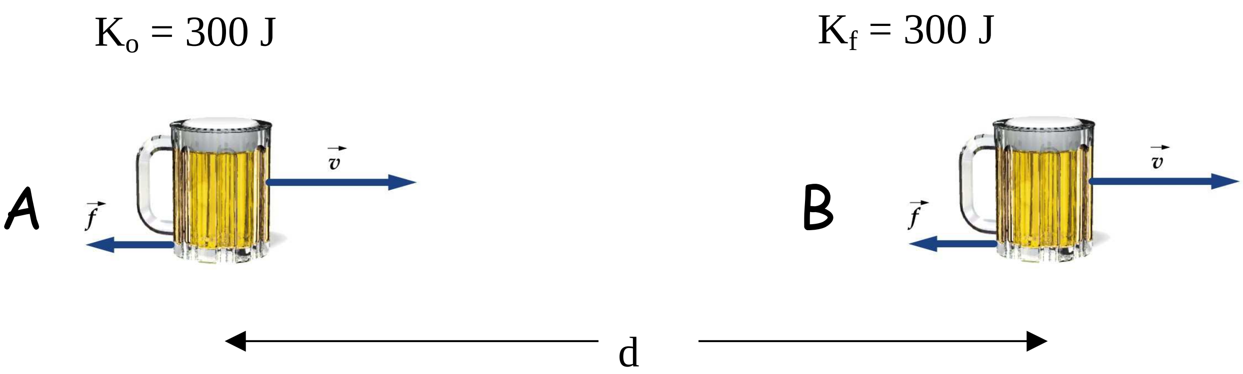
$E_f = E_o - E_{\text{lost due to friction}}$

We write E_{lost} = 100J as a positive #.

$\Delta K_{NC} = -100$ J, but $E_{lost} = 100$J.

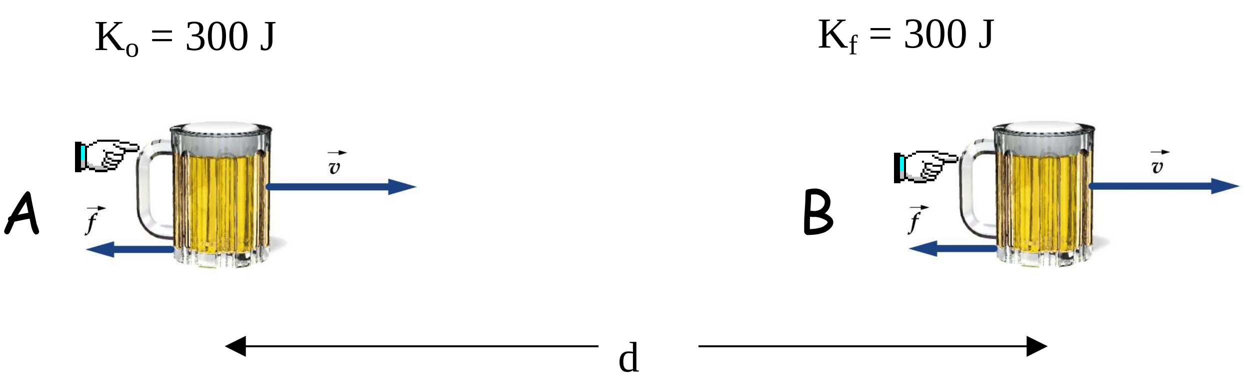
$\therefore\ E_f = E_o - E_{lost}$

Let's say we observed this for the same mug:



$E_f \;=\; E_o \;-\; E_{\text{lost due to friction}}$

300J = 300J - 100J ??? What is wrong here?



There must be another external force ☞ doing work!

Now we can modify our previous expression to include these other forces doing work:

$$\therefore \boxed{E_f = E_o - E_{lost} + W_{other}},$$

where W_{other} = the work done by other nonconservative forces (fingers, ropes,…).

We can use this general expression for ALL of our energy problems.

Tarzan, who weighs 800.0 Newtons, is standing on the edge of a cliff while holding on to the end of a convenient 15.00-meter vine. From the top of the cliff to the bottom of the swing, Tarzan would fall by 2.60 meters. The vine has a breaking strength of 1112 Newtons. Will the vine break?