Weds: HW 6 by 5pm — Read: 6.7.

Group Ex:

Fri: No Class

Energy transfer and energy conservation

We have seen that for systems where springs and gravity are the only forces that can change speed, the total energy

$$E = KE + PE + E_{elas}$$

- $KE = \frac{1}{2} \times \text{mass} \times (\text{speed})^2$ — kinetic energy
- $PE = \text{mass} \times 9.8 \times \text{height}$ — gravitational potential energy
- $E_{elas} = \frac{1}{2} \times \text{spring constant} \times (\text{compress/stretch})^2$ — elastic potential energy

stays constant. As the object moves we find that there is a constant transfer between types of energy.

DEMO: PhET Energy Skate Park (Basics)

→ Intro Tab → Bar Graph, Pie Chart

There is a constant interchange of energy between the two types.

Quiz!

Thus as the skater ascends

This is analogous to operating bank accounts where the only possibilities are transfers between accounts.

Quiz 2

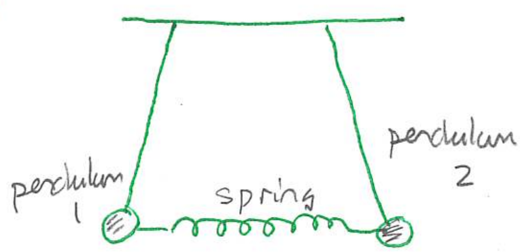
When there is a third type of energy, its equivalent to adding a third bank account or participant.

DEMO: PhET Springs and Masses

- Energy Tab – no friction
- Observe exchange

Conservation of energy is equivalent to stating that the total amount of money stays constant, It just exchanges between the participants and as we add more participants, there are more types of transfer possible.

DEMO:



→ Total energy

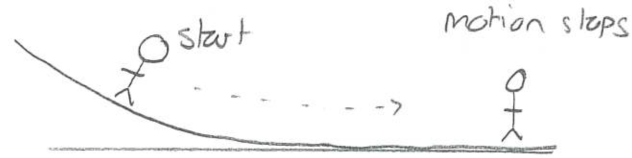
$$E = KE_1 + PE_1 \quad \leftarrow \text{pendulum 1}$$
$$+ E_{elastic} \quad \leftarrow \text{spring}$$
$$+ KE_2 + PE_2 \quad \leftarrow \text{pendulum 2}$$

Show energy transfer

In general one can often (but not always) find a new type of energy for each new constituent or force in a system and add these to give a total energy that is conserved.

Friction and energy (thermal energy)

Consider a skater sliding down a realistic track.



DEMO: PhET ESP (Basics)
Create
Friction = lots

Does $E = KE + PE$ stay constant?

Quiz3 40% – 50%

The sum of kinetic and potential energies does not stay constant. These types of energy must be transformed into some type that is not associated with visible motion.

DEMO: Rub Hands – not warming

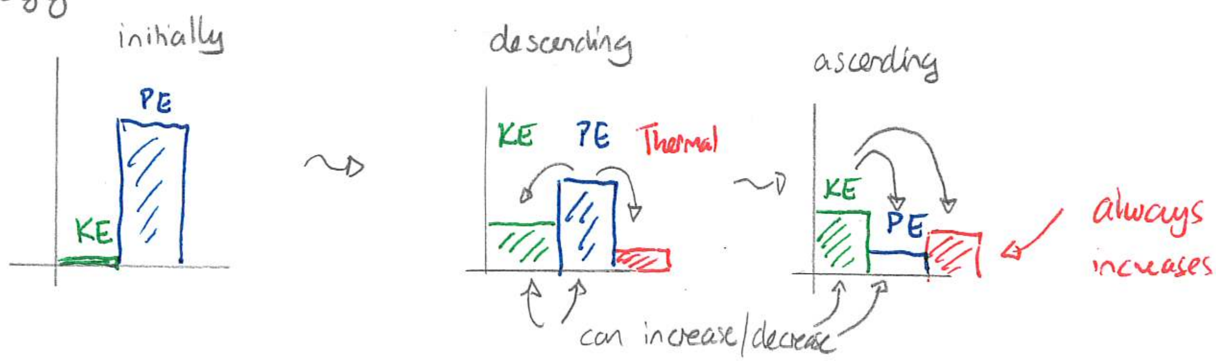
This is thermal energy, associated with the invisible constituents of matter and their temperature.

DEMO: PhET States of Matter
– water → ~~cool then heat~~ liquid then heat.

We have to account for this invisible thermal energy.

DEMO: ESP Basics → Friction

We note that in this process the thermal never decreases. We never observe thermal energy converted into the other types. In this sense it is waste energy



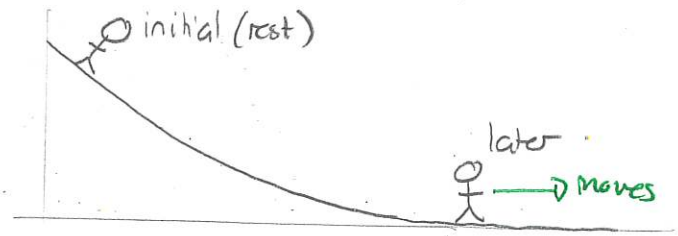
The thermal energy is still present and

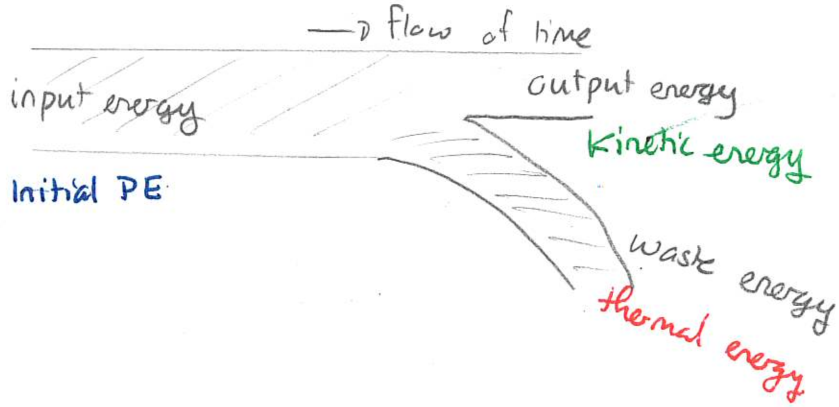
$$E = KE + PE + \underbrace{\text{Thermal Energy}}_{\text{inaccessible (mostly!)}}$$

is constant but we cannot readily access the thermal energy and in this regard it is waste energy.

Energy efficiency

Consider again the skater released from a high point on the track. By raising the skater we provide an initial or (input energy). Later on this is converted to useful output energy and also waste energy





We want to know

> What fraction of the input energy is converted to useful output energy?

Note that energy conservation implies:

> Input energy = useful output energy + waste energy

Quiz 4 80% – 100%

Quiz 5

We quantify the energy conversion process using

$$\text{Efficiency} = \frac{\text{useful output energy}}{\text{input energy}} \longrightarrow \text{useful output energy} = \text{input energy} \times \text{efficiency}$$

1 Energy efficiency and skaters

A skater is at rest at the top of a ramp and skates down reaching a low point at the ground level. In all cases the initial potential energy of the skater is 4000J.

a) The skater uses a more efficient skateboard and reaches the low point with a kinetic energy of 3000 J. Determine the thermal energy at the bottom of the ramp. Determine the efficiency of the process.

b) The skater uses a less efficient skateboard and reaches the low point with a kinetic energy of 1000 J. Determine the thermal energy at the bottom of the ramp. Determine the efficiency of the process.

Answer: a) Total energy = 4000J

	KE	PE	Thermal E	Total
Top	0J	4000J	0J	4000J
Bottom	3000J	0J	1000J	4000J.

$$\text{efficiency} = \frac{3000J}{4000J} = 0.75 \quad (75\%)$$

b)

	KE	PE	Thermal E	Total
Top	0J	4000J	0J	4000J.
Bottom	1000J	0J	3000J	4000J

$$\text{efficiency} = \frac{1000J}{4000J} = 0.25 \quad (25\%)$$