SPH3U UNIVERSITY PHYSICS

ENERGY & SOCIETY

- Energy (P.230-235)

Energy

How are people, machines, and Earth able to do mechanical work? The answer is simple: energy. ***Energy*** *is the capacity (ability) to do work.*

NOTE!

Energy comes in many forms. They are all scalar quantities measured in joules.

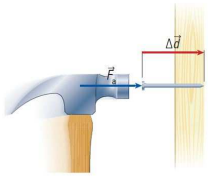
Energy

ENERGY (E)

- the capacity (ability) to do work
- comes in many forms
- scalar quantity
- measured in joules (J)

Kinetic Energy

A moving object has the ability to do work because it can apply a force to another object and displace it. The energy possessed by moving objects is called ***kinetic energy (E_k)****. For example, a moving hammer has kinetic energy because it has the ability to apply a force on a nail and push the nail into a piece of wood.*



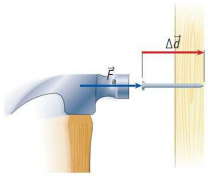
Kinetic Energy

In general, the kinetic energy of an object of mass, m, travelling at a speed, v, is given by the following formula:

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

NOTE!

The faster the hammer moves or the greater its mass, the greater its kinetic energy, and the greater the displacement of the nail.



Kinetic Energy

KINETIC ENERGY (E_k)

- the energy possessed by a moving object

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

where E_k is the kinetic energy (J)
m is the mass (kg)
v is the speed (m/s)

Kinetic Energy

PRACTICE

1. What is the kinetic energy of a 480 g lawn dart travelling at a speed of 3.4 m/s?

   E_k = 2.8 J

Kinetic Energy

PRACTICE

2. A softball with a mass of 170 g has a kinetic energy of 98 J. What is its velocity?

   v = 34 m/s

Potential Energy

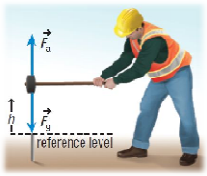
Kinetic energy is not the only type of energy an object may have. The ability of an object to do work because of forces in its environment is called ***potential energy****. Potential energy may be considered a stored form of energy.*

POTENTIAL ENERGY

- a stored form of energy

Gravitational Potential Energy

As such, an object positioned above the ground has the ability to fall and gain kinetic energy that could do mechanical work. The type of energy possessed by an object because of its position relative to a lower position is called ***gravitational potential energy (E_g)****.*



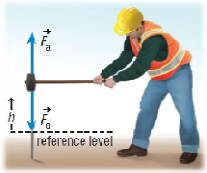
Gravitational Potential Energy

In general, the gravitational potential energy of an object of mass, m, lifted to a height, h, above a reference level is given by the following formula:

$$E_g = mgh$$

NOTE!

Consider the construction worker with a sledgehammer. The greater the height or the mass of the sledgehammer, the greater its gravitational potential energy.



Gravitational Potential Energy

GRAVITATIONAL POTENTIAL ENERGY (E_g)

- the energy possessed by an object due to its position relative to Earth

$$E_g = mgh$$

where E_g is the gravitational potential energy (J)
m is the mass (kg)
g is the gravitational field strength (N/kg)
h is the height relative to a reference (m)

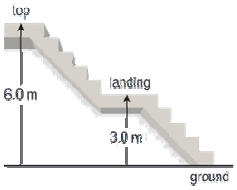
NOTE!

Recall that ***g*** *is also equal to the acceleration due to gravity (m/s^2) on the planet.*

Gravitational Potential Energy

PRACTICE

3. A 58 kg person walks down a flight of stairs. Use the ground as the reference level.
   (a) Calculate the person's gravitational potential energy at the top of the stairs, on the landing, and at ground level.

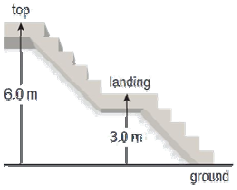


(a) E_g = 3400 J
E_g = 1700 J
E_g = 0 J

Gravitational Potential Energy

PRACTICE

3. A 58 kg person walks down a flight of stairs. Use the ground as the reference level.
   (b) What happens to the gravitational potential energy as you walk down/up a set of stairs?



(b) as h decreases/increases then E_g decreases/increases as well

Gravitational Potential Energy – DYK?

Some animals are known to take advantage of gravitational potential energy. One example is the bearded vulture, the largest of all vultures. This bird, found in South Africa, is able to digest bones. Often its food consists of bones picked clean by other animals. When confronted with a bone too large to digest, the vulture carries the bone to a great height and drops it onto a rock. Then it circles down to scoop out the marrow with its tongue.

Mechanical Energy

Objects may possess kinetic energy only, gravitational potential energy only, or a combination of both relative to a particular reference level. For example,

- *a hockey puck sliding on flat ice has kinetic energy only*
- *an acorn hanging in a tree has gravitational potential energy only*
- *a parachutist falling to the ground has both kinetic and gravitational potential energy*

Mechanical Energy

*The sum of an object's kinetic energy and gravitational potential energy is called **mechanical energy**.*

MECHANICAL ENERGY

- the sum of an object's kinetic energy and gravitational potential energy

$$E_{mechanical} = E_k + E_g$$

Mechanical Energy & Work

*If the speed and/or the height of an object changes, this means that work was done. In other words, work is a change in energy. This relationship between energy (kinetic energy, gravitational potential energy, ...) and mechanical work is known as the **work-energy principle**.*

WORK-ENERGY PRINCIPLE

- the net amount of mechanical work done (W_{net}) on an object is equal to the object's change in energy

$$W_{net} = \Delta E_{mechanical}$$
$$= E_{mech\ final} - E_{mech\ initial}$$

Mechanical Energy & Work

PRACTICE

4. A 13 kg object travelling at 10 m/s accelerates to a speed of 14 m/s over a displacement of 8.2 m.
   (a) Calculate the net work done on the car. (Hint: you can find the force causing the acceleration and then use W = Fd but there is an easier way – think change in energy!)

   (a) $W_{net} = \Delta E_k = 620$ J

Mechanical Energy & Work

PRACTICE

4. A 13 kg object travelling at 10 m/s accelerates to a speed of 14 m/s over a displacement of 8.2 m.
   (b) Calculate the net force acting on the car.

   (b) $F_{net} = 76$ N

✔ Check Your Learning

TEXTBOOK

P.235 Q.1,3,5