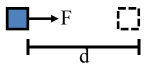
Work

Work – The energy that is transferred by a force that moves an object a certain distance

work = force × distance moved

W = F · d



If a force is applied but an object does not move, then no work was done!!

Unit – Work is measured in joules (J)

W = Force (N) × distance (m) = N·m

These units together are called a joule (J)

N·m = **J**

The joule is a derived unit:

$$1\ J\ = 1\ N \cdot m = 1\ \frac{kg \cdot m^2}{s^2}$$

Work Problem Example:

If a man moves a boulder a distance of 10 meters and uses a force of 100 N, how much work has been done?

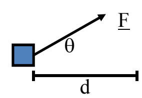
d = 10 m F = 100 N W = ?

W = F x d

W = (100N)(10m) = 1000 N·m = 1000 J

Work done at an angle

W = F d cos θ



The force component performing work is only in the direction of movement

3. Example:

If a man pulls a box a 10m and uses a force of 100N at an angle of 30° from the ground, how much work has been done?

W = F x d cos θ

W = (100N)(10m) cos 30° = 866 N·m = 866 J

Power

Power – the rate of work performed over time

$$Power = \frac{Work}{Time} \qquad P = \frac{W}{t}$$

The faster work is done, the harder it is to do. Power is the speed that work is performed

Another formula is: $P = \frac{F \cdot d}{t}$

Unit – Power is measured in watts (W)

$$P = \frac{Work(J)}{time(s)} \quad so \quad P = \frac{J}{s}$$

These units together are called a watt (W)

$$\frac{Joule}{\sec} = W$$

The watt is a derived unit:

$$1\,W = 1\,\frac{J}{s} = 1\,\frac{N \cdot m}{s} = 1\,\frac{kg \cdot m^2}{s^3}$$

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Power Problem Example:

It takes 100 J of work to lift a bowling ball over your head. If this is done in 20s, what is the power output of your arms during this process?

W = 100 J   t = 20 s   P = ?

$$P = \frac{W}{t}$$

$$P = \frac{100\,J}{20\,s} = \frac{5\,J}{s} = 5W$$

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What is Energy?

Energy – the ability to do work or cause change

- SI Unit: Joules (J)
- Whenever work is done, energy is transformed or transferred from one system to another

Energy can be split into two main categories

- Potential Energy – Stored energy that due to an objects position, shape, or condition.
- Kinetic Energy - Energy of an object due to its motion.

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Common Forms of Energy

Potential Energy Examples:

- Stored Mechanical Energy
- Gravitational Energy
- Chemical Energy
- Nuclear Energy

Kinetic Energy Examples:

- Motion Energy
- Electrical energy
- Heat (thermal energy)
- Light (radiant energy)
- Sound

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Mechanical Energy

Mechanical Energy – The amount of work an object can do from its potential and kinetic energies

Common forms of mechanical energy

- Elastic Potential Energy
  - Stretched rubber band or compressed spring
- Gravitational Potential Energy
  - Water at the top of a waterfall
  - Hammer raised up in the air
- Kinetic Energy
  - Hammer in motion, about to hit a nail

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Gravitational Potential Energy

Gravitational Potential Energy (PE) – Potential energy due to an elevated position.

This is caused by gravity and is measured by the amount of work needed to lift the object to that point.

$PE_{gravity}$ = Work

Remember

W = Fd and $F_{gravity}$ = mg

The distance is the height(h) of elevation

$$PE = mgh$$

g = 9.8 m/s^2

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Potential Energy Example

A 3.0 kg mallet (A big hammer) is lifted to a height of 0.45 meters to drive in a railroad spike. What is the potential energy of the hammer while it is in the air?

$$PE = mgh$$

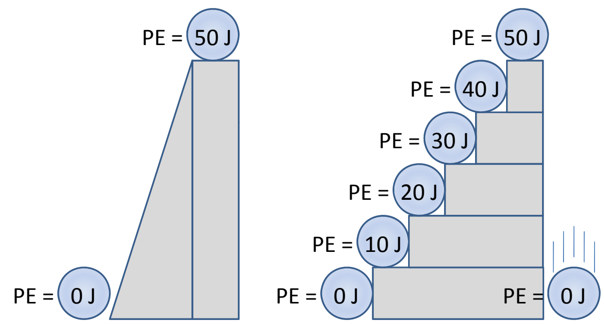
g = 9.8 m/s^2

m = 3.0 kg h = 0.45 m

PE = 3.0 kg · 9.8 m/s^2 · 0.45 m = 13.2 J

Gravitational Potential Energy

PE is dependent on its relative height

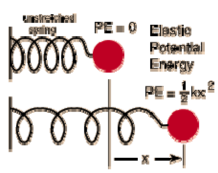


Elastic Potential Energy

An object can store energy because of its position.

Elastic Potential Energy (PE) – Energy stored in an object that is compressed or stretched to change the distance between its parts.

$$PE = \frac{1}{2} k x^2$$



k = spring constant for material
Units: N/m

Kinetic Energy

A moving object has the ability to do work.

Kinetic Energy(KE) – Energy of motion

The KE depends on an objects mass and speed
Both an increase of speed or mass will increase energy, but speed has a bigger impact on KE

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

Kinetic Energy Example

Determine the kinetic energy of a 625 kg roller coaster car that is moving with a speed of 18.3 m/s.

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

m = 625 kg v = 18.3 m/s

KE = ½ · 625 kg · (18.3 m/s)^2 = 105000 J

Conservation of Energy

Work-Energy Theorem

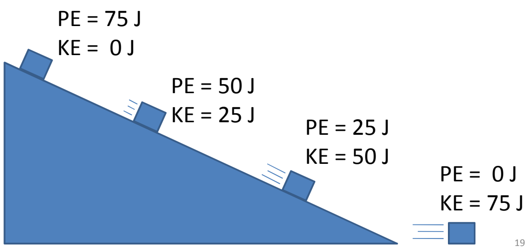
The change in Kinetic Energy is equal to the amount of work that can be done.

In most cases the moving object doing work will not lose mass (unless it breaks somehow).

$$Work = \frac{1}{2} m\left(v_{final}^{\ 2} - v_{initial}^{\ 2}\right)$$

Law of Conservation of Energy
Energy may be transformed from one form into another or transferred from one object to another, but the total amount of energy never changes

$$PE_i + KE_i = PE_f + KE_f$$



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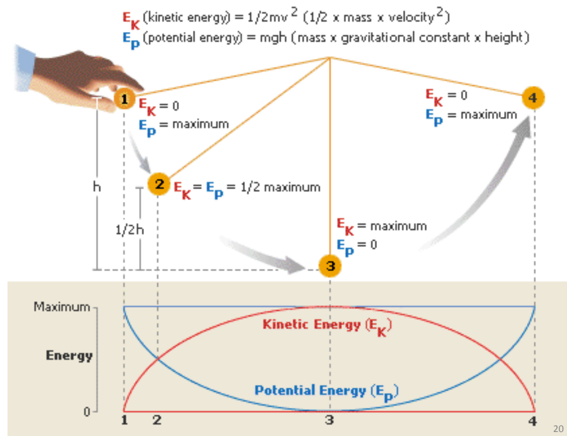

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