

WORK AND ENERGY

When the force acts on an object to change the way it is moving, **work** is done and **energy** is transferred. (No movement by force means no work is done).

The amount of work done (energy transferred) to the object is found by:

$$\text{Work (Joules)} = \text{force (N)} \times \text{distance moved (m)}$$

$$\boxed{W = F \times d}$$

Example

Find the work done when a force of 20 Newton's is used to move an object by five metres.

$$\begin{aligned} \text{Work done} &= 20 \text{ N} \times 5 \text{ m} \\ &= 100 \text{ Joules} \end{aligned}$$

POWER

Power is the measure of **how fast** work is being done (or energy transferred)

$$\text{Power (watts)} = \frac{\text{work done (Joules)}}{\text{time taken (s)}}$$

Example

A crane is required to lift a weight of 5000 N by 20 metres. It takes five seconds to complete the lift. What is the power of the crane?

$$\begin{aligned} \text{Work done by crane} &= 5000 \text{ N} \times 20 \text{ m} \\ &= 100,000 \text{ Joules} \end{aligned}$$

$$\begin{aligned} \text{Power developed by crane} &= \frac{100,000 \text{ J}}{5 \text{ s}} \\ &= 20,000 \text{ watts (20 kw)} \end{aligned}$$

Energy

Kinetic Energy

When work is done to cause an object to move, then that object gains **Kinetic energy**. The amount of kinetic energy gained depends on the mass and the speed of the object.

$$E_k = \frac{1}{2} m \cdot v^2$$

M = mass of object
V = speed (velocity)

Example

Find the kinetic energy of a 10 kg mass which is moving at 20 m/s.

$$\begin{aligned} E_k &= \frac{1}{2} \times 10 \text{ kg} \times (20 \text{ m/s})^2 \\ &= 2000 \text{ Joules} \end{aligned}$$

When moving objects be stopped, all their kinetic energy must be transformed into another form of energy.

Work done to stop object = kinetic energy lost.

Example

A car moving at 100 km/h has **4 times** as much kinetic energy as a car moving at 50 km/h. This is because the K.E. is proportional to **V squared**. This means that takes 4 times the braking force to stop the faster car (or 4 times the distance to stop in, for equal braking forces).

Likewise, the faster car will do 4 times the damage if it is stopped by collision with another object!

Potential Energy

When work is done to shift an object to a position where it has the potential to do work, then that object gains **potential energy**.

For example: a boulder at the top of a hill, or water behind a dam.

Gravitational potential energy = work done in raising object

$$\begin{aligned} E_p &= \text{weight (N) x height (m)} \\ &+ \text{mass (kg) x 9.8 x height (m)} \end{aligned}$$

$$E_p = m \times g \times h$$

Example

Find the potential energy of 1000 kg of water at the top of a 100 m hill.

$$\begin{aligned} \text{Weight of water} &= \text{mass (kg) x 9.8 N/kg} \\ &= 9800 \text{ N} \\ E_p &= 9800 \text{ N x 100 m} \\ &= 980,000 \text{ Joules} \\ &= 980 \text{ k J} \end{aligned}$$

SUMMARY

- $\text{Speed} = \frac{\text{distance travelled}}{\text{time taken}}$
- Basic unit for speed is m/s
- $\text{Acceleration} = \frac{\text{change in speed}}{\text{time taken}}$
- Basic unit for acceleration is m/s^2
- Unbalanced forces may cause :
 - change of speed
 - change of direction
 - change of shape
- Force = mass x acceleration
- Basic unit for force is N (Newton)
- "Weight" is a measure of the earth's gravitational force on an object.
- On earth, weight = 9.8 N/kg
- Falling objects will accelerate at 9.8m/s^2 if air resistance is not significant

- The acceleration due to gravity is independent of the mass of the object
- In practice, most falling objects reach a “terminal velocity where gravitational force is balanced by opposing air resistance force.
- Speed of a falling object = $9.8 \text{ m/s}^2 \times \text{time (s)}$
- Distance an object falls = $\frac{1}{2} \times 9.8 \text{ m/s}^2 \times (\text{time(s)})^2$
- Frictional forces always oppose the movement between surfaces
- When work is done to overcome friction, this energy is converted to heat
- Friction can be reduced by reducing the area of contact between surfaces
- When work is done, energy is transferred.
- Work done (to move an object) = force required x distance moved
- Basic unit of work is J (Joule)
- $$\text{Power} = \frac{\text{work done}}{\text{time taken}}$$
- Basic unit of power is W (watt)
- Kinetic energy is the energy that objects have when they are moving
- Kinetic energy = $\frac{1}{2} \times \text{mass of object} \times (\text{speed})^2$
- Kinetic energy is measured in Joules (J)
- Gravitational potential energy is energy that is stored in an object by virtue of it's position
- Gravitational P.E. = weight of object x height raised
- Gravitational P E. is measured in Joules (J)