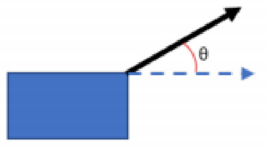
Module 3 Section 3: Work, Energy and Power

Work and Power

When a force is applied to an object that moves, work is done by that force.

$W = F \times \cos\theta$

Where θ is the angle between the force and the direction of movement.



The **work done is equal to the amount of energy transferred**. For example, if 100J of work is done to lift an object at a constant velocity, it will gain 100J of gravitational potential energy.

Power is the rate of transfer of energy, measured in Watts where 1 W = 1 J s^{-1}

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

Sometimes, for a moving object, it's easier to use another version of the power equation. It's derived like this:

- You know $P = \frac{W}{t}$.
- You also know $W = Fx$, which gives $P = \frac{Fx}{t}$.
- But $v = \frac{x}{t}$, which you can substitute into the above equation to give:

$$P = Fv$$

P = power in W; *F* = force causing the motion in N; *v* = velocity in ms^{-1}

If the force and motion are in different directions, you can replace *F* with $F\cos\theta$ to get:

$$P = Fv\cos\theta$$

θ = angle at which the force acts from the direction of motion

Conservation of energy

The law of conservation of energy states that **energy cannot be created or destroyed**, it can only be **transferred** from one form to another.

This means that in any situation the **total energy of the system must remain constant**.

For example,

- A cannonball fired vertically upwards with 1000J of kinetic energy will transfer to 1000J of gravitational potential energy at its highest point.
- A slingshot spring with 50J of elastic potential energy will transfer 50J of kinetic energy to a ball when fired.

In both these examples no energy has been lost as heat due to dissipative forces such as friction.

In reality, **friction and air resistance will cause some losses** during the transfer but the total energy must remain the same. Therefore, if the cannonball only gains 950J of gravitational energy the rest, 50J, must be **lost as heat due to the work done by air resistance**. The frictional forces can be calculated using the work equation,

$$Work = F\,d$$

$$\text{efficiency} = \frac{\text{useful output energy}}{\text{total input energy}} \times 100$$

GPE and KE

Gravitational potential energy:

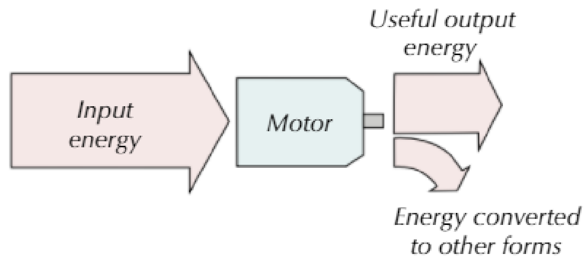
Gravitational potential energy is the energy of an object due to its position above the surface of the Earth.

$$\Delta E = mg\Delta h$$

Kinetic energy:

Kinetic energy is the energy of an object due to its motion.

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



total energy in

=

total energy out

Transfers between KE and GPE

You're usually told to ignore friction in exam questions — this means that in the examples above you can assume that the sum of the kinetic and gravitational potential energy is constant. So for a falling object with no air resistance, the gain in kinetic energy is equal to the loss in gravitational potential energy:

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