

## Chapter 5 Work, energy, and power

### 5.1 Energy conservation

Candidates should be able to:

- 1 understand the concept of work, and recall and use *work done = force × displacement* in the direction of the force
- 2 recall and apply the principle of conservation of energy
- 3 recall and understand that the efficiency of a system is the ratio of useful energy output from the system to the total energy input
- 4 use the concept of efficiency to solve problems
- 5 define power as work done per unit time
- 6 solve problems using  $P = W/t$
- 7 derive  $P = Fv$  and use it to solve problems

- In physics, **work (W)** is the **energy** transferred to or from an object through the application of **force (F)** along a **displacement (d)**

$$W = F \times d$$

- The SI units for work is in **Joules**
- The **principle of conservation of energy** states that **energy is neither created nor destroyed. But may transform from one type to another.**
- E.g. work can be transformed to heat (friction!), electric to light.
- Not all energy transferred is useful. E.g. when transferring electric to light, some energy is wasted in the form of heat!
- **Efficiency** is the **ratio of useful energy output** from the system to the **total energy input**

$$\eta = \frac{\text{Useful Output}}{\text{Total Input}}$$

- Power is the amount of energy (E), transferred per unit time

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

- The SI units for work is in **Watt** or Joules/ second.
- Moving power is defined by the equation

$$P = F \times v$$

- This equation is used when a force is moving a body at a constant velocity
- Below is how you derive the equation

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

Substitute E with

$$W = F \times d$$

$$P = \frac{F \times d}{t}$$

Recall  $d/t$  is velocity (Chapter 1). Therefore

$$P = F \times v$$

## 5.2 Gravitational potential energy and kinetic energy

Candidates should be able to:

- 1 derive, using  $W = Fs$ , the formula  $\Delta E_p = mg\Delta h$  for gravitational potential energy changes in a uniform gravitational field
- 2 recall and use the formula  $\Delta E_p = mg\Delta h$  for gravitational potential energy changes in a uniform gravitational field
- 3 derive, using the equations of motion, the formula for kinetic energy  $E_k = \frac{1}{2}mv^2$
- 4 recall and use  $E_k = \frac{1}{2}mv^2$

- The change in **Gravitational potential energy ( $\Delta E$ )** is the energy stored in a **mass ( $m$ )** relative to its **position in a gravitational field ( $\Delta h$ )**

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

Derivation



- **Kinetic energy (KE)** is the energy an object possesses due to its **velocity**.

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

Derivation

Start with

$$v^2 = u^2 + 2ad$$

(Chapter 1)

Assume initial velocity is 0 ( $u = 0$ ) and rearranging

$$a = \frac{v^2}{2d}$$

Recall  $F = ma$  (Chapter 2)

Substituting

$$F = m\left(\frac{v^2}{2d}\right)$$

and finally, into the work equation

$$W = Fd$$

We have

$$W = m\left(\frac{v^2}{2d}\right)d$$

Therefore

$$W = m\left(\frac{v^2}{2}\right)$$

Or

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