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**

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

- 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

$$\boldsymbol{P = F \times v}$$

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 (ΔE)** is the energy stored in a **mass (m)** relative to its **position in a gravitational field (Δh)**

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

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

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

and finally, into the work equation

W = Fd

We have

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

Therefore

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

Or

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