

## Kinetics and Dynamics

|                    |      |  |
|--------------------|------|--|
| Symbols and units: | $a$  | acceleration in metres per second squared ( $\text{ms}^{-2}$ ) |
|                    | $F$  | force in newtons (N)   |
|                    | $g$  | acceleration due to gravity = $9.8\text{ms}^{-2}$              |
|                    | $h$  | height in metres (m)   |
|                    | $I$  | impulse in newton-seconds (Ns)                                 |
|                    | $KE$ | kinetic energy in joules (J)                                   |
|                    | $m$  | mass in kilograms (kg)   |
|                    | $M$  | momentum in newton-seconds (Ns)                                |
|                    | $P$  | power in watts (W)   |
|                    | $PE$ | potential energy in joules (J)                                 |
|                    | $R$  | resistive force in newtons (N)                                 |
|                    | $s$  | displacement in metres (m)                                     |
|                    | $t$  | elapsed time in seconds (s)                                    |
|                    | $T$  | tension in newtons (N)   |
|                    | $u$  | initial velocity in metres per second ( $\text{ms}^{-1}$ )     |
|                    | $v$  | final velocity in metres per second ( $\text{ms}^{-1}$ )       |
|                    | $W$  | work done in joules (J)  |

### Kinematics (the study of motion)

Motion in a straight line with constant acceleration:

$$v = u + at \quad s = \left(\frac{u + v}{2}\right)t \quad s = ut + \frac{1}{2}at^2 \quad v^2 = u^2 + 2as$$

Motion in a straight line with variable acceleration:

$$v = \frac{ds}{dt} \quad a = \frac{dv}{dt} \quad s = \int v dt + k \quad v = \int a dt + k$$

Motion of a projectile - if  $\theta$  is the launch angle, then initial velocity has components:

$$u \cos \theta \text{ (horizontal)} \quad u \sin \theta \text{ (vertical)}$$

### Dynamics (the study of the relationship between force and motion)

#### Newton's Laws of Motion:

A particle will only accelerate if it is acted upon by a resultant force

The force applied to a particle is proportional to its mass and the acceleration produced ( $F = ma$ )

The forces between two bodies in contact are equal in magnitude but opposite in direction

Momentum, work and energy:

$$M = mv \quad I = Ft \quad W = Fs \quad P = Fv \quad KE = \frac{1}{2}mv^2 \quad PE = mgh$$

Conservation of momentum (when two particles collide):

$$\text{Total momentum before impact} = \text{Total momentum after impact} \quad (m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2)$$

Momentum is perseverance of motion

Impulse is the change of momentum

Power is the rate of doing work