



Motion

Distance is how far an object has travelled.

Displacement is how far an object is from a fixed position.

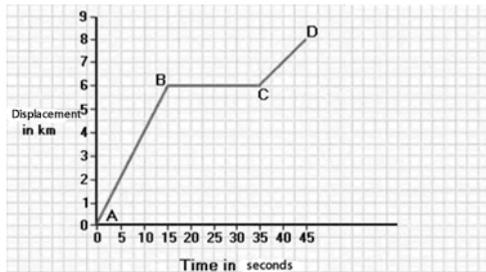
Displacement can be positive or negative.

Speed is how much distance is covered in a certain time.

Velocity is speed in a certain direction. Velocity can be positive or negative.

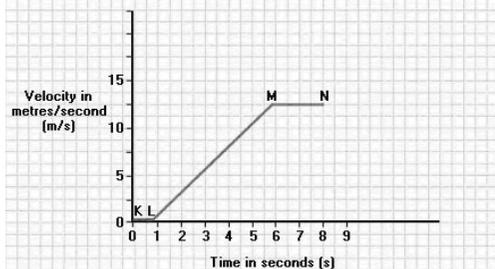
Acceleration is the rate of change of velocity, how much the velocity changes every second.

Acceleration can be positive or negative.



Gradient = velocity

A horizontal line shows a constant displacement (i.e. at rest).



Gradient = acceleration

A horizontal line shows a constant velocity.

The area under a velocity-time graph represents the distance travelled.

Equations

$$v_f = v_i + at$$

$$d = v_i t + \frac{1}{2} at^2$$

$$d = \frac{v_i + v_f}{2} t$$

$$v_f^2 = v_i^2 + 2ad$$

d = ?

v_f = ?

v_i = ?

a = ?

t = ?



You will be given 3 and asked to work out one. Choose the equation that only has these four.

Terminology:

“At rest”/“Dropped”: v_i = 0

“Falling”: a = 9.8 ms⁻²

“Thrown upwards”: a = - 9.8 ms⁻²

Projectile Motion

Involves jumping up and down and moving forwards at the same time.

Use this equation

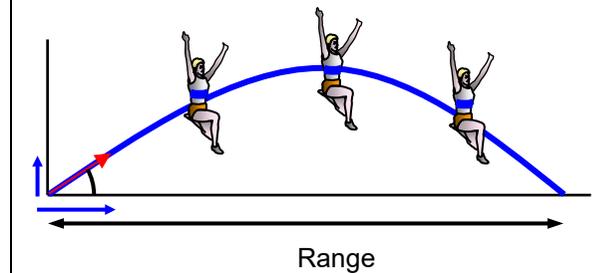
$$v_f = v_i + at$$

where v_i = vertical component, v_f = 0 and a = -9.8 to find t. Time of flight = 2t.

Use this equation

$$d = v_i t + \frac{1}{2} at^2$$

where v_i = horizontal component and a = 0 to find d. d = Range.





Forces

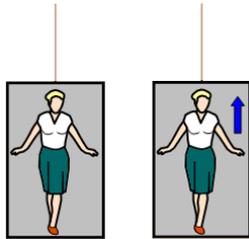
Forces are measured in newtons (N).

$$F = ma$$

F is the resultant force when all the forces acting on a body have been included.

- Balanced forces can change the shape of an object.
- Unbalanced forces can change the direction and/or speed of an object.

Apparent weight



Mass of girl = 50kg so her normal weight is 500 N.
 If the lift accelerates upwards at 4 ms^{-2} she will feel an extra force of $4 \times 50 = 200 \text{ N}$.
 Total force (reaction) of floor = $500 + 200 = 700 \text{ N}$.
 She will therefore feel as if she weighs = 700 N.

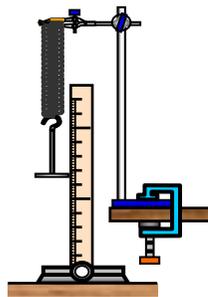
Hooke's Law

If an object obeys Hooke's law then force is proportional to extension up to the limit of proportionality.

$$F = -kx$$

The energy stored in a stretched or compressed spring can be calculated by

$$E_p = \frac{1}{2} kx^2$$



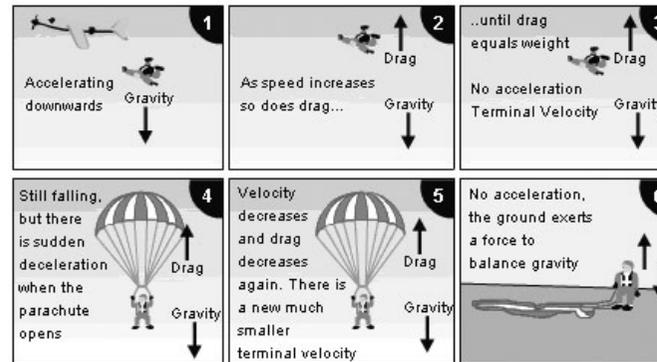
Mass, Weight and Gravity

Mass is the amount of matter in an object, it is measured in kilograms (kg).
 Weight is the force due to gravity.

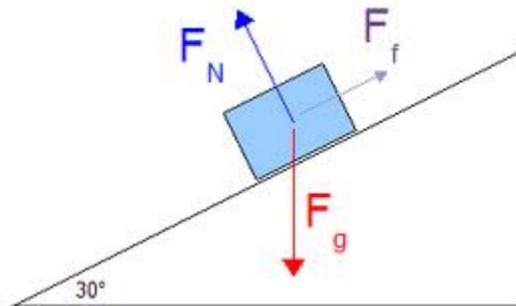
The mass of an object remains constant wherever it is. The weight of an object depends on the mass of the object and the strength of gravity where the object is. On Earth it acts downwards, towards the centre of the Earth.

Weight = mass \times g (On Earth $g = 10 \text{ ms}^{-2}$)

Terminal velocity

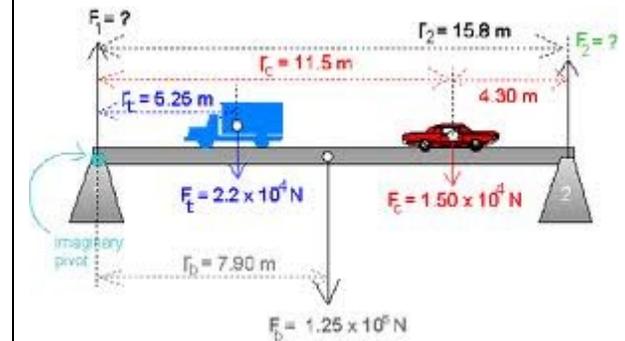


Force diagrams



Torque

$$\tau = Fd$$



To solve:

- Upward forces = downward forces
- The sum of the anticlockwise moments about any point is equal and opposite to the sum of the clockwise moments about that point.

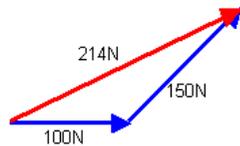


Vectors

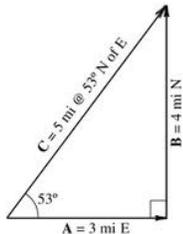
A vector is represented by a line, the length of the line being the magnitude of the vector and the direction of the line the direction of the vector.



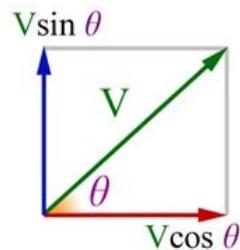
Adding by Scale drawing



Adding by Calculation

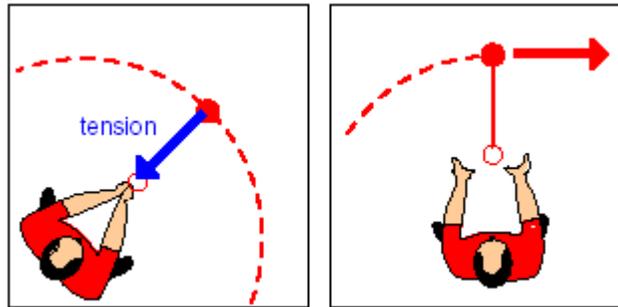


Resolving into components



Circular Motion

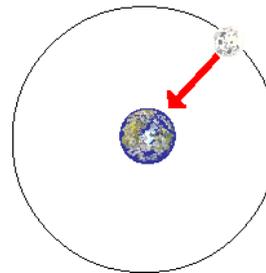
Newton's first law states that a body will continue at a constant velocity in a straight line unless it is acted on by an external force. The velocity of the metal ball is constantly changing so there must be an external force acting upon it - the centripetal force. Remove the centripetal force and the object flies off at a tangent.



$$F_c = \frac{mv^2}{r}$$

$$a_c = \frac{v^2}{r}$$

Gravity provides the centripetal force which keeps the moon orbiting the Earth.



Momentum

Moving objects resist being stopped, a quality which we call their inertia. We experience a force when struck by a moving object created by a change in momentum.

$$\Delta p = F\Delta t$$

The bigger the momentum change, the greater the force.

Momentum

$$p = mv$$

Collisions



Momentum is conserved in a collision.

Momentum before = momentum after

Kinetic energy is conserved in an elastic collision.

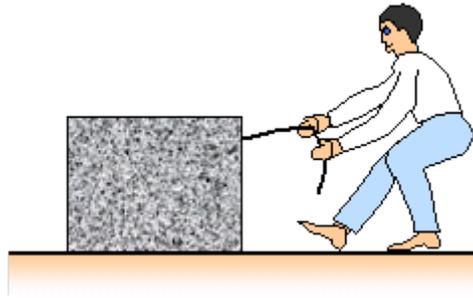
Kinetic energy is converted to other types of energy (e.g. heat, sound) and not conserved in an inelastic collision.



Work

Work is done only when a force makes something move, or tries to stop it moving.

Whenever work is done **energy** is transferred.



Work done against frictional forces is transferred mainly as heat e.g. when a car brakes and slows down its kinetic energy is transferred as heat and some sound.

The amount of work done depends on the size of the force applied and the distance something moves.

$$W = Fd$$

Energy

Kinetic Energy

Kinetic energy is the energy an object has because of its movement.

As an object speeds up it gains kinetic energy.

As it slows down its kinetic energy decreases.

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

Gravitational Potential Energy

When an object is able to gain kinetic energy in the future on account of its **position**, being raised above ground

$$\Delta E_p = mg\Delta h$$

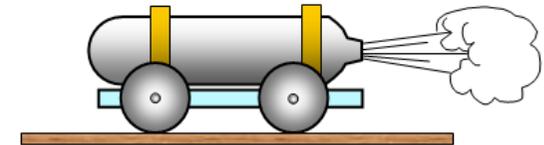
Power

The rate of change of energy is Power.

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

Newton's Laws

- 1. Every object in a state of uniform motion tends to remain in that state of motion unless an external force is applied to it** (If an object is motionless, it will stay motionless unless acted upon by some force. If an object is moving at a constant velocity, it will continue at that velocity unless acted upon by some force).
- 2. The acceleration of an object of constant mass is proportional to the force acting upon it** ($a = F/m$).
- 3. Whenever one body exerts force upon a second body, the second body exerts an equal and opposite force upon the first body** (if you push against a door with a certain force, the door is also pushing with the same force against you).



A rocket works because:

- (a) Action and reaction are equal and opposite
- (b) Momentum is conserved.

