Edexcel Physics IGCSE

Topic 1: Forces and Motion

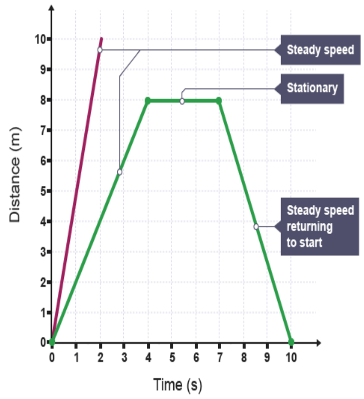
Summary Notes

(Content in bold is for physics only)

Movement and position

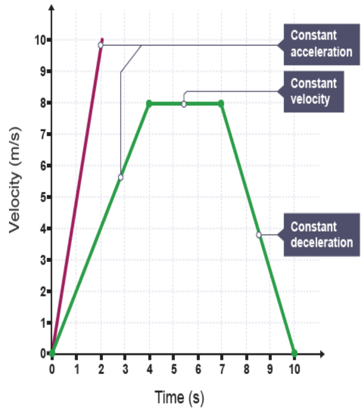
- Speed is defined as the distance travelled per unit time. If the speed of something is changing, it is accelerating. The acceleration of free fall near to the Earth is constant.
- $average\ speed = \frac{total\ distance}{total\ time}$
- Velocity is the speed in a given direction.
- Acceleration is the change in velocity per unit time.
- $acceleration = \frac{change\ in\ velocity}{time\ taken}$ $\quad a = \frac{v-u}{t}$
- $(final\ speed)^2 = (initial\ speed)^2 + (2 \times acceleration \times distance)$ $\quad v^2 = u^2 + 2as$
- Distance is measured in metres (m), time in seconds (s), speed and velocity in metres per second (m/s), and acceleration in metres per second squared (m/s^2).

In a distance-time graph:



- The gradient is velocity
    - Negative gradient is returning back to the starting point
- A horizontal line means it is stationary
- If the distance is zero, it is back at the starting point
- A curved line means that the velocity is changing, and it is accelerating.

In a velocity-time graph:



- The gradient is acceleration
    - Negative gradient (i.e. negative acceleration) is deceleration
- If the speed is zero, it is at rest
- A horizontal line means constant speed
- The area under the line is the distance travelled
- A curved line means that the acceleration is changing.

Forces, movement, shape and momentum

Vectors & scalars:

- A vector has magnitude and direction
- A scalar has just a magnitude

Examples:

Scalars	Vectors
Distance	Displacement
Speed	Velocity
Time	Acceleration
Energy	Force

Effects of forces:

Forces can change the speed, shape or direction of a body and they are measured in Newtons (N). There are various different types of forces (e.g. gravitational, electrostatic).

Friction is a force between two surfaces which impedes motion and results in heating. Air resistance is a form of friction.

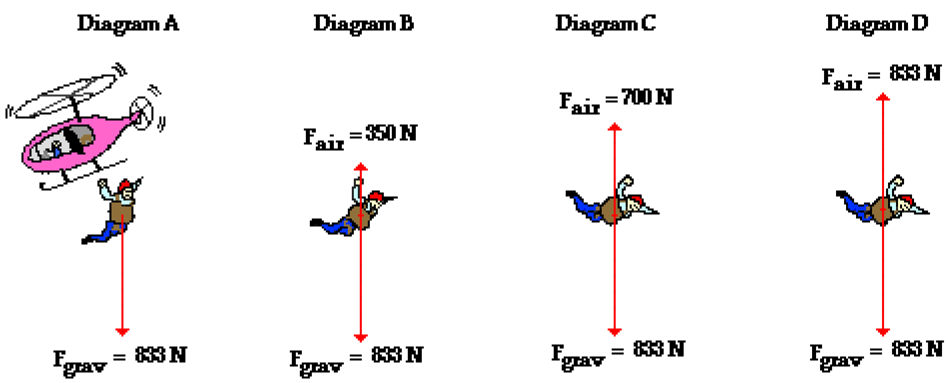
To find the resultant of two or more forces acting along the same line, they should be added together if in the same direction and subtracted if in the opposite direction.

- Newton's first law states that an object has a constant velocity unless acted on by a resultant force.
- Newton's second law states that $force = mass \times acceleration$ $\quad F = ma$
- **Newton's third law states that every action force has an equal and opposite reaction force. For example, the force of the Earth's gravity on an object is equal and opposite to the force of the object's gravity on the Earth.**

Mass is a measure of how much matter is in an object, measured in kilograms (kg). Weight is a gravitational force (the effect of a gravitational field on a mass).

- $weight = mass \times gravitational\ field\ strength$ $\quad W = mg$
- The gravitational field strength on Earth is 10N/kg.
- **The weight of an object acts through its centre of gravity.**

For example, motion of a body falling in a uniform gravitational field:
- Initially, there is no air resistance and the only force acting on it is weight
- As it falls, it accelerates which increases its speed and hence air resistance
- This causes the resultant force downwards to decrease
- Therefore, the acceleration decreases, so it is not speeding up as quickly
- Eventually they are equal and opposite and balance so there is no resultant force
- So, there is no acceleration and the terminal velocity is reached



When a driver notices a hazard:

- The distance travelled in the time between the driving realising he needs to brake and actually pressing the brakes is called the thinking distance. Factors which increase the thinking distance include:
  - Greater speed
  - Slower reaction time due to alcohol, tiredness or distractions. Reaction time can also be increased by caffeine, which reduces the thinking distance.
- The distance travelled in the time between pressing the brakes and the vehicle coming to a stop is called the braking distance. Factors which increase the stopping distance include:
  - Greater speed or mass
  - Poor road conditions (icy, wet) or car conditions (worn tires, worn brake pads)
- The stopping distance is the sum of the thinking distance and braking distance.

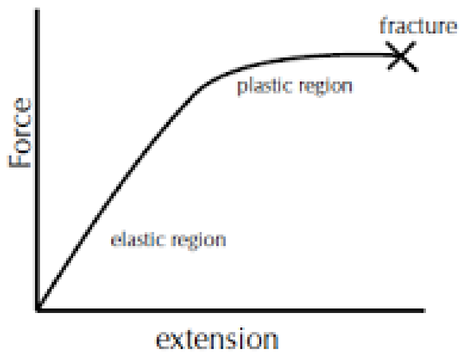
A force may produce a change in size and shape of a body. This is called deformation:

- Elastic deformation is when the object returns to its original shape when the load has been removed, an example being a spring being stretched under normal usage.

Hooke's law states that for a spring, $F = kx$ where F is the force applied to the spring, k is the spring constant, and x is the extension.

Linear (straight line) force-extension graph:

- Elastic deformation following Hooke's law
  - The point it stops being linear is called the limit of proportionality. From then on, it does not obey Hooke's law.
- Gradient is the spring constant, k



Non-linear (curved line) force-extension graph:

- Deformation not following Hooke's law
- After this region, it will fracture

The moment of a force is a measure of its turning effect, measured in Newton metres (Nm).

- $moment = force \times perpendicular\ distance\ from\ the\ pivot \quad moment = Fd$
- **An object is in equilibrium when the sum of clockwise moments equals the sum of anticlockwise moments (the principle of moments) and there is no resultant force.**
- **For a horizontal beam supported at its ends, the upwards forces at the supports change with the position of a heavy object placed on the beam. The nearer the heavy object to a given support, the greater the force at that support.**

The momentum of an object is the product of its mass and velocity:

- $momentum = mass \times velocity \qquad p = mv$
- It is measured in kilogram metres per second (kgm/s).

The force exerted on an object is equal to its change in momentum over time:

- $force = \frac{change\ in\ momentum}{time\ taken} \qquad F = \frac{mv - mu}{t}$
- Safety features in cars work by increasing the time taken for the people in the car to come to rest (i.e. there is the same change in momentum in a longer time, so the force is reduced). For example, a seatbelt achieves this by stretching.

In a collision, the total momentum before is equal to the total momentum afterwards, known as the principle of the conservation of momentum.

For example: a 10kg stationary gun is loaded with a 0.01kg bullet. It is fired, with the bullet travelling at 100m/s. What is the recoil speed of the gun?

$$total\ momentum\ before = 0$$

$$total\ momentum\ before = total\ momentum\ afterwards$$

$$0 = 0.01 \times 100 + 10v$$

$$v = -0.1 m/s$$

So, the recoil speed is 0.1m/s (-0.1m/s is the velocity which is a vector, so we take the magnitude of it as we are finding the speed).