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.

\[
\text{average speed} = \frac{\text{total distance}}{\text{total time}}
\]

- **Velocity** is the speed in a given direction.
- **Acceleration** is the change in velocity per unit time.

\[
\text{acceleration} = \frac{\text{change in velocity}}{\text{time taken}}
\]

\[
(v^2 - u^2) = 2as
\]

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/s²).

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:

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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 \( \text{force} = \text{mass} \times \text{acceleration} \) \( F = ma \)
- **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).

- \( \text{weight} = \text{mass} \times \text{gravitational field strength} \) \( W = mg \)
- 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** = \( force \times perpendicular\ distance\ from\ the\ pivot \) \( moment = Fd \)
- 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:
- \( p = mv \)
- 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:
- \( F = \frac{\text{change in momentum}}{\text{time taken}} \)
- \( F = \frac{mv - mu}{t} \)
- 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?

\[
\text{total momentum before} = 0 \\
\text{total momentum before} = \text{total momentum afterwards} \\
0 = 0.01 \times 100 + 10v \\
v = -0.1\text{m/s}
\]

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).