OCR B Physics A Level

Module 4.2: Space, Time and Motion

Notes

Motion

Vectors and Scalars

Scalar quantities only have **magnitude**. **Vectors** have both **magnitude and direction**.

In terms of motion…

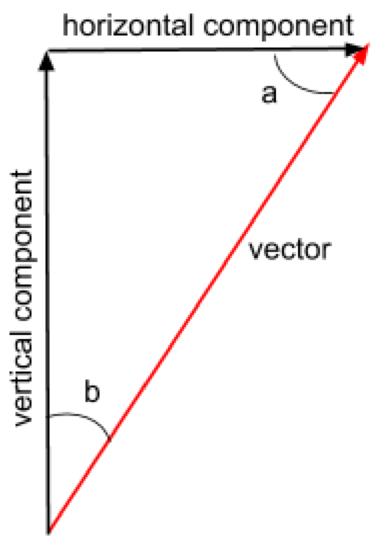
Scalars	Vectors
Speed Distance	Velocity Displacement Acceleration

average velocity = (change in displacement) / time
average speed = (change in distance) / time

Vector diagrams can be drawn and added **tip to tail**.

Relative velocity is the velocity of one moving object relative to another (usually moving) object. This is calculated by subtracting the first vector from the other.

Vector diagrams can be resolved using **trigonometry**.



cos(a) = horizontal/vector
cos(b) = vertical/vector

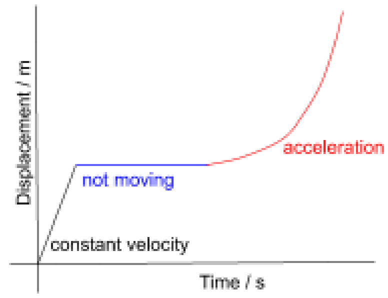
sin(a) = vertical/vector
sin(b) = horizontal/vector

tan(a) = vertical/horizontal
tan(b) = horizontal/vertical

Graphs of Motion

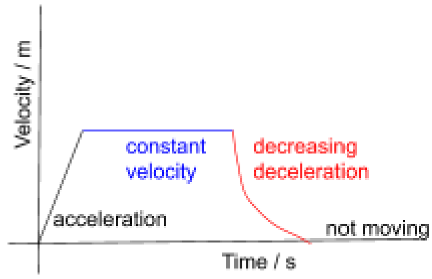
Displacement-time graphs:

- Gradient = velocity
- A straight line represents a constant velocity, a curved line represents acceleration/deceleration.
- A horizontal/flat line represents no movement.



Velocity-time graphs:

- Gradient = acceleration
- A horizontal/flat line represents constant velocity.
- A straight line represents acceleration.
- A curved line represents changing acceleration.
- No motion appears when y=0.
- Area under the graph = displacement



Acceleration = (change in velocity) / time

Modelling Motion

Iterative models apply a calculation repeatedly at different intervals of time to produce an estimation of motion.

The problem with iterative models is that they assume no change occurs within the sampled time intervals (eg. if the calculation is applied at 5 second intervals, it is assumed that the motion is constant between 5 and 10 seconds). The **accuracy** of iterative models can always be improved by **decreasing the time interval**.

Kinematic Equations - SUVAT

The **suvat** equations can be used to calculate components of motion with constant/**uniform acceleration**.

s - displacement / m
u - initial velocity / m/s
v - final velocity / m/s
a - acceleration / m/s²
t - time / s

$v = u + at$ $\qquad s = \frac{u+v}{2}t$ $\qquad s = ut + \frac{1}{2}at^2$ $\qquad v^1 = u^2 + 2as$

Cars

The **overall stopping distance** of a car is the sum of its **thinking distance** and **braking distance**. It also depends on the **speed** of the vehicle; the faster it is travelling, the greater distance it will travel in the same time it takes for the driver to react, hence producing a larger thinking distance. The car will also need to undergo a greater **braking force**, resulting in an increased braking distance.

Momentum, Force and Energy

Conservation of Momentum

momentum, p = mass, m x velocity, v

In collisions and explosions, momentum is conserved. This means that the momentum before the event is the same as the momentum after.

mass before x velocity before = mass after x velocity after

Remember, momentum has **direction** (so it is a **vector**) because the equation contains velocity, which is a vector.

Newton's Laws

Newton's First Law - the law of **inertia**. This states that a body at rest will continue at rest, or a body in motion will continue in constant motion, unless acted upon by an external force.

Newton's Second Law - the acceleration of an object is directly proportional to the force applied (F = ma). This also applies to momentum - the rate of change of momentum is directly proportional to the force.

The **impulse** of a force is equal to the force multiplied by the time it is applied for. The impulse is equal to the change in momentum.

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

$$F = \frac{\Delta p}{\Delta t} = ma$$

Newton's Third Law - "every action has an equal and opposite reaction." This means that when an object exerts a force on another object, the other object exerts a force with the same magnitude in the opposite direction.

Conservation of Energy

$$\text{Work (J) = Force (N) x distance moved in the direction of the force (m)}$$

The principle of conservation of energy states that energy is never created or destroyed, but simply transferred from one form to another. When energy is transferred between forms, **work is done**.

If the force acts at an angle, it needs to be **resolved** into components, and the component acting in the direction of motion is used for the calculation.

For Kinetic Energy (KE) and Gravitational Potential Energy (GPE):

$$KE = \frac{1}{2} mv^2$$
$$GPE = mgh$$

Power is the rate at which work is done:

$$\text{power} = \text{work done} / \text{time}$$

Projectiles

The suvat equations can be applied to **projectile motion**.

The horizontal and vertical components of motion must be dealt with separately. If speed is given, it should be **resolved** into vertical and horizontal components.