GCSE P5 – Forces and Motion 2

science physics

1. Motion in a straight line

Distance = how far an object moves (scalar)
Speed = the distance travelled per unit time (scalar)

v = s/t
velocity (m/s) = displacement (m) ÷ time (s)

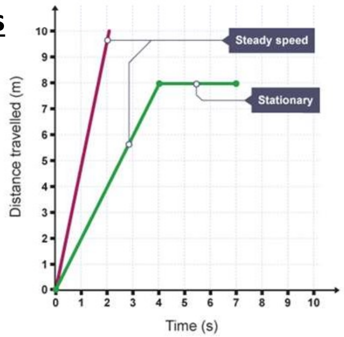
Method of travel	Typical speed (m/s)
walking	1.5
running	3
cycling	6
car	13-30
aeroplane	250

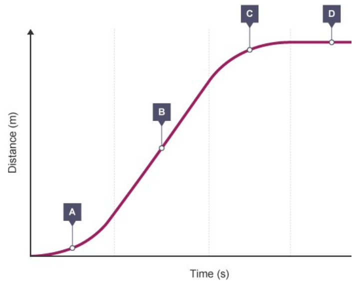
Velocity = speed in a particular direction (vector)
Acceleration = rate of change of velocity (vector)

a = Δv/t
acceleration (ms^{-2}) = velocity change (m/s) ÷ time (s)

2. Distance-time graphs

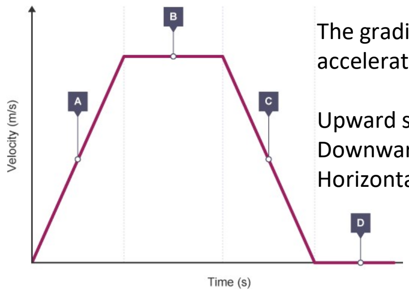
The gradient of the line shows the speed of the object.
The steeper the gradient the faster the object is moving





HIGHER TIER
A curved line shows the object is accelerating or decelerating
The speed at any point can be worked out by drawing a **tangent** to the curve and calculating its gradient

3. Velocity-time graphs



The gradient of the line shows the acceleration of the object.

Upward slope = acceleration
Downward slope = deceleration
Horizontal line = constant velocity

HIGHER TIER
The displacement of an object can be calculated from the **area under** a velocity-time graph.

$$v^2 - u^2 = 2as$$

(final velocity)² - (initial velocity)² = 2 × acceleration × distance

4. Terminal velocity

As an object falls through a fluid:
1. the object accelerates downwards due to the force of gravity
2. as the object's speed increases, frictional forces increase
3. at terminal velocity, the weight of the object is balanced by the frictional forces, and the resultant force is zero

5. Newton's laws of motion

1st law: an object remains in the same state of motion unless a resultant force acts on it. Eg an object at rest stays at rest, a moving object continues moving at the same speed and direction.

2nd law:

F = m a
Force (N) = mass (kg) x acceleration (ms^{-2})

3rd law: when two objects interact, they exert equal and opposite forces on each other.

HIGHER TIER
The tendency of an object to continue in its current state (at rest or in uniform motion) is called **inertia**.

Inertial mass is a measure of how difficult it is to change the velocity of an object

6. Stopping distance

When a force is applied to the brakes, work is done by the friction force between the brakes and the wheels. This reduces the kinetic energy and increases the temperature of the brakes. The greater the speed, the greater the braking force needed to stop it.

Stopping distance (m) = thinking distance (m) + braking distance (m)

Thinking distance	Braking distance
Drugs and alcohol Tiredness Age of driver Distractions (phone)	Quality of Brakes Quality of tyre tread Road conditions (icy/wet)

7. HIGHER TIER - Momentum

All moving objects have momentum

***p* = m v**
Momentum (kgm/s) = mass (kg) x velocity (m/s)

Principle of conservation of momentum:
'in a closed system (where no other forces act), total momentum before is always equal to total momentum after'
Momentum is conserved in collisions and explosions.

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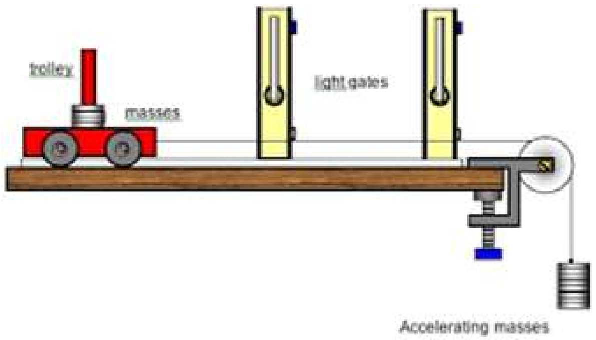
8. Required practical - investigating F=ma



Expt 1: Effect of changing the mass on the acceleration

- Independent = Mass of system (not just the trolley)
- Dependent = Acceleration (change in velocity ÷ time)
- Controls = Force applied, type of trolley, slant of ramp

Expt 2: Effect of changing the force applied on the acceleration

- Independent = Force applied
- Dependent = Acceleration
- Controls = Mass, type of trolley, angle of ramp

Light gates are used as they are more accurate – to measure the velocity at each light gate we do v = s/t

To measure the acceleration, we need to know the change in velocity) between each light gate and the time it takes to get between the two light gates.

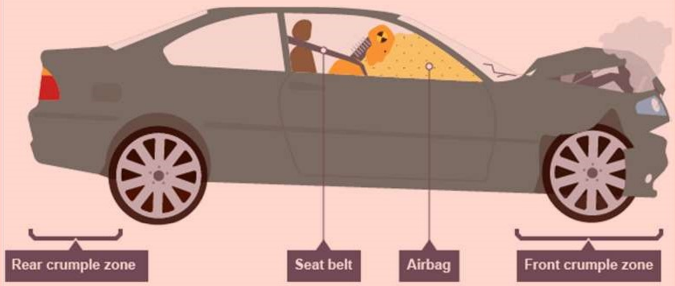
Sources of error = friction between the trolley and the ramp and in the pulley system.

SINGLE PHYSICS ONLY

9. Car safety

During a collision there is a change in momentum.
The force of the collision is equal to the rate of change of momentum.

Car safety features such as seatbelts, airbags and crumple zones all work to increase the time taken for the collision and so reduce the force of the collision.



$$F = \frac{m\,\Delta v}{t}$$

$$\text{Force (N)} = \frac{\text{change in momentum (kgm/s)}}{\text{time (s)}}$$