

# Chapter 10: Force and motion 1

## Knowledge organiser

### Force and acceleration

If the velocity of an object changes it must be acted on by a **resultant force**. The acceleration is always in the same direction as the resultant force.

### Gravity

The force of **gravity** close to the Earth is due to the planet's **gravitational field strength**.

Weight is the force acting on an object due to gravity.

The weight of an object

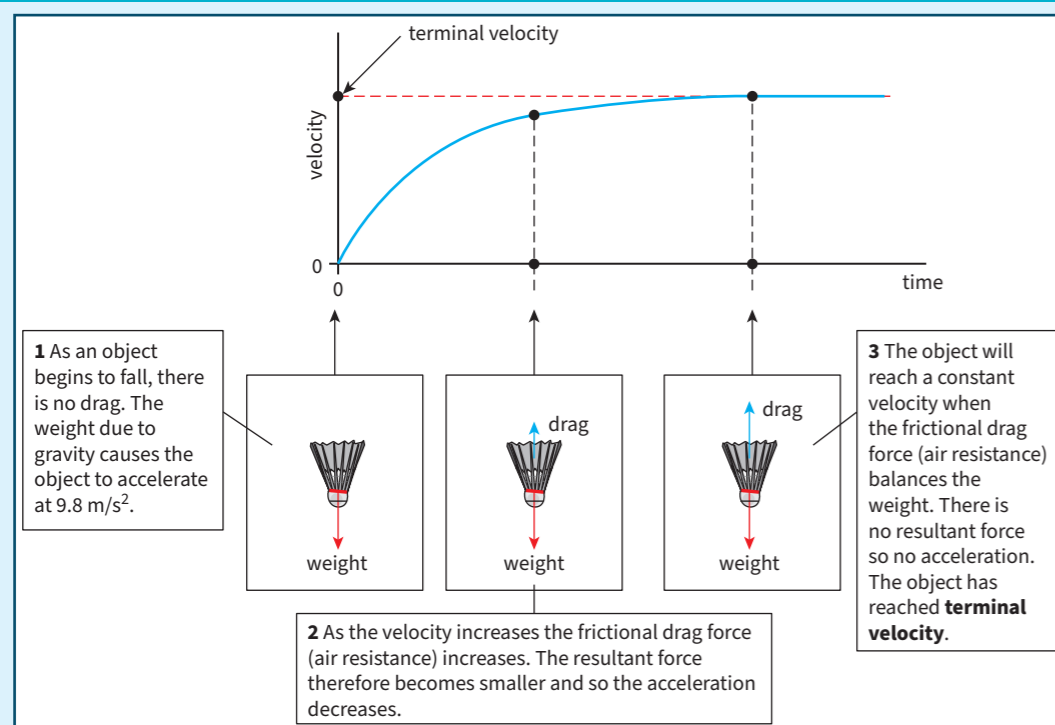
- can be considered to act at the object's **centre of mass**
- can be measured using a calibrated spring-balance (newtonmeter).

**L** weight (N) = mass (kg) × gravitational field strength (N/kg)

$$W = m g$$

Weight and mass are directly proportional to each other, which can be written as  $W \propto m$ , so as the mass of an object doubles, its weight doubles.

### Graph of terminal velocity



### Newton's Second Law

**Newton's Second Law** says that the acceleration  $a$  of an object:

- is proportional to the resultant force on the object
- is inversely proportional to the mass of the object

$$a \propto F$$

$$a \propto \frac{1}{m}$$

Resultant force, mass and acceleration are linked by the equation:

**L** resultant force (N) = mass (kg) × acceleration ( $\text{m/s}^2$ )

$$F = ma$$

The **inertial mass** of an object is a measure of how difficult it is to change the velocity of an object. It can be found using:

$$\text{inertial mass (kg)} = \frac{\text{force (N)}}{\text{acceleration (m/s}^2\text{)}}$$
$$m = \frac{F}{a}$$

### Terminal velocity

For an object falling through a fluid:

- there are two forces acting – its weight due to gravity and the drag force
- the weight remains constant
- the drag force is small at the beginning, but gets bigger as it speeds up
- the resultant force will get smaller as the drag force increases
- the acceleration will decrease as it falls
- if it falls for a long enough time, the object will reach a final steady speed.

**Terminal velocity** is the constant velocity a falling object reaches when the frictional force acting on it is equal to its weight.

If an object is only acted on by gravity the acceleration will be  $9.8 \text{ m/s}^2$

### Momentum (HT only)

**Momentum** is a property of all moving objects. It is a vector quantity.

Momentum depends on the mass and velocity of an object and is defined by the equation:

$$\text{momentum (kg m/s)} = \text{mass (kg)} \times \text{velocity (m/s)}$$



$$p = mv$$

### Law of Conservation of Momentum

The **Law of Conservation of Momentum** states that:

In a closed system, the total momentum before an event (e.g., a collision or an explosion) is **equal** to the momentum after an event.

If two moving objects collide the law of conservation can be written as:

$$m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$$

$$m_1 = \text{mass of object 1}$$

$$m_2 = \text{mass of object 2}$$

$$u_1 = \text{initial velocity of object 1}$$

$$u_2 = \text{initial velocity of object 2}$$

$$v_1 = \text{final velocity of object 1}$$

$$v_2 = \text{final velocity of object 2}$$



### Key terms

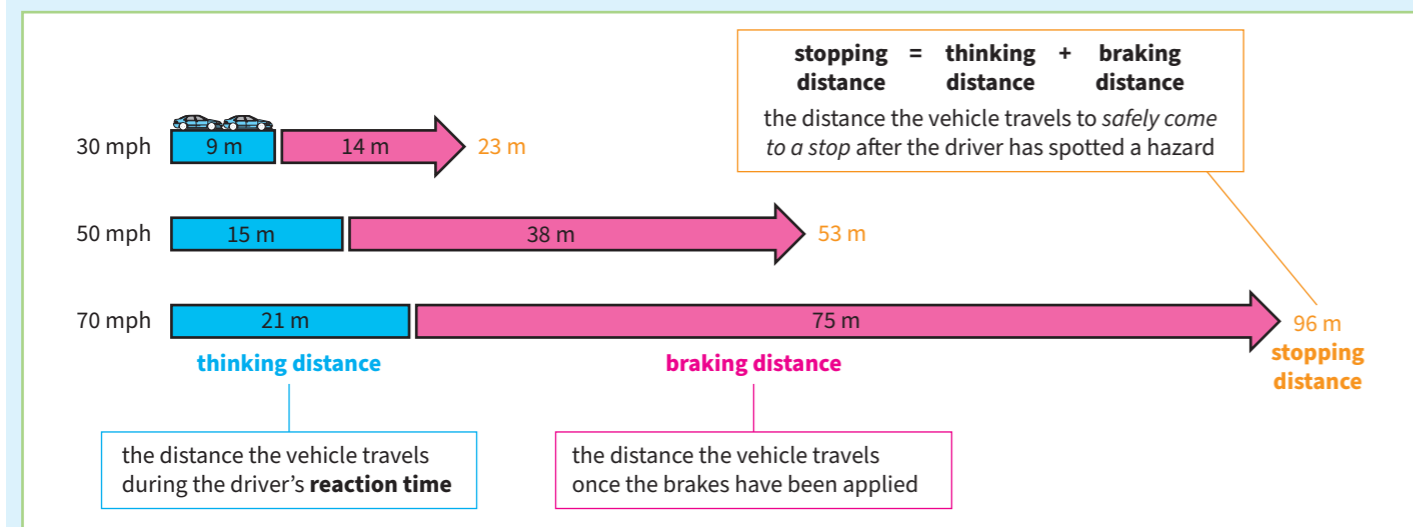
Make sure you can write a definition for these key terms.

acceleration    centre of mass    gravitational field strength    inertia    inertial mass    momentum  
Newton's Second Law    recoil    resultant force    terminal velocity    weight

# Chapter 10: Force and motion 2

## Knowledge organiser

### Forces and braking



#### Factors affecting braking distance:

- speed of the car
- road conditions
- conditions of the brakes and the tyres

#### Factors affecting thinking distance:

- speed of the car
- tiredness
- drugs
- alcohol
- distractions

### Deceleration (HT only)

Deceleration of a vehicle can be calculated using the equation

$$v^2 = u^2 + 2as$$

where  $s$  is the distance travelled,  $u$  is the initial speed, and  $v$  is the final speed.

### Deformation

**Deformation** is a change in the shape of an object caused by stretching, squashing (compressing), bending, or twisting.

More than one force has to act on a stationary object to deform it, otherwise the force would make it move.

**Elastic deformation** – the object can go back to its original shape and size when the forces are removed.

**Inelastic deformation** – the object does not go back to its original shape or size when the forces are removed.

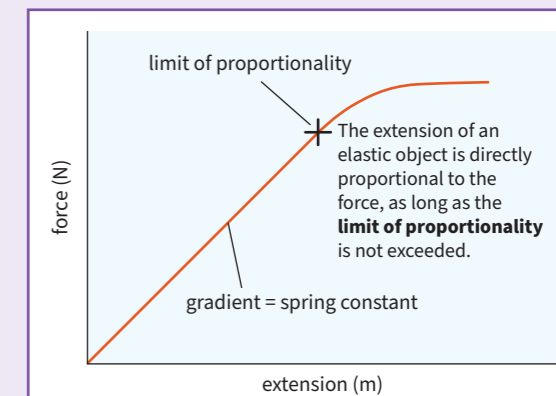
### Graphs of force against extension for elastic objects

The spring constant can be calculated using the equation:

**L** force applied (N) = spring constant (N/m) × extension (m)

$$F = k e$$

This relationship also applies to compressing an object, where  $e$  would be compression instead of extension.



### Key terms

Make sure you can write a definition for these key terms.

braking distance    deceleration    deformation    elastic    inelastic    limit of proportionality    reaction time    stopping distance    thinking distance

# Chapter 10: Force and motion

## Retrieval questions

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many as you can. Check and repeat.

### P10 questions

### Answers

1	What is the name given to the distance a vehicle travels to safely come to a stop after the driver has spotted a hazard?	Put paper here	stopping distance
2	What is thinking distance?	Put paper here	the distance vehicle travels during driver's reaction time
3	What is braking distance?	Put paper here	the distance vehicle travels once brakes have been applied
4	What is the relationship between stopping distance, thinking distance, and braking distance?	Put paper here	stopping distance = thinking distance + braking distance
5	Does the speed of a vehicle have a bigger effect on braking distance or thinking distance?	Put paper here	braking distance
6	Which distance is proportional to the speed of the vehicle?	Put paper here	thinking distance
7	What are three factors that can affect the braking distance of a vehicle?	Put paper here	speed, road conditions, condition of tyres and brakes
8	What can happen if the braking force used to stop a vehicle is very large?	Put paper here	brakes may overheat / the car may skid
9	What is elastic deformation?	Put paper here	an object can go back to its original shape and size when deforming forces are removed
10	What is inelastic deformation?	Put paper here	an object does not go back to its original shape and size when deforming forces are removed
11	How do you find the spring constant from a force-extension graph of a spring?	Put paper here	find the gradient of the straight line section