Forces i

Weight

Explain how to find the centre of mass for an irregular shape

How to you calculate weight?

Work done

Define work done and create the formula triangle?

What is important about the distance in the equation?

Resultant Forces

What does a resultant force do to an object?

How do you calculate a resultant force?

Contact Vs Non-contact

What is Newton's third law?

Make a list of contact and non-contact forces

List 3 common action/reaction pairs of forces

Free body diagrams

What do we use to represent forces? Draw a free body diagram for a car moving at a steady speed

What does it mean in terms of forces when an object is in equilibrium?

Elasticity

What is the relationship between extension and force?

How do you work out the energy stored in a spring?

Scalars and Vectors

Define vector and scalar quantities and give examples of each

Resources

- 1) Your exercise book
- 2) Your CGP Revision book
- 3) This revision pack
- 4) Items on the school website ..search 'Y10 forces' or 'SCI Revision'
- 5) Visit Kerboodle and look up the following:
  - www.kerboodle.com
  - User name: Surname then first initial (*burroughsa)*
  - *Password: Surname then first initial (burroughsa)*
  - *Code: fi8*
  - *Search for:* P8.1 Interactive: Vectors and scalars / P8.2 Interactive: Forces between objects / P8.3 Bump up your grade photo support sheet / P8.3 Interactive: Resultant force / P8.4 Interactive: Centre of mass / P8.5 Interactive: Finding the resultant force / P8.5 Interactive: Finding the resultant force / **P8 Checkpoint**
  - ***Basically just search for P8 and the resources will appear***

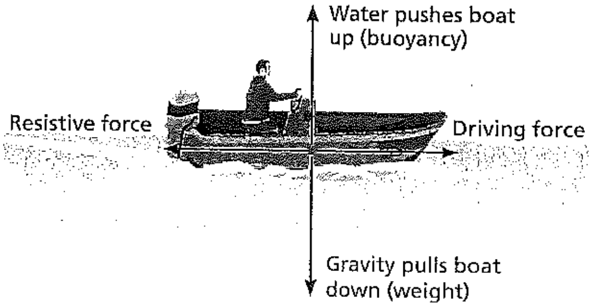
Forces – An Introduction

You must be able to:

- Describe the difference between a vector and a scalar quantity
- Use vectors to describe the forces involved when objects interact
- Calculate the resultant of two forces that act in a straight line
- Explain the difference between mass and weight
- Recognise and use the symbol for proportionality
- HT Use vector diagrams to show resolution and addition of forces.

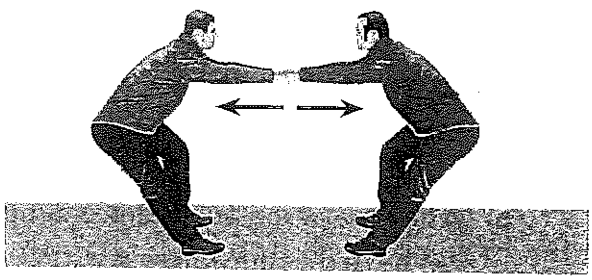
Scalar and Vector Quantities

- A scalar quantity has magnitude (size) only, e.g. number of apples.
- A vector quantity has magnitude and direction, e.g. velocity, which shows the speed *and* the direction of travel.
- Arrows can be used to represent vector quantities :
  - the length of the arrow shows the magnitude
  - the arrow points in the direction that the vector quantity is acting.
- Forces are vector quantities.
- The diagram shows the forces acting on a boat. The arrows indicate the direction they are acting.



Contact and Non-Contact Forces

- A force occurs when two or more objects interact.
- Forces are either:
  - contact forces – the objects are actually touching, e.g. the tension as two people pull against one another
  - non-contact forces – the objects are not touching, e.g. the force of gravity acts even when the objects are not touching.



[illegible]	[illegible]
Friction Air-resistance / drag Tension Normal contact force Upthrust	Gravitational force Electrostatic force Magnetic force

Key Point

A force is a vector quantity. It occurs when objects interact.

Gravity

- Gravity is a force of attraction between all masses.
- The force of gravity close to Earth is due to the gravitational field around the planet.
- The mass of an object is related to the amount of matter it contains and is constant.
- Weight is the force acting on an object due to gravity.
- The weight of an object depends on the gravitational field strength where the object is and is directly proportional to its mass.

- This symbol is used to indicate two things are proportional: ∝.

> LEARN
>
> weight = mass × gravitational field strength
>
> $W = mg$

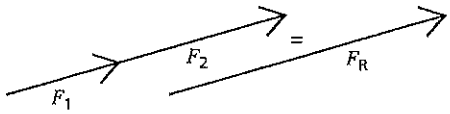
Weight (W) is measured in newtons (N).
Mass (m) is measured in kilograms (kg).
Gravitational field strength (g) is measured in newtons per kilogram (N/kg).

Resultant Forces

- When more than one force acts on an object, these forces can be seen as a single force that has the same effect as all the forces acting together.
- This is called the resultant force.

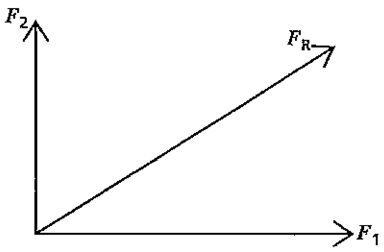
HT Vector Diagrams

- A free body diagram can be used to show different forces acting on an object (see the diagram on the boat on page 8).
- Scale vector diagrams are used to illustrate the overall effect when more than one force acts on an object:
  - The forces are added together to find a single resultant force, including both magnitude and direction.
  - The vectors are added head to tail and a resultant force arrow is drawn.



$F_R = F_1 + F_2$

- Scale vector diagrams can also be used when a force is acting in a diagonal direction:
  - Expressing the diagonal force as two forces at right-angles to each other can help to work out what effect the force will have.
  - The force F_R can be broken down into F_1 and F_2.
  - F_1 is the same length as the length of F_R in the horizontal direction.
  - F_2 is the same length as the length of F_R in the vertical direction.
  - F_R is also the vector found by adding F_1 and F_2 head to tail.

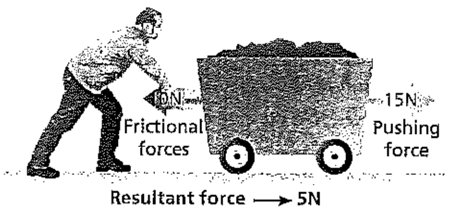


Quick Test

1. How is a scalar quantity different from a vector quantity?
2. Use an example to explain what is meant by 'non-contact force'.
3. An astronaut with a mass of 80kg stands on the moon. What is his weight? (g = 1.6N/kg)
4. A car travels in a straight line to the east with a driving force of 500N. If total frictional forces are 400N, what is the resultant force and in which direction does it act?

Key Point

The gravitational field strength (g) on Earth is 10N/kg, so a student with a mass of 50kg has a weight of (50 × 10 =) 500N.



Key Point

Weight is a force that can be measured using a newtonmeter (a calibrated spring-balance). The unit of measurement is newtons (N).
weight ∝ mass

Key Words

scalar
vector
force
contact force
non-contact force
gravity
mass
weight
resultant
HT free body diagram

Forces

Forces in Action

You must be able to:

- Describe the energy transfers involved when work is done
- Explain why changing the shape of an object can only happen when more than one force is applied to the object
- Interpret data showing the relationship between force and extension
- Perform force calculations for balanced objects
- Explain how levers and gears work.

Work Done and Energy Transfer

- When a force causes an object to move, work is done on the object.
- This is because it requires energy to move the object.
- One joule of work is done when a force of one newton causes a displacement of one metre: 1 joule = 1 newton metre.

LEARN

work done = force × distance (moved along the line of action of the force)

$W = Fs$

Work done (W) is measured in joules (J).
Force (F) is measured in newtons (N).
Distance (s) is measured in metres (m).

- When work is done, energy transfers take place within the system, e.g. work done to overcome friction causes an increase in heat energy.

Key Point

Overcoming forces requires energy. When a force is used to move an object, work is done on the object. The movement of the object is called displacement.

Forces and Elasticity

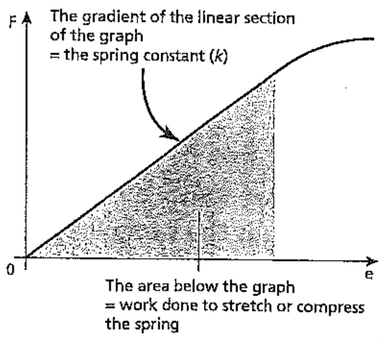
- To change the shape of an object, more than one force must be applied, e.g. a spring must be pulled from both ends to stretch it.
- If the object returns to its original shape after the forces are removed, it was elastically deformed.
- If the object does *not* return to its original shape, it has been inelastically deformed.
- The extension of an elastic object is directly proportional to the applied force, i.e. they have a linear relationship and produce a straight line on a force–extension graph.
- However, once the limit of proportionality has been exceeded:
  - doubling the force will no longer exactly double the extension
  - the relationship becomes non-linear
  - a force–extension graph will stop being a straight line.
- This equation applies to the linear section of a force–extension graph:

LEARN

force = spring constant × extension

$F = ke$

Force (F) is measured in newtons (N).
Spring constant (k) is measured in newtons per metre (N/m).
Extension (e) is measured in metres (m).



- This also applies to the compression of an elastic object.
- The spring constant indicates how easy it is to stretch or compress a spring – the higher the spring constant, the stiffer the spring.
- A force that stretches or compresses a spring stores elastic potential energy in the spring.
- The amount of work done and the energy stored are equal, provided the spring does not go past the limit of proportionality.

Key Point

The work done to stretch or compress a spring is equal to the energy stored in the spring, provided the spring has not been inelastically deformed.

Practice Questions

Forces – An Introduction

1. The mass of an object is a scalar quantity, but the weight of an object is a vector quantity.

   Explain what is meant by this statement and the link between mass and weight. [4]

2. **Figure 1** represents the forces acting on an object.

   Figure 1

   a) Compare the forces F_1 and F_2. [2]

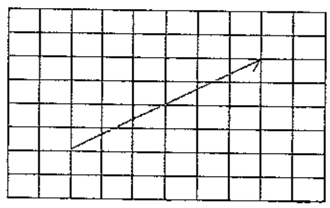
   b) The force F_2 increases until it is of equal magnitude to F_1.

   What will be the magnitude of the resultant force? [1]

3. HT **Figure 2** represents the resultant force acting on an object.

   Draw the horizontal and vertical components of the arrow onto **Figure 2**.

   Figure 2



[1]

Total Marks ______ / 8

Forces in Action

1. A car travelling along a straight, level road at 30mph has 150kJ of kinetic energy.
   The driver applies the brakes and comes to a complete stop in 50m.

   a) What happens to the temperature of the brakes during braking? [1]

   b) How much work is done by the brakes to stop the car? [1]

   c) Calculate the braking force applied by the brakes. [2]

2. A wheelbarrow is loaded with 60kg of soil.
   The load is a distance of 20cm from the wheel, which acts as the pivot point when the barrow is lifted.

   a) Show that the soil weighs around 590N (g = 10N/kg). [2]

   b) The handles of the wheel barrow are positioned 60cm from the wheel.

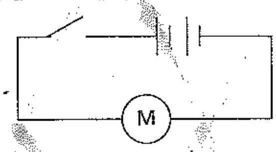
   Estimate the force needed to use the wheelbarrow to lift the soil. [2]

Total Marks ______ / 8

Answers

Pages 6–7 Review Questions

1. a) It moves backwards / to the left / away from the wall [1]
   b) It will slow it down [1]
2. a) A simple series circuit drawn with the correct with symbol for battery [1]; motor [1]; and switch [1]



   b) The battery [1]
   c) It will be slower [1]
3. Both bulbs will go out [1]
4. Both bulbs will stay the same [1]
5. a) There is a limited amount [1]; so it will run out [1]
   b) **Any two of:** coal [1]; gas [1]; nuclear [1]
6. chemical [1]; electrical [1]; light [1]; thermal [1]
7. 30N [1]
8. a) B [1]
   b) C is bigger than A [1]
   c) B and D [1]
   d) D is bigger than B [1]
9. a) It is reflected [1]
   b) Black absorbs light / the cyclist does not reflect any light [1]; so no light from the cyclist enters the driver's eyes [1]; and they appear black against a black background [1]

Pages 8–19 Revise Questions

Page 9 Quick Test
1. A scalar quantity just has size, but a vector has size and direction.
2. Magnetism / gravity / electrostatic attraction is a non-contact force; a magnet will attract or repel another magnet without needing to touch it / one mass will gravitationally attract another / one charge will attract or repel another charge without physical contact.
3. 128N
4. 100N to the east

Page 11 Quick Test
1. 100J
2. 37.5cm

Page 13 Quick Test
1. When particles collide with the surface of an object they exert a force. The pressure is the force per unit area.
2. 10 000N
3. 900kg/m³
4. 2 000 000Pa

Page 15 Quick Test
1. Distance is the total distance travelled in any direction; displacement is the total distance from the start point and includes the direction from the start point.
2. 20m/s
3. Speed

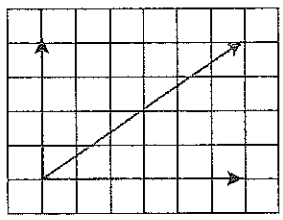
Page 17 Quick Test
1. 2m/s²
2. The object represented by graph A is accelerating at twice the rate of the object represented by graph B.
3. To identify anomalous results, which can then be removed and allow a mean to be taken.

Page 19 Quick Test
1. 40 000kg m/s
2. As the fish swims it exerts a force backwards on the water. This creates an equal and opposite force from the water on the fish, that pushes the fish forwards.
3. a) 600 × 8 = 4800Nm
   b) $\frac{4800}{12}$ = 400kg

Page 21 Quick Test
1. It might increase the stopping distance, as it increases the thinking distance by causing a distraction.
2. Answer should be between 2160N and 3375N using city speeds as 12–15m/s.
3. One person holds a ruler with the bottom of the ruler level with the other person's hand. They let go of the ruler and the other person catches it when they see it move. The reaction time is calculated from the distance the ruler falls before being caught.
   OR
   One person presses a switch that turns on a light and starts a timer. The other person presses a switch that stops the timer when they see the light.

Pages 22–25 Practice Questions

Page 22 Forces – An Introduction
1. A scalar quantity has size only [1]; a vector quantity has size and direction [1]; mass is the measure of how much matter is in an object [1]; weight is the force of gravity and, as a force, it acts in a particular direction [1]
2. a) F_1 is twice the size of F_2 [1]; and acts in the opposite direction [1]
   b) Zero [1]
3. Correctly drawn vertical and horizontal arrows [1]



Page 22 Forces in Action
1. a) It increases [1]
   b) 150 000J [1]
   c) $\frac{150\,000}{50}$ [1]; = 3000N [1]
2. a) 60 × 10 [1]; = 600N [1]
   b) Three times the distance of the soil from the pivot, so a third of the forced needed [1]; around 200N [1] (Accept accurate calculation of 196N)

Page 23 Pressure and Pressure Differences
1. It is caused by the random movement the particles [1]; colliding with objects or the walls of a container [1]
2. pressure = $\frac{\text{force normal to a surface}}{\text{area of that surface}}$ / $p = \frac{F}{A}$
3. 10 × 100 [1]; = 1000N [1]
   Pressure is constant, so 10 times the area must be 10 times the force.
4. a) 100 × 1000 × 10 [1]; = 1 000 000N/m [2] (1 mark for correct value; 1 mar for correct units)
   b) The pressure falls by [1]; 3 × 1000 × 10 [1]; = 30 000N/m² [1]
5. a) $\frac{2597}{10}$ = 259.7 [1]; = 260kg (to the nearest kg) [1]
   b) 260 + 100 = 360kg
   c) 360 × 10 [1]; = 3600N [1]
   d) Mass displaced = 365kg [1]; volume = $\frac{\text{mass}}{\text{density}}$ [1]; = $\frac{365}{1000}$ [1]; = 0.365m³ [1]

Page 24 Forces and Motion
1. a) 5 miles
   b) 1 mile [1]; east [1]
2. a) i) 52 × 3.65 = 189.8 miles
   ii) 0 miles
   iii) $\frac{189.8}{1.5}$ [1]; = 126.5mph (to 1 decim place) [1]
   b) This occurs when direction is changing [1]; but speed is constant [1]; so, could occur on bends / corners [1]
3. a) 3 seconds
   b) C to D
   c) $\frac{3}{5}$ [1]; 0.6m/s [1]
   d) Change in speed / acceleration and deceleration

Page 24 Forces and Acceleration
1. $v^2 = 2as + u^2$ [1]; $v^2 = (2 \times 4 \times 100) + 10$ [1]; $v^2 = 900$ [1]; $v = \sqrt{900}$ = 30m/s [1]
2. a) Correct axes and labels [1]; accurate plotted points [1]; straight lines joining points [1]