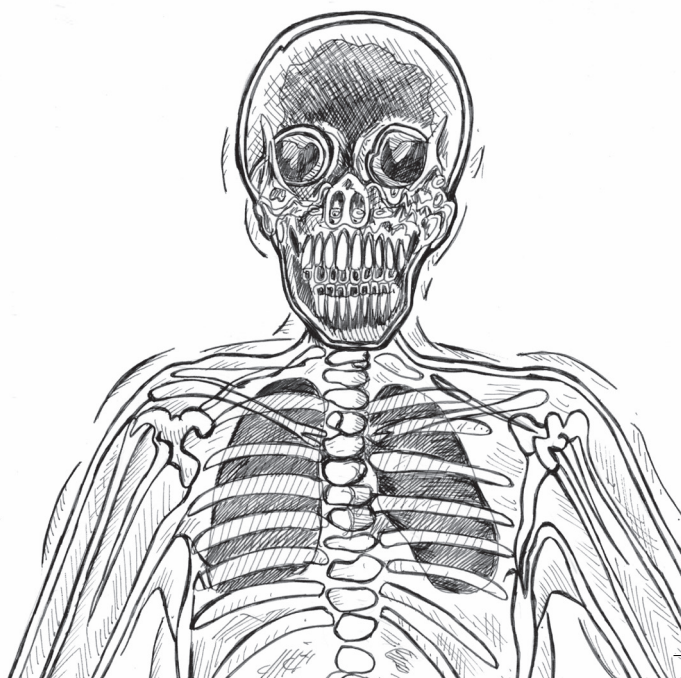
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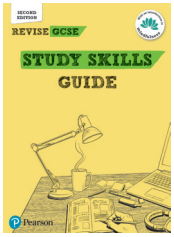
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Series consultant: Harry Smith
Authors: Helen Sayers and Jim Newall

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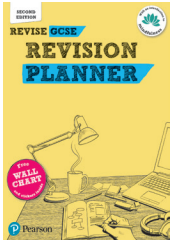
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Use this quick quiz to check that you are confident with the core skills and knowledge you need for the Pearson Edexcel GCSE (9–1) Physics Higher exam or Combined Science Higher exam.

Check your understanding with solutions to all the exam-style questions.

A small bit of small print

Pearson Edexcel publishes Sample Assessment Material and the Specification on its website. This is the official content and this book should be used in conjunction with it. The questions in the *Exam practice* sections have been written to help you revise topics and practise answering exam questions. Remember – the real exam questions may not look like this.

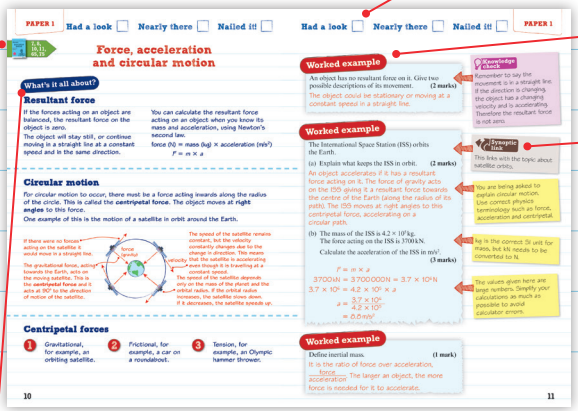
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Welcome to Nail it!

This book provides revision and practice to help you nail down a top grade in your Pearson Edexcel GCSE (9–1) Physics Higher exam or Combined Science Higher exam. Designed for students aiming for a grade 7, 8 or 9, it's packed with exam tips, support for tricky topics, and exam-style practice questions to make sure you are ready to tackle the toughest questions and achieve top marks.

For more help with these topics, check out these pages in the Revise Pearson Edexcel GCSE (9–1) Physics Higher Revision Guide. To check out pages in the Revise Pearson Edexcel GCSE (9–1) Combined Science Higher Revision Guide, see the table on page 74.

Track your progress by ticking these boxes.


PAPER 1 Had a look ☐ Nearly there ☐ Nailed it! ☐

Force, acceleration and circular motion

What's it all about?

Resultant force

If the forces acting on an object are balanced, the resultant force on the object is zero. The object will stay still, or continue moving in a straight line at a constant speed and in the same direction.

You can calculate the resultant force acting on an object when you know its mass and acceleration, using Newton's second law:

force (N) = mass (kg) × acceleration (m/s²)

$F = m \times a$

Circular motion

For circular motion to occur, there must be a force acting inwards along the radius of the circle. This is called the **centripetal force**. The object moves at **right angles** to this force.

One example of this is the motion of a satellite in orbit around the Earth.

The speed of the satellite remains constant, but the velocity changes because there is a change in direction. This means that the satellite is accelerating – even though it is travelling at a constant speed.

The gravitational force, acting towards the Earth, acts on the moving satellite. This is the **centripetal force** and it acts at 90° to the direction of motion of the satellite.

If there were no forces acting on the satellite it would move in a straight line.

Force (gravity)

Velocity

The speed of the satellite depends only on the mass of the planet and the orbital radius. If the orbital radius increases, the satellite moves slower. If it decreases, the satellite speeds up.

Centripetal forces

1. Gravitational, for example, an orbiting satellite.
2. Frictional, for example, a car on a roundabout.
3. Tension, for example, an Olympic hammer thrower.

10

Had a look ☐ Nearly there ☐ Nailed it! ☐ PAPER 1

Worked example

An object has no resultant force on it. Give two possible descriptions of its movement. (2 marks)

The object could be stationary or moving at a constant speed in a straight line.

Knowledge check: Remember to say the movement is in a straight line. If the direction is changing, the object has a changing velocity and is accelerating. Therefore the resultant force is not zero.

Worked example

The International Space Station (ISS) orbits the Earth.

(a) Explain what keeps the ISS in orbit. (2 marks)

An object accelerates if it has a resultant force acting on it. The force of gravity acts on the ISS giving it a resultant force towards the centre of the Earth (along the radius of its path). The ISS moves at right angles to this centripetal force, accelerating on a circular path.

Synoptic link: This links with the topic about satellite orbits.

(b) The mass of the ISS is 4.2×10^5 kg. The force acting on the ISS is 3700 kN. Calculate the acceleration of the ISS in m/s². (3 marks)

You are being asked to explain circular motion. Use correct physics terminology such as force, acceleration and centripetal.

kg is the correct SI unit for mass, but kN needs to be converted to N.

$F = m \times a$

$3700\text{kN} = 3700000\text{N} = 3.7 \times 10^6\text{N}$

$3.7 \times 10^6 = 4.2 \times 10^5 \times a$

$a = \frac{3.7 \times 10^6}{4.2 \times 10^5}$

$= 8.8\text{m/s}^2$

The values given here are target numbers. Simplify your calculations as much as possible to avoid calculator errors.

Worked example

Define inertial mass. (1 mark)

It is the ratio of force over acceleration, $\frac{\text{force}}{\text{acceleration}}$. The larger an object, the more force is needed for it to accelerate.

11

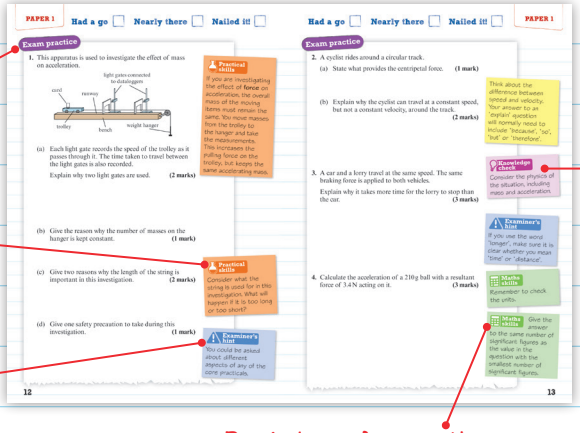
Worked exam-style questions show you exactly how to tackle tricky questions and set out your working.

Support in bringing in knowledge from other topics to enhance your answer is given in the synoptic links.

Knowledge check hints give reminders of key information and core skills – you need to be confident with these to achieve a top grade.

Revise the key facts and formulae for this topic.

Check that you are on track for a top grade with these exam-style questions. There are answers at the back of the book.


PAPER 1 Had a go ☐ Nearly there ☐ Nailed it! ☐

Exam practice

1. This apparatus is used to investigate the effect of mass on acceleration.

Practical skills: If you are investigating the effect of force on acceleration, the overall mass of the moving items must remain the same. You move masses from the trolley to the hanger and take the measurements. This increases the pulling force on the trolley, but keeps the same accelerating mass.

(a) Each light gate records the speed of the trolley as it passes through it. The time taken to travel between the light gates is also recorded. Explain why two light gates are used. (2 marks)

(b) Give the reason why the number of masses on the hanger is kept constant. (1 mark)

(c) Give two reasons why the length of the string is important in this investigation. (2 marks)

Practical skills: Consider what the string is used for in this investigation. What will happen if it is too long or too short?

(d) Give one safety precaution to take during this investigation. (1 mark)

Examiner's hint: You could be asked about different variables of any of the core practicals.

12

Had a go ☐ Nearly there ☐ Nailed it! ☐ PAPER 1

Exam practice

2. A cyclist rides around a circular track.

(a) State what provides the centripetal force. (1 mark)

Think about the difference between speed and velocity. Your answer to an 'explain' question will normally need to include 'because', 'so', 'but' or 'therefore'.

(b) Explain why the cyclist can travel at a constant speed, but not a constant velocity, around the track. (2 marks)

3. A car and a lorry travel at the same speed. The same braking force is applied to both vehicles.

Explain why it takes more time for the lorry to stop than the car. (3 marks)

Knowledge check: Consider the physics of the situation, including mass and acceleration.

Examiner's hint: If you use the word 'longer', make sure it is clear whether you mean 'time' or 'distance'.

Maths skills: Remember to check the units.

4. Calculate the acceleration of a 210g ball with a resultant force of 3.4N acting on it. (3 marks)

Maths skills: Give the answer to the same number of significant figures as the value in the question with the smallest number of significant figures.

13

Check that you are on track for a top grade with these exam-style questions. There are answers at the back of the book.

Reminders of how the question links to the Core Practical.

Examiner hints give top tips for exam success.

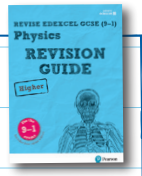
Reminders of any maths skills needed to answer a question.

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Knowledge check

If you're aiming for a top grade, you need to be confident with core skills and knowledge, such as acceleration, electrical circuits and sound waves. Take this quick quiz to find out which skills you might need to brush up on before tackling the topics in this book. Answers are on page 66.

Revise core skills



Use the **Revise Pearson Edexcel GCSE (9–1) Physics Higher Revision Guide** if you need to revise any of the core skills. The green arrow next to each question tells you which page to look at for more help.

6

1. What is the acceleration, g, in free fall?

- ☐ **A** 0.1 m/s^2
- ☐ **B** 1 m/s^2
- ☐ **C** 10 m/s^2
- ☐ **D** 100 m/s^2

6

2. What is the typical speed of a cyclist?

- ☐ **A** 1 m/s
- ☐ **B** 2.5 m/s
- ☐ **C** 6 m/s
- ☐ **D** 15 m/s

5

3. What is the formula to calculate the area of a right-angled triangle with base b and height h?

- ☐ **A** $0.5 \times b \times h$
- ☐ **B** $(b \times h)^2$
- ☐ **C** $2 \times b \times h$
- ☐ **D** $0.5\ (b \times h)^2$

8

4. Define Newton's second law.

.....

.....

9

5. What is the weight of an object with mass 2.5 kg?

- ☐ **A** 0.25 N
- ☐ **B** 2.5 N
- ☐ **C** 25 N
- ☐ **D** 250 N

12

6. What is the momentum of an object with a mass of 5 kg travelling at 15 m/s?

- ☐ **A** 0.3 kg m/s
- ☐ **B** 3 kg m/s
- ☐ **C** 75 kg m/s
- ☐ **D** 1125 kg m/s

15

7. Which equation is correct?

- ☐ **A** braking distance = thinking distance + stopping distance
- ☐ **B** stopping distance = thinking distance + braking distance
- ☐ **C** thinking distance = braking distance + stopping distance
- ☐ **D** stopping distance = braking distance – thinking distance

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27 **8.** What type of wave is a sound wave?

.....

29 **9.** What is the formula for frequency?

- ☐ **A** wavelength ÷ wave speed
- ☐ **B** wave speed ÷ wavelength
- ☐ **C** wave speed × wavelength
- ☐ **D** wave speed^2 × wavelength

28 **10.** What type of sound waves are used to destroy kidney stones?

.....

37 **11.** What do all electromagnetic waves transfer?

.....

45 **12.** What is the typical diameter of an atom (approximately)?

- ☐ **A** 0.02 nm
- ☐ **B** 0.2 nm
- ☐ **C** 2 nm
- ☐ **D** 20 nm

46 **13.** What do isotopes of an element have different numbers of?

- ☐ **A** electrons
- ☐ **B** neutrons
- ☐ **C** positrons
- ☐ **D** protons

46 **14.** What is represented by 59 in $^{59}_{27}Co$?

- ☐ **A** atomic number
- ☐ **B** mass number
- ☐ **C** neutron number
- ☐ **D** relative electric charge

51 **15.** What is the plum pudding model?

.....

.....

52 **16.** What happens during β^+ decay?

.....

.....

64 **17.** List the eight planets in increasing order of their distance from the Sun.

....

....

....

....

67 **18.** Which correctly describes the effects on the wavelength and frequency of an EM wave when red-shift occurs?

		Wavelength	Frequency
☐	**A**	decreases	decreases
☐	**B**	decreases	increases
☐	**C**	increases	decreases
☐	**D**	increases	increases

75 **19.** What happens to an object when a resultant force acts on it?

.....

.....

.....

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76 **20.** Which would have the biggest increase on the turning effect of a spanner?

- ☐ **A** A longer spanner with a smaller force.
- ☐ **B** A shorter spanner with a larger force.
- ☐ **C** A longer spanner with a larger force.
- ☐ **D** A shorter spanner with a smaller force.

76 **21.** What is the unit of the turning effect of a force?

.....

79 **22.** Draw the electrical symbol for a diode.

81 **23.** What is the unit of electrical charge?

.....

81 **24.** Define electric current.

.....

.....

84 **25.** What would you connect to a circuit to find the resistance of a component?

- ☐ **A** An ammeter and a voltmeter in parallel with the component.
- ☐ **B** An ammeter and a voltmeter in series with the component.
- ☐ **C** An ammeter in parallel and a voltmeter in series with the component.
- ☐ **D** An ammeter in series and a voltmeter in parallel with the component.

88 **26.** Which store is energy transferred to when an electric current flows in a resistor?

.....

89 **27.** What formula is used to calculate electrical power?

- ☐ **A** $P = (IR)^2$
- ☐ **B** $P = I^2 \times R$
- ☐ **C** $P = I \times R$
- ☐ **D** $P = I \times R^2$

93 **28.** If a material loses electrons, what does it become?

- ☐ **A** negatively charged
- ☐ **B** neutral
- ☐ **C** positively charged
- ☐ **D** repellent to other electrons

93 **29.** On which type of materials can electric charge build up?

- ☐ **A** conductors
- ☐ **B** insulators
- ☐ **C** magnets
- ☐ **D** metals

95 **30.** What term is used to describe the removal of excess charge?

.....

.....

105 **31.** What is the name of the UK high voltage electric power transmission network?

.....

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107 **32.** Name the process by which a solid changes directly into a gas.

.....

113 **33.** Which substances can be compressed?

- ☐ **A** gases only
- ☐ **B** solids and liquids
- ☐ **C** liquids only
- ☐ **D** solids only

34. What is 135.06 written to 2 significant figures?

- ☐ **A** 130
- ☐ **B** 135
- ☐ **C** 135.1
- ☐ **D** 140

35. Write 0.003 18 in standard form.

.....

36. Convert 5000 W to MW.

- ☐ **A** 5×10^{-6} MW
- ☐ **B** 0.005 MW
- ☐ **C** 5 MW
- ☐ **D** 5 000 000 MW

37. Convert 76 A to mA.

- ☐ **A** 0.076 mA
- ☐ **B** 7.6 mA
- ☐ **C** 7600 mA
- ☐ **D** 76 000 mA

38. How can you convert μm to m?

- ☐ **A** divide by 1000
- ☐ **B** multiply by 1000
- ☐ **C** divide by 1 000 000
- ☐ **D** multiply by 1 000 000

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Had a look ☐ Nearly there ☐ Nailed it! ☐



2–6

Distance, speed and time

What's it all about?

Distance, speed and time are all physical quantities. Physical quantities are either scalar or vector.

	Scalar	Vector
Magnitude	Yes	Yes
Specific direction	No	Yes
Examples	• distance • speed • time • mass	• acceleration • momentum • velocity • displacement

Vector quantities can have both positive and negative values to show their direction.

Velocity is speed in a stated direction.

Displacement is distance in a stated direction.

Equations of motion

You need to be able to recall and apply these two equations.

Average speed

Objects often change speed during a journey, so it is better to use average speed:

$$\text{average speed (m/s)} = \text{total distance travelled (m)} \div \text{total time taken (s)}$$

Acceleration

Acceleration is a change in velocity per second. Acceleration is a vector quantity.

$$\text{acceleration (m/s}^2\text{)} = \frac{\text{change in velocity (m/s)}}{\text{time taken (s)}}$$

$$a = \frac{(v - u)}{t}$$

Velocity

Velocity is the change in distance per second.

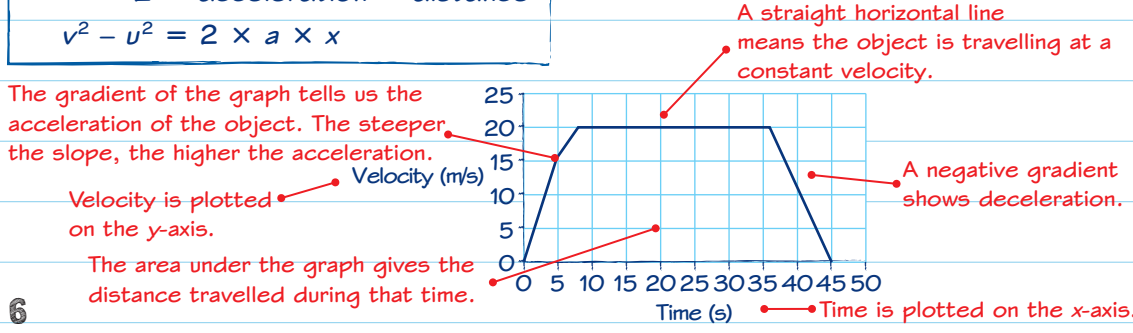
Velocity is a vector quantity.

$$(\text{final velocity})^2 - (\text{initial velocity})^2 = 2 \times \text{acceleration} \times \text{distance}$$

$$v^2 - u^2 = 2 \times a \times x$$

Velocity/time graphs

Velocity/time graphs show how velocity changes with time. You can use them to find the acceleration of an object and the distance travelled.



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Worked example

An athlete sprints from stationary with an acceleration of 8 m/s² for 5 m.

Calculate the velocity reached by the athlete. **(3 marks)**

$v^2 - u^2 = 2 \times a \times x$

$v^2 - 0^2 = 2 \times 8 \times 5$

$v^2 = 80$

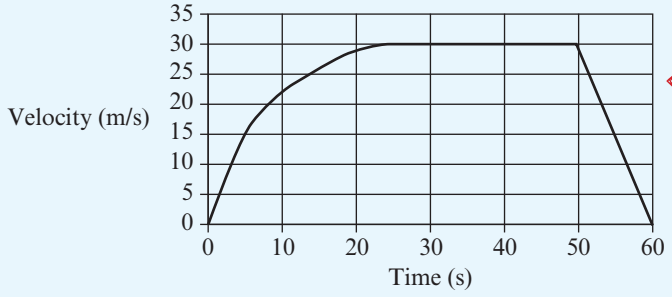
$v = \sqrt{80} = 9$ m/s (rounded to 1 sf)

Substitute the given values into the correct equation. Simplify the equation and then calculate the answer.

The equation gives v^2 so you will need to find the square root.

Worked example

The diagram shows the velocity/time graph of a car.



In the exam, you will only be asked to make velocity/time graph calculations relating to straight lines showing uniform acceleration or constant velocity.

(a) Calculate the acceleration of the car between 50 and 60 seconds. **(2 marks)**

acceleration = change in velocity ÷ time taken

$= \frac{0 - 30}{60 - 50}$

$= \frac{-30}{10}$

$= -3$ m/s²

Maths skills

A negative gradient (downward slope) shows deceleration. Remember the − sign.

(b) Determine the distance travelled, in metres, m, between $t = 25$ seconds and when the car stops. **(3 marks)**

distance = area of rectangle + area of triangle

area of rectangle = (50 − 25) × 30 = 750 m

area of triangle = 0.5 × (60 − 50) × 30 = 150 m

distance travelled = 750 + 150 = 900 m

Maths skills Split the area into rectangles and triangles and find the areas of these shapes:

area of rectangle = length × width

area of triangle = $\frac{1}{2}$ × base × height

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Exam practice

1. A cyclist increases speed from 5 m/s to 9 m/s with an acceleration of 1.2 m/s^2.

(a) Calculate the time taken for this acceleration to take place. **(3 marks)**

Knowledge check

The equation you need is one you need to be able to recall.

Examiner's hint

Show each stage of the calculation as marks may be awarded for working even if your answer is wrong.

..... s

(b) Calculate the distance travelled during this acceleration. **(3 marks)**

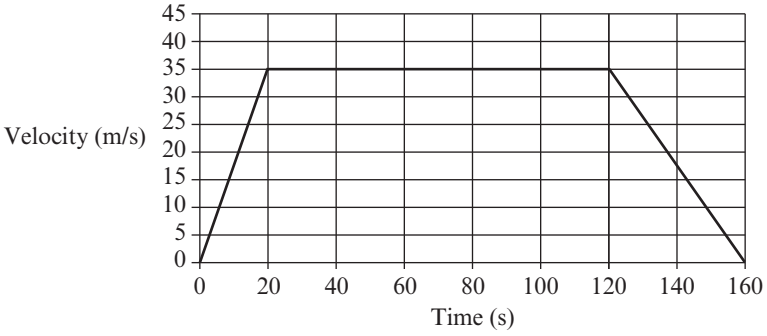
Use an equation from the formula sheet on page 73. This list will also be given to you with the exam paper.

..... m

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Exam practice

2. The diagram shows a velocity/time graph for a train.



(a) Compare the distance travelled by the train when it is speeding up with the distance it travels at a constant velocity. **(4 marks)**

Examiner's hint

Clearly show the areas you are calculating from the graph.

Examiner's hint

You are told to compare the values after you have calculated them.

(b) Calculate the deceleration of the train between 120 and 160 seconds. **(3 marks)**

The train is slowing down so the acceleration must be negative.

Maths skills The values on the graph are given to 2 significant figures so give your answer in the same way.

..... m/s^2

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7, 8, 10, 11, 65, 75

Force, acceleration and circular motion

What's it all about?

Resultant force

If the forces acting on an object are balanced, the resultant force on the object is zero.

The object will stay still, or continue moving in a straight line at a constant speed and in the same direction.

You can calculate the resultant force acting on an object when you know its mass and acceleration, using Newton's second law.

force (N) = mass (kg) × acceleration (m/s^2)

$F = m \times a$

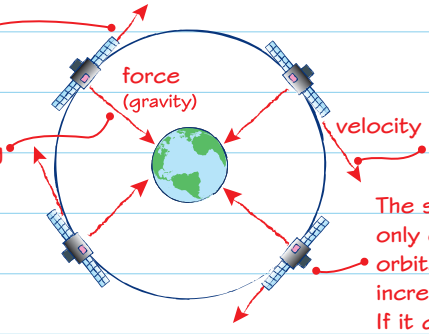
Circular motion

For circular motion to occur, there must be a force acting inwards along the radius of the circle. This is called the **centripetal force**. The object moves at **right angles** to this force.

One example of this is the motion of a satellite in orbit around the Earth.

If there were no forces acting on the satellite it would move in a straight line.

The gravitational force, acting towards the Earth, acts on the moving satellite. This is the **centripetal force** and it acts at 90° to the direction of motion of the satellite.



The speed of the satellite remains constant, but the velocity constantly changes due to the change in direction. This means that the satellite is accelerating even though it is travelling at a constant speed.

The speed of the satellite depends only on the mass of the planet and the orbital radius. If the orbital radius increases, the satellite slows down. If it decreases, the satellite speeds up.

Centripetal forces

1. Gravitational, for example, an orbiting satellite.
2. Frictional, for example, a car on a roundabout.
3. Tension, for example, an Olympic hammer thrower.

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Worked example

An object has no resultant force on it. Give two possible descriptions of its movement. **(2 marks)**

The object could be stationary or moving at a constant speed in a straight line.

Knowledge check

Remember to say the movement is in a straight line. If the direction is changing, the object has a changing velocity and is accelerating. Therefore the resultant force is not zero.

Worked example

The International Space Station (ISS) orbits the Earth.

(a) Explain what keeps the ISS in orbit. **(2 marks)**

An object accelerates if it has a resultant force acting on it. The force of gravity acts on the ISS giving it a resultant force towards the centre of the Earth (along the radius of its path). The ISS moves at right angles to this centripetal force, accelerating on a circular path.

Synoptic link

This links with the topic about satellite orbits.

You are being asked to explain circular motion. Use correct physics terminology such as force, acceleration and centripetal.

(b) The mass of the ISS is 4.2×10^5 kg.
The force acting on the ISS is 3700 kN.

Calculate the acceleration of the ISS in m/s^2. **(3 marks)**

$$F = m \times a$$

$$3700\,\text{kN} = 3\,700\,000\,\text{N} = 3.7 \times 10^6\,\text{N}$$

$$3.7 \times 10^6 = 4.2 \times 10^5 \times a$$

$$a = \frac{3.7 \times 10^6}{4.2 \times 10^5}$$

$$= 8.8\,\text{m/s}^2$$

kg is the correct SI unit for mass, but kN needs to be converted to N.

The values given here are large numbers. Simplify your calculations as much as possible to avoid calculator errors.

Worked example

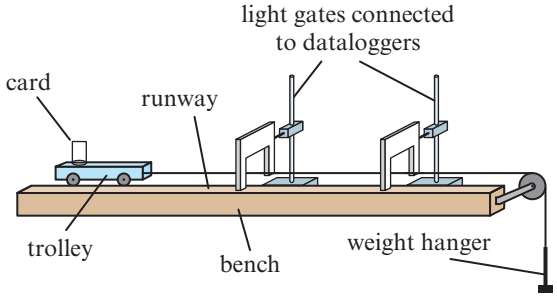
Define inertial mass. **(1 mark)**

It is the ratio of force over acceleration, $\frac{\text{force}}{\text{acceleration}}$. The larger an object, the more force is needed for it to accelerate.

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Exam practice

1. This apparatus is used to investigate the effect of mass on acceleration.



(a) Each light gate records the speed of the trolley as it passes through it. The time taken to travel between the light gates is also recorded.

Explain why two light gates are used. **(2 marks)**

Practical skills

If you are investigating the effect of **force** on acceleration, the overall mass of the moving items must remain the same. You move masses from the trolley to the hanger and take the measurements. This increases the pulling force on the trolley, but keeps the same accelerating mass.

(b) Give the reason why the number of masses on the hanger is kept constant. **(1 mark)**

(c) Give two reasons why the length of the string is important in this investigation. **(2 marks)**

Practical skills

Consider what the string is used for in this investigation. What will happen if it is too long or too short?

(d) Give one safety precaution to take during this investigation. **(1 mark)**

Examiner's hint

You could be asked about different aspects of any of the core practicals.

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Exam practice

2. A cyclist rides around a circular track.

(a) State what provides the centripetal force. **(1 mark)**

(b) Explain why the cyclist can travel at a constant speed, but not a constant velocity, around the track. **(2 marks)**

Think about the difference between speed and velocity. Your answer to an 'explain' question will normally need to include 'because', 'so', 'but' or 'therefore'.

3. A car and a lorry travel at the same speed. The same braking force is applied to both vehicles.

Explain why it takes more time for the lorry to stop than the car. **(3 marks)**

Knowledge check

Consider the physics of the situation, including mass and acceleration.

Examiner's hint

If you use the word 'longer', make sure it is clear whether you mean 'time' or 'distance'.

4. Calculate the acceleration of a 210 g ball with a resultant force of 3.4 N acting on it. **(3 marks)**

Maths skills

Remember to check the units.

Maths skills

Give the answer to the same number of significant figures as the value in the question with the smallest number of significant figures.

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Momentum and collisions

What's it all about?

Momentum and force

Momentum is a **vector** quantity. It depends on an object's mass and velocity:

momentum (kg m/s) = mass (kg) × velocity (m/s)

$$p = m \times v$$

This is another way to write **Newton's second law**, usually shown as: $F = m \times a$

Force is the rate of change in momentum. It is also a vector quantity:

$$\text{force (N)} = \frac{\text{change in momentum (kg m/s)}}{\text{time take for change (s)}}$$

This can be rewritten as:

$$F = \frac{(mv - mu)}{t}$$

As the time taken, t, increases, the force, F, acting on an object decreases.

Collisions

Since momentum is a vector quantity, you must think about the direction of the moving object. Momentum has opposite signs (+ or −) for opposite directions.

You can apply **Newton's third law** to collisions between objects:

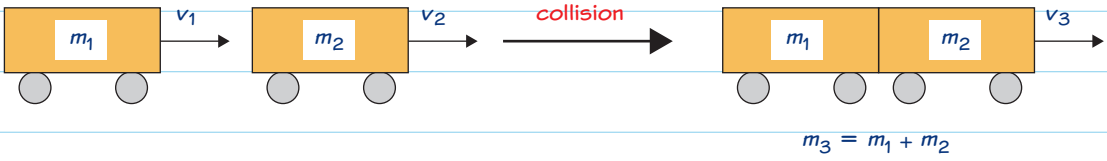
- Colliding objects exert an equal and opposite force on each other.
- They are in contact for the same time (unless they then stick together).
- Momentum is conserved.

Total momentum is the same after a collision as it is before the collision.

If objects stick together in a collision, you get one new object. Its mass is the total mass of the colliding objects.

The diagram shows two moving objects that collide, stick together and move off together.

If objects do not stick together in the collision, the number of objects and their masses stay the same. You calculate their individual momentums.



total momentum before the collision = total momentum after the collision

total mass after collision, $m_3 = m_1 + m_2$, so $(m_1 \times v_1) + (m_2 \times v_2) = m_3 \times v_3$

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Worked example

(a) State Newton's third law when applied to a collision between two objects. **(1 mark)**

When two objects collide, they exert equal and opposite forces on each other.

(b) Explain how Newton's third law shows momentum is conserved when the two objects collide. **(3 marks)**

$$\text{force} = \frac{\text{change in momentum}}{\text{time for change}}$$

The force and time taken for the collision are the same for each object.

Therefore, the change in momentum for each object must also be the same but in opposite directions, so the overall change is zero.

Use the correct physics terms and be as concise as possible.

Worked example

An ice skater, mass 50 kg, skates at 5.0 m/s. The skater bumps into another skater, mass 45 kg, moving in the same direction at 2.0 m/s. They then slide together on the ice.

Calculate their velocity when they slide together. **(4 marks)**

momentum before collision = momentum after collision

$p = m \times v$

momentum before $= (50 \times 5.0) + (45 \times 2.0)$

$= 340$ kg m/s

momentum after $= (50 + 45) \times v = 340$

$95 \times v = 340$

$v = \frac{340}{95} = 3.6$ m/s

Use the idea of conservation of momentum.

The total momentum before is the momentum of both skaters added together.

As the skaters are moving in the **same** direction, the momentum of both will be +.

As the skaters are now moving together, their masses need to be added together.

Give your answer to 2 sf as in the question.

Check your answer makes sense. After the collision, the faster skater will slow down and the slower skater will speed up, so the answer should be between 5 and 2 m/s.

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Had a go ☐ Nearly there ☐ Nailed it! ☐

Exam practice

1. A car travels at 25 m/s. The mass of the car and driver is 2500 kg. The driver applies the brakes for 0.5 s and the car slows down to 20 m/s.

Calculate the force applied by the brakes. **(3 marks)**

The equation linking force and change in momentum is given on the formula sheet in the exam paper. You will also find it on page 73.

..... N

2. A snooker player hits a white ball with a mass of 0.17 kg. It moves with an initial velocity of 0.82 m/s.

(a) Calculate the initial momentum of the white ball. **(2 marks)**

You need to be able to recall and use the equation for momentum.

..... kg m/s

(b) The white ball collides with a stationary red ball. After the collision, the white ball continues to move in the same direction with a velocity of 0.10 m/s. The red ball moves in the same direction with a velocity of 0.74 m/s.

Calculate the mass of the red ball. **(3 marks)**

Knowledge check

Collision questions will involve understanding, and use of, ideas about the conservation of momentum.

..... kg

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Exam practice

3. A car has a crumple zone. It is designed to bend and crush during a collision.

Explain the effect of a crumple zone in a car on the force in a collision. **(3 marks)**

Synoptic link

This links with knowledge about the hazards of large decelerations and how they can be reduced.

4. A cyclist travels at 6.0 m/s and takes 0.30 s to stop when hitting a post. The force acting on the bicycle is −1700 N.

(a) Explain why the force has a negative sign. **(2 marks)**

(b) Calculate the total mass of the cyclist and bicycle. **(3 marks)**

Examiner's hint

Check your answer by considering what would be a reasonable value for the mass of a person and a bicycle.

..... kg

5. An electric toy train, with a mass of 0.30 kg, moves on a track with a velocity of 0.20 m/s. There is a stationary carriage on the track with a mass of 0.10 kg. The train hits the carriage and they move on together.

Calculate the velocity of the train and carriage as they move on together. **(3 marks)**

Examiner's hint

It is a good idea to draw a simple diagram showing the information you have.

For collisions where objects stick together, remember you may need to calculate the new mass.

..... m/s

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13, 73, 74, 75

Force diagrams

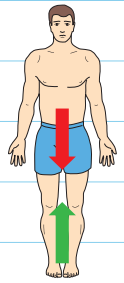
What's it all about?

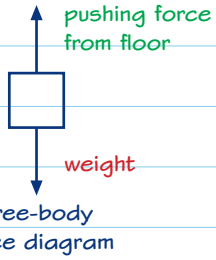
Free-body force diagrams

A free-body force diagram is a simplified diagram showing the forces acting on an object. The object is shown as a dot or a box. The force arrows act away from the dot or centre of the box. Balanced forces mean there is no resultant force. Unbalanced pairs show that there is acceleration.

A force is a vector quantity. It has direction as well as magnitude (size).

The longer the arrow, the larger the force. It is good practice to draw the arrows to scale.





Free-body force diagram

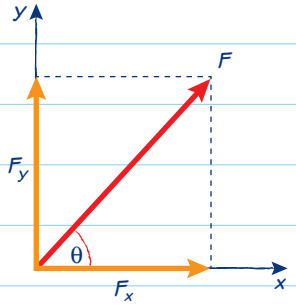
Vector diagrams and scale drawings

A resultant force can be resolved into its component horizontal and vertical forces by drawing a vector diagram.

A net force from two forces can also be found using scale drawings.

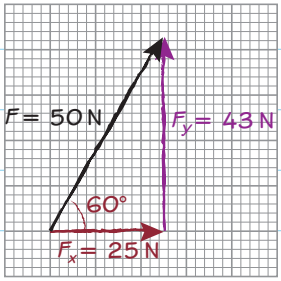
The horizontal and vertical components of motion do not affect one another – they are independent.

You can resolve a force into its horizontal and vertical components using a scale drawing on graph paper.



1. Decide on an appropriate scale. For example, for a force of 50N acting at 60° to the horizontal, use a scale where 1cm represents 10N.

2. Using a ruler, protractor and pencil, draw a line at the correct angle to represent the force.



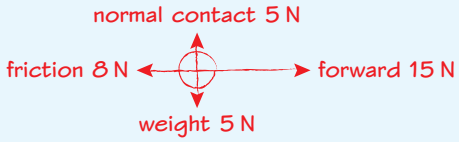
3. Draw the horizontal and vertical components.

4. Measure the lengths and convert to a force using the same scale.

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Worked example

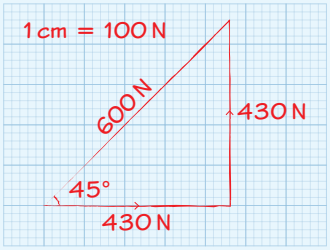
A ball has a weight of 5 N. Draw a free-body diagram of the ball accelerating on a floor with a forward force of 15 N. The friction force is 8 N. **(2 marks)**



Label each arrow with the force value and type. Different words are sometimes used to describe the same force e.g. forward, push, thrust.

Worked example

Draw a force of 600 N acting at 45° to the horizontal.
Resolve the force into its horizontal and vertical components.
Choose a suitable scale for the grid. **(3 marks)**



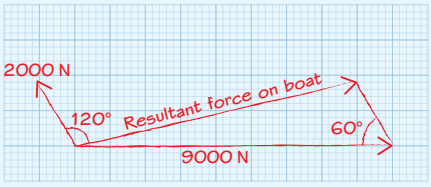
A suitable scale will usually mean the diagram fills at least half of the grid. In this case, 1 cm = 100 N is suitable.

Both lines are 4.3 cm so 430 N.

Worked example

A boat moves forwards with an engine force of 9000 N. A strong current of 2000 N pushes on the boat at an angle of 120° from the direction the boat is pointing.

Draw a scale diagram to work out the resultant force of these two forces on the boat. **(3 marks)**



Choose a start point that will leave space to draw the force arrows. Then draw the information you are given to scale.

Draw a parallelogram; the diagonal is the resultant force.

Measure the resultant force arrow and convert from cm to N.

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Exam practice

1. Draw a labelled free-body diagram of the balanced forces on a cup on a shelf. The cup weighs 2.5 N. **(1 mark)**

2. A drone moves upwards with a resultant vertical force of 20 N. A resultant horizontal wind force of 8 N to the right acts on the drone.

(a) Draw a free-body force diagram for the drone. **(2 marks)**

(b) Draw a scale drawing to show the overall resultant force on the drone. Include the value of the force. **(2 marks)**

3. A child holds a flying kite at an angle of 65° to the horizontal. The tension in the string is 30 N.

Draw a scale drawing to find the vertical and horizontal components of this force. **(3 marks)**

Synoptic link

Action–reaction (a–r) forces are not the same as balanced forces. In both cases, the forces are equal and act in opposite directions, but a–r forces act on different objects while balanced forces all act on the same object.

Remember to label the force arrows and indicate their sizes.

Maths skills

Scale drawings must be drawn very accurately.

Maths skills

You may need to measure angles. You will be told whether to measure the angle against the horizontal or the vertical.

Maths skills

For a scale drawing of forces involving a right angle, you can use Pythagoras' theorem to check the answers ($a^2 + b^2 = c^2$).