Physics

GCSE (9–1) | AQA | 8463

Maths Skills

for GCSE AQA Physics

Also applicable for GCSE Combined Science: Trilogy (8464)

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POD 11744

Contents

Teacher's Introduction

This GCSE Maths Skills pack will support students studying the AQA GCSE Physics or Combined Science specification with the key mathematical skills needed in their course.

Mathematical skills pose a challenge for many students, with some finding it difficult to see how a skill learned in a Maths lesson is applied in a Physics lesson. This resource has been designed to support students in making this connection. It gives a gentle, conversational review of the skill, with worked examples, and offers students the opportunity to practise the skill in isolation and then also in the context of an examination-style question.
By using this resource, students can ensure they have the skills they need for each section of the Physics course. They can work through the chapters proactively, or they can be directed to them as support for skills identified in class as in need of some improvement.

There are five chapters covering all the key maths skills needed for GCSE Physics. Each chapter contains the following elements:

- **Specification overview** – this provides an overview of the skills and explains what the exam board requires students to demonstrate in the exam with the skills.
- **Theoretical overview** – a brief summary recapping the skills and demonstrating how to apply the skills.
- **Worked examples** – shows one or more fully worked questions which use the relevant skill, to demonstrate how students should approach them.
- **Practice questions** – each skill is concluded with practice questions that increase in difficulty. All the physics knowledge needed to complete the question will be provided, and the question focuses on testing students' understanding of the maths skill itself.

There are two diagnostic tests for each chapter. The first is designed to be used before you work through each chapter and is provided at the start of the resource. The second is designed to be used after reviewing the chapter's content and is provided after the main content of the resource, just before the answers. The tests will allow you to identify areas for particular focus before undertaking the work, and then afterwards, should further focus on particular areas be necessary.

The chapters cover:

1. Arithmetic
2. Algebra
3. Handling data
4. Graphs
5. Trigonometry

I have covered some of the graphs content under algebra and handling data, since they naturally lend themselves to this.

October 2022

Students' Introduction

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DIAGNOSTIC TEST

A1 Arithmetic

1. Write ¼ as a decimal.

   ....

2. Write 0.333333 as a fraction.

   ....

3. Write 1024 in standard form.

   ....

4. 1 GB is 1×10^9 bytes. Write this number as a decimal.

   ....

5. An electric motor needs 12 V to operate normally. A cell provides 12.5 % of th a decimal.

   ....

6. If I am making a string of 125 LED lamps and I have only 25 LEDs, what perc do I have?

   ....

7. Estimate how many adult males you would need in order to have the same m

   ....

   ....

B1 Algebra

1. Write the following expression in words: $x >> y$

   ....

2. Make variable t the subject of this equation: $v = u + at$

   ....

3. A certain constant can be calculated using the equation

$$\text{constant} = \frac{\text{force} \times \text{distance}^2}{\text{mass}^2}$$

   Given that the units of mass = kg, force = N and distance = m, what are the u

   ....

4. A car is travelling at 10 m/s and accelerates to 20 m/s in 1.5 seconds. Calcu
   of the car. Use the equation in question 2, where u = 10 m/s, v = 20 m/s an

   ....

   ....

5. If I start 10 m from my house and walk away at 3 m/s in a straight line, descr
   my distance from the house and the time I walk for.

   ....

6. Sand pours into a bucket at a rate of 150 g per second. If the bucket was em
   relationship between the weight of sand in the bucket and the time for which th

   ....

7. If the current, I, through a lamp increases from 0 A to 5 A in 0.002 s, calculate
   current through the lamp.

   ....

   ....

C1 Handling data

1. Write 12 323 to three significant figures.

   ....

2. The finishing times in seconds for a group of athletes running a 100 m race we

   10.01 10.01 10.28 9.97 10.52 10.72 10

   a. Calculate the mean time for the race.

   ....

   ....

   b. State the median time for the race.

   ....

   c. State the modal time for the race.

   ....

3. A survey of the heights of trees in a forest is conducted by a group of students. W

   a. Record the data they collect?

   ....

   b. Represent those data on a graph (what type of graph should be plotted)

   ....

4. The survey in question 3 is expanded to consider leaf shapes found in the fore be plotted of the data collected?

   ....

5. A rectangle is 10 cm wide by 120 cm long. What is the order of magnitude o

   ....

6. An experiment to find the relationship between the potential difference ('volt the current through it was conducted. The results are shown in the table below

Potential difference (V)	0	1	2	3	4	5
Current (A)	0	0.02	0.04	0.05	0.078	0.1

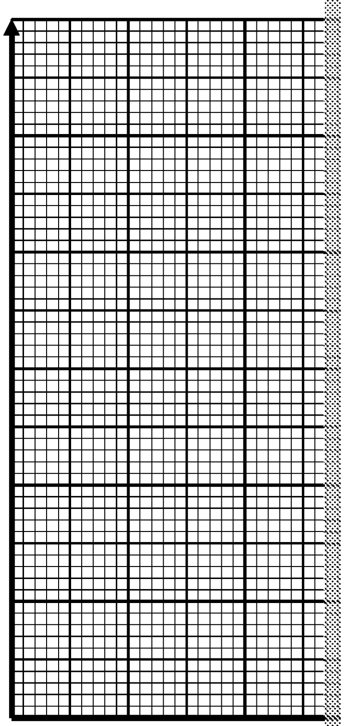
Draw a graph of these data.
State the relationship between the potential difference across the wire and the current through it.

....

....

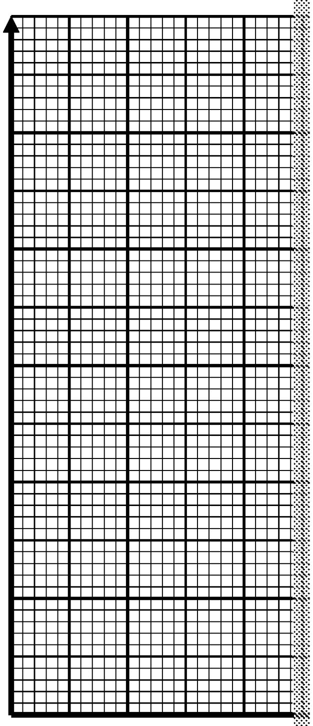
....

....



D1 Graphs

1. What is the general equation of a straight line graph? How would this be different if the graph represented a directly proportional relationship?

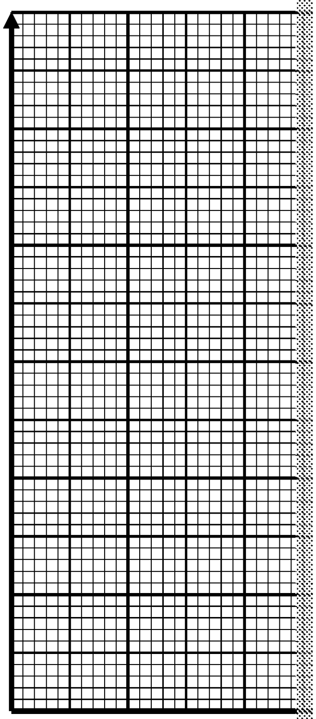


2. a. Plot a graph of $y = 3x + 2$ for values of x from 0 to 9.
   b. What is the gradient of this graph?
   c. What is the y-intercept of this graph?

3. The power of a resistor is related to the potential difference across it and its resistance by the equation

$$P = \frac{V^2}{R}$$

   a. Plot a graph of P against V for values of V from 0 V to 5 V. Use a value of $R = 10\ \Omega$.
   b. Measure the gradient of the graph at $V = 4$ volts.
   c. What does this value of the gradient tell you?



4. Give an example of when you would calculate the area between a graph and the x-axis, and explain the importance of that area in the example you give.

E1 Geometry and trigonometry

1. What instrument would you use to measure an angle?

 ....

2. What units do we use to measure angles?

 ....

3. What is the formula for each of the following?
 a. The area of a rectangle

 ....

 b. The volume of a cube

 ....

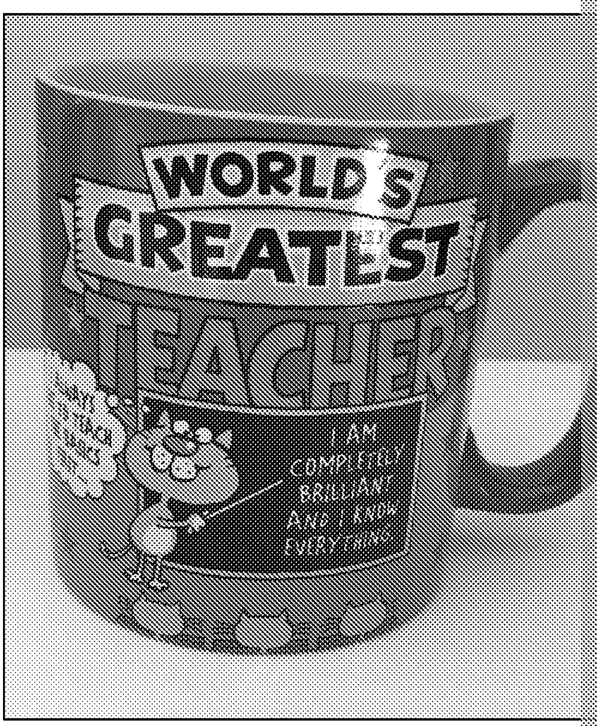
 c. The area of a triangle

 ....

 d. The surface area of a cube

 ....

4. Here is a picture of a mug. What would it look like in 2D? Draw a diagram



ARITHMETIC

SPECIFICATION OVERVIEW

1a – Recognise and use expressions in decimal form
1b – Recognise and use expressions in standard form
1c – Use ratios, fractions and percentages
1d – Make estimates of the results of simple calculations

THEORETICAL OVERVIEW

This section is about getting the basic toolkit in place for you: recognising numbers i fractions, percentages) and being able to convert between these forms. It also intr we'll revisit in Chapter 3.

Let's start by being clear about what we mean by each of the terms we're looking

Decimal

Expressing a number as a decimal means having a decimal point in it. For example

There are other ways of expressing the same number. You could also say 'ten and

$$4 \times 0.25 = 1$$

so 0.25 is 1 ÷ 4, or $\frac{1}{4}$

WORKED EXAMPLE

Express $\frac{5}{2}$ as a decimal.

Solution

$\frac{5}{2} = \frac{4}{2} + \frac{1}{2} = 2 + \frac{1}{2} = 2.5$ (as $\frac{1}{2} = 0.5$ since $0.5 \times 2 = 1$)

Fraction

One number divided by another is a fraction. For example:

$$\frac{30}{4}$$

Of course, we could also express this as a decimal by calculating the value of this

$$\frac{30}{4} = 7.5$$

It can be helpful to remember some fraction to decimal conversions so that you rec use a calculator.

Fraction	decimal	Fraction
$\frac{1}{2}$	0.5	$\frac{1}{10}$
$\frac{1}{3}$	0.33	$\frac{1}{100}$
$\frac{1}{4}$	0.25	$\frac{1}{1000}$
$\frac{1}{5}$	0.2	

WORKED EXAMPLE 1

Write $\frac{3}{5}$ as a decimal.

Solution

Use your calculator to do $3 \div 5 = 0.6$

When we write fractions, we should always look to simplify them. For example, $\frac{9}{27}$ is c

WORKED EXAMPLE 2

Simplify $\frac{9}{27}$

Solution

Since both 9 and 27 can be divided by 9 (this is the biggest number that 'goes i

factor, as you would say in maths), we can write it as $\frac{1}{3}$ because $\frac{9}{9} = 1$ and

You could also see this as $\frac{27}{9} = \frac{9 \times 3}{9 \times 1} = \frac{3}{1} = 3$

Percentage

This is a fraction which is evaluated (worked out) and then multiplied by 100. It is c
For example, what percentage of a day is three hours?

$$\frac{3}{24} = 0.125$$

$$\text{and } 0.125 \times 100 = 12.5\ \%$$

It is possible for the percentage to be greater than 100, of course. The average c
is 64 mg (milligrams). There can be 200 mg of caffeine in an energy drink, so the

$$\frac{200}{64} \times 100\ \% = 313\ \% \text{ of the caffeine in one espre}$$

WORKED EXAMPLE

If we had an electric car with a 77 kWh battery, this means that the battery c
electrical energy. (1 kWh = 3 600 000 joules.)
We might want to know what percentage of this charge we have when the b

Solution

So, we express our numbers as a fraction: $\frac{55}{77}$

Then we evaluate this (put the numbers into a calculator):

= 0.714

So, this is the decimal form of the fraction.

Now we multiply by 100 to get the percentage:

$0.714 \times 100 = 71.4\ \%$

Estimation

This is about making an *educated* guess at the answer. So we might want a rough textbooks we could stack floor to ceiling in a room.

> **WORKED EXAMPLE**
> **Estimate how many Physics textbooks you could stack floor to ceiling in a r**
>
> **Solution**
> *We could estimate the thickness of one textbook to be 5 cm, and the height of t*
> *250 cm. So we could stack* $\frac{250}{5}$ *= 50 books between the floor and the ceiling.*
>
> *This is an estimate – I didn't measure the thickness of the textbook or the heigh*
> *are about the sort of size you might expect. Books vary and rooms vary, but th*

Standard form

Standard form is where a number is written so that it is in two parts:

1. A number greater than 1 and less than 10
2. This number is then multiplied by 10 to a power

> **WORKED EXAMPLE 1**
> **Express 900 in standard form.**
>
> **Solution**
> $900 = 9 \times 10^2$
>
> *9 is a number greater than 1 and less than 10; to make our standard form val*
> *multiplied by 100. 100 is* 10^2.

Another example, to illustrate the point further, is 0.9.

> **WORKED EXAMPLE 2**
> **Express 0.9 in standard form.**
>
> **Solution**
> *0.9 is less than 1, so we have to write the number as '9'. Now we have to have*
> *our standard form value the same as 0.9.*
>
> *So we are actually dividing the 9 by 10 to get to 0.9:* $\frac{9}{10}$
>
> *but* $\frac{1}{10}$ *can be written* 10^{-1}
>
> *So, 0.9 in standard form is* 9×10^{-1}

Look at the pattern in the values of the powers of 10 and the equivalent fraction o

Power of 10	10^{-4}	10^{-3}	10^{-2}	10^{-1}	10^{0}	10^{1}
Decimal	0.0001	0.001	0.01	0.1	1	10
Fraction	$\frac{1}{10\,000}$	$\frac{1}{1000}$	$\frac{1}{100}$	$\frac{1}{10}$	$\frac{1}{1}$	Not really

Ratio

A ratio expresses how many of one thing you have, compared to another. For exa
with car shampoo, the label on the bottle might instruct you to 'Put 30 ml of shamp

WORKED EXAMPLE 1

What is the ratio of shampoo to water required in the example above?

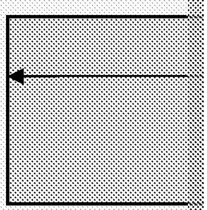
Solution

We have a ratio of 30 to 5000 (since there is 1000 ml in 1 L).

This is usually written 30 : 5000, or, better still, 3 : 500.

WORKED EXAMPLE 2

What is the ratio of the height of this rectangle to its length?



Solution

The ratio will be expressed height : length because that's how the question is asked.

The height is 7 cm and the length is 21 cm, so the ratio is 7 : 21. However, we can simplify this by dividing both numbers by 7 (since 7 is the highest common factor of both numbers – the highest number that divides exactly into each), giving us 1 : 3 as our final answer.

PRACTICE QUESTIONS

1. Copy and complete the table below. Use a calculator to calculate the decima

   Some of the answers will come out as an exact number (e.g. $\frac{1}{10} = 0.1$), while oth

   If the number is NOT exact, give your answer to three significant figures.

	Fraction	Decimal		Fraction	Decimal	
A	$\frac{1}{16}$		**D**	$\frac{3}{7}$		**G**
B	$\frac{1}{20}$		**E**	$\frac{82}{3}$		
C	$\frac{1}{5}$		**F**	$\frac{213}{5}$		

2. Copy and complete the table below. Calculate the percentages.

	Number	Percentage		Number	Percentage	
A	$\frac{1}{16}$		**D**	$\frac{3}{7}$		**G**
B	$\frac{1}{20}$		**E**	0.22		**H**
C	$\frac{1}{5}$		**F**	$\frac{75}{136}$		**I**

3. Copy and complete the table below. Express the percentages as fractions. W simplest fraction possible.

	Percentage (%)	Fraction
A	5	
B	22	
C	12	
D	40	
E	67.67	
F	75	
G	90	

4. Convert the numbers in the left-hand column into standard form.

	Number	
A	365.25 days in a year	
B	1 500 000 km is the average Earth–Sun distance	
C	0.000 000 000 144 m is the radius of an atom of gold	
D	101 000 N/m² is atmospheric pressure	
E	24.8 N/kg is the value of gravity on Jupiter	

5. Convert the numbers in the left-hand column from standard form into a decim

	Standard form	
A	1×10^3 cm³ in one litre	
B	$3.1\ 557\ 6 \times 10^7$ seconds in a year	
C	1×10^{-5} m is the diameter of a human hair	
D	1×10^{-9} m is one nanometre	
E	9.1×10^9 km is the diameter of the solar system	

6. Estimate the values of the following:
   a. How long it would take to walk 10 km.
   b. How long it would take to run 300 m.
   c. How far you've travelled if you were on a passenger aircraft for two ho
   d. (**Harder!**) How long it would take a ball to hit the ground when dropped acceleration due to gravity is 9.8 m/s². You might find it helpful to sketc would look like.

7. If 75 % of my domestic electricity is used for heating and cooking, and the re running other electrical devices, what is the ratio of usage for heating and co

8. The constant π is the ratio of the circumference of a circle to the diameter of i circular around the equator, calculate the circumference at the equator, if the Use π as 3.14.

ALGEBRA

SPECIFICATION OVERVIEW

3a – Understand and use the symbols =, <, <<, >>, >, ∝, ~
3b – Change the subject of an equation
3c – Substitute numerical values into algebraic equations using appropriate units fo
3d – Solve simple algebraic equations

THEORETICAL OVERVIEW

This section is about equations and the relationships they represent. It is also a fur put together in Chapter 1.

Let's start by being clear about the meanings of the terms we will be using:

Proportional

When two things are proportional, whichever operation (e.g. multiply, divide, squa happen to the other. For example:

distance = speed × time

We could say 'the distance travelled is proportional to the speed the object travel distance travelled is proportional to the time of travel'.

What this means is that if we travel for 2 × as long, **keeping the speed the same,** multiplied by 2, or

if we travel at twice the speed, we will cover twice the distance **in the same perio** by 2.

To look at this in terms of division rather than multiplication, if we were to travel at half the distance **in the same period of time** – both divided by 2.

Notice that in each of the examples, one of the variables on the right-hand side of time) was kept the same (see the parts of the examples **in bold**), while we looked changed the other – so one was a **<u>constant</u>**.

Generally, when one thing (let's call it y) is proportional to another (let's call it x),

$$y \propto x$$

The symbol ∝ is the Greek letter alpha and it means 'proportional to' in this case. radioactivity and it'll represent a type of radiation then.

So, this means 'y is proportional to x'; that is, whatever we do to x (multiply, divide number), the same will happen to y.

Moving from 'proportional to', in order to get an equation, we need that constant

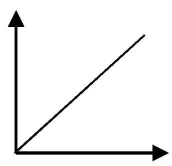
$$y \propto x$$

So $y = \textbf{constant} \times x$

We normally write the constant as 'k', so our equation looks like this:

$$y = k \times x$$

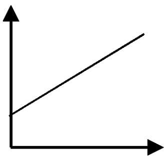
This is a proportional (sometimes called **directly proportional**) relationship betwee straight line graph which passes through the origin (see 'Graphs' section later).



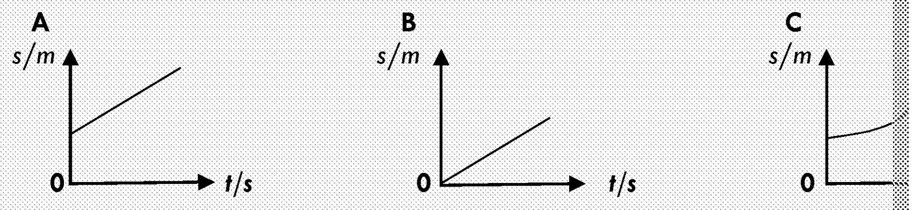
If we had

$$y = kx + \text{constant}$$

we would have what is sometimes called **indirect proportion**. This will still give us a
go through the origin if the constant is not equal to zero. Again, we'll talk about g



WORKED EXAMPLE
Which of these graphs shows displacement, *s*, directly proportional to time, *t*



Solution
The answer is B. It is the only straight line which also goes through the origin (

Symbols

There are some symbols that you just need to recognise and understand. These ar
read from left to right:

< means 'less than'. So y < x means 'y is less than x'.
<< means 'much less than'. So y << x means 'y is much less than x'.
\> means 'greater than'. So a > b means 'a is greater than b'.
\>> means 'much greater than'. So a >> b means 'a is much greater than b'.

**Note: for each of these arrow symbols, the bigger quantity goes nearest to the
smaller quantity goes at the 'point' of the arrow.**

~ means 'approximately equal to'. So you might say that a T-shirt priced at £9
approximately £10. You would write that the cost of the T-shirt is ~ £10.

A more scientific example would be the number pi (π). It has an endless number o
use 3.14, so strictly we should write π ~ 3.14.

WORKED EXAMPLE
**Rewrite the following statement replacing the underlined word with the mos
from either <, >, >>, << or ~.**

The mains electricity supply is <u>approximately</u> 230 V.

Solution
The mains electricity supply is ~ 230 V.

Rearranging and using equations

Equations tell us how two or more quantities (things) relate to each other. We all k
you buy (e.g. 1 kg bags of sugar), the heavier your bag of shopping will be. Ther

total weight = weight of a bag of sugar × number o

You might reasonably say 'Why would I want an equation? That's just common sen
we need equations. They allow us to:

- Predict the outcome of an event ('If I increase the number of electrical items I
  tripping the circuit breaker?')
- Plan how to do something successfully ('If I build this motorway bridge with the
  take the weight of traffic it needs to be able to carry?')
- Answer exam questions!

You will have lots of equations you need to memorise in order to succeed in your G
You will have a smaller number that you will be given, if you need them.

However, you need to be able to rearrange all of them so that the quantity you're
subject. For example, let's take Ohm's law, which tells us how the electrical current
the voltage across the conductor. It states:

potential difference = current × resistance

In symbols, $V = I \times R$

So, if we are given the current through a lamp (I) and the resistance of the lamp (R
$I \times R$ to get V.

But what if we are given the values of V and I in order to find R?

Now we need to rearrange the equation so that R is the subject (that is to say the

Remember, it's an equation, so, to keep both sides equal, whatever we do to one s
the other.

WORKED EXAMPLE 1

Rearrange $V = I \times R$ to make R the subject.

Solution

On the right we have $I \times R$, but we just want R. So, if we divide this by I, that

$$\frac{I \times R}{I}$$

Now, the rules of maths mean that we can divide either of the things on the to
line – it doesn't matter which.

In $\frac{I}{I} \times R$, *since* $\frac{I}{I} = 1$ *then* $\frac{I}{I} \times R = R$

Now, since we divided the right-hand side by I, we must do the same to the lef

equal. So $\frac{V}{I} \times \frac{I \times R}{I} = R$

We can rewrite this, with the subject (R) on the right:

$$R = \frac{V}{I}$$

What we've done, then, is to divide both sides of the equation by the thing we w
side, in order to get just the thing we want on that side.

Here's another example:

WORKED EXAMPLE 2
y = mx + c
Let's make x the subject.

Solution
Step 1: *deal with the c on the right-hand side – subtract c from both sides:*

$y - c = mx + c - c$

So $y - c = mx$

Step 2: *get x on its own on the right – divide both sides by m:*

$$\frac{y-c}{m} = \frac{mx}{m}$$

So $\frac{y-c}{m} = x$

Rate of change and Δ symbol

Rate of change is actually just what it sounds like – how quickly one thing is changi
Velocity is the rate of change of displacement with time (the increase or decrease i
acceleration is the rate of change of velocity with time (the increase or decrease in

The symbol Δ is the Greek capital letter 'delta' and we use it to say 'change in'. S
would be written Δs. This gives us velocity (the change in displacement every seco

$$\frac{\Delta s}{t}$$

where *t* is the time over which the change Δs took place. Displacement is the vecto
'Geometry and trigonometry' section for some help with vectors).

WORKED EXAMPLE
**If I drive 200 m (my displacement, s) in a period of 10 seconds, what is the r
my displacement?**

Solution

rate of change $= \frac{\Delta s}{t}$

$= \frac{200}{10} = 20$ m/s

PRACTICE QUESTIONS

1. Ohm's law states that the voltage across a conductor and the current through
   equation voltage = current × resistance
   And that, if the temperature remains constant, the resistance is constant.
   a. Describe the relationship between the voltage and the current.
   b. Sketch the shape of graph you would expect for this relationship.
   c. The power developed by an electrical device can be calculated using th

      $$\text{power} = \text{current}^2 \times \text{resistance}$$

      (i) Rearrange this equation to make resistance the subject.
      (ii) A certain wire produces 50 W of thermal energy (the power) when hrough it. Calculate the resistance of the wire.
      (iii) Use the equation voltage = current × resistance to calculate the pot (voltage) across the wire in part (ii) when it is producing 50 W of th
      (iv) What is the ratio of the voltage to the current?
   d. An electric lamp is marked '40 W'. This represents the electrical power If the efficiency of the lamp is 0.25:
      (i) Calculate the useful power output (light) of the lamp using the equa
      $\text{efficiency} = \frac{\text{useful power output}}{\text{total power input}}$
      (ii) Express the efficiency as a fraction.
      (iii) Express the efficiency as a percentage.
      (iv) Express the power in standard form.
      (v) Estimate how long the lamp can be used for with one unit of electric 1 W = 1 joule per second).

HANDLING DAT/

SPECIFICATION OVERVIEW

2a – Use an appropriate number of significant figures
2b – Find arithmetic means
2c – Construct and interpret frequency tables and diagrams, bar charts and histog
2f – Understand the terms mean, median and mode
2g – Use a scatter diagram to identify a correlation between two variables
2h – Make order of magnitude calculations

THEORETICAL OVERVIEW

In this section, we want to develop the use of the skills we've looked at in our first t mean, median and mode for a set of data, seeing the pattern in the data (correla way the examiner wants them (significant figures and decimal places).

Arithmetic mean

The arithmetic mean is the average of a set of numbers:

$$\textbf{mean} = \frac{\textbf{total of the numbers}}{\textbf{the number of data points}}$$

You'll use this particularly with data from experiments – you'll be given a table of mean. The extra challenge here is to spot the anomaly (the value that doesn't fit t include that value in the mean.

WORKED EXAMPLE 1

If we measured the heights of all the boys in an A Level Physics class, we n

Name	Height (m)
Jake	1.72
Peter	1.70
Saul	0.40
Mobashir	3.20
Ahmed	1.71
Kevin	1.70
Sunil	1.67

Find the mean height of the boys in the class.

Solution

We would look at Mobashir and see that he is unusually tall! It would seem tha incorrectly or that his height has been recorded incorrectly. If we want a mean a student in sixth form, we need to leave Mobashir out of the calculation. Equa probably for the same reasons as Mobashir, so we would not include him in the

So, our mean would be:

mean = (1.72 + 1.70 + 1.71 + 1.70 + 1.67) / 5 = 1.70 m

If we were to include both Mobashir and Saul, we would have:

mean = (1.72 + 1.70 + 0.40 + 3.20 + 1.71 + 1.70 + 1.67) / 7 = 1.73 m

If you look at the table, you can see that only Mobashir is this height or more, s data, whereas 1.70 m does, as we have a spread of heights around this value.

Significant figures (s.f.)

The point here is about not claiming a level of accuracy you don't have a right to c
what we mean by 'significant'.

Zeros before a number and zeros after a number aren't significant:

0024 only 2 s.f. as the leading zeros don't count
2400 only 2 s.f. as the trailing zeros don't count

Zeros after a decimal point ARE significant:
24.00 is 4 s.f.

This can all get a bit much, so I ALWAYS write (or at least think about) my number
significant when written in standard form:

1000 is1 s.f.

1×10^3 is 1 s.f.

1.0×10^3 is 2 s.f.

1.00×10^3 is 3 s.f.

1.000×10^3 is 4 s.f.

Imagine you dropped an earring in an area of long grass and I know where it is, s
If I tell you to walk 27.425 m north, then turn east and walk 12.552 m, if you follo
end up right where the earring is. If I said walk for 27 m north and then 13 m eas
you'll probably have to look around a bit to find the earring.

The first set of directions was given to five significant figures, the second to two sig

Now, if I said walk 27.425 m north and 13 m east, how easily you find the earring
direction.

So, significant figures are important when we are writing down our answers. We ca
accurate piece of data we're using to get the answer. For example, if we are work

length = 1.10 m, width = 1.50 m

Each of these numbers is given to three significant figures, so the answer should be

area = $1.10 \times 1.50 = 1.65$ m² to 3 s.f.

But if we had

length = 1.10 m, width = 1.5 m

then, because the width is given to only two significant figures, our answer can only

area = $1.10 \times 1.5 = 1.65$
= 1.7 m² to 2 s.f.

If this isn't clear, imagine a ridiculous scenario – I give you the length (in metres) of
millimetre (1.100 m) but the width to the nearest metre (1 m). Now it just isn't poss
nearest mm², only to the nearest m², because you just don't have the level of accur
significant figures in the width limits the accuracy of our answer.

WORKED EXAMPLE

Let's take a number and consider it to different numbers of significant figure 12356.124561 is to 11 significant figures

Solution

Number of significant figures	Number	Note
1	10 000 or 1×10^4	We look at the second It's a 2, so we ro
2	12 000 or 1.2×10^4	We look at the third It's a 3, so we ro
3	12 400 or 1.24×10^4	We look at the fourth It's a 5, so we
4	12 360 or 1.236×10^4	We look at the fifth It's a 6, so we
5	12 356 or 1.2356×10^4	We look at the sixth It's a 1, so we ro
6	12 356.1 or 1.23561×10^4	We look at the seventh It's a 2, so we ro
7	12 356.12 or 1.235612×10^4	We look at the eighth It's a 4, so we ro

Frequency tables and diagrams

Frequency tables are just what they sound like – a table showing how often a part for a variable occur(s). Frequency diagrams are the graphs (e.g. bar chart, histog data in the frequency table

We might look at the shoe sizes across a year group at school. The frequency tab

Shoe size	Frequency
3	3
3½	8
4	21
4½	25
5	58
5½	33
6	18
6½	16
7	49
7½	32
8	16
8½	3

WORKED EXAMPLE

How many students have size 5 feet in the year group above?

Solution

The frequency table shows us the numbers of students with each shoe size in the the row with shoe size 5, there are 58 students with size 5 feet.

Bar charts and histograms

These can be confused, but they are different. Bar charts are used to display disc
display continuous data. You need to know the difference! Continuous data can t
extremes. For example, time – you can measure time to many decimal places, limi
device. Discrete data can only take certain values – no values in between. For ex
circuit – it can be zero, or one, or two… but never any value in between. Shoe siz
data, and temperature would be another example of continuous data.

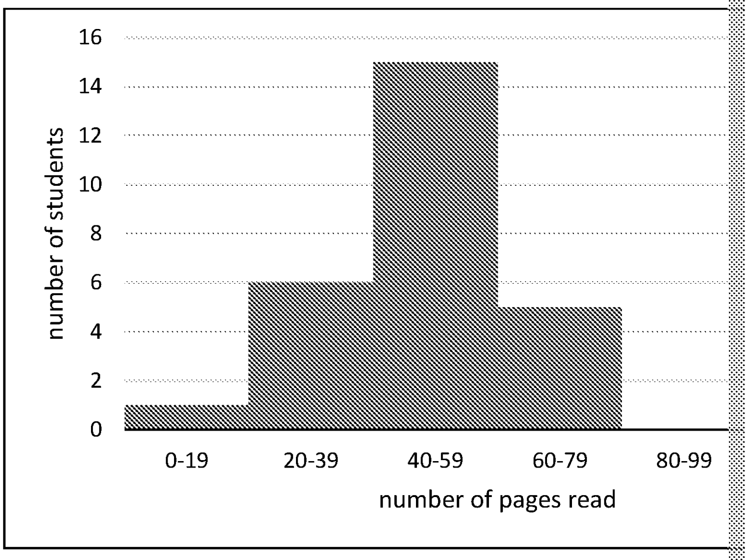
An obvious difference, which you can see at a glance, is that a bar chart has gaps
histogram the bars are touching (because the data is continuous, so there is no 'bre
being plotted horizontally).

So, if you were representing our shoe size data, it would be a bar chart because t

If you were representing the ages in the school population, it would be a histogram
being 13, they become 14 – no gap, no break, just a continuous flow from one ag

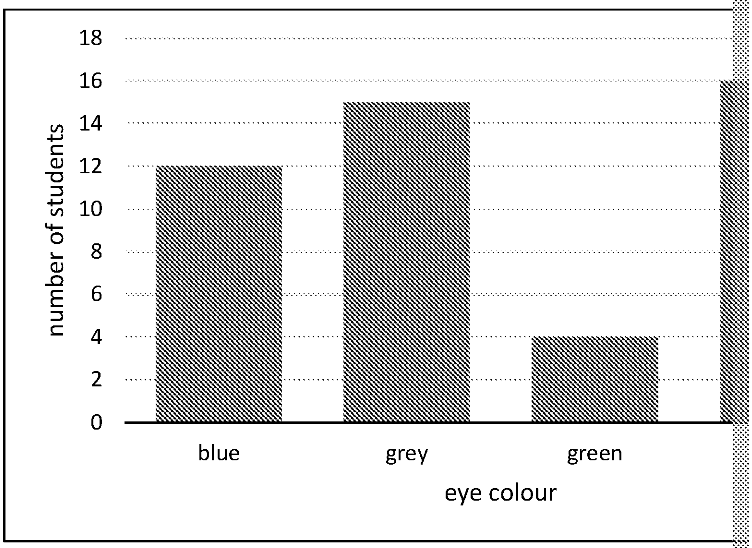
Here's an example of a histogram. The data is a survey of progress through a
students after one week:

number of pages read	0–19	20–39	40–59	60–79
number of students	1	6	15	5



And here's an example of a bar chart. This is data for the eye colour in a group o

eye colour	blue	grey	green
number of students	12	15	4



Mean, median, mode

These are terms that relate to a set of data.

Mean – the average of a set of numbers

WORKED EXAMPLE 1

Let's take 15 scores in a Physics test as an example:

32 %, 33 %, 45 %, 56 %, 56 %, 56 %, 64 %, 64 %, 72 %, 75 %, 81 %

What is the mean score?

Solution

For our set of 15 results, the mean is:

mean science score = (32 + 33 + 45 + 56 + 56 + 56 + 64 + 64 + 72 + 75 + 81

= 68 % (2 s.f.)

Median – the middle number, when they are written in order of size

WORKED EXAMPLE 2

What is the median score?

Solution

For our data, which is already in order of size, the middle number is the eighth,

Now, what if we have an even number of data points – there isn't a 'middle' one t average of the two in the middle.

WORKED EXAMPLE 3

What is the median of the following set of numbers?

3 5 7 9 11 13

Solution

The median is the average of 7 and 9 because 7 and 9 lie in the middle (two data

So the median = (7+9)/2 = 8

Mode – the most frequent value in a data set

WORKED EXAMPLE 4

What is the mode of the Physics test scores?

Solution

In our example using test data (above), 56 occurs three times, and 64 occurs tw

So the mode is 56 because it occurs most frequently.

Probability – the probability of something happening is a number from 0 (it is imp

WORKED EXAMPLE 4

What is the probability of throwing any number on a regular six-sided die?

Solution

Dice have numbers 1 to 6 on their sides. When throwing a die, you have a one-

the probability of each number coming up is 1/6, or 0.17.

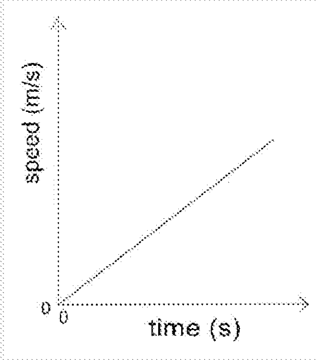
There is a lot more to probability, but this is all we really need to know here.

Correlation (between variables)

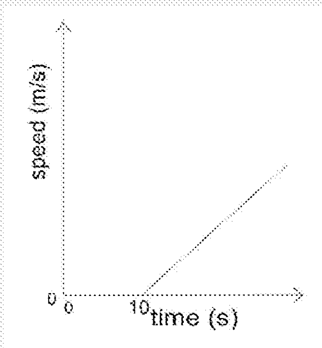
This means a relationship between the variables – 'as x increases, y increases/dec
'there is a linear relationship between x and y', and so on.

So, this skill is about looking at the points on a graph and seeing the relationship b

WORKED EXAMPLES



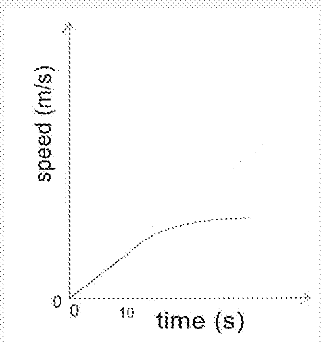
Here we have a simple 'speed is directly pro relationship – as time increases by a factor does the speed (i.e. if the time doubles, so d



Here's another:

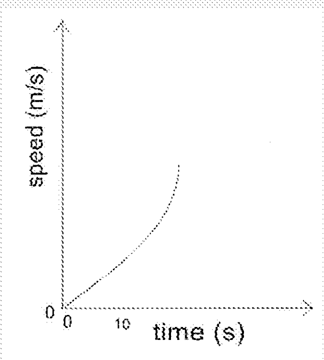
Here the speed remains at 0 m/s until 10 s linearly.

You might see that the relationship changes graph. You just need to be aware that the relationship to talk about.



For example

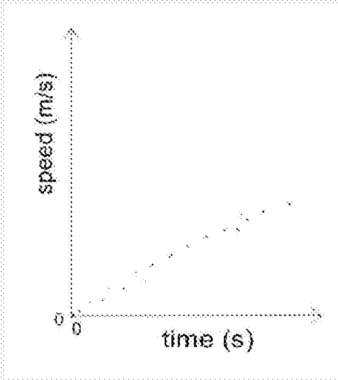
In this example, there are two different sec and comment on. Up to 10 seconds, speed After 10 seconds, the rate of change of spe slowly), tending to a constant value of spee



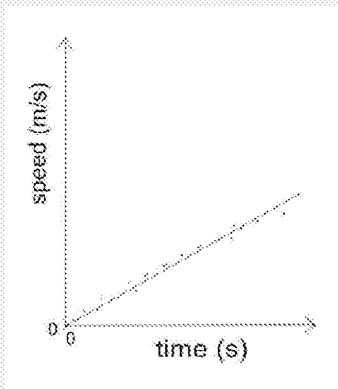
Here's another:

Here, we have the same proportional relati then, at 10 seconds, it changes. After 10 s bigger rate of change – it is increasing mor increasing acceleration).

WORKED EXAMPLES



It might be that you are given a graph, o data, and then you're asked to state the variables. You might have a graph like t



Now, you can see that these points basic and also that this line passes through the proportional relationship.

Drawing lines of best fit is a skill and only really comes with practice and, therefor smooth line that best represents the trend of the data. It may be straight, it may b

So, a good line of best fit will:

- Have as many points on one side of it as it does on the other (see the exampl
- Ignore anomalies
- Be a smooth curve or a straight line – don't join the dots!

Orders of magnitude calculations

Here you're giving your answer to the nearest power of 10 – or order of magnitu

WORKED EXAMPLE

The Sun is 150 400 000 km away from the Moon at one point in its cycle. If 300 000 km/s, which answer shows the correct order of magnitude for the tin Moon from the Sun, measured in seconds?

A 10^{13}
B 10^{40}
C 10^{8}
D 10^{3}

Solution

The distance, in standard form, is 1.504×10^8 km, so the order of magnitude o
The speed, in standard form, is 3.00×10^5 km/s, so the order of magnitude is 5
*The time taken, using **speed = distance/time**, is*
time = distance/speed
so, in terms of orders of magnitude, this is $10^8/10^5$.
This is the same as $10^{(8-5)}$, so 10^3.
If we do the full calculations, we get an answer of 501 seconds. This rounds up t figure, which is 10^3.

PRACTICE QUESTIONS

1. The data below represent the prices found for a 128 GB USB flash drive:

Retailer	Price (£)
1	9.69
2	16.99
3	14.79
4	26.00
5	28.99
6	25.03
7	1.50
8	11.00
9	13.19
10	16.99
11	18.99
12	13.59
13	26.99
14	1.38
15	24.99
16	14.93
17	23.99

   a. Copy and complete the frequency table below, for these data.

Price (£)	Frequency
0–5.99	
6–10.99	
11–15.99	
16–20.99	
21–25.99	
26–30.99	

   b. Plot a graph of these data.
   c. Calculate the mean price of the USB flash drive.
   d. What is the median price of the USB flash drive?
   e. Taking the prices to the nearest pound, what is the mode in these data?

2. By plotting a scatter graph, determine the correlation between the variables

Current (A)	Force (N)
0.0	0.00
0.5	0.13
1.0	0.25
1.5	0.38
2.0	0.50
2.5	0.63
3.0	0.75
3.5	0.88
4.0	1.00
4.5	1.13
5.0	1.25

3. The force on a wire carrying a current at a right angle to a magnetic field is
   force = magnetic field strength × current in the wire × length of wire in the
   For a certain wire, the current is 1000 A, the length is 22 km and the magneti
   What is the order of magnitude of the force on the wire?

GRAPHS

SPECIFICATION OVERVIEW

4a – Translate information between graphical and numeric form
4b – Understand that y = mx + c represents a linear relationship
4c – Plot two variables from experimental or other data
4d – Determine the slope and intercept of a linear graph
4e – Draw and use the slope of a tangent to a curve as a measure of rate of cha
4f – Understand the physical significance of area between a curve and the x-axis
squares as appropriate

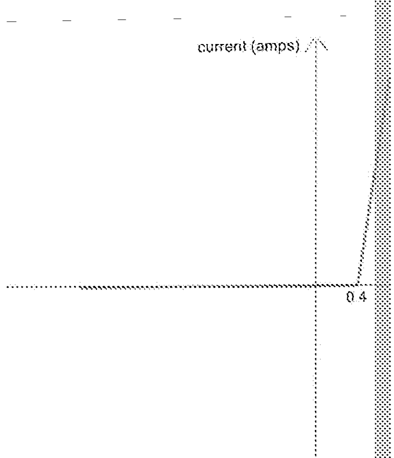
THEORETICAL OVERVIEW

In this section, we are building on the graphical skills we looked at earlier (in the 'A sections), and extending them. Previously, we have looked at data and plotted a from graphs. We have also looked at the general equation of a straight line (*y* = graph is directly proportional, c = 0. If c does not equal zero, we have indirect p straight lines and so we call them **linear relationships**. Now, we are looking at fu they can tell us about the data used to plot them. Once again, let's get our termin

Intercept

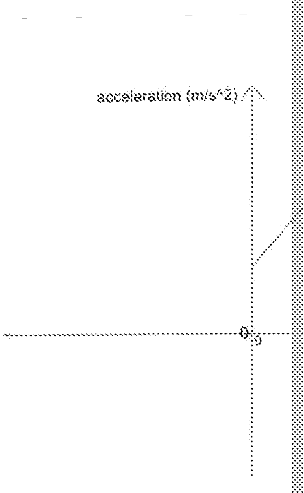
This is the point at which the line of the graph crosses either the y-axis (when the x *y* value = 0). Note carefully that it's where the other variable (*x* or *y*) = 0. Look x-axis is drawn crossing the y-axis at a value other than zero, and vice versa. The represent the intercept.

The intercept can tell you that there are other factors at work that you haven't considered or haven't fully allowed for. For example, a diode is a device that only allows current to flow freely in one direction – the resistance in the reverse direction is very high, so current almost doesn't flow at all. BUT, current only starts to flow when there is a potential difference (p.d.) or voltage of around 0.4 V across the diode, so we have an intercept on the potential difference axis (the x-axis because the potential difference is the independent variable – the current depends on it, not the other way around).



So this graph tells us that no current flows until there is a p.d. of 0.4 V across the d direction. In the 'reverse' or negative direction, a p.d. does not cause a current to

We can also have intercepts on the y-axis. If we were to conduct an experiment to find the relationship between the force on an object and the acceleration of it, we might get a graph like this:



This graph is expected to be directly proportional – a straight line through (0,0). However, it shows that even though there is no applied force, the object is still accelerating! This must be because there is some other force that we have not considered, which is acting on the object. This might be because we are rolling our object down a ramp, but the ramp is too steep.

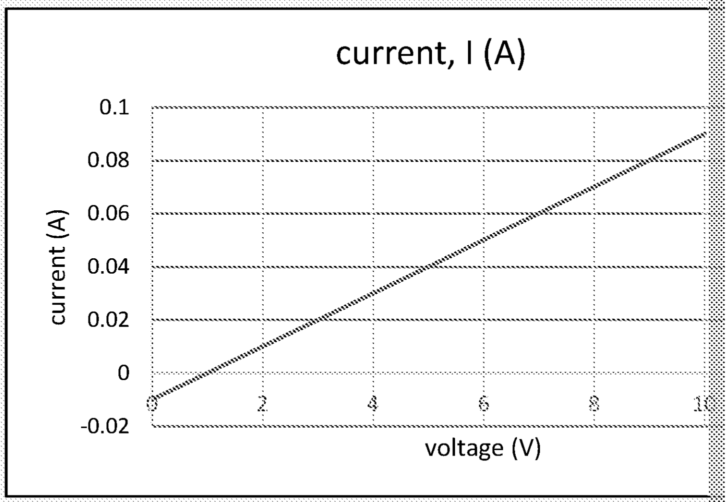
WORKED EXAMPLE

Here is some experimental data, investigating the relationship between the p
across a wire and the current flowing through it:

voltage, V (volts)	0	1	2	3	4	5	6	
current, I (A)	-0.01	0	0.01	0.02	0.03	0.04	0.05	0

Plot a graph of these data to find the value of the y-intercept.

Solution



The y-intercept is -0.01 A. This tells us that the ammeter had a zero error –
though there was no voltage across the wire (and so there couldn't be any curre

Slope/gradient

The slope/gradient is literally the steepness of the line of the graph. Of course, h
scale of the graph! So we actually calculate the slope or gradient using

$$\textbf{gradient} = \frac{\textbf{change in the } y \textbf{ value}}{\textbf{change in the } x \textbf{ value}}$$

Looking back at the earlier graph of acceleration against force, the gradient or sl
acceleration changes for every one newton increase in the force applied.

WORKED EXAMPLE

(continuing with the previous worked example)

Here is some experimental data, investigating the relationship between the p
a wire and the current flowing through it:

voltage, V (volts)	0	1	2	3	4	5	6	
current, I (A)	-0.01	0	0.01	0.02	0.03	0.04	0.05	0

Plot a graph of these data to find the gradient of the graph.

Solution

The graph will be the same, of course! The gradient is calculated by
gradient = (change in the current value) / (change in the potential difference va
So we take the longest section of straight line we can – choosing points as far a
We can choose (0, -0.01) and (10, 0.09):
gradient = (0.09 – (-0.01)) / (10 - 0) = 0.1 / 10 = 0.01

Tangent

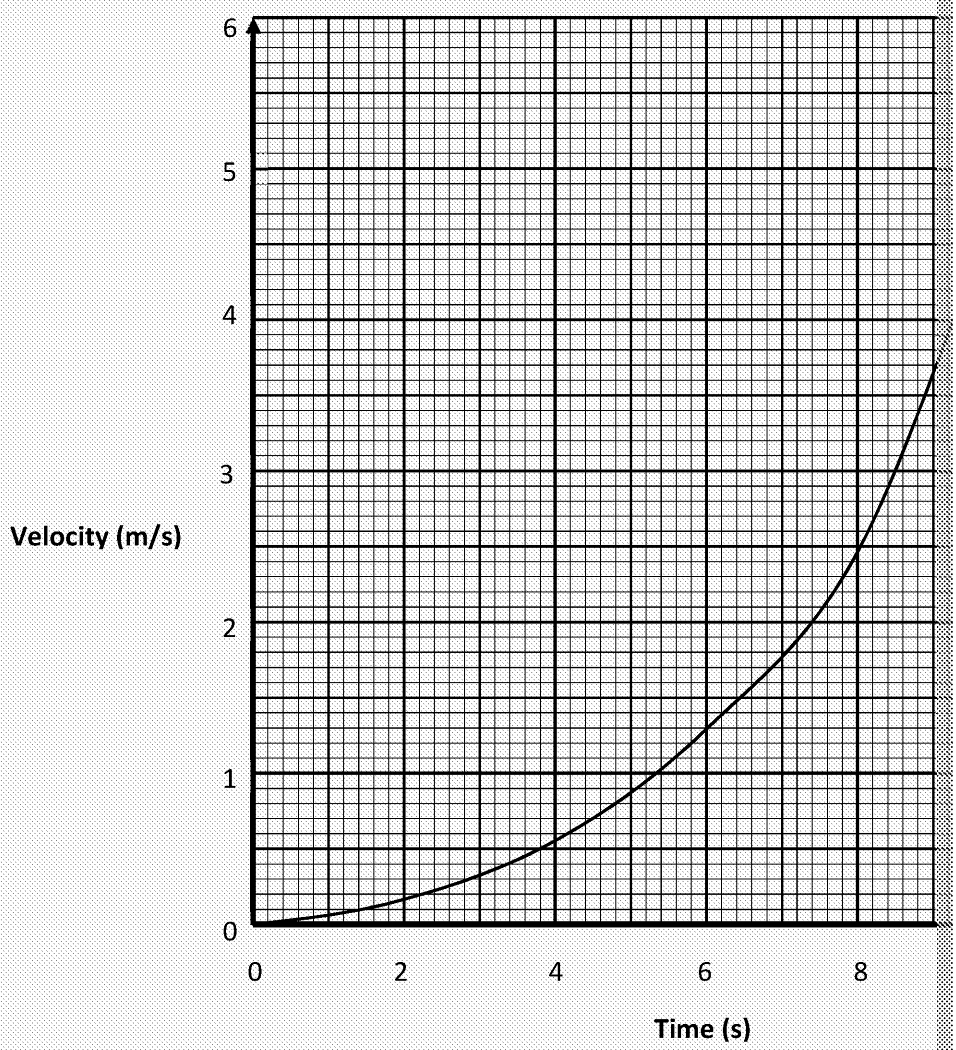
Sometimes, the graph we have isn't straight, but we still need to know how the valu
values of x change. To do this, we take the gradient of the tangent to the graph.
just touches the graph at one point only.

Rate of change – when we are measuring the slope or the gradient of a line, what
the rate of change of the y variable with the x variable – how much the y changes

WORKED EXAMPLE

Here is a graph of velocity/time for a car moving off from a set of traffic lig

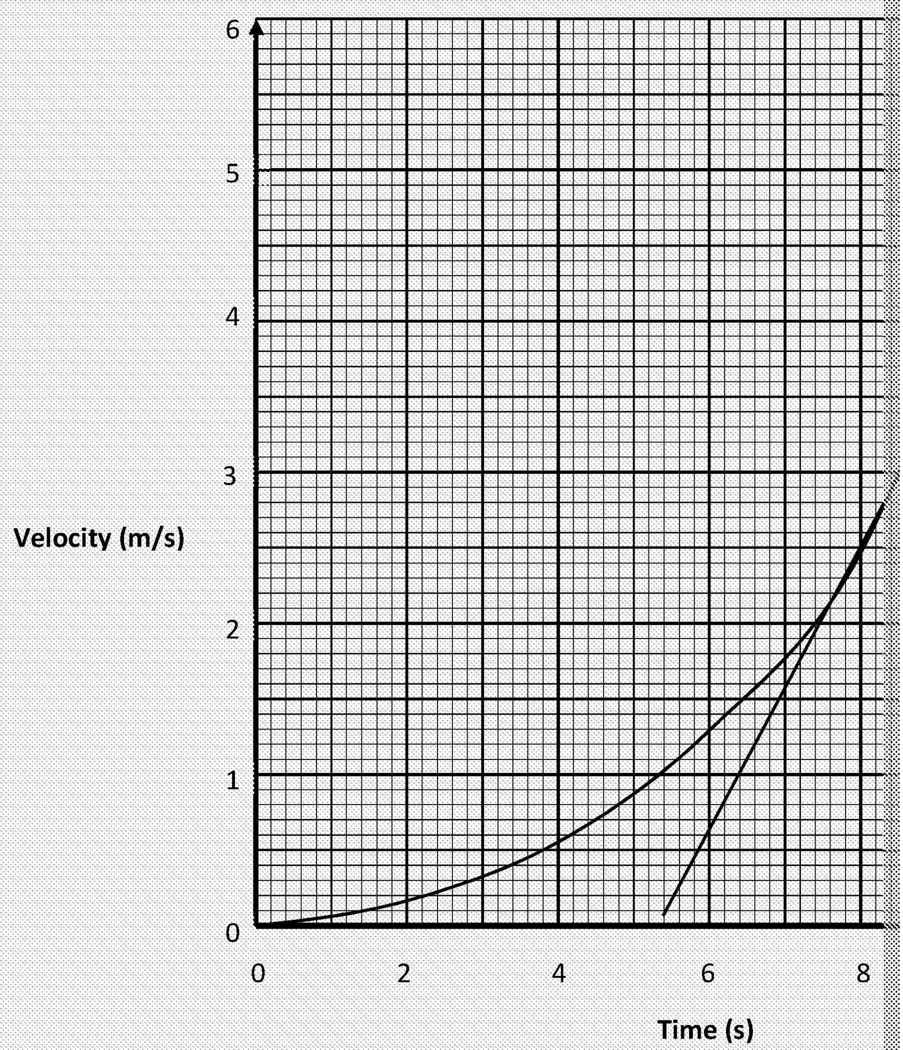
Calculate the acceleration of the car at 8 seconds.



Solution

What we need to do is draw a tangent to the curve at 8 seconds. Note that w
rather than picking a data point which isn't on the line.

WORKED EXAMPLE CONTINUED



Now we work out the gradient of the tangent (the rate of change of the velocit what we're asked for). We would choose two points as far apart on the tangen (5.4, 0.2) are ideal. The reason is so that we have the biggest difference betwe This means that any error we make in plotting the points / reading the points impact on the answer.

So, the gradient is

gradient = (change in the velocity value) / (change in the time value)

= (5.9 – 0.2) / (11.6 – 5.4)

= 0.92 m/s²

The units come from the fact that the units of the y-axis are m/s and the unit

When you divide m/s by seconds, we get m/s ÷ s

Which gives us m/(s × s)

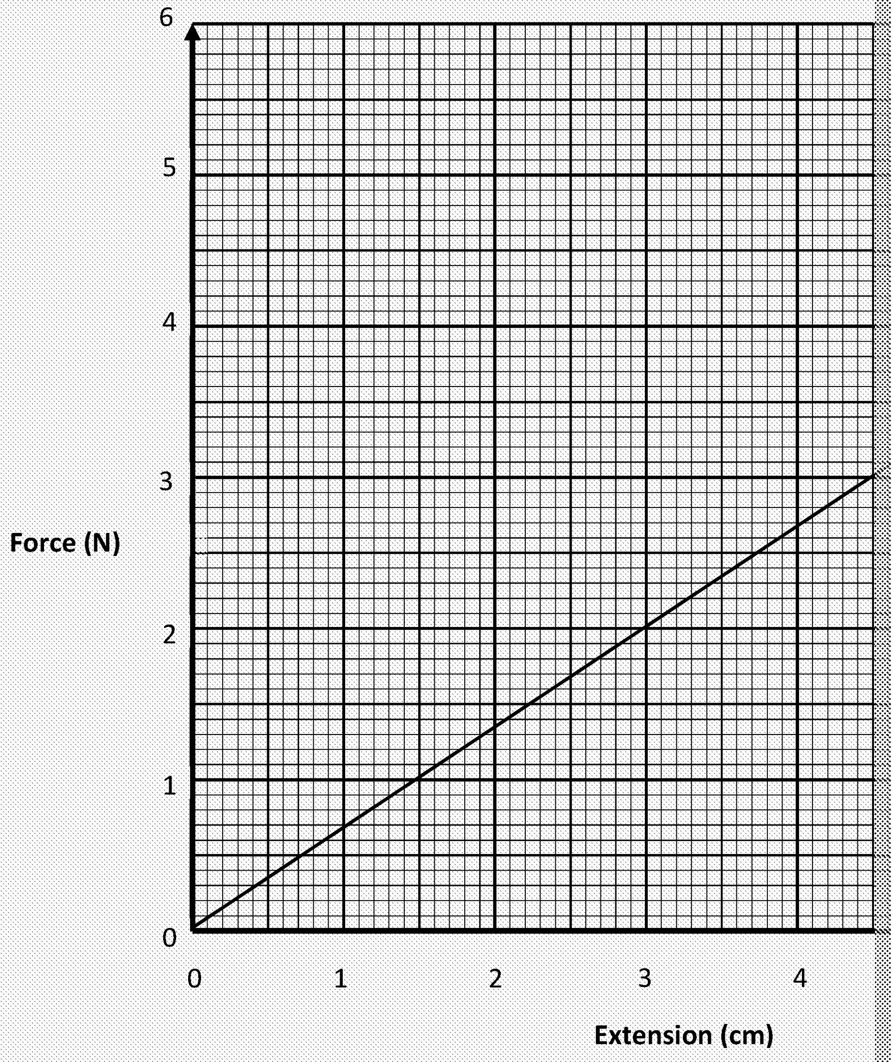
Which we write as m/s²

Area under a graph

The area under a graph is basically two numbers multiplied together. If we have a
area under it will be a force × a distance. You might recall that force × distance m

WORKED EXAMPLE 1

What is the area under the graph between 0 cm and 3 cm?

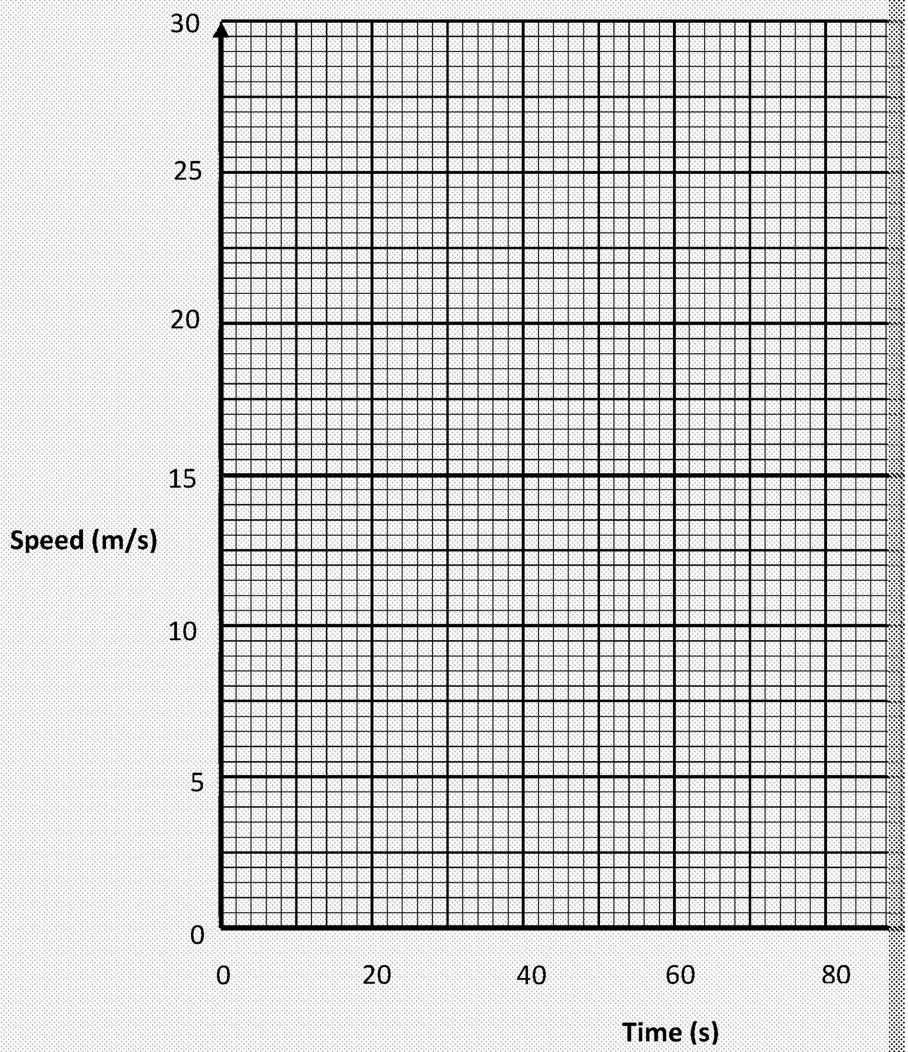


Solution

If we work out the area under the graph between 0 cm and 3 cm, we have the
area of a triangle = ½ × base × height (see 'Geometry and trigonometry' section
= 0.5 × 3 × 2 = 3
Of course, we know that the unit of work is the joule and if this was going to b
and the extension to be in SI (standard units), so extension needs to be in metr
0.5 × 0.03 × 2 = 0.03 J

WORKED EXAMPLE 2

If we had a car travelling at a constant speed, we'd have a graph like this:



What is the area under this graph?

Solution

From our equation speed = distance/time

we know that distance = speed × time, which is the area under the graph!

So, the distance travelled between 40 seconds and 60 seconds is the area of the

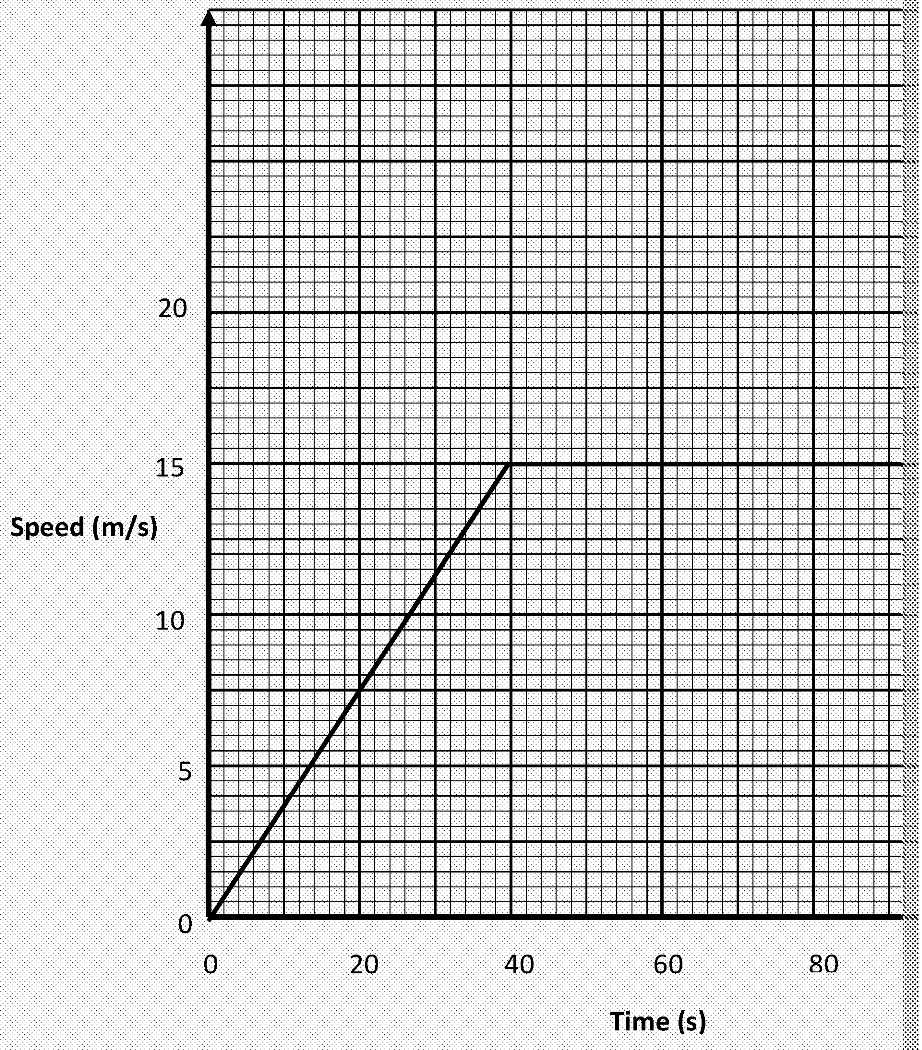
height 15 m/s and length 20 seconds (60 – 40).

Distance = 15 × 20 = 300 m

Sometimes, we get a change in the shape of the graph and so we have two areas o

WORKED EXAMPLE 3

What is the area under this graph?



Solution

In this case, the distance travelled between 0 seconds and 120 seconds is the the graph up to 40 seconds and the area from 40 seconds to 120 seconds, add

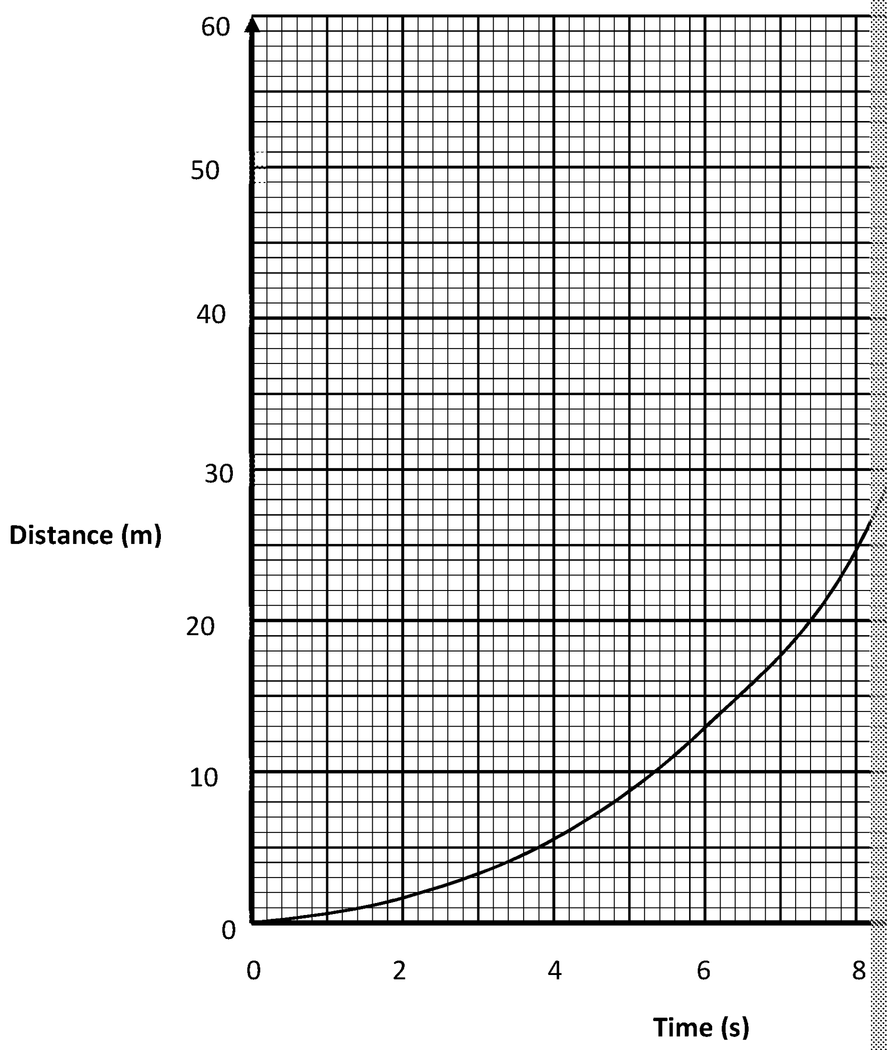
Area of triangle: 0.5 × 40 × 15 = 300 m

Area of rectangle: 80 × 15 = 1200 m

Total distance = 1500 m

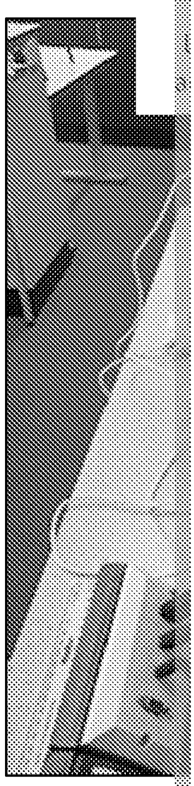
PRACTICE QUESTIONS

1. a. Find the rate of change of distance with time at time = 7.8 seconds in the



   b. How does this rate of change vary as time gets larger?

2. The experiment shown in the picture to the right was conducted to find the relationship between the force on an object and the acceleration of the object. The table of data collected is shown below:



Force (N)	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0
Acceleration (m/s^2)	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5

   a. Plot a graph of these data and draw the line of best fit to your data. (4 marks)
   b. State the relationship between the acceleration and the force. (1 mark)
   c. What is the general equation which describes a relationship like this? (1 mark)
   d. Calculate the gradient of the graph. (2 marks)
   e. Calculate the area under the line between F = 0 N and F= 9 N. (2 marks)
   f. What is the value of the y-intercept? (1 mark)
   g. What is the significance of this intercept? (1 mark)

GEOMETRY AND TRIGON

SPECIFICATION OVERVIEW

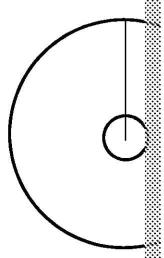
5a – Use angular measures in degrees
5b – Visualise and represent 2D and 3D forms, including two-dimensional repres
5c – Calculate areas of triangles and rectangles, surface areas and volumes of c

THEORETICAL OVERVIEW

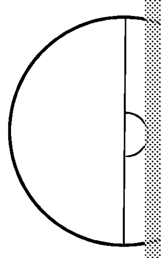
This section wraps up our toolkit. We look at measuring angles and calculating som nothing too scary!

Degrees (°)

There are 360° in a circle.

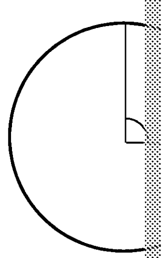


So in a semicircle (half a circle) there are 180°.

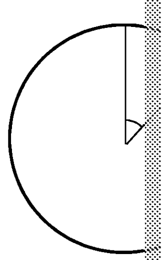


If you think about it, if you go from any point on the circumference of a circle to th from where you started, you've just gone along a diameter of the circle. So movin straight line!

Continuing this idea, in a quarter of a circle there are $\frac{360}{4} = 90°$ and a quarter of a circle describes a 'right angle'.



Half of 90 is 45 and that is the angle we'd go through going ⅛ of the way around a circle.

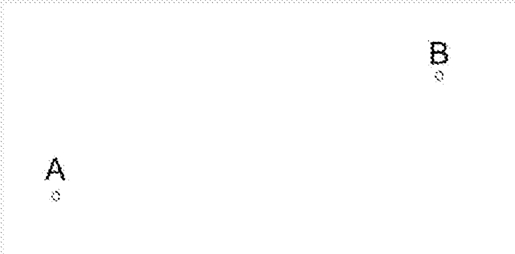


Measurement of angles in a question relies on the skilful use of a protractor. Take you're doing it properly and check that your answer makes sense and it will be co

In order to state the displacement, velocity or acceleration of an object, we need t magnitude) of the quantity and the direction. The direction is often found by meas

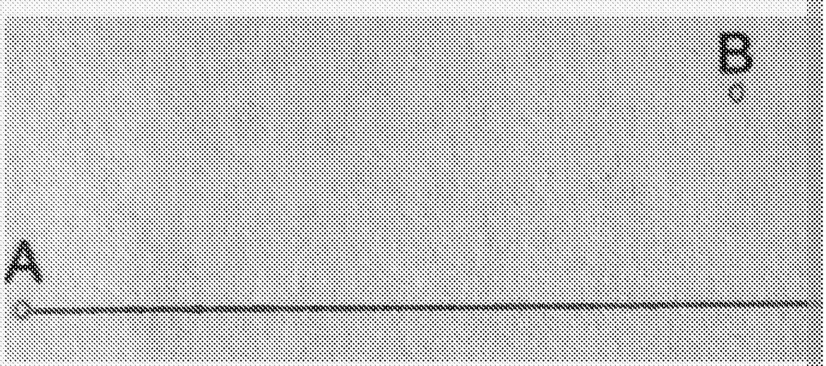
WORKED EXAMPLE

Measure the angle between the horizontal, on which A lies, and point B.

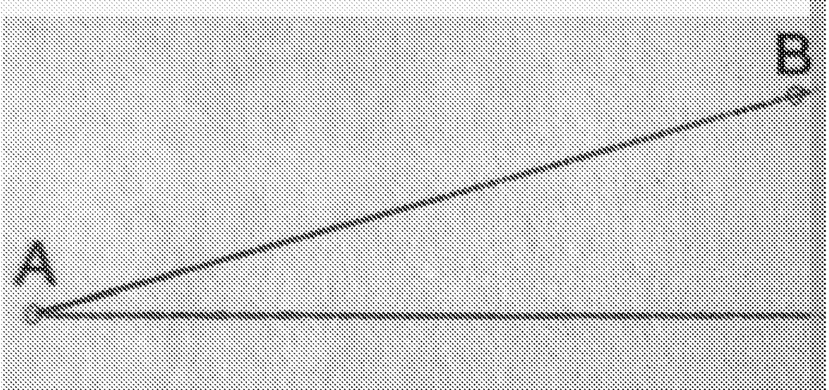


Solution

What we do is to draw a horizontal line through A – this is a reference line for



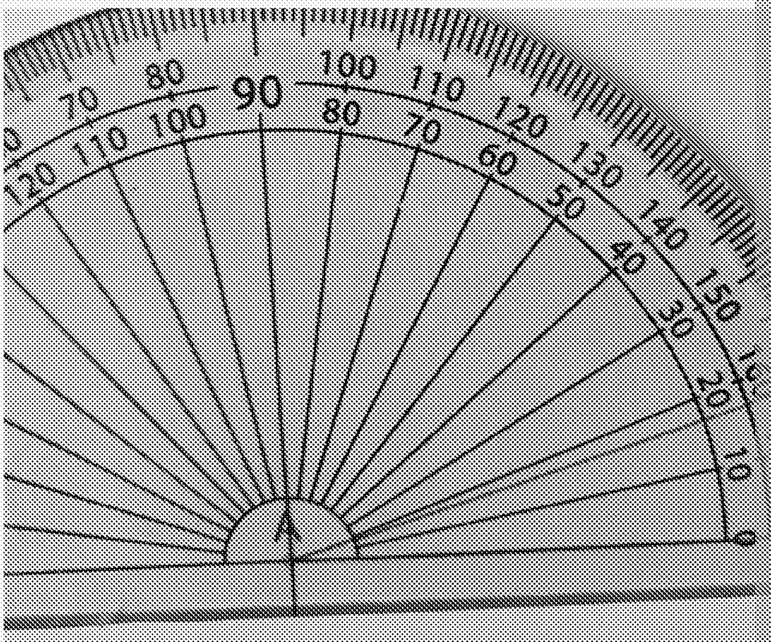
Then we draw a line from A through B.



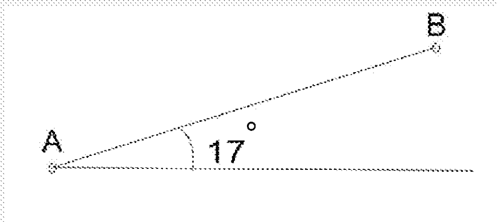
WORKED EXAMPLE CONTINUED

Then we place the protractor so that:

1. *The cross in the middle of the 0° line is on A.*
2. *The horizontal line through A runs right through the middle of the 0° mar*



Then we measure the angle:

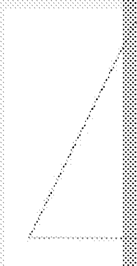


Representing 3D objects as 2D

One of the things that you need to be able to do is to draw a two-dimensional vie

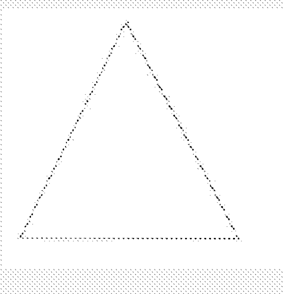
WORKED EXAMPLE

Here is a 3D diagram of a glass prism.
Draw a 2D version of this diagram.



Solution

This will just look like a triangle in 2D.



Areas and volumes

Formulae you'll need to know:

area of a triangle: $A = \frac{1}{2}\text{base} \times \text{height}$

(the height is the vertical distance from the base to the apex or top point of the tri

area of a rectangle: $A = \text{length} \times \text{width}$

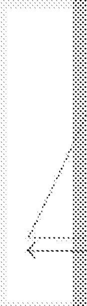
surface area of a cube: $A = 6 \times \text{length} \times \text{width} = 6 \times \text{length}^2$

(a cube is a 3D shape where all the sides are the same length – so each face is a

volume of a cube: $V = \text{length}^3$

WORKED EXAMPLE 1

Calculate the area of the triangle shown.



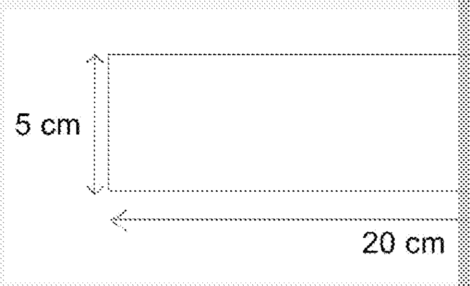
Solution

area = ½ base × height

= ½ × 7 × 10 = 35 cm²

WORKED EXAMPLE 2

Calculate the area of the rectangle shown.



Solution

area = length × width

= 20 × 5 = 100 cm²

WORKED EXAMPLE 3

Calculate the surface area of a cube of side 3 cm.

Solution

surface area = 6 × length²

= 6 × 3² = 54 cm²

WORKED EXAMPLE 4

Calculate the volume of the cube in worked example 3.

Solution

volume = length³

= 3³ = 27 cm³

Vectors

Although this isn't actually mentioned in the maths skills, it is part of the specificatio

What a vector is

A vector is a quantity that has both size (magnitude) AND direction. Velocity is a v the right', for example. If you just said '3 m/s', you haven't fully said what the vel important. On its own, '3 m/s' is just a speed – which is scalar NOT a vector. To il something accelerates, its velocity changes (acceleration = change in velocity/time force is required to cause the acceleration (F = ma, remember?). Now, since veloc changed, so has the velocity (3 m/s to the left and 3 m/s to the right are NOT the direction, the fact that the object had completely turned around would be missed a resultant force has been acting to make this happen.

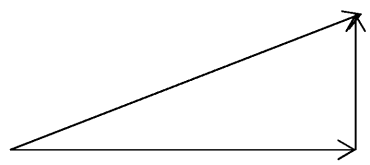
How to describe vectors

The description must include BOTH the size AND the direction. So a distance (scala A displacement (vector) version would be '22 m north'.

How to take any vector and break it up (resolve it) into two ve each other (You only need to know how to do this at Higher ti

For example, here's a vector, representing a force, which makes an angle of 20° to the horizontal:

You can see that it has an effect horizontally to the right and also has an effect vertically upwards. So, we could achieve the same effect with two forces – one horizontally to the right and the other vertically upwards. These three forces form a triangle:



This process of breaking down a vector into two parts (**<u>components</u>**) which are at **<u>resolution</u>**. We have resolved this force at 20° into its horizontal and vertical com

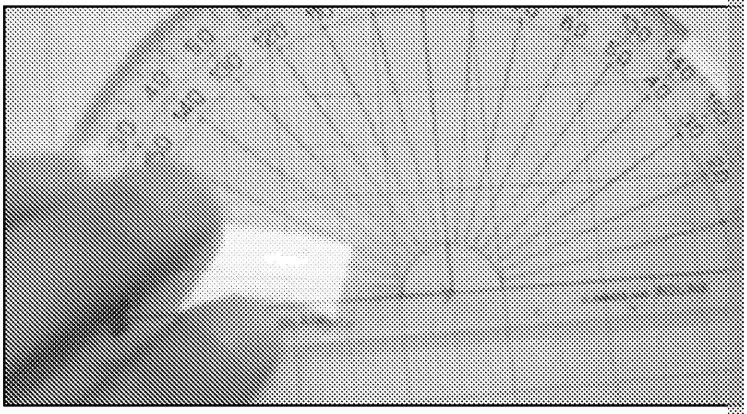
How to add vectors together, using scale drawing (this is find (You only need to know how to do this at Higher tier.)

Let's look at adding two forces together to get the resultant. One is 5 N horizonta an angle of 30° to the horizontal and acting upwards.

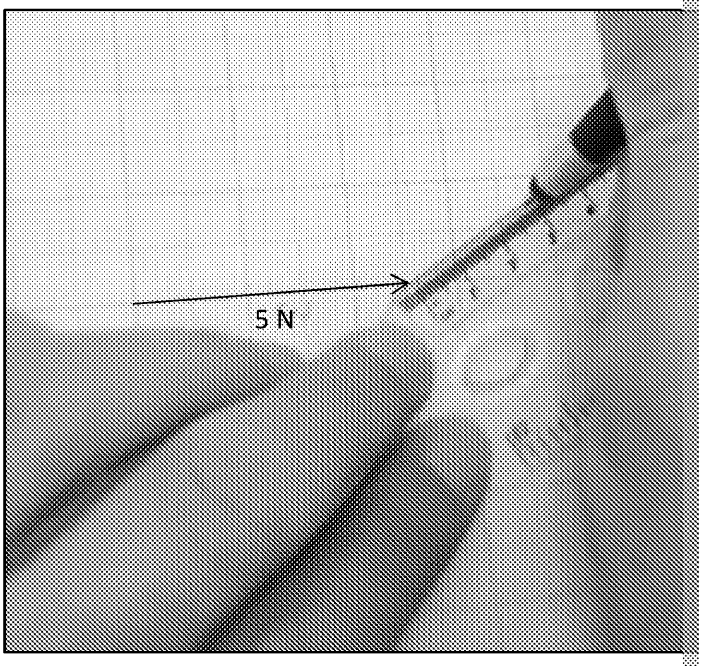
So, the first step is to choose a scale for our diagram – 1 cm to each newton works well here. If we had a force of 500 N, we would probably say 100 N to each cm.

Then draw our 5 N vector – a horizontal line 5 cm long:

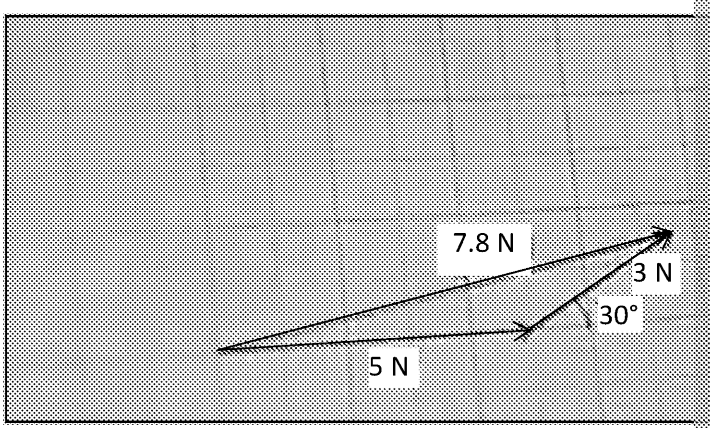
Now we add our 3 N force vector, but first we have to measure the 30° angle we



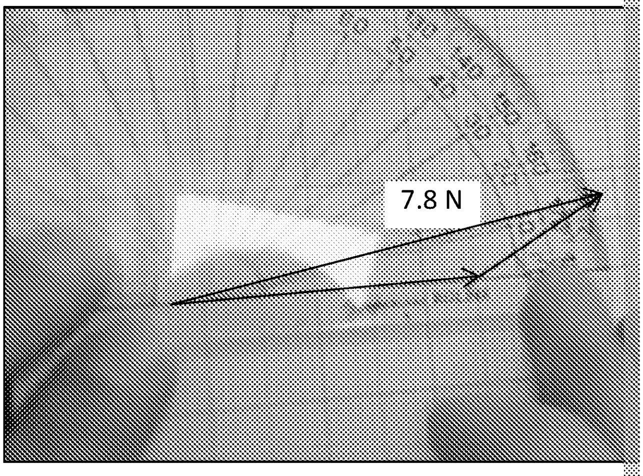
Now we can draw our 3 N force vector – 3 cm long at 30° to the horizontal:



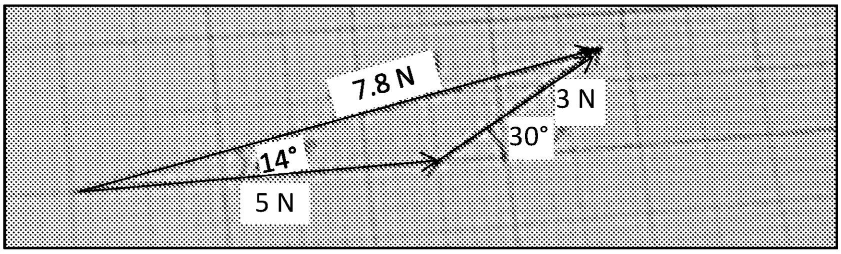
Then we join the point where we started the 5 N force to the point where we finish resultant of the two. The length is measured and, using the scale we decided on, th



The final stage of the work is to measure the angle – remember a vector MUST be the direction:



So the resultant of our two vectors has been found by scale drawing!

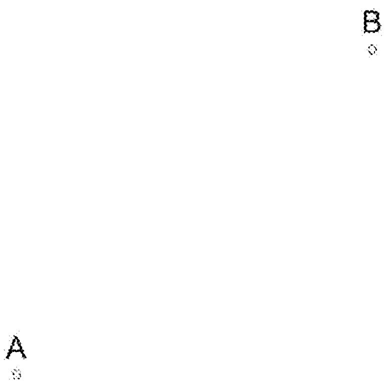


Resu

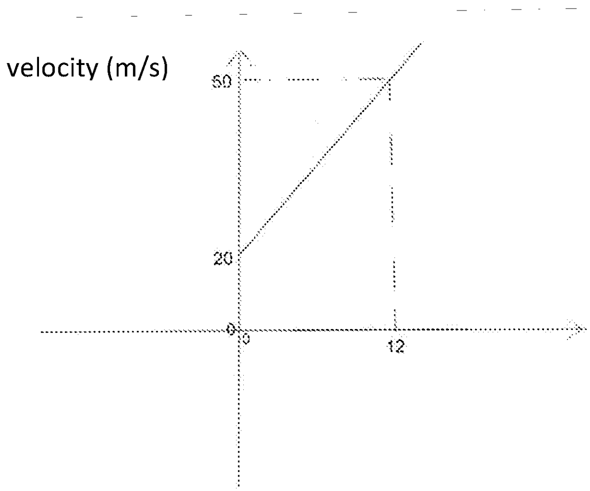
$\theta =$

PRACTICE QUESTIONS

1. The displacement is the vector distance between two points. That means we n straight line between the two points, but also the angle that line makes with th example. By making measurements from the diagram, write down the displa The diagram is to scale.

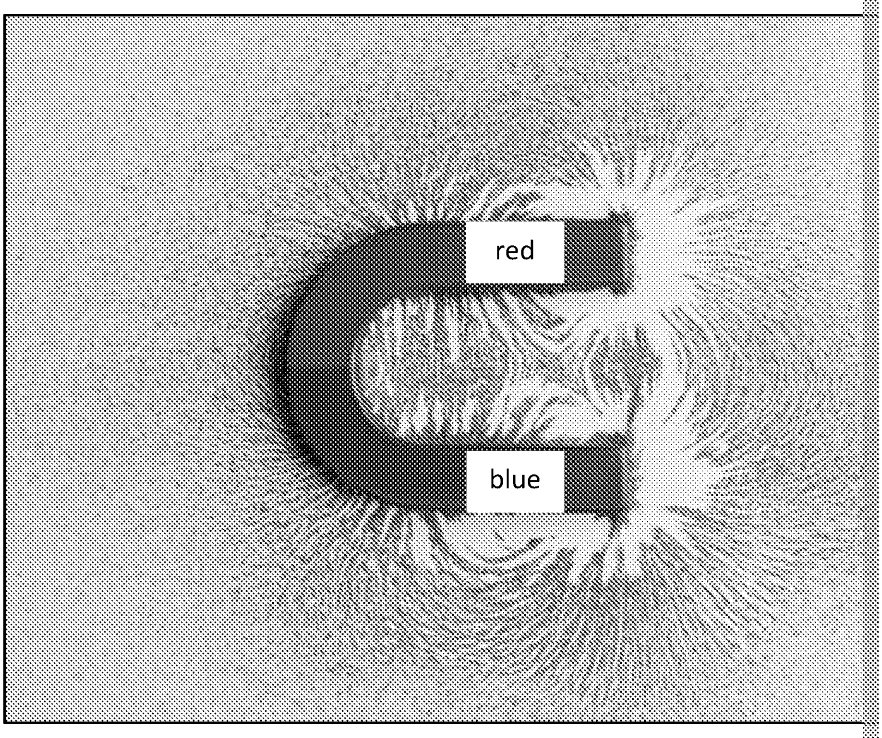


2. The magnitude (size) of the displacement can be found by working out the area a moving object. Calculate the displacement of the car for which the velocity–ti



3. In a children's soft play area there are lots of inflated cubes for the children t Each of these cubes has a side of length 50 cm. Taking the density of air as 1 density $= \frac{\text{mass}}{\text{volume}}$, calculate the mass of air in one cube, in kg.

4. Here is a picture of a magnet's field lines being highlighted using iron filings:



Draw a 2D representation of this picture. Just draw four field lines from the p Assume the red side is north and put arrows on your lines accordingly.

Diagnostic Test 2

A2 Arithmetic

1. Write down $\frac{3}{12}$ as a decimal.

   ....

2. Write down 0.2 as a fraction, in its simplest form.

   ....

3. Write 512 in standard form.

   ....

4. 1 TW is 1×10^{12} watts. Write this number as a decimal.

   ....

5. An electric car has a range of 350 miles. The owner drives 37 % of this rang

   ....

6. If the car in question 5 is driven 150 miles, what percentage of the range is th

   ....

7. A water tap in my house is dripping at the rate of one drop per second. Estir fill a 5 L washing up bowl placed underneath.

   ....

   ....

B2 Algebra

1. Write the following expression in words: $x \sim y$

   ....

2. Make variable u the subject of this equation.

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

   ....

3. A certain constant can be calculated using the equation

$$\text{constant} = \frac{\text{force}}{\text{current} \times \text{length}}$$

   Given that the units of force = N, current = A and length = m, what are the u

   ....

4. A car is travelling at 10 m/s and accelerates at 3 m/s² to 20 m/s. Calculate during the acceleration. Use the equation in question 2, where u = 10 m/s, v

   ....

   ....

5. If I eat one square of chocolate from a bar of chocolate every minute until I'v relationship between the amount of chocolate **remaining** and the time I have

   ....

6. Water pours into a bucket at a rate of 50 cm³ per second. If the bucket cont with, describe the relationship between the volume of water in the bucket and flowing into the bucket.

   ....

7. If the temperature, θ, of a cup of tea falls from 95 °C to 85 °C in 300 second change of the temperature of the tea.

   ....

   ....

C2 Handling data

1. Write 86 400 to two significant figures.

   ....

2. A world-class female shot-putter achieves the following distances, in metres, c

   21.91 20.85 22.05 22.50 21.55 22.50 22

   a. Calculate the mean distance.

   ....

   ....

   b. State the median distance.

   ....

   c. State the modal distance.

   ....

3. A survey of the number of books in a library, separated by type (e.g. fiction,
   What is the most appropriate way to:

   a. Record the data collected?

   ....

   b. Represent those data on a graph (what type of graph should be plotted

   ....

4. A car is driven 50 km a day for a year. What is the order of magnitude of t

   ....

5. An experiment to find the relationship between the potential energy of an ob
   centre of a planet is done. The results are shown in the table below:

Distance (km)	6400	12 800	19 200	25 600	32 000	38 40
Energy (J × 10^5)	6.00	3.00	2.00	1.50	1.20	1.00

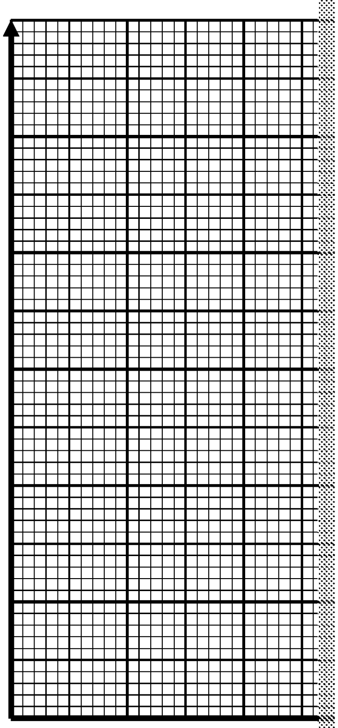
Draw a graph of these data.
State the relationship between the force between the objects and the distance between them.

....

....

....

....



D2 Graphs

1. What would the graph of a/F (a vs F) look like for the equation $F = ma$? Assu

   ....

2. a. Plot a graph of $3y = 4x + 12$ for values of x from 0 to 9.

   b. What is the gradient of this graph?

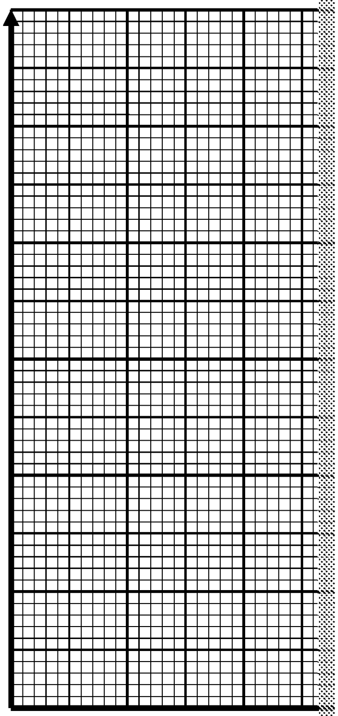
   ....

   ....

   c. What is the y-intercept of this graph?

   ....

   ....



3. a. Plot a graph of time against speed for the values in the table below:

Speed (m/s)	5.5	11	16.5	22	27.5	33	38.5
Time (s)	1.82	0.91	0.61	0.45	0.36	0.30	0.26

   b. Measure the gradient of the graph at speed = 5.5 m/s.

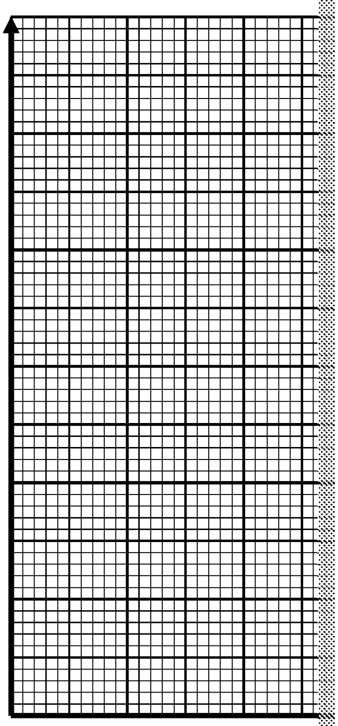
   ....

   ....

   c. What does this value of the gradient tell you?

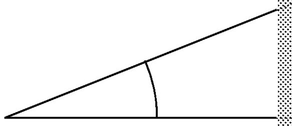
   ....

   ....



E2 Geometry and trigonometry

1. Measure the angle shown in the diagram.



....

2. Calculate:

   a. The area of a rectangle of length 5 cm and width 2 cm

   ....

   b. The volume of a cube of side 5 cm

   ....

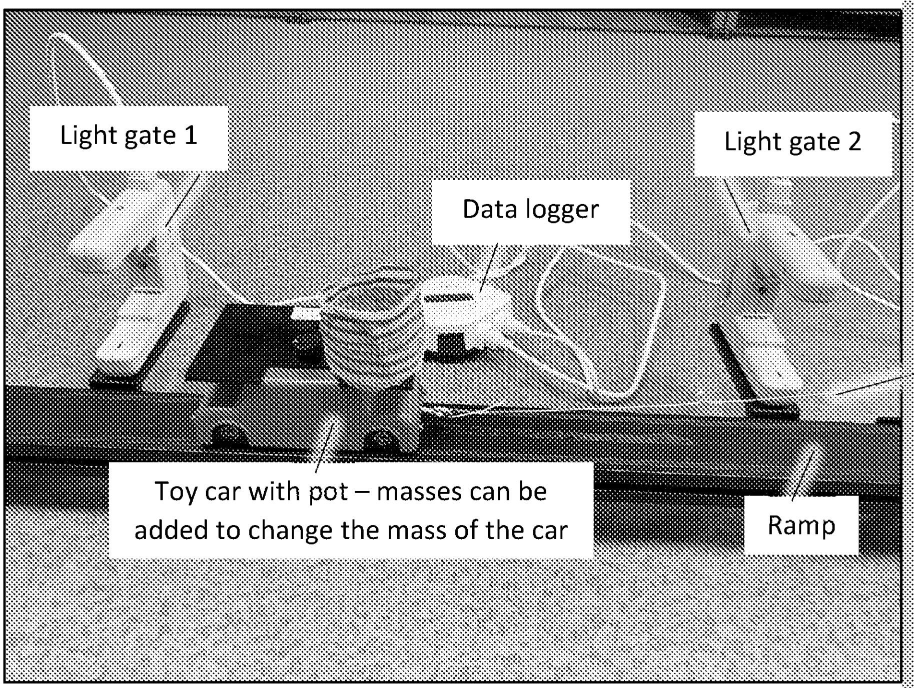
   c. The area of a triangle of height 20 cm and a base of 10 cm

   ....

   d. The surface area of a cube of side 5 cm

   ....

3. Here is a picture of the equipment used to measure the acceleration of a toy
   What would it look like in 2D from this perspective? Draw a diagram to show
   data logger.



SOLUTIONS TO QUES

DIAGNOSTIC TEST 1

A1 Arithmetic

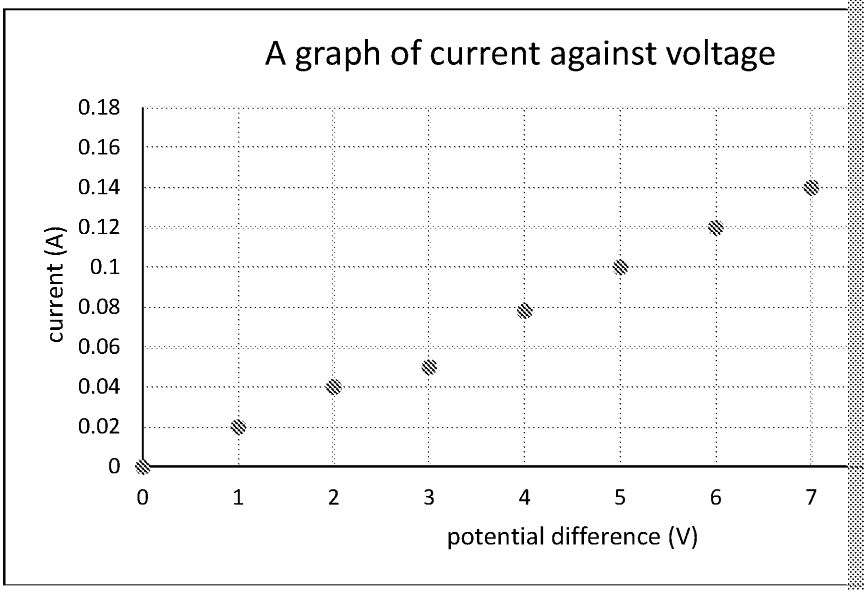
1. 0.25
2. ⅓
3. 1.024×10^3
4. 1 000 000 000 bytes
5. 0.125
6. 20 %
7. Estimate the mass of an adult male as 80 kg. Estimate the mass of a small car as 120 males to have the same mass as the car. There are no absolutely correct answers her reasonably be taken as a value between 70 kg and 100 kg, and that of the car as b

B1 Algebra

1. x is much greater than y
2. $t = \frac{v - u}{a}$
3. Units are Nm^2/kg^2
4. 6.7 m/s^2 (6.67)
5. Linear
6. Proportional
7. a. $\Delta I = 5$ A
   b. 2500 A/s

C1 Handling data

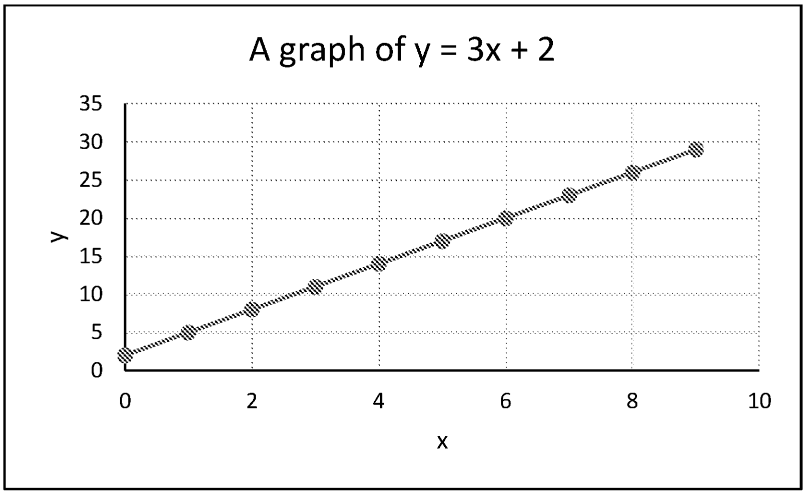
1. 12 300
2. a. 10.25 s
   b. 10.22 s
   c. 10.01 s
3. a. Frequency table
   b. Histogram
4. Bar chart
5. In metres, the dimensions are 0.1 m and 1.2 m
   The area is then
   $0.1 \times 1.2 = 0.12$ m^2
   which is 1.2×10^{-1}, so the order of magnitude is -1
6. a.



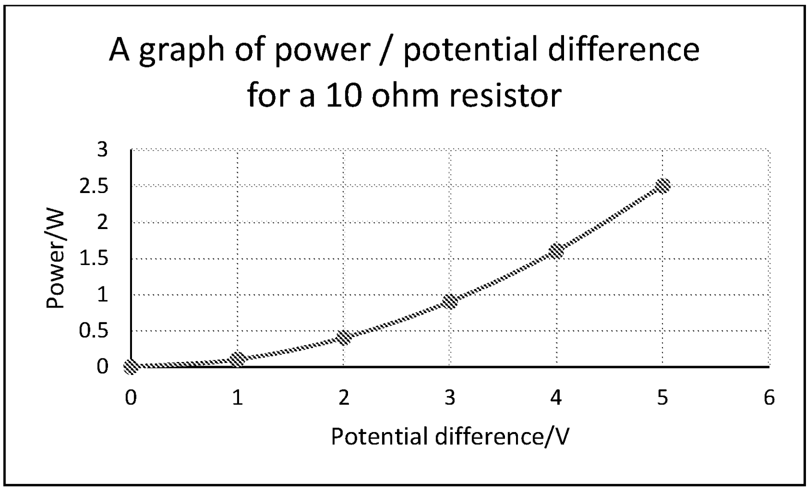
   b. The current is directly proportional to the potential difference

D1 Graphs

1. $y = mx + c$. It would become $y = mx$ for a directly proportional graph.
2. a.



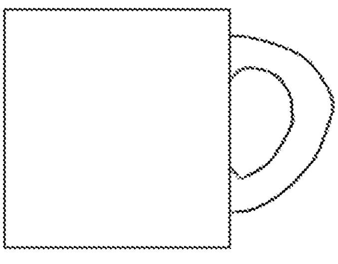
   b. 3
   c. 2
3. a.



   b. 0.8 (in range 0.7–0.9)
   c. The rate of change of power with potential difference when $V = 4$ volts
4. There are several examples you could give here. Examples include:
   A graph of current/time – the area under the graph is the charge that has flowed
   A graph of velocity/time – the area under the graph is the displacement
   A graph of force/time – the area under the graph is the impulse or the change in mo
   A graph of force/distance moved – the area under the graph is the work done
   A graph of power/time – the area under the graph is the work done

E1 Geometry and trigonometry

1. Protractor
2. Degrees
3. a. area = length × width
   b. volume = length^3
   c. ½ base × height
   d. 6 × length^2
4.



PRACTICE QUESTIONS

Arithmetic

1.

	Fraction	Decimal		Fraction	Decimal		Fraction	Decimal
A	$\frac{1}{16}$	0.0625	**D**	$\frac{3}{7}$	0.429	**G**	$\frac{1002}{17}$	58.9
B	$\frac{1}{20}$	0.05	**E**	$\frac{82}{3}$	27.3			
C	$\frac{1}{5}$	0.2	**F**	$\frac{213}{5}$	42.6			

2.

	Number	Percentage		Number	Percentage		Number	
A	$\frac{1}{16}$	6.25	**D**	$\frac{3}{7}$	43 (42.9)	**G**	$\frac{55}{127}$	
B	$\frac{1}{20}$	5	**E**	0.22	22	**H**	$\frac{133}{100}$	
C	$\frac{1}{5}$	20	**F**	$\frac{75}{136}$	55	**I**	$\frac{49}{8}$	

3.

	Percentage (%)	Fraction		Percentage (%)	Fraction
A	5	$\frac{1}{20}$	**E**	67.67	$\frac{2}{3}$
B	22	$\frac{11}{50}$	**F**	75	$\frac{3}{4}$
C	12	$\frac{3}{25}$	**G**	90	$\frac{9}{10}$
D	40	$\frac{2}{5}$			

4.

	Number	Sta
A	365.25 days in a year	3.65
B	1 500 000 km is the average Earth–Sun distance	1.
C	0.000 000 000 144 m is the radius of an atom of gold	1.
D	101 000 N/m² is atmospheric pressure	1.0
E	24.8 N/kg is the value of gravity on Jupiter	2.4

5.

	Standard form	
A	1×10^3 cm³ in one litre	
B	3.15576×10^7 seconds in a year	3
C	1×10^{-5} m is the diameter of a human hair	
D	1×10^{-9} m is one nanometre	0.0
E	9.1×10^9 km is the diameter of the solar system	9 10

6. a. 10 km = 10 000 m. 10 000 m at 2 m/s: 5000 s (about 83 minutes)
   b. 300 m at 5 m/s: 60 s
   c. 800 km/h average aircraft speed, 800 km/h for 2 hours = 1600 km
   d. Gravity is 9.8 m/s², so after one second the ball would be travelling at 9.8 m/s graph is the distance travelled = ½ × 1 × 9.8 = 4.9 m, so it takes about 1 s to
7. 3 : 1
8. circumference = 3.14 × 12 756 = 40 054 km

Algebra

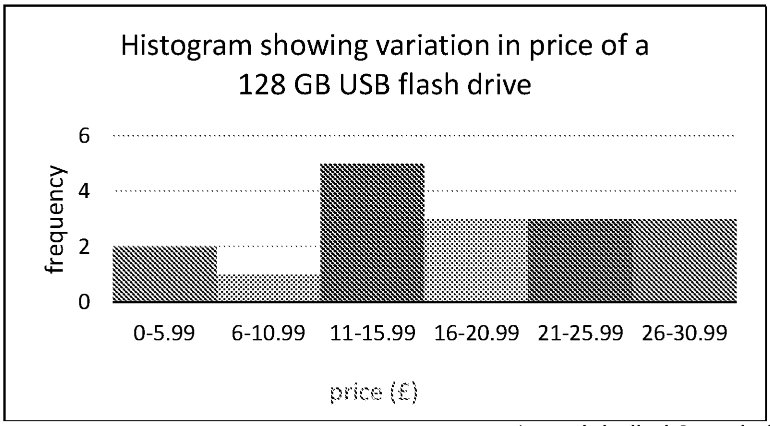
1. a. (Directly) Proportional
   b. The graph is a straight line (1 mark), passing through the origin (0,0)
   c. (i) resistance $= \frac{\text{power}}{\text{current}^2}$
      (ii) resistance $= \frac{50}{5^2}$
      $= 2\ \Omega$ (1 ma
      (iii) voltage = current × resistance
      $= 5 \times 2$
      $= 10$ V (1 ma
      (iv) 2 : 1
   d. (i) 10 W
      (ii) ¼
      (iii) 25 %
      (iv) 4.0×10^1 W
      (v) 9×10^4 seconds = 25 hours

Handling data

1. a.

Price (£)	Frequency
0–5.99	2
6–10.99	1
11–15.99	5
16–20.99	3
21–25.99	3
26–30.99	3

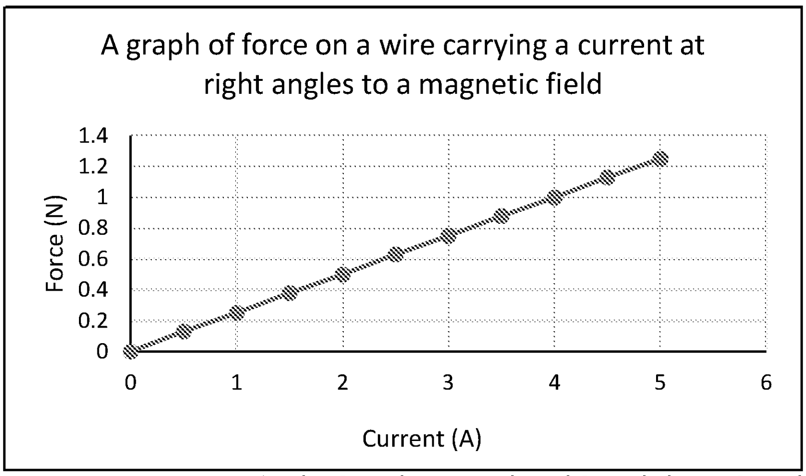
   b.



(axes labelled 1 mark; bars in

   c. £17.00
   d. £16.99
   e. £15, £17 and £25 as each occurs twice

2.



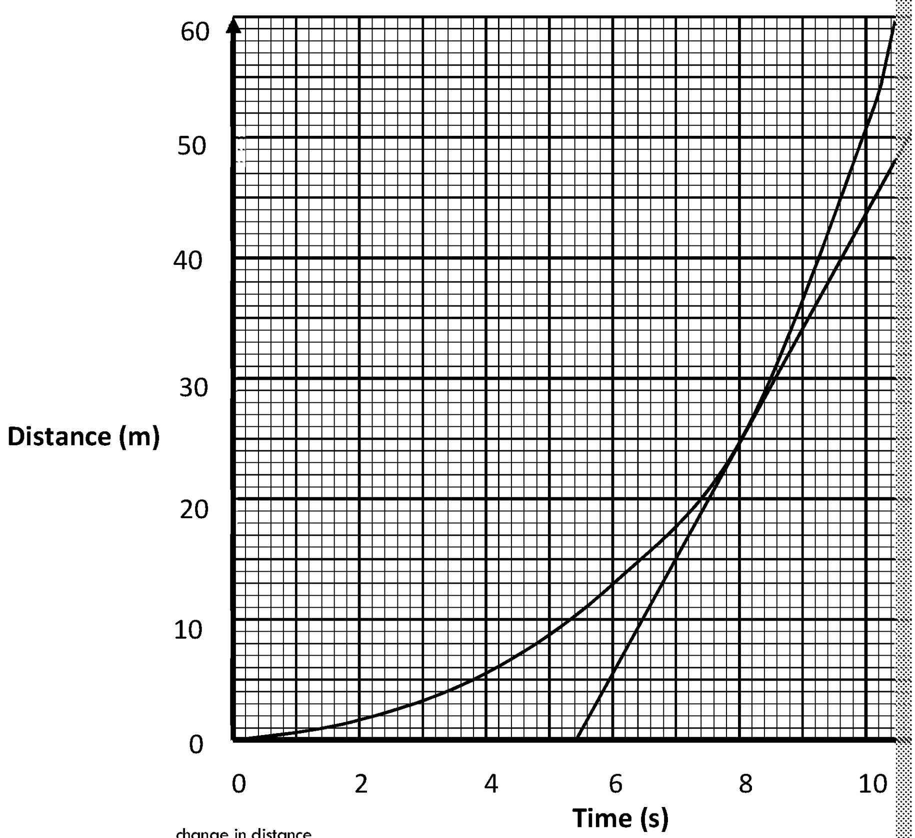
(scales 1 mark; points plotted 1 mark, losing 1 mark for any

The graph shows a directly proportional relationship

3. Conversion of km to metres
   10^3

Graphs

1. Gradient of the tangent to the graph at time = 7.8 seconds = rate of change of dist



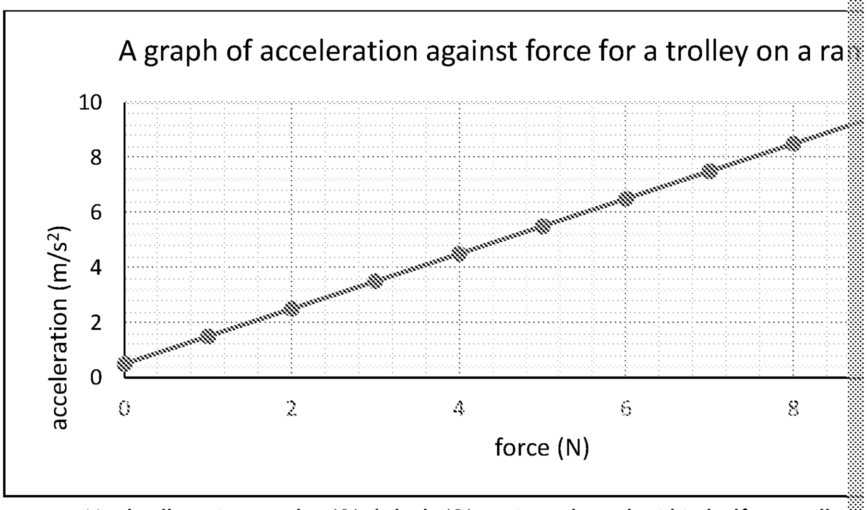
a. gradient = $\frac{\text{change in distance}}{\text{change in time}}$

= gradient = $\frac{60-0}{11.2-5.4}$ (allow +/– 0.5 small square in values read from graph)

= 10.3 (m/s)

b. Increases

2 a.



Mark allocation: scales (1), labels (1), points plotted within half a small s

b. Linear

c. y = mx + c

d. gradient = $\frac{\text{change in y}}{\text{change in x}}$

gradient = $\frac{9.0-1.0}{9.5-1.5}$

gradient = 1.0 (m/Ns^2)

e. area = area of parallelogram = ½ × sum of parallel sides × right angle distan

= $\frac{0.5+9.5}{2}$ × 9 = 45

Or area = area of rectangle of side 0.5 m/s^2 and length 9 N + area of triangle c

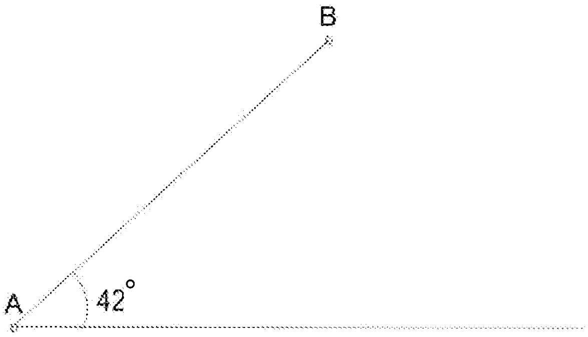
= 4.5 + 4.5 × 9 = 45

f. 0.5 m/s^2

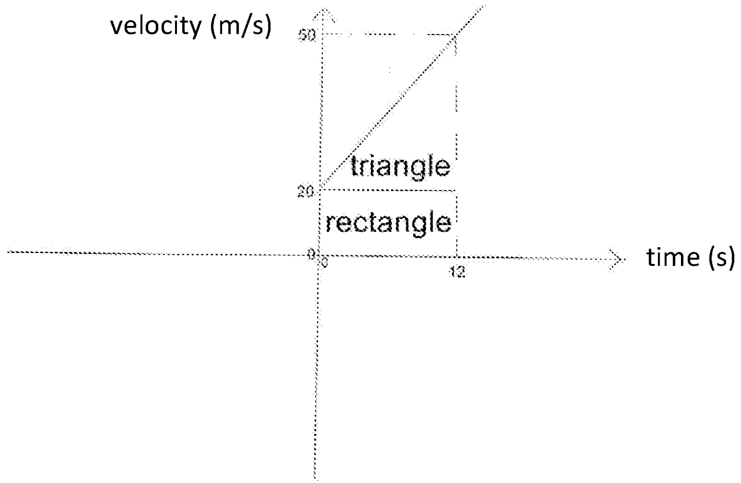
g. It shows that the trolley is accelerating even though there is no force applied to

Geometry and trigonometry

1. AB = 6.4 cm



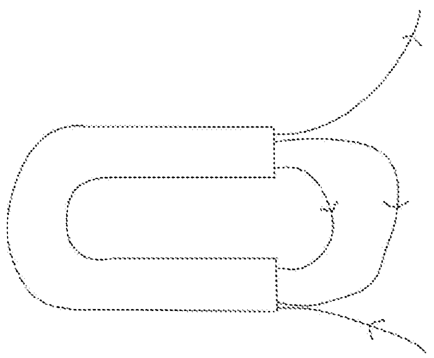
2. area = area of rectangle of length 12 s and width 20 m/s + area of triangle of base 12 s a



$= (12 \times 20) + (½ \times 12 \times 30)$
$= 240 + 180 = 420$ m
Or
area = ½ sum of the parallel sides × right angled distance between them
$= ½ \times (20 + 50) \times 12 = 420$ m

3. density $= \frac{\text{mass}}{\text{volume}}$
So, rearranging to make mass the subject: mass = density × volume
convert 50 cm into metres = 0.5 m
volume = length^3
volume = $0.5^3 = 0.5 \times 0.5 \times 0.5$
volume = 0.125 m^3
mass = 1.2×0.125
mass of air in one cube = 0.15 kg

4.



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DIAGNOSTIC TEST 2

A2 Arithmetic

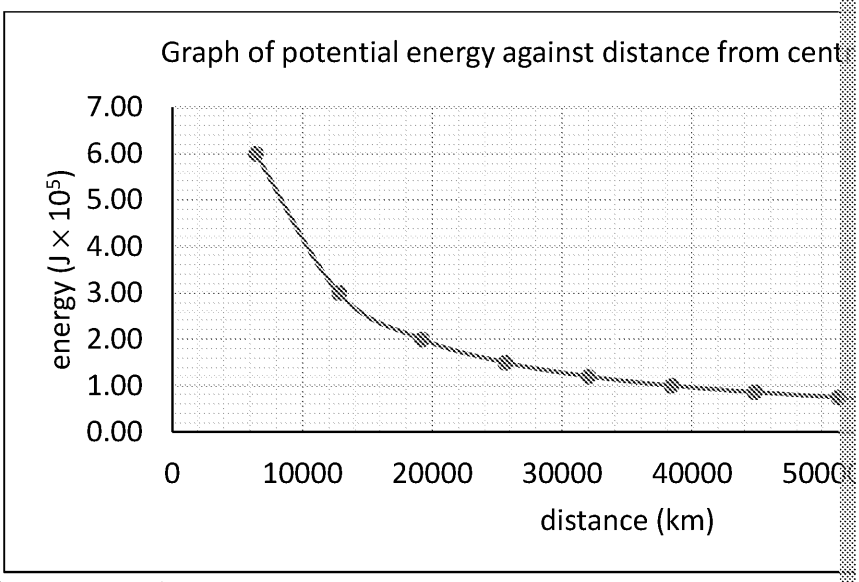
1. 0.25
2. $\frac{1}{5}$
3. 5.12×10^2
4. 1 000 000 000 000 W
5. 0.37
6. $\frac{150}{350} \times 100 = 43\ \%$
7. Estimate the volume of each drip between 0.25 cm^3 and 2 cm^3, giving the time to del seconds (5 h 33 min 20 s) and 2500 seconds (41 min 40 s) respectively.

B2 Algebra

1. x is approximately equal to y
2. $u = \sqrt[2]{\frac{v^2}{2aS}}$
3. N/Am
4. 50 m
5. Inverse proportion
6. Indirect proportion
7. a. 10 °C
   b. 0.033 °C/s

C2 Handling data

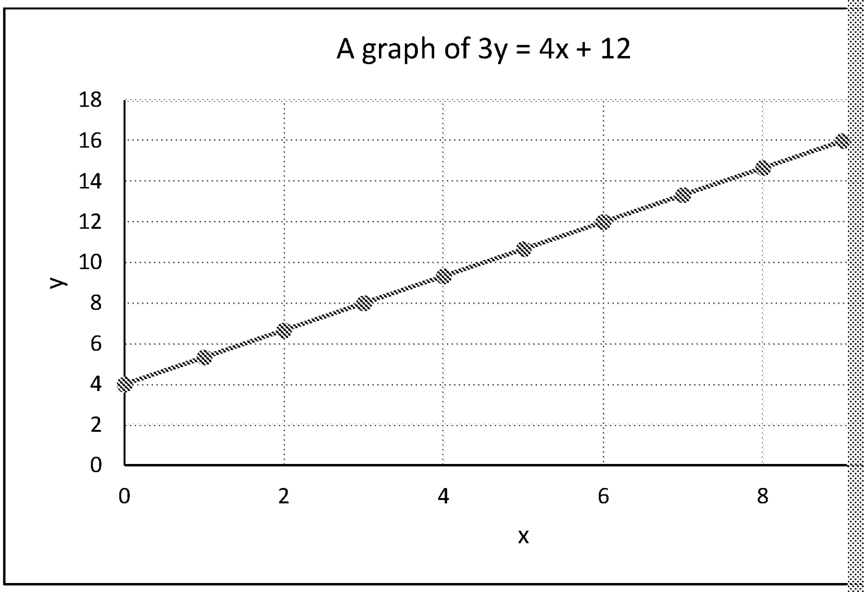
1. 86 000
2. a. 22.03 m
   b. 22.05 m
   c. 22.50 m
3. a. Frequency table
   b. Bar chart
4. $50 \times 365 = 18\ 250$, which is 10^4, so the order of magnitude is 4
5. a.



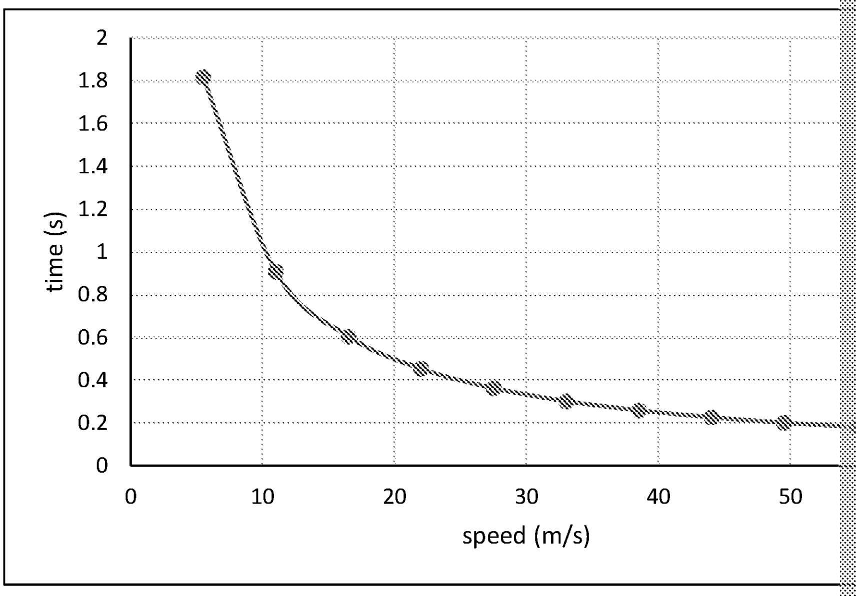
   b. Inverse proportion

D2 Graphs

1. Straight line through the origin (directly proportional)
2. a.



   b. 1.3 or 4/3
   c. 4
3. a.



   b. Gradient = -0.11
   c. How quickly the time for the journey is decreasing at a speed of 5.5 m/s

E2 Geometry and trigonometry

1. 20° in the range of 19° to 21°
2 a. 10 cm^2
   b. 125 cm^3
   c. 100 cm^2
   d. 150 cm^2
3.