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IGCSE Statistics Coursebook
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> Chapter 1

Data and its Collection

BY THE END OF THIS CHAPTER YOU WILL BE ABLE TO:

- classify data and variables according to their type
- know the terms associated with different types of sample and understand the sampling methods used to obtain them
- understand that some sampling methods can be biased
- use a random number table to select a simple random, systematic or stratified sample
- use open and closed questions in a survey

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GETTING STARTED

What do you already know?

- When a quantity, N , is divided in the ratio $a:b$, the two shares are $\frac{a}{a+b} \times N$ and $\frac{b}{a+b} \times N$
- When a number is rounded, there are lower and upper limits for the original number.

Check your skills

- Find the greater share when:
 - 2.7 kg is divided in the ratio 1:2
 - 63.21 cm is divided in the ratio 4:3
 - \$420 is divided in the ratio 3:11
- An influenza virus has so far infected exactly 8567 people.
 - Write down the number that will appear in a newspaper article, if the journalist approximates the number of infected people to the nearest hundred.
 - One week later, the journalist writes a second article in which she reports that, to the nearest ten, 9320 people have now been infected by the influenza virus.
Find the least and greatest possible number of infections that could have occurred in the week between the first and second articles.

Data is something we use all the time, but what is it?

Data are pieces of information, and a set of data is a collection facts and statistics that are gathered together and analysed to help answer questions. Data are often collected to investigate people's opinions and behaviours, or to discover the characteristics and qualities of objects. This might be to help national and local governments make sensible decisions about spending on public services, or for quality-control testing in manufacturing industries.

Imagine you want to answer one of these questions:

- What do the people living in your town think about a plan to build a new road nearby?
- Which internet service provider gives you the best value for money?
- How much did your friends and family enjoy their meal at a restaurant?

To answer these sorts of questions you need to collect some data. This can be done by carrying out a survey. Before you carry out a survey, you will need to decide what data to collect and how you will collect it. For example, you can:

- use interviews and questionnaires
- make observations and measurements
- collect responses online by asking customers to rate services and products.

When you look at the results of a survey that has been completed by another person or by an organisation, you should think about whether the people who carried out the survey are prejudiced or if they might be trying to influence you in a certain way.

KEY WORDS

raw data
quantitative
qualitative
discrete
continuous
census
population
sample
representative
bias
sampling error
sampling frame
questionnaire
open question
closed question

2 >

1 Data and its Collection

Exercise 1B

- A sample of 11 people is chosen from 431 people who work outdoors and 754 people who work indoors.
Calculate the number of people that are selected from each group, if the sample is stratified by place of work.
- Omar wants to investigate the musical preferences of the students in Stages 10 and 11 of his school using a stratified sample of 30. There are 368 students in the population and there are 205 students in Stage 10.
Find the number of students in Stage 10 and the number of students in Stage 11 that should be in the sample if it is to be representative in terms of school stage.
- The two-digit random numbers in the table are used to select a simple random sample of five from a list of 40 names that are numbered from 00 to 39.

34	41	55	67	04	70	82	26	92	23
12	09	38	27	09	27	12	09	38	12
57	61	24	50	94	17	02	31	24	36

- Explain why the first row of numbers cannot be used to select the sample.
- Explain why the second row of numbers cannot be used to select the sample.
- Use the third row to select the required sample and list the numbers of those selected.

- Various samples are to be selected from a list of the names of 25 boys and 35 girls. The boys are numbered from 00 to 24, and the girls are numbered from 25 to 59. The two-digit random numbers in the table are used to select the samples.

07	63	77	20	07	68	94	37	63	22
41	67	03	26	19	24	80	13	71	37
03	28	67	43	11	70	34	49	25	73

Starting at the left and moving along a row, use:

- the first row to select a simple random sample of four children
- the second row to select a simple random sample of two boys and three girls
- the third row to select a systematic sample of six children.

- A population consists of 80 cars. There are 47 electric cars, numbered from 00 to 46 and there are 33 petrol cars numbered from 47 to 79.
The random two-digit numbers in the table are used to select samples from the population.

13	36	81	45	06	27	22	58	34	55	71	20	97	45	77
78	62	18	51	03	99	31	57	29	46	16	92	10	23	56
04	17	82	90	48	37	23	38	48	17	21	89	19	77	84

17 >

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SELF-ASSESSMENT

For most of the questions in Exercise 2A you needed to carry out a calculation, but for some questions you had to give an explanation or an answer in words.

Give yourself a tick for including your working in the calculation questions and a tick for including a reason in the explanation questions. How successful were you at answering these different types of question?

Do you find it easier to do calculations or write explanations?

Can you think of any strategies to help you improve your answers to each type of question?

INVESTIGATION

In the tip for Worked example 2.5, you saw how the number of favourable outcomes or selections can sometimes be used to multiply a probability. This often reduces the amount of working you need to do.

In this activity, you will think about the number of selections of 2 people that can be made from groups of different sizes:

	Group size (n)	Selections of 2 people	How many different selections of 2 people? (s)
A B	2	A and B	1
A B C	3	A and B A and C B and C	3
A B C D	4	A and B B and C A and C B and D A and D C and D	6

Here are the results in a table:

Group size (n)	1	2	3	4	5	6	7	8	9	10	11	12
Number of selections (s)		1	3	6								

32 >

Exercise 3B

- 1 A group of doctors are each asked how many children they have. Their responses are:
2 4 2 0 1 0 0 2 1 3 0 2 5 1 3 1 0 2 1 4 1 0 2 0 3
- Show the data in a frequency distribution table. Use row or column headings 'Number of children (x)' and 'Number of doctors (f)'.
 - Copy and complete the following sentence by writing in two appropriate totals: 'These ____ doctors have ____ children altogether.'
 - Work out how many of these doctors have more than 1, but fewer than 5, children.
- 2 The numbers of students arriving late at a school during each school day in June were:
5 3 4 0 1 2 7 3 3 1 4 3 3 2 4 3 0 5 3 4 2
- Display the data in a frequency distribution table. Use rows or columns with headings 'Number of late arrivals (x)' and 'Number of days (f)'.
 - Add a third row or column, with the heading xf , to your table and insert the eight appropriate values.
 - Include two totals in your table and explain what each of them represents.
 - Find:
 - the most common number of late arrivals
 - the number of days on which there were fewer than 4 late arrivals
 - the number of days on which there were 5 or more late arrivals.
 - Calculate the percentage of days on which there were exactly 3 late arrivals.
 - Albert arrived late in June more frequently than any other student. What is the greatest possible number of days on which Albert arrived late in June?
- 3 The numbers of daily flights from an airfield during a period of 30 days are given in the table.

No. flights	5	6	7	8	9	10	11	12
No. days (f)	2	4	7	9	4	3	0	1
$\Sigma f = 30$								

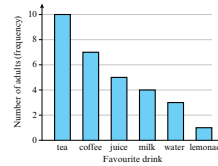
- Write down the most common number of flights per day.
 - Find the number of days on which there were more than 9 flights.
 - Calculate the percentage of days on which there were at most 6 flights.
 - Determine the value of p , given that there was a total of p flights during this 30-day period.
- 4 The following table shows the numbers of members of 40 clubs at a university.

No. members	12	13	14	15	16	17	18
No. clubs (f)	3	5	11	17	2	1	1
$\Sigma f = 40$							

44 >

WORKED EXAMPLE 3.4

Each adult in a group was asked to name their favourite drink. Their responses are displayed in the (vertical) bar chart.



- Work out the number of adults in this group.
- Calculate the percentage of these adults whose favourite drink is neither coffee nor juice.
- Find the probability that the favourite drink of a randomly selected adult is tea or lemonade.

Answers

- Add together the frequencies of all the bars:
 $10 + 7 + 5 + 4 + 3 + 1 = 30$ adults
- The number of adults whose favourite drink is neither coffee nor juice is $30 - (7 + 5) = 18$
As a percentage of the total, this is $\frac{18}{30} \times 100\% = 60\%$
- P(tea or lemonade) = $\frac{\text{number of favourable outcomes}}{\text{total number of outcomes}} = \frac{10 + 1}{30} = \frac{11}{30}$

DISCUSSION

Can you think of a situation where it would be more appropriate and convenient to draw a horizontal bar chart instead of a vertical bar chart?

WORKED EXAMPLE 3.5

Each pupil in a class is asked how many times they checked their emails yesterday. The results are displayed in the bar chart.



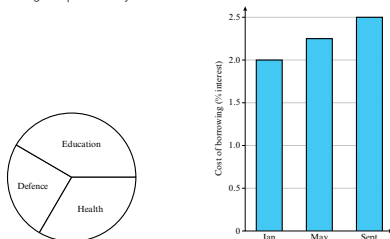
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DISCUSSION

A statistician was asked to produce simple, unbiased diagrams to represent two sets of data to be used in a magazine. The diagrams are to show:

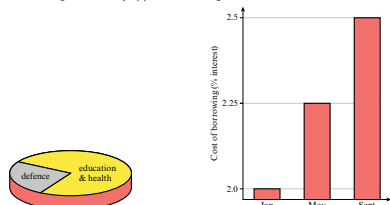
- the proportion of a large budget that the government plans to spend on defence, education and health
- the cost of borrowing (interest rates for bank loans) at three points in the year.

Here are the two diagrams produced by the statistician:



The magazine owner insists that these diagrams must be modified.

Here are the modified diagrams as they appear in the magazine:



Discuss the diagrams with your classmates, noting in particular:

- how they have been modified
- what has been achieved by modifying them
- the possible reasons why the magazine owner decided to modify them.

67 >

CONTINUED

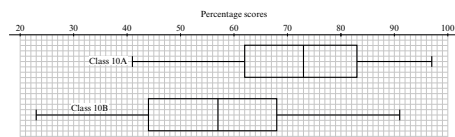
- Give a five-number summary of these two sets of data in a table and also in two box-and-whisker diagrams.
- Write a brief comparison of the two sets of percentage scores.

Answers

- For Class 10A, $N = 27$:
 Q_1 is the $\frac{27+1}{4} = 7$ th value; Q_2 is the $\frac{27+1}{2} = 14$ th value, and Q_3 is the $\frac{3(27+1)}{4} = 21$ st value
So, $Q_1 = 62\%$, $Q_2 = 73\%$ and $Q_3 = 83\%$, which are circled in the diagram.
For Class 10B, $N = 28$:
 Q_1 is the $\frac{28+1}{4} = 7.5$ th value; Q_2 is the $\frac{28+1}{2} = 14.5$ th value, and Q_3 is the $\frac{3 \times 28 + 2}{4} = 21.5$ th value
The 7.5th value is halfway between the 7th and 8th values. This means that Q_1 is halfway between 43 and 45, so $Q_1 = 44\%$. Similarly, $Q_2 = 57\%$ and $Q_3 = 68\%$.
These three values are marked * on the diagram.

Five-number summaries (smallest and largest values and the three quartiles) for the two sets of data are given in the table (which also includes the range and IQR) and in the box-and-whisker diagrams.

	Smallest	Q_1	Q_2	Q_3	Largest	Range	IQR
Class 10A	41	62	73	83	97	$97 - 41 = 56$	$83 - 62 = 21$
Class 10B	23	44	57	68	91	$91 - 23 = 68$	$68 - 44 = 24$



- The higher median for Class 10A suggests that they performed better on average than Class 10B. The smaller range and smaller interquartile range for Class 10A suggest that they performed more consistently than Class 10B because their scores are less dispersed.

200 >

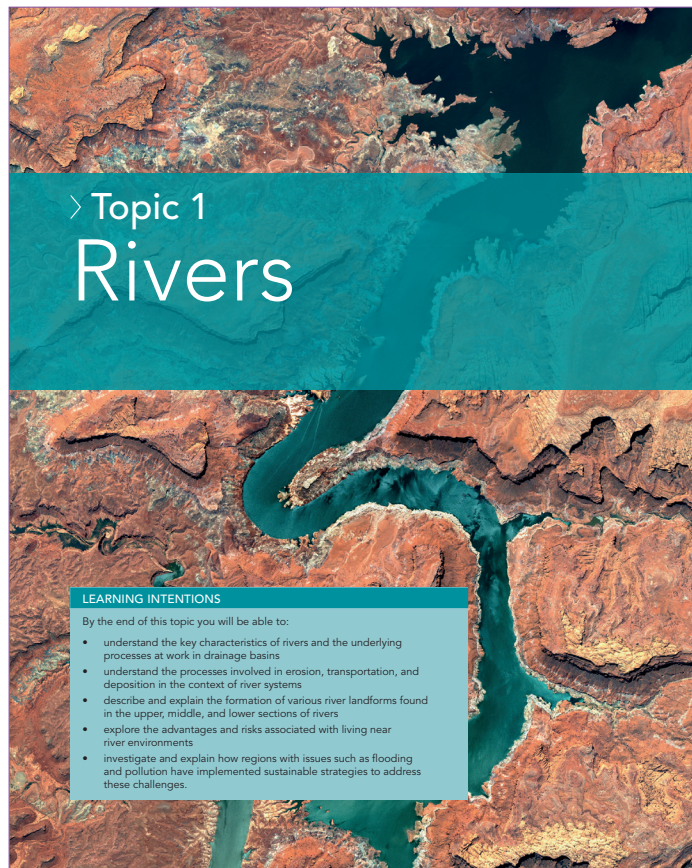
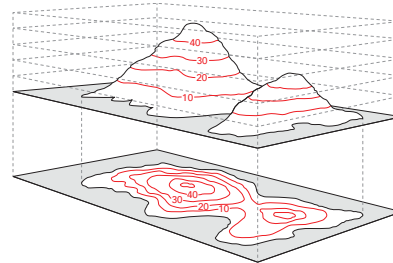
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Figure 0.27: How the spacing and shape of contour lines translate into the shape of a landscape

Drainage density

Drainage of an area refers to features of both rivers and river valleys (Figure 0.28). When you are identifying drainage features, there are a number of features to observe:

- 1 the presence or lack of rivers or lakes
- 2 names of the main rivers or lakes, or any main tributaries
- 3 the density of the drainage, an estimate of how many rivers there are and how close together they are
- 4 the shape of the river valley
- 5 compass directions to state where the river or lake is found
- 6 the direction in which the main river is flowing
- 7 main confluence points (using grid references)
- 8 the length of the river valley
- 9 main river features such as waterfalls (where contour lines are very close together), flood plains, meanders, ox-bow lakes, or braiding
- 10 the shape of the main river
- 11 evidence of human construction or activity (dams, river straightening)
- 12 the number of river valleys feeding into the main river.

22 >

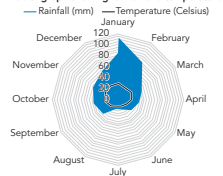
CAMBRIDGE IGCSE™ AND O LEVEL GEOGRAPHY: COURSEBOOK**Radial graph showing rainfall and temperature**

Figure 0.13: A radial graph

Map charts

You can use different types of graphs on maps to give information linked to a location. Map charts (Figure 0.14) allow you to position your data in context. When reading them, take time to determine the location being discussed and then what the information is showing you.

You can use proportional symbols on map charts to represent data. Symbols of varying size represent differing quantity. For example, Figure 0.14 shows energy consumption by country in Europe. The size of the circle represents the energy consumed in relation to other areas on the map. A small circle represents a lower energy consumption than a large circle. The key will indicate what the proportional symbol represents.

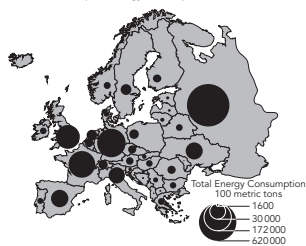
European Energy Consumption 2001

Figure 0.14: A map chart using proportional symbols to show energy consumption by country

12 >

1 Rivers**1.5 Detailed Specific Example:
The Mississippi River, USA**

The Mississippi River in the USA is the largest river in the North American continent. Its drainage basin extends over 31 states, covering around 15% of the land area of North America. The river and surrounding basin are economically important; they are used for agriculture, transportation, and the provision of clean water and energy.



Source 0.1: The Mississippi River basin

The Mississippi River experiences frequent and sometimes devastating floods. This is not a new trend; flooding has always taken place along the Mississippi, and the Great Mississippi Flood of 1927 remains one of the most destructive in the country's history.

TASK 1: Study Source 0.1

Discuss in pairs why the Mississippi's tributaries contribute to flooding downstream.

57 >

PROJECT

Rising sea levels are threatening this Pacific paradise

Good luck finding Tuvalu on a map. The Pacific paradise, located between Australia and Hawaii, is one of the smallest countries in the world. Its nine tiny islands make up just 10 square miles. It's incredibly picturesque. But because of climate change, it's also incredibly fragile. 'The highest point in Tuvalu is only a few metres above sea level, so everybody is aware that if changes happen in the sea, this will immediately affect life there,' said Sean Gallagher, a photographer and filmmaker who visited in March.

Tuvalu already struggles with the rising sea. Between January and March, its seasonal 'king tides' cause severe flooding. It's been that way for decades. 'Water literally seeps up through the ground below,' Gallagher said. 'This could happen in minutes, and I witnessed many communities being suddenly flooded. Even the airport runway was underwater at times. Locals told me that this is an increasing problem, and they worry about it getting worse as sea levels rise.'

The encroaching sea brings with it a host of problems. The country's limited farmland can be poisoned by the salt water. Its groundwater is at risk. And the sea's warming temperature presents a threat to the coral reefs that surround the islands and the fish that live there. 'Climate change is having real-world impacts right now,' Gallagher said. 'It's not a problem for the future. It's a crisis for today.'

Source B: A 2019 CNN news report about the impacts of sea level rise on Tuvalu

Read Source B. Imagine your class are a team of environmental consultants hired by the government of Tuvalu to develop a sustainable management plan to mitigate and adapt to the impacts of climate change.

Your task is to assess the current situation, propose effective strategies, and create a management plan that considers the unique geographical, social, and economic context of Tuvalu. You will then present this as a class. You should conduct your research online and produce a slideshow to present.

The class could split into the following research groups:

Initial assessment

Research and evaluate the current impacts of climate change on Tuvalu, focusing on key indicators such as sea level rise, temperature change, and extreme weather events. Identify vulnerable areas, industries, and communities.

Stakeholder analysis

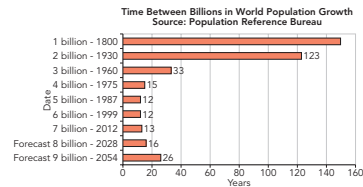
Identify key stakeholders involved in or affected by climate change in Tuvalu. You should include government agencies, local communities, non-governmental organisations (NGOs), and international organisations. Assess their interest in, influence, and potential contributions to the management plan.

Risk assessment

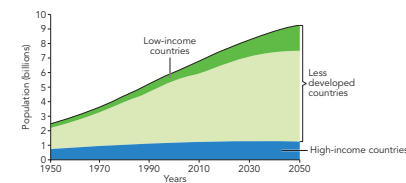
Conduct a comprehensive risk assessment considering both short-term and long-term impacts of climate change on Tuvalu. Rank the risks based on their severity and potential consequences.

Mitigation and adaptation strategies

Research and propose a range of mitigation and adaptation strategies that suit Tuvalu's specific needs. Rank the strategies based on their effectiveness and cost.



Source A: A graph showing the number of years to add an additional one billion people to the world



Source B: Differences in population growth and projected growth in LICs and HICs between 1950 and 2050

TASK 1: Study Sources A & B

- With the help of Sources A and B, briefly **describe the growth** of the human population over time.
- It took all of human history until around 1800 years for the world population to reach one billion. **How many years did it take for the world's population to increase from:**
 - one to two billion?
 - six to seven billion?
- By 2100, there are likely to be over three billion more people living in the world than today. Suggest two problems which this could cause. Explain why you think each of these problems will be difficult to solve.
- The figures for 2100 are an estimate. Explain why it is difficult to predict exact population numbers for the future.

6.4 Causes and impacts of migration

Migration is the movement of people across a specified boundary to establish a new permanent place of residence. Sometimes this happens across a country's borders. This is known as **international migration**. A migrant who has moved out of their country is called an **emigrant**. A migrant who has moved into a country is called an **immigrant**.

There has been significant growth in the numbers of people migrating across international borders in the 21st century. In 2020, according to the United Nations Population Fund, 281 million people, or 3.6% of the world's population, were living outside their country of origin. The impact of migration has affected every country either as a place of origin, a place of transit, or as a destination. These consequences are demographic, economic, social, cultural, environmental, and political.

Causes of migration

The reasons for migration are diverse. People migrate due to various **push and pull factors** (Table 6.5). Push factors are negative factors that encourage or force people to move from a place. Pull factors are the perceived positive factors that encourage people to move to a place.

Voluntary migration occurs when people freely choose to move. For example, to join their family members, to get a better job, or to improve their lifestyle. Globally, most migrants are **economic migrants**, seeking work and social opportunities. They often send money back to their family, known as **migrant remittances**. In 2019, the International Labour Organization estimated that, globally, there were 169 million international migrant workers, making up nearly 5% of the global labour force.

Forced migration occurs when people have no choice but to move. For example, they may be escaping from political conflict (including religious or ethnic persecution) or because of the effects of environmental disasters. A **refugee** is someone who has a well-founded fear of persecution for reasons of race, religion, nationality, political opinion, or membership to a particular social group. They cannot safely return home and are therefore specifically defined and protected in international law. Today, some 52% of all refugees originate from only three countries: Syria, Ukraine, and Afghanistan. Some people leave their country and apply for residence in another country, **seeking asylum** under international law. They are waiting for a decision on their asylum claim in the country they have fled to but haven't yet been legally recognised as a refugee.

KEY TERMS

Forced migration: the involuntary movement of people away from their home usually as a result of conflict or persecution.

Refugee: a person who has fled their home to escape persecution, conflict, violence, serious human rights violations, or other events seriously disturbing public order, and who seek safety in another country.

Asylum seeker: a person who has left their country and is seeking international protection from persecution or human rights violations in another country (but hasn't been legally recognised as a refugee).

KEY TERMS

International migration: the permanent movement of people from one country to another country.

Emigrant: a person who leaves their country of origin to live in another country permanently.

Immigrant: a person who moves to a foreign country to live there permanently.

Push factor: negative factors that encourage or force people to move from a place.

Pull factor: the perceived positive factors that encourage people to move to a place.

Voluntary migration: when someone chooses to move usually for better opportunities.

Economic migrant: a person seeking work in another country.

Remittances: the money or goods that migrants send back to families and friends in origin countries.

Investigating dune vegetation

Investigating changes to vegetation as you move away from the highwater mark can give you insight into how plants colonise dunes and coastal zones. We can use transects and **quadrats** to study the distribution of organisms in an area along a straight line.

Using a transect and quadrats

A transect is a physical line that is used to analyse a change within a habitat. For example, a piece of string placed along the ground. By analysing the habitat along this line, you can observe and record the habitat that occurs at regular intervals along the transect (Figure 11.9). This data can then be recorded on a graph.

Using a transect for investigating dune vegetation, take the following steps to measure changes in vegetation:

- You will need a pen, paper, table to record data, quadrat, and a long tape measure/rope.
- Working at a right angle to the highwater mark, lay out your tape measure/rope.
- Using the quadrat, at predetermined distances (for example, every five or ten metres), count the number of individual plants and the different number of plant species you find in each quadrat (Figure 11.9). Where the plants are too dense to count, you can work out % cover of the plants by estimating how much of the quadrat that plant type covers.
- Record the data for each quadrat, including the distance from the highwater mark each time.
- Analyse the data to determine how vegetation density and diversity changes as you move away from the highwater mark.

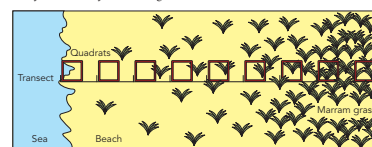


Figure 11.9: A transect running from the highwater mark up the dunes, showing the placement of quadrats along the transect to sample plant diversity and density.

TASK 10

- Design a table** to record the data recorded along a transect 100 metres long, where you are sampling every 10 metres.
- In pairs, discuss how you think vegetation will change as you move away from the highwater mark. Write down two bullet points suggesting how you think it will change.

KEY TERM

Quadrat: square frames of a known size, such as 1m², that geographers place on the ground to measure abundance of plants or organisms in an area.

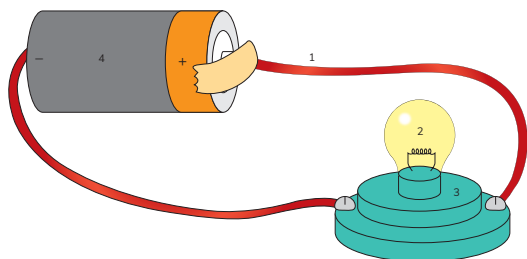
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6 Electricity

> 6.1 Which materials conduct electricity?

We are going to...

- use a fair test to group objects into conductors and insulators of electricity
- identify risks and carry out practical work safely
- make predictions and identify if results support predictions or do not support predictions
- describe simple patterns in results and make a conclusion from results.

**Getting started**

- 1 Name the components of the circuit numbered 1, 2, 3 and 4.
- 2 What is the function of the component 4?
- 3 Why does the lamp light up in this circuit?

conductor insulator

124 >

6 Electricity**Continued****Step 2**

- Check that your circuit works. Hold the wires and clips where they are covered in plastic. Allow the crocodile clips to touch.
- If the lamp lights up, the circuit is complete. If the lamp does not light up there is a break in the circuit. Check that you have connected the wires properly.
- If you separate the crocodile clips, you break the circuit and the lamp goes out. This is your testing equipment. You will use the same testing equipment to see which materials allow electricity to pass through.
- Before you begin, predict which materials will allow electricity to pass through and which will not. Record your predictions in a table like the one below. Place a tick ✓ in the 2nd or 3rd column.

Material	Prediction		Result	
	conductor	insulator	conductor	insulator

Step 3

- Test each material. Hold one crocodile clip at one end of the object. Hold the second crocodile clip at the other end of the object.
- If the lamp does not light up you can try again to make sure.
- Record your results by placing ticks ✓ in the last two columns of your table.

126 >

6 Electricity

> 6.2 Does water conduct electricity?

We are going to...

- investigate if water conducts electricity
- identify and explain risks and carry out practical work safely
- make predictions and identify if results support predictions or do not support predictions
- make a conclusion from results
- identify the risks and carry out practical work safely.

distilled water
pure water**Getting started**

- 1 If we put salt into water and stir it, what happens to the salt?
- 2 How can we test to see if a material conducts electricity or not?

Is water pure?

Water from a river or the tap is not **pure water**. It has salts dissolved in it. **Distilled water** is pure water. Distilled water is water that has

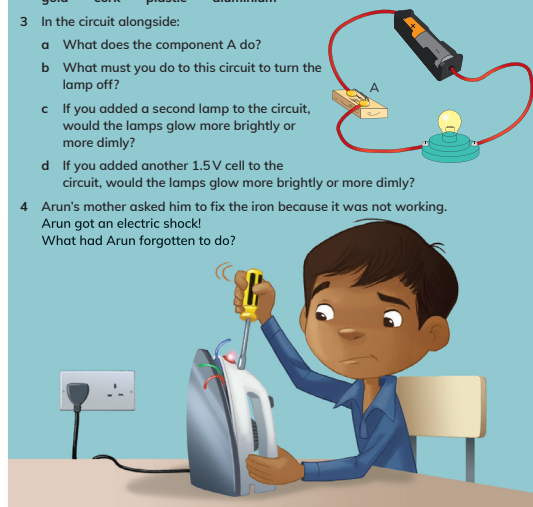
been boiled and the steam has been allowed to cool down to form liquid water again. This water is distilled water and contains no salts. All living things contain water. Our bodies are about 65% water! This water has salts dissolved in it so it is not pure.



128 >

6 Electricity**Check your progress**

- 1 Write one word or two words to describe each of the following:
 - a A device for closing or opening a circuit.
 - b A device in a circuit for holding a lamp in place.
 - c Something that pushes electricity around a circuit.
- 2 Which of the following materials are insulators of electricity?
gold cork plastic aluminium
- 3 In the circuit alongside:
 - a What does the component A do?
 - b What must you do to this circuit to turn the lamp off?
 - c If you added a second lamp to the circuit, would the lamps glow more brightly or more dimly?
 - d If you added another 1.5V cell to the circuit, would the lamps glow more brightly or more dimly?
- 4 Arun's mother asked him to fix the iron because it was not working. Arun got an electric shock! What had Arun forgotten to do?



146 >

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Typesetting and Page Design

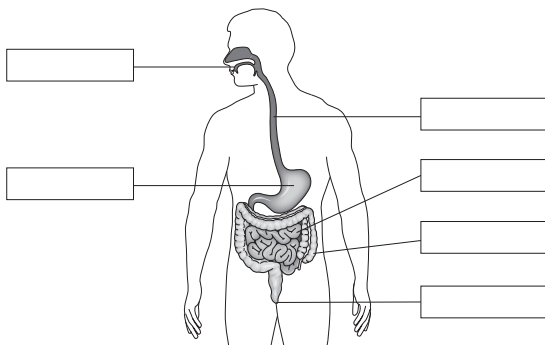
4 The digestive system

> 4.1 Parts and functions of the digestive system

Focus

- 1 Label the diagram of the digestive system. Use these words to help you.

oesophagus small intestine stomach
mouth large intestine anus



51 >

4 The digestive system

- 2 a Match each of the labelled parts in question 1 with its function (A-F) listed in the table. Write the name of the part next to its function.

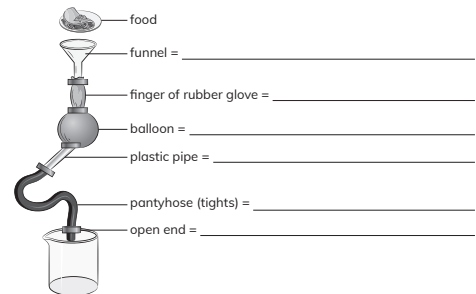
Part	Function
	A Pushes food into the stomach
	B Mixes food with digestive juices
	C Absorbs water and some minerals into the blood
	D Chews food and starts digestion
	E Removes undigested food from the body
	F Breaks food down into very tiny particles

- b The functions in the table are not in the same order as they happen in the body. Write the letters of the functions in the correct order.

_____ → _____ → _____ → _____ → _____ → _____

Practice

Sofia's group made a model of the human digestive system in the picture.



52 >

4.2 Balanced diets

> 4.2 Balanced diets

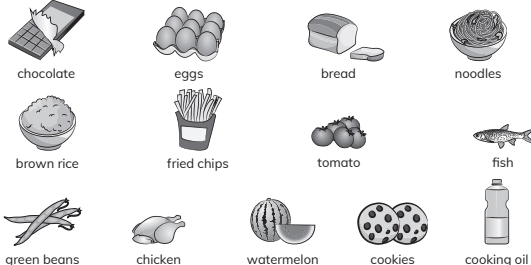
Focus

- 1 Tick (✓) the True or False box for each of these sentences.

- a A balanced diet gives us all the foods we need to grow and be healthy.
- b Proteins build the body.
- c We should eat as much sugar as possible to give us energy.
- d Vegetables and fruits contain vitamins and minerals our bodies need.

True	False
☐	☐
☐	☐
☐	☐
☐	☐

- 2 Look at the pictures of different foods.

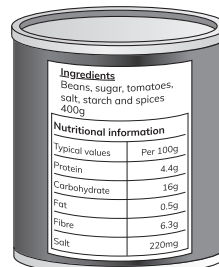


- a Circle the foods that contain carbohydrates in yellow.
- b Circle the foods that contain proteins in red.
- c Circle the foods that are fruits and vegetables in green.

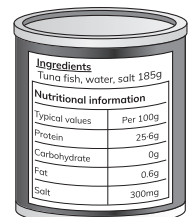
55 >

4 The digestive system

Challenge



Beans with tomato sauce



Tuna in water

- 5 List the different food groups found in the can of beans.

- 6 Explain why you need to eat foods containing proteins.

- 7 Budi ate 100 g of beans.

- a How much protein did he eat?

58 >

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Unit 1

Convincing Arguments

Unit at a Glance

Required Lessons: 15

Optional Lessons: 0

Suggested pacing for each lesson is at least 45 minutes.

Alignments

Addressed
G-CO.9, G-CO.10, G-CO.11, G-GMD.6

Assessed
Check Your Readiness
7.G.2, 8.G.2, 8.G.5, 8.G.7

End-of-Unit Assessment
G-CO.9, G-CO.10, G-CO.11, G-GMD.6

Section Learning Goals

Section A

Determine what information is known and what information is needed to solve a problem involving triangles.

Justify informally and use the Triangle Inequality Theorem.

Section B

Label diagrams in order to write precise conjectures.

Prove theorems about lines and angles.

Section C

Critique others' justifications about quadrilaterals.

Use previously proven theorems to write new proofs about quadrilaterals.

Assessment

Formative Assessments

Lesson Cool-downs

Lesson Practice Problems

Check Your Readiness

Section A Checkpoint

Section B Checkpoint

Section C Checkpoint

Summative Assessments

End-of-Unit Assessment

INTEGRATED MATH 2 • UNIT 1 • UNIT AT A GLANCE

5

Unit 1

Convincing Arguments

Unit Materials

Provide access as needed throughout the unit:

1-inch strips cut from card stock with evenly spaced holes

Copy the two sizes of strips on different colors of card stock so that students can see at a glance whether the two strips being used are congruent or not.

After the strips are cut, punch holes as indicated in each segment.

A standard hole punch makes holes that are a little larger than needed for the metal paper fasteners, causing the cardboard strips to wiggle around. If possible, find a way to punch holes that are slightly smaller than the size of a standard hole punch. A commercial version of these materials is available, sometimes called "geo strips".

Chart paper

Geometry toolkits (HS)

Index cards to use as straightedges, compasses, tracing paper, blank paper, colored pencils, and scissors.

Note: "Tracing paper" is easiest to use when it's a smaller size. Commercially available "patty paper" is 5 inches by 5 inches and ideal for this. If using larger sheets of tracing paper, consider cutting them down for student use.

Graph paper

Internet-enabled device

Markers

Math Community Chart

Metal paper fasteners, brass brads

Protractors

Clear protractors with no holes and with radial lines printed on them are recommended.

Protractors

Rulers

Sticky notes

Lesson	Materials to Gather	Materials to Copy
1	Geometry toolkits (HS): Activity 1, Activity 2, Cool-down	
2	Chart paper: Warm-up	6–12 Blank Math Community Chart (1 copy for every 30 students)
3	Geometry toolkits (HS): Activity 2	
4	Geometry toolkits (HS): Activity 1, Activity 2	
5	Math Community Chart: Warm-up, Cool-down	
6		Quilt Questions Information Gap (1 copy for every 2 students)
7	Math Community Chart: Warm-up, Cool-down	
8	Geometry toolkits (HS): Activity 2	Name That Image Cards (1 copy for every 2 students)
9	Math Community Chart: Lesson, Warm-up, Cool-down	
10	Geometry toolkits (HS): Cool-down	
11	Geometry toolkits (HS): Warm-up	
12		Lots of Lines (Part 1) Handout (1 copy for every 2 students)
13	1-inch strips cut from card stock with evenly spaced holes: Warm-up, Activity 1	Brace Yourself Cutouts (1 copy for each student)
14	Internet-enabled device: Warm-up	

INTEGRATED MATH 2 • UNIT 1 • UNIT MATERIALS

6

Unit 1

Convincing Arguments

Unit Materials

Materials Needed (continued)

Lesson	Materials to Gather	Materials to Copy
15	1-inch strips cut from card stock with evenly spaced holes: Warm-up, Activity 1, Activity 2, Cool-down	Brace Yourself Cutouts (1 copy for each student)

Note on materials

For many activities in this unit, students have access to a geometry toolkit that includes many tools that students can choose from strategically: compass and straightedge, tracing paper, colored pencils, and scissors. In some lessons, students will also need access to a ruler and protractor. When students work with quadrilaterals, instructions for making 1-inch strips cut from cardstock with evenly spaced holes are included. These strips allow students to explore dynamic relationships among sides and diagonals of quadrilaterals. Finally, there are some activities that are best done using dynamic geometry software, and these lessons indicate that digital materials are preferred. Students have the opportunity to choose appropriate tools in nearly every lesson as they select among these options. For this reason, this math practice is highlighted only in lessons where it's particularly noteworthy.

Starting in the first section, a blank reference chart and reference material from a previous course are provided for students, and a completed reference chart is provided for teachers. The reference chart is a resource for students to refer to as they make formal arguments. To model clear communication with mathematical language, point students toward particular entries by describing their content instead of by number. For example, say "definition of 'congruent'" instead of "definition 2." Students will continue adding to the reference chart throughout the course. Refer to the Course Guide for more information.

These materials use words rather than symbolic notation to allow students to focus on the content. By using words, students do not need to translate the meaning of a symbol while reading. To increase exposure to different notations, images with given information marked using ticks, right angle marks, or arrows also have a caption with the symbolic notation. Feel free to use the symbolic notation when recording student responses, as that is an appropriate use of shorthand.

This unit intentionally allows extra time for students to learn new routines and establish norms for the year.

INTEGRATED MATH 2 • UNIT 1 • UNIT MATERIALS

7

10

Unit 1

Check Your Readiness

6 Problems

Assessment

Teacher Instructions

Students will need a protractor. We recommend making available geometry toolkits, graph paper, and scientific calculators.

Problem 1 Addressing 8.G.7

Narrative

The content assessed in this problem is first encountered in Lesson 4: *Big Angles, Long Sides, Small Angles, Short Sides*.

This item tests whether a student remembers how to use Pythagorean Theorem on a right triangle. If most students struggle with this item, review the Pythagorean Theorem during the Activity Synthesis of the activity *Which Three Go Together?: Tri-angles*.

Here is right triangle ABC .

$m\angle ABC = 90^\circ$

Find the length of side BC .

$\sqrt{75}$ (or equivalent)

Problem 2 Addressing 8.G.5

Narrative

The content assessed in this problem is first encountered in Lesson 4: *Big Angles, Long Sides, Small Angles, Short Sides*.

In this unit students will solve for missing angles in a triangle and prove the Triangle Angle Sum Theorem.

If most students struggle with this item, review the Triangle Angle Sum Theorem during the Activity Synthesis of the activity *Which Three Go Together?: Tri-angles*.

Here is triangle ABC .

What is the measure of angle B ?

60°

10 INTEGRATED MATH 2 • UNIT 1 • CHECK YOUR READINESS

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Section A

Contents

- Checkpoint 18
- Lesson 1 What's Up, Triangle? 19
- Lesson 2 A Triangle's Sides 29
- Lesson 3 There's an Inequality Describing Any Triangle's Sides 37
- Lesson 4 Big Angles, Long Sides, Small Angles, Short Sides 47
- Lesson 5 Unknown Angles 60
- Lesson 6 Quilt Questions 72

Inspire Math

Time Travel video

First Optional Viewing: Before Lesson 5, show this video to introduce the content. ilclassroom.com/1/1006900

Please log in to the site before using the QR code or URL.

17 INTEGRATED MATH 2 • UNIT 1 • SECTION A • OVERVIEW

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Section A

Triangles and Proof

Section Goals

- Determine what information is known and what information is needed to solve a problem involving triangles.
- Justify informally and use the Triangle Inequality Theorem.

Section Narrative

In this section, students explore properties of triangles. The first three lessons of this section are purposefully paced to allow class time to learn routines and build math community.

First, students make observations about possible side lengths of a triangle and practice communicating their ideas. Next, students write the Triangle Inequality Theorem as a conjecture, an initial step to the proof writing students will do in this unit. In the following lesson, students write the Triangle Inequality Theorem as an explicit mathematical statement, informally justify their ideas, and practice using the theorem in a problem in which they engage with aspects of mathematical modeling.

In the next three lessons, students explore what happens to sides in a triangle as the angle opposite that side changes. This leads to an understanding that longer sides are across from larger angles and vice versa. Students review angle pairs and triangle properties to solve for unknown angles in figures made up of several triangles and use those angles to make conclusions about the sides of the triangles. Students end the section with an *Information Gap* designed to solidify their understanding of triangle properties and to build their communication skills.

Teacher Reflection Questions

- Math Content and Student Thinking:** This unit reintroduces a lot of mathematical vocabulary. Referring to the reference chart is one way students can build confidence using vocabulary. How else will you continue to support students building their mathematical language?
- Pedagogy:** Which curriculum resources are you using as you plan lessons? In what ways are they helping you use student thinking to drive the learning during the lessons?
- Access and Equity:** What students would benefit from the *Stronger and Clearer Each Time* routine in Lesson 3, Activity 1 *Make It Mathy*?

Alignments

Building On: 7.G.2, 7.G.5, 8.G.Cluster-2, G-CO.8

Addressing: G-GMD.6

Building Towards: A-CED.3, G-CO.9, G-CO.10, G-CO.11, G-GMD.5

Mathematical Practice: MP.1, MP.3, MP.4, MP.5, MP.6, MP.7, MP.8

16 INTEGRATED MATH 2 • UNIT 1 • SECTION A • OVERVIEW

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Lesson 11

Are Those Triangles Congruent?

Goals

- Identify a triangle congruence theorem that proves two triangles are congruent.
- Identify corresponding parts in congruent figures.
- Use the triangle congruence theorems to prove (in writing) figures are congruent.

Learning Targets

- I can identify corresponding parts in congruent figures.
- I can identify the triangle congruence theorem that proves two triangles are congruent.
- I can use the triangle congruence theorems to prove two triangles are congruent.

Lesson Narrative

In this lesson, students review triangle congruence criteria and practice writing proofs that use triangle congruence theorems. Students begin by identifying corresponding parts in a pair of congruent triangles and practice naming the theorem that proves the triangles are congruent. Students continue that practice in the following activity with pairs of triangles that aren't necessarily congruent. Finally, students use triangle congruence theorems to write a proof about two triangles formed by the diagonals of a quadrilateral. The proof can be written using any of the three triangle congruence theorems. Students who complete a proof early will be asked to try the proof using a different congruence theorem, which encourages them to make sense of the problem and persevere in solving it.

Student Learning Goal

Let's identify congruent triangles and corresponding parts.

Access for Students with Diverse Abilities

- Action and Expression (Activity 2)

Access for Multilingual Learners

- MLR8: Discussion Supports (Warm-up)

Instructional Routines

- 5 Practices (Activity 2)

Required Materials

Materials to Gather

- Geometry toolkits (HS) (Warm-up)

Required Preparation

Prepare sentence frames to support discourse. (Activity 2)

Alignments

Building On: G-CO.8

Addressing: G-CO.11

Building Towards: G-CO.10, G-CO.11

Mathematical Practice: MP.1

Lesson Timeline

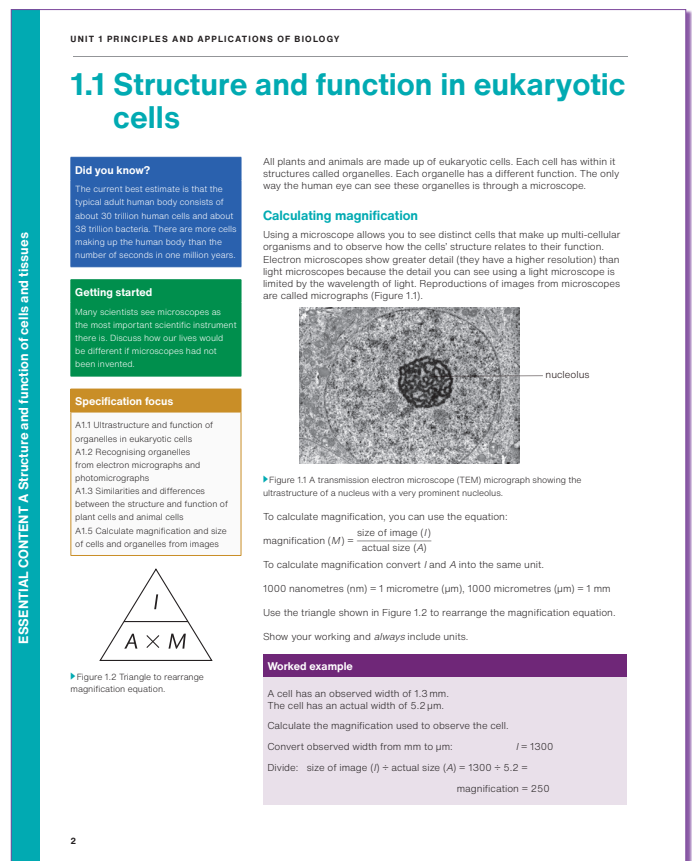
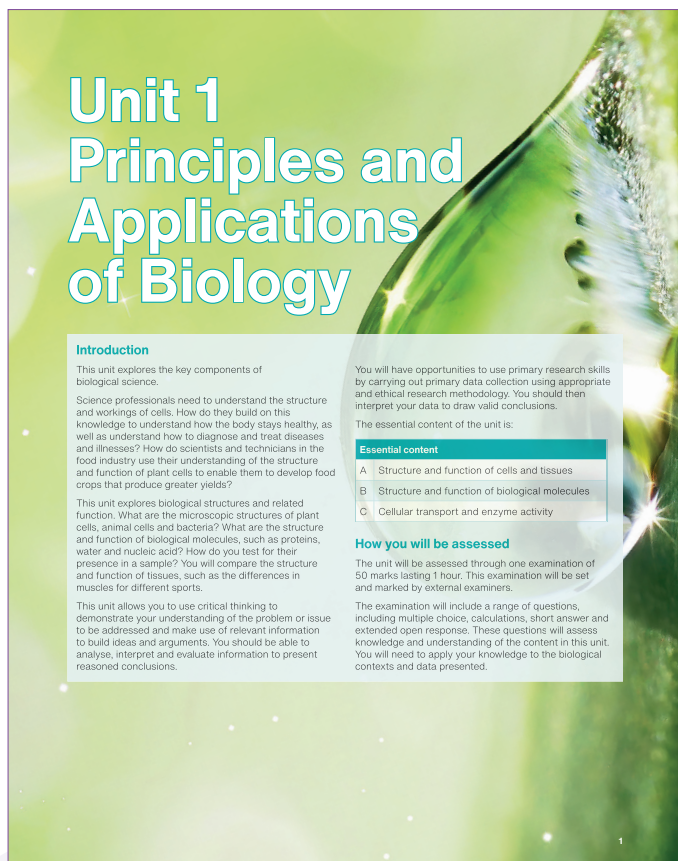
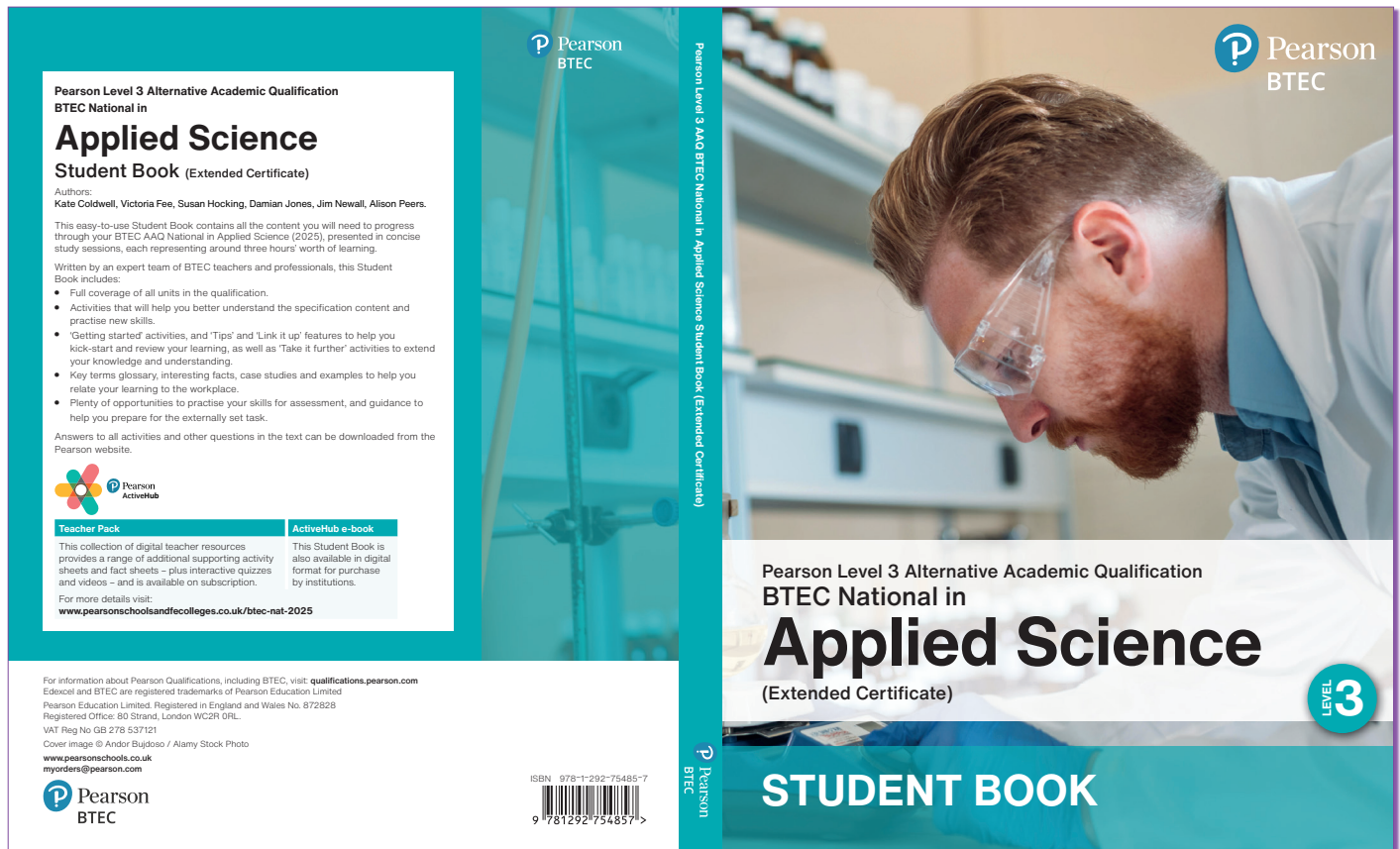
5 min	10 min	20 min	10 min	5 min
Warm-up	Activity 1	Activity 2	Lesson Synthesis	Cool-down

146 INTEGRATED MATH 2 • UNIT 1 • SECTION C • LESSON 11

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1.2 STRUCTURE AND FUNCTION IN PROKARYOTIC CELLS

Table 1.1 Structure and function of prokaryote organelles

Organelle	Structure	Function
Cell wall	Prokaryotic cells are surrounded by a cell wall made of peptidoglycan.	Protects and supports each cell.
Capsule	Slippery layer outside the cell wall of some species of bacteria.	Protects the cell and prevents desiccation.
Ribosomes	Prokaryote ribosomes are smaller than ribosomes found in eukaryotic cells. They consist of two sub-units and they are not surrounded by a membrane.	Protein synthesis occurs at the ribosomes.
Nucleoid	The nucleoid (meaning nucleus-like) is the irregularly shaped region that holds nuclear material without a nuclear membrane and where the genetic material is localised. The DNA forms one circular chromosome.	The nucleoid is the region where genetic information can be found and controls cellular activity.
Plasmid	Small loops of DNA.	Plasmids carry genes that may benefit the survival of the organism.
Cytoplasm	A thick, gelatinous, semi-transparent liquid.	The cytoplasm maintains cell shape and stores chemicals needed by the cell for metabolic reactions.
Plasma membrane	A phospholipid bilayer, with proteins embedded in the layer.	The membrane is selectively permeable and regulates the transport of materials into and out of the cell. Separates cell contents from the outside environment.
Mesosomes	An invagination of the plasma membrane.	Involved in DNA replication and cell division. Involved in the excretion of exoenzymes.
Flagellum	A long, thin part, similar to a tail, made from several proteins.	Helps an organism with movement. Can also act as a sensory organ to detect temperature and pH changes.
Pilus	Thin, rigid fibres made of protein that project out from the cell surface.	Helps with adhesion and attachment to other cells or specific surfaces.

How Gram-positive and Gram-negative bacteria respond differently to antibiotics

Microbiologists need to identify bacteria that cause infections correctly so that they can decide the most effective treatment, such as the correct antibiotic.

Hans Christian Gram, a Danish microbiologist, developed a staining technique to distinguish between two groups of bacteria: Gram-positive and Gram-negative (Figure 1.6).

Each type of bacteria has a different cell wall structure and responds differently to antibiotics. For example, penicillin stops the synthesis of the cell wall on growing Gram-positive bacteria, but it does not have the same effect on Gram-negative bacteria. Gram-negative bacteria have a thinner cell wall and two lipid membranes.

5

UNIT 1 PRINCIPLES AND APPLICATIONS OF BIOLOGY

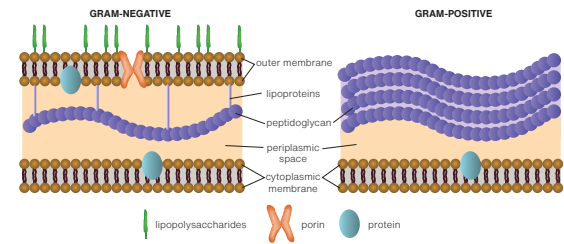


Figure 1.6 Gram-negative and Gram-positive bacteria.

Link it up
See Session 1.11 for more detail about cell membranes.

Take it further
Analyse how the differences between Gram-negative bacteria and Gram-positive bacteria mean that they are treated with different antibiotics.

During the **Gram staining** technique, you add two stains to the bacterial smear: crystal violet and safranin. When you observe a purple smear stain under the microscope, it means that Gram-positive bacteria are present. When the smear has retained the pink safranin stain, then Gram-negative bacteria are present. This is because Gram-negative bacteria have thinner cell walls and lipid membranes that allow ethanol (applied during the method) to wash off all the crystal violet purple stain and to then retain the pink safranin stain.

Activity

Produce a flow diagram of the Gram stain procedure and explain each step.

1.3 Structure and function of specialised cells in organisms

Did you know?

The nucleus of a human cell is only about 6 µm in diameter. The human nucleus contains 46 chromosomes (23 pairs). Each chromosome is tightly packed DNA and if you stretched out the DNA in one cell it would be approximately 2 metres long.

Many organisms are multi-cellular, meaning that they are made from billions of cells. Cells in a multi-cellular organism become specialised for different roles with particular functions.

Getting started

There are some exceptions to the cell theory and this includes viruses. Discuss exceptions to the cell theory.

Specification focus

A2.1 The structure and function of specialised eukaryotic cells

6

UNIT 3 PRINCIPLES AND APPLICATIONS OF PHYSICS

Activity 1

- Use the circuit shown in Figure 3.43 to investigate the relationship between potential difference and current through a resistor. Set the power pack to 12 V. Vary the resistance of the variable resistor and record the current through and potential difference across the resistor.

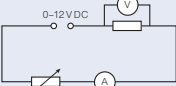


Figure 3.43 Circuit diagram.

- Using a digital tool, plot a graph of current on the vertical axis against potential difference on the horizontal axis. Draw a line of best fit.
- The graph for this activity should be a straight line passing through the origin. If it is, this means that the current and potential difference are directly proportional.

The resistance of the resistor is the reciprocal of the gradient. Work out the gradient and hence the resistance.

- Take the resistor out of the circuit. Use an ohmmeter to measure the resistance of the resistor. Compare it with your calculated value.

Safety tip

Resistors can become hot when potential differences are high, so do not touch the resistor straight after completing the practical. Wait for it to cool down.

Activity 3

Plan and carry out an investigation to show the effect of temperature on the resistance of a thermistor. You can

Activity 2

Investigate how the resistance of a light-dependent resistor varies with the intensity of incident light using the circuit shown in Figure 3.44.

- Measure the current through and the potential difference across the light-dependent resistor for different intensities of light.
- Use the equation $R = \frac{V}{I}$ to work out the resistance. Plot a graph of resistance on the vertical axis against light intensity on the horizontal axis.

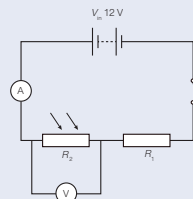


Figure 3.44 Circuit for investigating resistance of a light-dependent resistor.

- Replace the light-dependent resistor with an LED and the resistor with a variable resistor. Investigate how the potential difference and current vary by changing the value of the variable resistor.
- Using a digital tool, plot a graph of current on the vertical axis against potential difference on the horizontal axis.

use digital tools to plot a graph of resistance against temperature, write a conclusion and evaluate your method.

Take it further

Suggest how each of the following could be used in a device:

- thermistor
- LED
- light-dependent resistor
- photodiode.

124

UNIT 3 PRINCIPLES AND APPLICATIONS OF PHYSICS

Electromagnetic spectrum

The parts of the electromagnetic spectrum are shown in Table 3.1 and Figure 3.19. The regions for γ-rays and X-rays usually overlap – the boundary given in the table is approximate. For every frequency of radiation, f , you can calculate a corresponding wavelength in a vacuum, λ , using the speed of light, c in the wave equation, $c = \lambda f$.

Table 3.2 shows uses of some parts of the electromagnetic spectrum.

Table 3.1 Frequencies and wavelength of electromagnetic spectrum

Part of spectrum	Frequency range	Wavelengths
Radio	30 kHz (10^4 Hz) to 3 GHz (10^9 Hz)	10 km to 100 mm
Microwaves	3 to 300 GHz	100 mm to 1 mm
Infrared (IR)	300 GHz to 400 THz (10^{12} Hz)	1 mm to 740 nm (10^{-9} m)
Visible light	400 to 800 THz	740 to 370 nm
Ultraviolet (UV)	800 THz to 30 PHz (10^{16} Hz)	370 to 10 nm
X-rays	30 PHz to about 30 EHz (10^{18} Hz)	0.01 to 10 nm
γ-rays	generally > about 30 EHz	generally < 0.01 nm

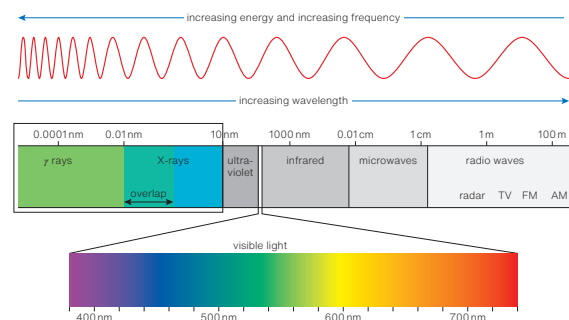


Figure 3.19 The electromagnetic spectrum.

108

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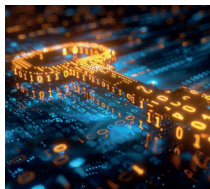
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Book 2 Number 8

1

Number 8

In October 2024, the largest known prime number, $2^{136,279,841} - 1$, was found by prime-hunter Luke Durant on a cloud-based virtual machine. This is only the 52nd Mersenne Prime, a type of prime number that can be expressed as $2^p - 1$, ever discovered, and the first to be discovered by the Great Internet Mersenne Prime Search in nearly 6 years. The number is over 40 million digits long, more than 16 million digits larger than the previous record prime number. A roll of paper 87 km long would be needed to print this number out. Prime numbers this large could prove useful in the future for encryption.



Learning objectives

- Write a number in standard form
- Calculate with numbers in standard form
- Write a number as a **product** of its prime factors
- Find the HCF and LCM of two or more numbers
- Solve problems involving HCF and LCM
- Compare ratios
- Find quantities using ratios
- Solve problems involving **ratio**

Basic principles

- $10^m \times 10^n = 10^{m+n}$, $10^m \div 10^n = 10^{m-n}$, $(10^m)^n = 10^{mn}$

Multiples

- The multiples of 4 are 4, 8, 12, 16, ... i.e. the numbers that 4 divides into exactly.
- When two or more numbers have the same **multiple**, this is called a **common multiple**.

Factors

- The factors of 10 are 1, 2, 5 and 10. These are the only numbers that divide into 10 exactly.
- If two or more numbers have the same **factor**, this is called a **common factor**.

Prime numbers

- Every prime number has exactly two factors: itself and 1.
- 1 is not a prime number as it only has 1 factor (1).
- The prime factors of a number are the factors that are also prime.

Book 2 Number 8

5

For questions 13 to 18, write each number in standard form.

- 13 ► 0.543 14 ► 0.0708
15 ► 0.007 16 ► 0.0009
17 ► 0.67 18 ► 0.000707
- For questions 19 to 22, write each answer as an ordinary number.
- 19 ► $10^{-2} \times 10^4$ 20 ► $10^3 \times 10^{-1}$
21 ► $(3.2 \times 10^{-2}) \times (4 \times 10^3)$ 22 ► $(2.4 \times 10^{-2}) \div (8 \times 10^{-3})$

Exercise 2*

For questions 1 to 6, write each answer as an ordinary number.

- 1 ► $10^1 \times 10^{-2}$ 2 ► $10^{-1} \times 10^{-2}$
3 ► $10^{-2} \times 10^{-3}$ 4 ► $10^{-1} \times 10^{-3}$
5 ► $10^{-3} \times 10^{-4}$ 6 ► $10^{-3} \times 10^{-1}$

For questions 7 to 10, write each number in standard form.

- 7 ► $10 \div 10^{-2}$ 8 ► $10^2 \div 10^{-2}$
9 ► $10^{-1} \div 10^{-2}$ 10 ► $10^{-4} \div 10^{-3}$

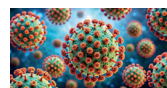
For questions 11 to 18, write each number in standard form.

- H 11 ► $(4 \times 10^2)^{-2}$ H 12 ► $(4 \times 10^{-3})^2$
H 13 ► $(6.9 \times 10^3) \div 10^{-4}$ H 14 ► $10^{-3} \div (2 \times 10^{-2})$
H 15 ► $(5 \times 10^2)^{-2}$ H 16 ► $(5 \times 10^{-3})^2$
H 17 ► $(4.8 \times 10^3) \div 10^{-3}$ H 18 ► $10^{-2} \div (5 \times 10^{-3})$

You will need this information to answer questions 19 to 21.

- Cough virus is 9.144×10^{-6} mm **diameter**.
- Human hair is 5×10^{-2} mm diameter.
- A pin is 6×10^{-1} mm diameter.

- H 19 ► How many viruses, to the nearest thousand, can be placed in a straight line across the width of a human hair?
- H 20 ► How many viruses, to the nearest thousand, can be placed in a straight line across the diameter of a pin?
- H 21 ► The **radius** of the nucleus of a hydrogen atom is 5.3×10^{-15} mm.
How many hydrogen atoms would fit in a straight line across the width of a human hair?



448 Book 2 Exam practice

Exam practice: Shape and Space 10

Question 1

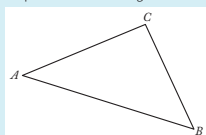
$$p = \begin{pmatrix} 2 \\ -2 \end{pmatrix} \quad q = \begin{pmatrix} 6 \\ 2 \end{pmatrix} \quad r = \begin{pmatrix} -1 \\ 5 \end{pmatrix}$$

$$p + 3r = 2q + s$$

- a Work out s as a column vector. [3]
b Calculate the magnitude of s . Give your answer to 1 d.p. [2]

Question 2

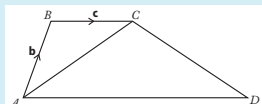
The diagram shows a triangle ABC where A , B and C represent the positions of three villages.



$$\vec{AB} = \begin{pmatrix} 8 \\ -3 \end{pmatrix} \text{ and } \vec{BC} = \begin{pmatrix} -2 \\ 6 \end{pmatrix}$$

Siri travels directly from A to B and then directly from B to C .
Mikael travels directly from A to C .
All distances are in kilometres.
Siri travels p km further than Mikael.
Calculate the value of p to 3 s.f. [4]

Question 3



BC is parallel to AD .

$$AD = 3BC$$

$$\vec{AB} = \mathbf{b}, \vec{BC} = \mathbf{c}$$

- a Find, in terms of $\mathbf{b}$ and $\mathbf{c}$, the vector $\vec{CD}$.
Give your answer in its simplest form. [2]
b A point P lies on AC such that BPD are collinear points.
Find the ratio of $AP:PC$. [2]
c If $\mathbf{b} = \begin{pmatrix} 4 \\ 1 \end{pmatrix}$ and $\mathbf{c} = \begin{pmatrix} 3 \\ 2 \end{pmatrix}$, find $|\vec{CD}|$.
Give your answer as a surd in its simplest form. [2]

464 Book 2 Exam Preparation 2

H Question 3

A , B , C and D are points on the circumference of a circle with centre O .

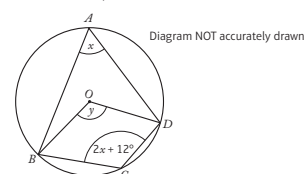


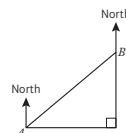
Diagram NOT accurately drawn

Work out the sizes of the angles marked x and y .
Give reasons for all statements you make. [3]

Question 4

Ship A is 40 km west and 50 km south of ship B .

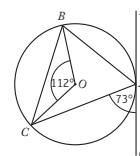
- a The distance between the ships is given by $k\sqrt{41}$.
Find the value of k . [2]
b Calculate the bearing of ship A from ship B .
Give your answer to the nearest degree. [2]



H Question 5

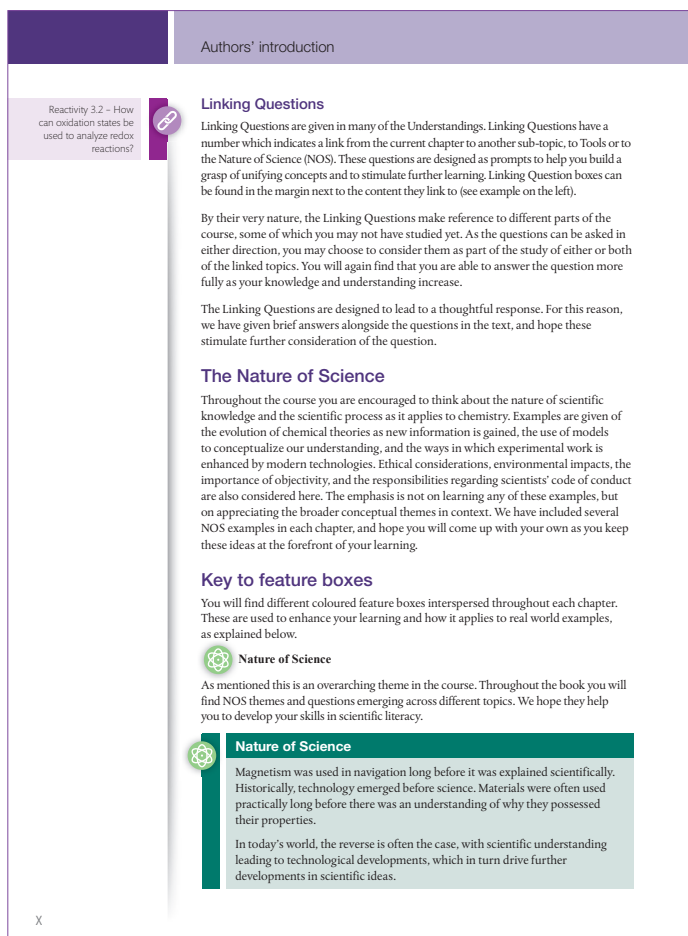
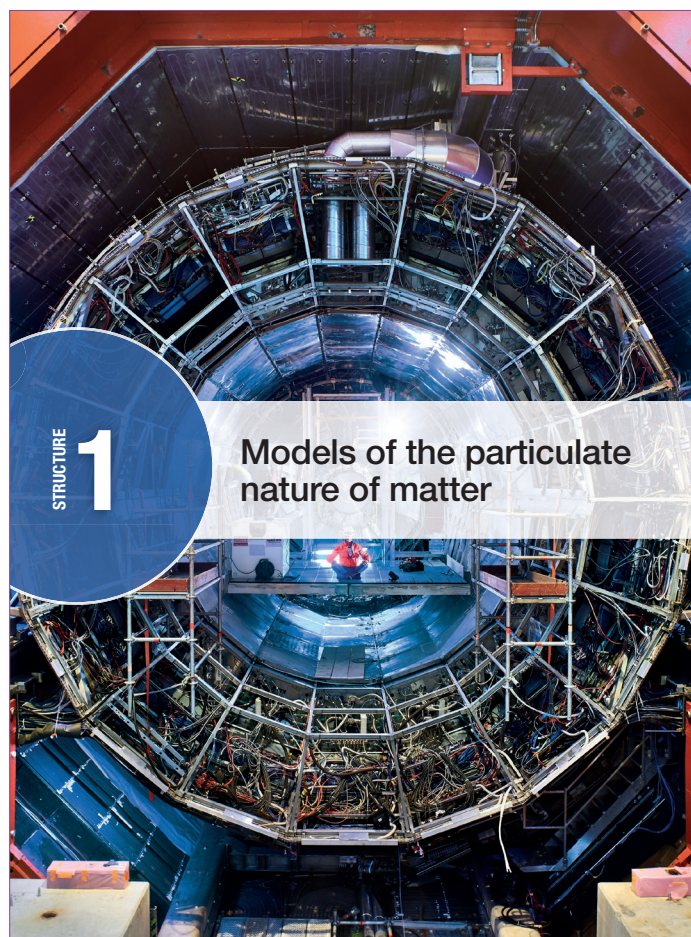
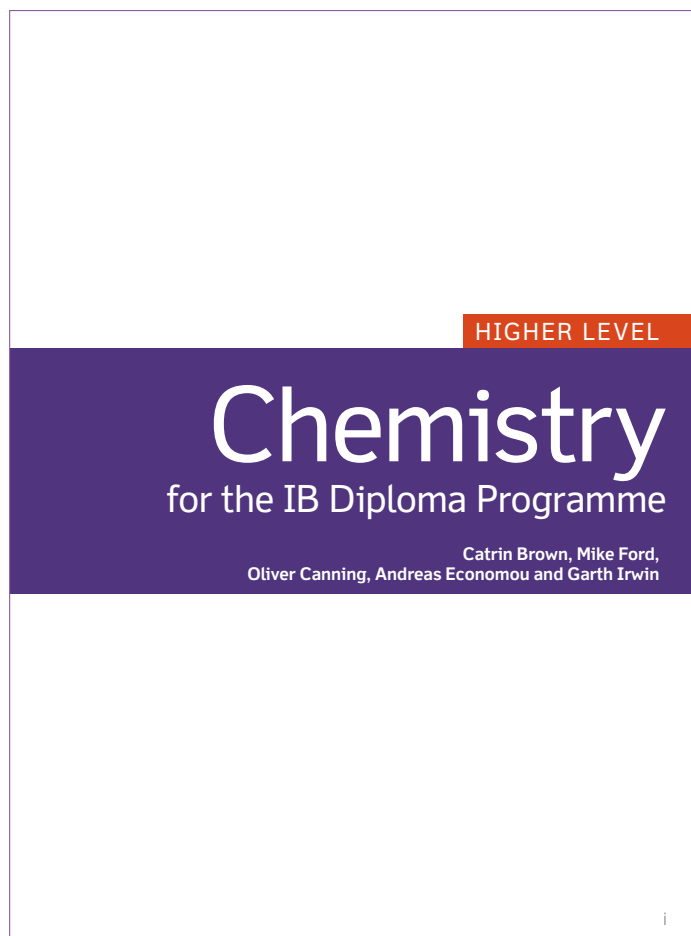
In the diagram, PAQ is the tangent at A to a circle with centre O .

Angle $BOC = 112^\circ$
Angle $CAQ = 73^\circ$
Work out the size of angle OBA .
Show your working, giving reasons for any statements you make. [2]



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Chemistry for the IB Diploma Programme Higher Level
Typesetting and Page Design



Introduction to the particulate nature of matter

also be harmful but for different reasons. These three samples are all made from the same particles: water molecules, H_2O . The difference in physical properties of the three states is explained by **kinetic molecular theory**.

Matter exists in different states as determined by the temperature and the pressure

From our common experience, we know that all matter (elements, compounds, and mixtures) can exist in different forms depending on the temperature and pressure. Liquid water changes into a solid form, such as ice, hail, or snow, as the temperature drops, and it becomes a gas, steam, at higher temperatures. These different forms are known as the **states of matter** and are characterized by the different energies of the particles.

51.1 Figure 2 Representation of the arrangement of the particles of the same substance in the solid, liquid, and gas states.

Solid	Liquid	Gas
• particles closely packed	• particles more spaced	• particles fully spread out
• inter-particle forces strong, particles vibrate in position	• inter-particle forces weaker, particles can slide over each other	• inter-particle forces negligible, particles move freely
• fixed shape	• no fixed shape	• no fixed shape
• fixed volume	• fixed volume	• no fixed volume

This is known as the kinetic molecular theory of matter as the three states are distinguished by the way the particles move. The temperature of the system is directly related to the average kinetic energy of the particles and the state of matter at a given temperature and pressure is determined by the strength of **inter-particle forces** that exist between the particles relative to this average kinetic energy. If the inter-particle forces are sufficiently strong to keep the particles in position at a given temperature and pressure, the substance will be a solid. If not, it will be a liquid or a gas. The different inter-particle forces are explored more fully in Structure 2.

Challenge yourself

3. What evidence based on simple observations can you think of that supports the idea that water is made from discrete particles?

STRUCTURE 1.1

A fourth state of matter, plasma, exists only at conditions of very high temperatures and pressures, such as those commonly found in stars such as our Sun.

Depending on the chemical nature of the substance, matter may exist as atoms such as $Ar(g)$, as molecules such as $H_2O(l)$, or as ions such as Na^+ and Cl^- in aqueous solution $NaCl(aq)$. The term **particle** is therefore used as an inclusive term that is applied in this text to any or all of these entities of matter.

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AS & A Level Maths
Typesetting and Page Design

3 Algorithms on graphs

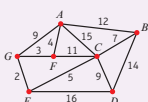
Objectives

After completing this chapter you should be able to:

- Use Kruskal's algorithm to find a minimum spanning tree → pages 53–57
- Use Prim's algorithm on a network to find a minimum spanning tree → pages 57–59
- Apply Prim's algorithm to a distance matrix → pages 60–65
- Use Dijkstra's algorithm to find the shortest path between two vertices in a network → pages 66–73
- Use Floyd's algorithm → pages 73–79

Prior knowledge check

The diagram shows a weighted network.



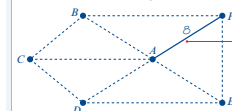
- State the order of vertex C.
- Draw a distance matrix for this network.
- Find a spanning tree with total weight less than 40. State clearly which arcs are included in your spanning tree and its total weight. → Chapter 2

Map apps model roads as arcs on a graph, and add weightings depending on traffic conditions. By finding the shortest path on the graph, the website can compute the quickest route to a destination. → Exercise 3D Q7

52

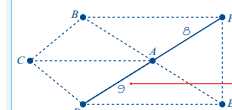
Chapter 3

Choose to start the tree at *A*.
Add the arc of least weight, *AF*, to the tree.



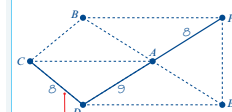
The arcs to consider are those linking *A* to another vertex: *AF*(8), *AB*(9), *AD*(9), *AE*(11) and *AC*(12). Add the one of least weight, *AF*, to the tree.

Add *AD* to the tree.



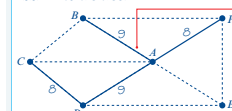
Now consider arcs that link either *A* or *F* to a vertex not in the tree: *AB*(9), *AD*(9), *AE*(11), *AC*(12), *FE*(12) and *FB*(15).

Add *DC* to the tree.



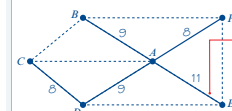
Add the arc of least weight, from *A* or *F*, that introduces a new vertex to the tree. In this case there are two arcs of least weight, *AD* and *AB*. You can choose either. In this case, *AD* is chosen.

Add *AB* to the tree.



The arcs linking *A*, *F*, *D* and *C* to the remaining vertices (*B* and *E*) are *AB*(9), *AE*(11), *FE*(12), *FB*(15), *DE*(14), *CB*(10). The one of least weight is *AB*.

Add *AE* to the tree.



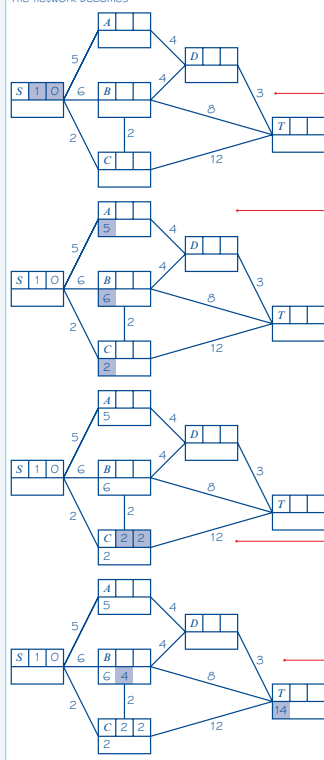
The arcs linking *A*, *F*, *D*, *C* and *B* to the remaining vertex, *E*, are *AE*(11), *FE*(12), *DE*(14). The one of least weight is *AE*.

Hint Notice that with Prim's algorithm the tree always grows in a connected fashion. The arcs do not jump around as they sometimes do in Kruskal's algorithm.

58

Algorithms on graphs

The network becomes



Give vertex *S* a final label of 0. Indicate that this is the first vertex to receive its final label by completing the top boxes at *S* like this:

$\begin{bmatrix} S & 1 & 0 \end{bmatrix}$

Give working values to *A*, *B* and *C* since they are **directly** connected to *S*.

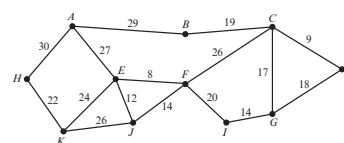
Look at the working values at *A*, *B* and *C*. The smallest is 2 (at *C*). This will become the next final label. *C* is now completed. It is the 2nd vertex to be completed.

Add working values to each vertex that is directly connected to *C*. Note that the algorithm has picked up the short cut to *B*. $S \rightarrow B$ has weight 6, but $S \rightarrow C \rightarrow B$ has total weight 4.

67

Algorithms on graphs

E/P 5



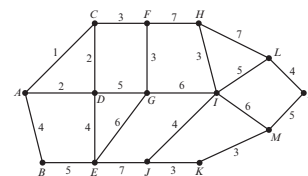
The diagram above shows a weighted network. The weights of each arc are given in the following table:

<i>AB</i>	<i>AE</i>	<i>AH</i>	<i>BC</i>	<i>CD</i>	<i>CF</i>	<i>CG</i>	<i>DG</i>	<i>EF</i>	<i>EJ</i>	<i>EK</i>	<i>FI</i>	<i>FJ</i>	<i>GI</i>	<i>HK</i>	<i>JK</i>
29	27	30	19	9	26	17	18	8	12	24	20	14	14	22	26

- Use a quick sort to write these arcs in order of weight, smallest first. (4 marks)
 - Use Kruskal's algorithm to find a minimum spanning tree for this network. (3 marks)
 - Draw your minimum spanning tree and state its total weight. (2 marks)
- For any connected network,
 e = number of edges in the minimum spanning tree
 v = number of vertices in the network.
- Write down the relationship between e and v . (2 marks)

E/P 6

A company is to install power lines to buildings on a large industrial estate. The lines are to be laid by the side of the roads on the estate. The estate is shown here as a network. The buildings are designated *A*, *B*, *C*, ..., *N* and the distances between them are given in hundreds of metres. The manager wants to minimise the total length of power line to be used.



- Use Kruskal's algorithm to obtain a minimum spanning tree for the network and hence determine the minimum length of power line needed. (4 marks)
- Owing to a change of circumstances, the company modifies its plans for the estate. The result is that the road from *F* to *G* now has a length of 700 metres.
- Determine the new minimum total length of power line. (3 marks)

81

Answers

Answers

CHAPTER 1

Prior knowledge check

- 1 a $5\sqrt{2}$ b $6\sqrt{3}$ c $6\sqrt{5}$
 2 a 0 b 2 c 1
 3 $4 \pm \sqrt{10}$
 4 $28 \pm 7\sqrt{3}$
 13 13

Exercise 1A

- 1 a 3i b 7i c 11i d 100i
 e 15i f $i/\sqrt{5}$ g $2i/\sqrt{3}$ h $3i/\sqrt{5}$
 i $10i/2$ j $7i/\sqrt{3}$
 2 a $13 + 11i$ b $5 + 2i$ c $4 + i$ d $3 + 2i$
 e $9 + 9i$ f $7 - 4i$ g $4 + 2i$ h $2/2 + 2i$
 i $11 - 5i$ j 0
 3 a $14 + 4i$ b $24 - 12i$ c $12 + 5i$ d $24 + 7i$
 e $3 - 2i$ f $3 + 5i$ g $3 + \frac{3}{2}i$ h $-\frac{1}{2} + \frac{3}{2}i$
 4 a $2/2 - i/2$ b $[-1 + \sqrt{3}] + [3 - 3\sqrt{3}]i$
 5 a $-12i$ b 14
 6 a $-10, b = 11$
 7 a $-3 + 4i$ b $28 - 12i$ c $43 - 13i$
 8 a $z + w = (a + bi) + (a - bi) = 2a$
 b $z - w = (a + bi) - (a - bi) = 2bi$

Exercise 1B

- 1 a $z = 2 + 11i$ b $z = 2i/\sqrt{10}$ c $z = 2i/\sqrt{15}$
 d $z = 2i/\sqrt{7}$ e $z = 2i/\sqrt{6}$ f $z = 2i/\sqrt{3}$
 2 a $z = 3 + i/\sqrt{7}$ b $z = 7 + 2i/\sqrt{3}$ c $z = -1 + \frac{3}{2}i$
 3 a $z = -1 + 2i$ b $z = 1 + 3i$ c $z = -2 + 5i$
 d $z = -5 + i$ e $z = -\frac{5}{2} + \frac{5i}{3}$ f $z = -\frac{3 + i/\sqrt{11}}{2}$
 4 a $z = -\frac{5}{4} + \frac{\sqrt{7}}{4}i$ b $z = \frac{11}{14} + \frac{5\sqrt{3}}{14}i$ c $z = \frac{1}{10} + \frac{\sqrt{59}}{10}i$
 5 $z_1 = 4 + \sqrt{5}i$ and $z_2 = 4 - \sqrt{5}i$
 6 $-44 < k < 44$ or $-2/\sqrt{11} < b < 2/\sqrt{11}$

Exercise 1C

- 1 a 11 + 23i b 36 + 33i c 15 + 23i d 2 - 110i
 e $-5 - 25i$ f 39 + 80i g $-77 - 36i$ h 10i
 i $54 - 62i$ j $-46 + 9i$
 2 a 41 b 53 c They are both real
 d $(a + bi)(a - bi) = a^2 + b^2$, which is real.
 3 a $z = 7, b = -6$ or $a = 18, b = -3$
 4 a -1 b 81 c 2i d -60i
 5 $-8i, a = 0, b = -8$
 6 $-119 - 120i$, so real part is -119
 7 a -2i
 8 Substitute $z = 1 - 4i$ into $f(z)$ to get $f(z) = 0$.
 9 a $i^3 = -i, i^4 = 1$ b $i^3 = i, i^4 = -1, i^5 = -i, i^6 = 1$
 c i 1 ii i iii i

Challenge

- a $(a + bi)^2 = a^2 - b^2 + 2abi$
 b $a^2 - b^2 = 40, 2ab = -42 \Rightarrow a = -21$
 $b^4 + 40b^2 - 441 = 0 \Rightarrow (b^2 - 9)(b^2 + 49) = 0$
 $b = -3$ ($b = 0 \Rightarrow a = 7, b^2 + 49 = 7^2 + 3^2 = 49 + 9 = 58 \neq 0$)

Exercise 1D

- 1 a $8 - 2i$ b $6 + 5i$ c $\frac{2}{3} + \frac{1}{3}i$ d $\sqrt{5} - i/\sqrt{10}$
 2 a $z + z^* = 12, zz^* = 45$ b $z + z^* = 20, zz^* = 125$
 c $z + z^* = \frac{3}{2}, zz^* = \frac{5}{8}$ d $z + z^* = 2/\sqrt{5}, zz^* = 50$
 3 a $-\frac{6}{5} - \frac{7}{5}i$ b $-\frac{11}{20} + \frac{23i}{20}$ c $\frac{3}{2} + \frac{43i}{2}$ d $\frac{16}{17} - \frac{17i}{17}$

- 4 $\frac{31}{2} - \frac{17}{2}i$
 5 a $\frac{5}{2} + \frac{3}{2}i$ b $\frac{7}{2} + \frac{1}{2}i$ c $\frac{41}{2} - \frac{3}{2}i$
 6 $\frac{3}{2} + \frac{5}{2}i$
 7 $6 + 8i$
 8 $8 - \sqrt{21} \times \frac{8 + \sqrt{21}}{8 + \sqrt{21}} = \frac{32 + 4i\sqrt{2}}{66} = \frac{16}{33} + \frac{2\sqrt{2}}{33}i$
 9 $\frac{1}{1 - 9i} \times \frac{1 + 9i}{1 + 9i} = \frac{9}{82}i$
 10 $\frac{z + 4}{z - 3} = \frac{8 - i/2(1 + i/2)}{(1 - i/2)(1 + i/2)} = \frac{10}{3} + \frac{7\sqrt{2}}{3}i$
 11 $z - 2i = \frac{16 - 4i(4 - 2i)}{(4 + 2i)(4 - 2i)} = \frac{16 - 28i}{20}$
 $z - 2i = \frac{4}{5} - \frac{7}{5}i \Rightarrow z = \frac{4}{5} + \frac{3}{5}i$
 12 $\frac{p - 7i(2 - 5i)}{(2 + 5i)(2 - 5i)} = \frac{2p - 35 - 5p - 14i}{29}$
 13 $\frac{z + \sqrt{5} + 4i}{z + \sqrt{5} + 4i} \times \frac{\sqrt{5} + 4i}{\sqrt{5} + 4i} = \frac{11 + 8\sqrt{5}i}{21 + 21i}$
 14 a $\frac{p + 5i}{p - 2i} \times \frac{p + 2i}{p + 2i} = \frac{p^2 - 10 + 7pi}{p^2 + 4}$
 $\frac{2p^2 - 20}{p^2 + 4} = \frac{p^2 + 4}{2}$
 $2p^2 - 20 = p^2 + 4 \Rightarrow p^2 = 24 \Rightarrow p = 2\sqrt{6}$
 b $\frac{1}{2} + \frac{10i}{2}$

Exercise 1E

- 1 a $-1 + 5i, -1 - 5i$ b -2 c 26
 2 a $4 + 3i, 4 - 3i$ b 8 c 25
 3 a $2 - 3i$ b $z^2 - 4z + 13 = 0$
 4 a $5 + i$
 b $(z - (5 - i))(z - (5 + i)) = 0$
 $z^2 - (5 + i)(z - (5 - i)) - (5 - i)(z - (5 + i)) = 0$
 $z^2 - 10z + 26 = 0 \Rightarrow p = -10, q = 26$
 5 $z^2 + 10z + 41 = 0$
 6 $z^2 - 2z + 5 = 0$
 7 $z^2 - 6z + 34 = 0$
 8 a $z = \frac{3}{2} + \frac{1}{2}i$
 b $(z - (\frac{3}{2} + \frac{1}{2}i))(z - (\frac{3}{2} - \frac{1}{2}i)) = 0$
 $z^2 - z(\frac{3}{2} + \frac{1}{2}i + \frac{3}{2} - \frac{1}{2}i) + (\frac{3}{2} - \frac{1}{2}i)(\frac{3}{2} + \frac{1}{2}i) = 0$
 $z^2 - 3z + \frac{5}{2} = 0$ so $p = -3, q = \frac{5}{2}$
 9 $(z - (5 + qi))(z - (5 - qi)) = z^2 - 10z + 25 + q^2 = 0$
 $\Rightarrow 4p = 10 \Rightarrow p = \frac{5}{2} \Rightarrow 25 + q^2 = 34 \Rightarrow q = 3$

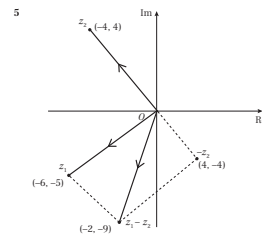
Exercise 1F

- 1 a $12i = 8 - 24 + 4i - 26 = 0$
 b $z = 2, z = 2 + 3i$ or $z = 2 - 3i$
 2 a Substitute $z = \frac{1}{2}$ into $f(z)$.
 b $b = 3, c = 6$
 c $z = i$, or $z = -\frac{3}{2} + \frac{\sqrt{15}}{2}i$
 3 $\frac{1}{2}, \frac{3}{2}, \frac{5}{2}$ and $-\frac{1}{2}$
 4 a $(z - (-4 + i))(z - (-4 - i)) = z^2 + 8z + 16 + 1 = z^2 + 8z + 17$
 b $z = 4, z = -4 + i$ or $z = -4 - i$
 5 a $z = 8, b = 25$ b $-1, -4 + 3i, -4 - 3i$ c -9
 6 a $3 - i$ b $c = 46, d = -60$
 7 $\frac{1}{2}, -\frac{1}{2}, \frac{\sqrt{3}}{2}$ and $-\frac{\sqrt{3}}{2}$
 8 a $k = -40$ b $2 - 4i, 2 + 4i$
 9 $2, -2, 2i$ and $-2i$

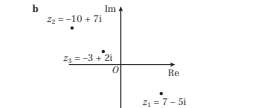
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Answers

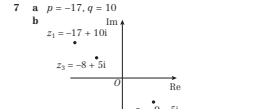
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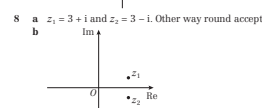
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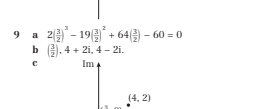
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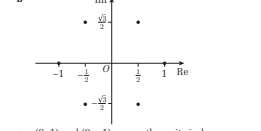


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Challenge

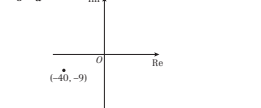
- a $1, -1, \frac{1}{2} + \frac{\sqrt{3}}{2}i, \frac{1}{2} - \frac{\sqrt{3}}{2}i, \frac{\sqrt{3}}{2} + \frac{1}{2}i$ and $\frac{\sqrt{3}}{2} - \frac{1}{2}i$



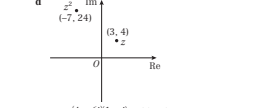
- c $(0, 1)$ and $(0, -1)$ are on the unit circle.
 $(-\frac{1}{2})^2 + (\frac{\sqrt{3}}{2})^2 = 1$, so other 4 points also lie on the unit circle.

Exercise 2B

- 1 a Modulus = 13, argument = 0.39
 b Modulus = 2, argument = $\frac{\pi}{6}$
 c Modulus = $3/5$, argument = 2.03
 d Modulus = $2\sqrt{2}$, argument = $-\frac{\pi}{4}$
 e Modulus = $\sqrt{13}$, argument = -2.42
 f Modulus = $\sqrt{13}$, argument = -1.92
 g Modulus = 17, argument = -2.06
 h Modulus = 17, argument = -2.06
 2 a $i/\sqrt{2} = 2/2$ ii $\frac{\pi}{4}$
 b $i/\sqrt{50} = 5/2$ ii $\frac{\pi}{4}$
 c $i/\sqrt{72} = 6/2$ ii $\frac{3\pi}{4}$
 d $i/\sqrt{2a^2} = a/\sqrt{2}$ ii $\frac{3\pi}{4}$
 3 a $i/\sqrt{2a^2} = a/\sqrt{2}$ ii $\frac{3\pi}{4}$



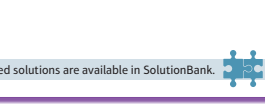
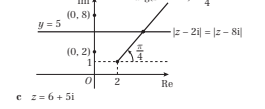
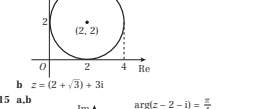
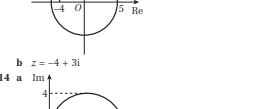
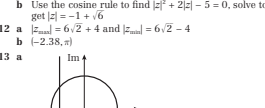
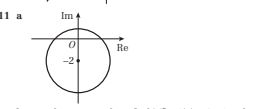
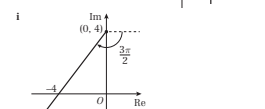
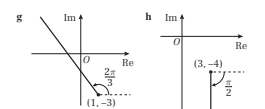
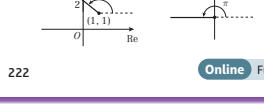
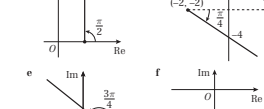
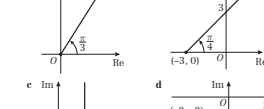
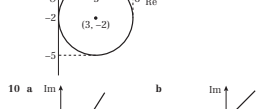
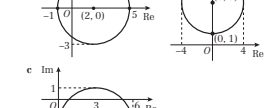
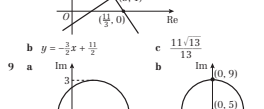
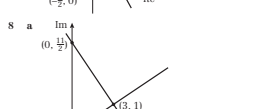
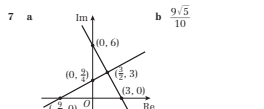
- 4 a $z^2 = 3 + 4i$ b $z^2 = 9 + 16i$ c $z^2 = -7 + 24i$
 b 25 c 1.85
 d $z^2 = (-7, 24)$



- 5 a $z_1 = \frac{4 + 6i(1 - i)}{2} = \frac{10 + 2i}{2} = 5 + i$
 b $\frac{26}{2} = 13$ c 0.20
 6 a $\frac{3 - 2p}{2} + \frac{3 + 2p}{2}i$ b $p = 1$
 c $\frac{26}{2} = 13$
 d Argand diagram showing $z_1 = 3 + i, z_2 = \frac{1}{2} + \frac{3}{2}i$ and $\frac{z_1}{z_2} = 1 - i$

219

Answers



222

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Answers

- 7 a $\frac{9\sqrt{5}}{10}$
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248

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MODULE 4

4 EMPLOYMENT

LEARNING OBJECTIVES

- Talk about places of work and jobs
- Use *should*, *must* and *have to* for giving advice
- Make suggestions and offers

SPRINGBOARD 1

JOBS AND PLACES OF WORK; DESCRIBING JOBS

Exercise 1 Circle the odd one out. Then match the word groups (1–5) to the definitions (A–E).

- farmer chef waiter server waitress
- pilot flight attendant bus driver dentist
- doctor nurse mechanic ambulance driver
- secretary office worker actor receptionist manager
- shop assistant manager cleaner artist

- A We work in a hospital.
B We work in a shopping centre.
C We work in a restaurant or in a café.
D We work in the transport industry, on a plane or on a bus.
E We work in an office.

Exercise 2 Look at the expressions in italics in Exercise 1. What do they have in common? Name at least three more places of work.

Exercise 3 Complete the table with jobs from Exercise 1. Then add your own ideas.

-er	
-or	
-ist	
-ant	
other	

Exercise 4 Play *Guess My Job* in pairs. Use the expressions in the box and the jobs from Exercises 1–3 to help you.

build houses
help sick people
look after people's teeth
paint pictures
repair machines
wear a uniform
work inside / outside
work / teach in a school / classroom
work in a theatre
work with machines
work with your hands

- I work with my hands.
- Are you a farmer?
- No, I don't work outside. I work inside. I help sick people.
- Do you work in a hospital?
- Yes, I do.
- Are you a doctor?
- Yes, I am!



74 seventy-four

Exercise 5

Complete the table with jobs from Exercises 1–3. Then write sentences to explain your answers.

Interesting	Boring	Fun	Difficult	Easy

Exercise 6

Complete the dialogues with the words in the boxes. Sometimes, more than one answer is possible. Listen and check. Then practise in pairs.

must mustn't should shouldn't

Darius: I want to be a doctor.
Lara: A doctor? That's hard! You ¹ study more and you ² play video games all the time!
Darius: That's true! I ³ spend so much time on the computer. I ⁴ work harder in science classes.



have to mustn't should should

Sita: I'd like to be an artist. What ⁵ I do?
Arjun: You ⁶ practise a lot! You don't paint enough.
Sita: You're right. I ⁷ forget to do that!
Arjun: I know, you ⁸ try to draw or paint every day.
Sita: Good idea!

Exercise 7

Write advice for these people. Use *should*, *must* or *have to*.

- I want to be a chef.
- I'd like to be a teacher.
- I want to be an actor.
- I want to be a police officer.
- I'd like to be a business manager.

Exercise 8

Work in pairs. Give a suggestion or make an offer for each situation using *shall*.

- 'My bag is very heavy.'
- 'I don't understand my homework.'
- 'We can't find our hotel.'
- 'I don't know what time the train leaves.'
- 'I'm really hungry!'

should, must and have to for advice

Use *should/shouldn't* to give advice:
You *should* ask the teacher how to do the exercise.
You *shouldn't* do that, it's not a good idea.
Use *must/mustn't* and *have to* to give strong advice.
This is often advice we give ourselves:
I *mustn't* forget to buy a present for my mum!
You *must* take your dog for a walk every day.
You *have to* study for the test.

We usually ask for advice with *should*:
I've got a problem. What *should* I do?

shall for suggestions and offers

Use *shall* to make suggestions or to offer something:
Shall we phone the manager?
Shall I help you with that?
Only use *shall* with I and we. Use it in the question form.

seventy-five 75

1 THE WORLD OF WORK

LEARNING OBJECTIVES

- Talk about volunteering and part-time jobs
- Use the past perfect continuous
- Understand purpose and function when listening

PART-TIME AND VOLUNTARY WORK

Exercise 1 Work in groups. Discuss the questions.

1 Match the photos in Exercise 2 with these jobs:

pet-sitter video game tester conservation volunteer

2 What do you think people do in these jobs?
3 Which personality characteristics do you need for each job?

confident curious enthusiastic flexible hard-working
open-minded organised patient reliable responsible sensible

enthusiastic = feeling or showing a lot of interest and excitement
hard-working = working with a lot of effort
open-minded = willing to consider and accept other people's ideas and opinions

Exercise 2 Read the text and choose the correct answers.

TEENS HAVE THEIR SAY Volunteering and part-time jobs
Someday, you'll have to earn your living, but for most teenagers, that's all in the future. So what can you do now to earn money or improve your skills? You don't have to babysit, be a server or work as a shop assistant. There are some amazing options out there! Three young people tell us about their experiences of work.

1 I'm a volunteer at the Canal and River Trust. I'd been thinking about volunteering for a while when I heard about the organisation and knew it'd be perfect for me. We do conservation work near rivers and canals, including picking up litter and removing rubbish from the water. It's manual work, but I don't mind because I love the fact that it means that others can enjoy these spaces. Voluntary jobs are unpaid, but I think I've learned some useful skills to help me find a job in the future. I'm definitely more confident and organised!
Kieran, aged 17

2 I was unemployed, but I've recently started my own business. I've been looking after people's pets during the holidays since I was 12 and decided to do it professionally. I offer several different services: I walk and feed dogs while their owners are at work or away, and I also pet-sit. That involves staying at someone's house while they're on holiday and looking after their pets. You have to be responsible, hard-working, and, above all, reliable.
Sam, aged 19

3 I suppose I've got my dream job: I'm a video game tester! It's hard work, despite what people think. I test games to find problems, so I often end up playing the same part of a game again and again. That can be stressful, and it isn't always easy to stay enthusiastic. I'd been playing video games for years before I got the job, but I know other testers who are less experienced. It can get a bit technical because you need good computer skills. You also need to be familiar with the latest video games and devices, but it's quite well paid. You can earn USD 325–35 an hour.
Lily, aged 16

EXAM SKILLS

Answers often use a word or phrase from the text as a 'distractor' (incorrect answer). Can you find an example of this in Exercise 2?

- Kieran...
A got the job soon after deciding to volunteer.
B doesn't enjoy working with his hands.
C feels he has benefitted from his job.
- Sara...
A sometimes lives at pet-owners' houses.
B had wanted to be a pet-sitter when she was a child.
C only looks after pets whose owners are on holiday.
- In her job, Lily...
A finds it almost impossible to stay enthusiastic.
B has to play the most stressful parts of video games.
C has to think of ideas for new video games.
- Lily is... the pay rate for game testing.
A disappointed with
B content with
C amazed by

earn your living = earn enough money to pay for everything you need
conservation = the protection of animals, plants and places in nature
be familiar with = know something very well

78 seventy-eight

MODULE 4

Exercise 3

Imagine you have got your dream job. Read the questions and think about your answers. Then work in pairs and interview your partner.

- What is your job? Why? How did you get it?
 - What does the job involve? What do you like or dislike about it?
 - What personality characteristics do you need for it?
 - What had you been doing before you got the job?
- My job is... I really like it!
● How did you get it?
● I'd been volunteering at... for a while when...

Past perfect continuous

Page 219

Use the past perfect continuous to talk about a repeated activity or to emphasise the duration of an activity or state before another time in the past.

I'd been thinking about getting a job when I saw the advert.

Alex *had been working* hard for weeks. He finally managed to finish the project.

When you talk about achievements or single actions, use the past perfect simple:

I'd been filling out application forms all morning and *I'd completed* two forms.

Exercise 4

Write an article using your answers from Exercise 3. Write 150–200 words.

A magazine is looking for articles by young people about the jobs they do. Write a description of your job. Look at the texts on page 84 to help you.

Exercise 5

Read the information about Peace Boat. Listen to the conversation. Are the statements True (T) or False (F)?

Peace Boat is an international NGO (non-governmental organisation) based in Japan. It works to promote peace and human rights around the world. Every year, it organises three Global Voyages that visit up to 20 different countries, as well as shorter trips around Asia. People go to find out about different cultures and the environment, as well as to learn English or Spanish. You can volunteer as a teacher or interpreter on these incredible trips.



- Joe and Akari know each other well.
- Akari is phoning because she wants to become a volunteer.
- The purpose of her call is to ask for information and schedule a job interview.
- By the end of the conversation, Akari has arranged a job interview.

EXAM SKILLS

The first time you listen to a conversation, listen for the general idea. Think about these things:
• Do the speakers know each other? • Why are they talking? • What is the end result of the conversation?

Exercise 6

Listen again. Choose the correct answers.

- Akari is interested in *teaching / studying / interpreting* on a Peace Boat voyage.
- Akari found out about Peace Boat and the work it does *online / in a magazine / from a friend*.
- Akari already knows about the *cultural events on board / the application process / the language courses*.
- Akari asks if it is possible to *look around Peace Boat / visit the office / help organise an event*.
- Habiki Yakima *regularly volunteers / has volunteered once / is planning to volunteer*.
- Akari arranges to meet Habiki on *Monday / Tuesday / Friday* next week.

Exercise 7

Listen again. Complete the sentences with a number.

- Akari can speak _____ languages.
- On Wednesdays, the office is open from _____ a.m. to _____ p.m.
- Habiki is meeting _____ other people on Tuesday.
- Akari is going to meet Habiki at _____ a.m.
- Akari's phone number is _____.

seventy-nine 79

MODULE 4

3 SKILLS FOR THE FUTURE
WORKFORCE

FUTURE EMPLOYMENT PLANS

LEARNING OBJECTIVES

- Talk about the workplace
- Use *will* and *going to* for prediction
- Listen for specific information

1 Work in pairs. Discuss the statements. Do you agree or disagree?

In the future...

- 1 Most people will upskill at work, but they won't reskill.
- 2 More people will work for themselves and freelance.
- 3 Skills like being able to network online will be important.
- 4 People are going to train for most jobs online.
- 5 Meetings and job interviews will happen using virtual reality technology.
- 6 People may even work on other planets.

upskill = develop your skills
reskill = learn new skills
freelance = sell your work or services to many different companies
network = meet / talk to people about business opportunities
train = teach someone to do a job

2 Read the infographic. Are the statements in Exercise 1 True (T) or False (F)?

The FUTURE of work

You'll LEARN all the time. Employees will take on multiple roles, upskilling regularly to climb the career ladder. Many people won't stay in the same career for a long time, either. Reskilling and changing jobs will be the norm.

The place WHERE you work will change. No more commuting to work. We've already got hybrid working, and being a digital nomad is becoming increasingly popular. We're going to see more of this. Someday, people may even work on other planets!

VIRTUAL REALITY (VR) at work is going to be huge! People use it now to train as pilots or doctors and even to practise for job interviews, but it's not hard to imagine that this kind of experience will replace all work meetings and interviews.

HOW you work will change. More people will be freelancers and work on projects rather than for a company. The number of people who have their own small businesses will increase.

You'll need SKILLS and lots of them. Employers will look for people who are proficient in multiple skills. Can you analyse data? Use social media to network? Code? Without skills like these, it will be difficult to get a job or advance at work.

be the norm = be the usual way something happens
digital nomad = someone who earns a living working online in different locations
hybrid working = working partly in an office and partly at home

3 Work in pairs. Discuss the questions.

- 1 Do you think the predictions in the infographic will be going to happen...?
 • soon • in the next five years
 • in your lifetime • never
- 2 Think of five more predictions about the future.

I think that soon... (everyone will work from home). In the next five years... (people are going to use VR all the time). I don't think people will... (all have their own businesses in my lifetime). People are never going to... (work on other planets). People are already... (reskilling, so in the future, that's going to happen more).

82 eighty-two

4 Work in groups. Discuss the questions.

- 1 How important are these personal qualities for success in the workplace? Rank them from 1 (most important) to 8 (least important).

adaptable competent consistent dynamic flexible focused proactive resilient

- 2 Many of these words are in the next listening activity. What do you think the podcast will be about?

will for prediction Page 221
 Will can be used for predictions. We tend to use **will** to give opinions, often with the verbs *think, hope, expect, and believe*.
 Many people think we **will** work on other planets.
 Experts believe that people **won't** meet face-to-face.

going to for prediction Page 221
 Going to can also be used for predictions. We tend to use **going to** when we are focussing on present evidence.
 Sam **isn't** going to get the job. The interview went badly.
 I'm **going to** reskill regularly. I have already completed two training modules.

5 Listen to the podcast. Choose the best description.

- Olivia talks about five different skills that people will need in the workplace, such as being able to use technology or solve problems.
- Olivia talks about the three most important skills that people need in the workplace now, and whether they'll need these skills in the future.

6 Listen to the podcast again and complete the notes.

WHAT?	WHY?
Tech-savvy	need tech skills for any job, use tech to ¹ _____, understand how tech will affect your ² _____
Communication skills	be able to communicate in ³ _____, able to get your message across and use the right kind of ⁴ _____
Problem-solving	come up with new ideas and be ⁵ _____ to solve problems, analyse information to make decisions, stay ⁶ _____ choose priorities
Adaptable	get more ⁷ _____ and be a leader, better jobs and more interesting ⁸ _____
Resilience	able to deal with different kinds of ⁹ _____, be ¹⁰ _____ and open to change, achieve more goals



EXAM SKILLS

To listen for specific information, read the table first and decide what kinds of words are missing from the gaps (nouns, verbs, adjectives, pronouns...). How can the words before and after the gaps help you decide? What form of the words do you need (infinitive, gerund, singular, plural...)?

7 Prepare text for an infographic about the top five workplace skills you think people will need in the future. Write 40–80 words for each bullet point.

- Think about how the workplace is going to change. What evidence is there for this?
- How do experts think the workplace will change?
- Look at the texts in Exercise 2 and the notes from Exercise 6 to help you find ideas.

8 Work in groups. Discuss the questions.

- 1 What skills are you learning now at school that will be useful in the workplace? What other skills would you like to learn?
- 2 Do you think it's possible to learn skills such as problem-solving and creative thinking at school? Can you develop resilience and creativity at school?
- 3 What are the advantages of studying an international curriculum to prepare you for future careers?



Culture point

It is predicted that around 65% of children at primary school now will do jobs that don't exist yet, like space pilot, self-driving car mechanic or 3D-printer chef.

eighty-three 83

6 JOB INTERVIEWS:
THE STAR METHOD

JOB APPLICATIONS

LEARNING OBJECTIVES

- Use the STAR job interview method
- Use reported questions
- Role play an interview using the STAR method

1 Read the questions. Which one would you NOT expect in a job interview? Why? Think of three more interview questions.

- 1 Do you prefer working alone or in a team?
- 2 What will you be doing in five years' time?
- 3 Who's your favourite singer?
- 4 What are your goals for the future?

2 Read the messages. Which two questions from Exercise 1 was Lucy asked?

How was your job interview?

It was a disaster!

Oh, no! Why?

They asked me what I would be doing in five years' time. Five years? I have no idea! I said I wasn't sure.

OK, that's not so bad, is it?

Then they asked if I preferred working alone or in a team.

So, what did you say?

Working alone, obviously... Then I remembered the job asked for team players!

Oh no :(Phone me!

Reported questions

When reporting questions, the question becomes a statement. Use the same tense/pronoun changes as in reported speech. Introduce the question with the *Wh-* question word. When there is no question word, use *if/whether*.

Direct question	Reported question
'Where did you study ?' they asked.	They asked me where I had studied .
'Why have you applied for the job?' she asked.	She asked me why I had applied for the job .
'Do you enjoy working in a team?' he asked me.	He asked me if I enjoyed working in a team .
'Are you working now?' the interviewer asked me.	The interviewer asked me if I was working now .

disaster = something that is a failure / has a very bad result
a team player = someone who works well with others as part of a group

3 Listen to Lucy and Amy's conversation and answer the questions.

- 1 What happened when Lucy talked about solving a problem?
- 2 Why was there a breakdown in communication?
- 3 Why didn't Lucy prepare for the interview?
- 4 What does Amy advise Lucy to find online?
- 5 How does Amy say Lucy should prepare to answer questions?
- 6 Which method does Amy recommend to answer questions?

4 Read the text. Are the statements True (T) or False (F)?

- 1 Experts recommend only answering the job interview questions you choose.
- 2 The first thing you should do to prepare for the interview is list the skills the advert specifies.
- 3 In a STAR method answer, you focus on describing your actions.
- 4 When you give a result in a STAR answer, it's fine to give a general answer.

88 eighty-eight

MODULE 4

How to STAR interviews!

You applied for a job and you've received an invitation to interview. Congratulations! But now what? The job market is very competitive, and unfortunately, you can't choose to answer some job interview questions and avoid the rest!

It is important to answer tricky questions in a way that's both professional and shows off your skills and achievements. To do this, experts recommend the STAR method.

First, look closely at the job advert and make a list of all the skills or qualities it asks for. Then prepare answers that show how you have demonstrated each one using the STAR method:

SITUATION	Describe the situation in 1–2 sentences. The interviewer doesn't need to know your life story, just enough to understand the context!
TASK	In 1–2 sentences, outline the task you had to do.
ACTION	Describe in detail, perhaps 3–5 sentences, what you personally did to complete the task. It's important to use 'I' here, even if you were part of a team. Don't include everything the team did: say what you contributed.
RESULT	State the results of your actions in 1–2 sentences. Be specific.

Imagine an interviewer asked you to talk about something you had achieved, and the job advert asked for **communication skills** and to be **organised**. Your answer might be:

S – Our school wanted to buy new computers.
T – We decided to organise a dance to raise money.
A – I was responsible for making the posters and advertising the event. I wrote an article for the school magazine and posted regularly on social media. I also organised people to put up posters.
R – As a result, over 200 people bought tickets. The event raised USD \$3,000 and the school was able to buy new computers.

This way, even if there is a lot of competition for the job, you can be confident you'll perform well at the interview. Good luck!

5 Listen. Make notes of David's STAR answer in a job interview.

6 Choose two questions. Answer them using the STAR method. Make notes.

- 1 When have you faced a challenging situation?
- 2 Tell us about a time when you took the initiative. What happened?
- 3 Give us an example of a time you solved a problem. How did you do it?
- 4 What is an achievement you are proud of? Why?

7 Work in pairs. Follow the instructions.

- Prepare to answer your two questions from Exercise 6.
- **Student A:** you are the interviewer. Ask the questions and make notes on the candidate's answers (situation, task, action and result).
- **Student B:** You are the candidate. Remember to use phrases to introduce each part of your answer. When you finish, exchange roles.

- Can you tell me about a time you solved a problem?
- Certainly. The situation was...

The situation was...
 The task was to...
 The action I took was to... First... Next... Then... Finally...
 The result was... / As a result...

8 Write a short article with five tips for preparing for a job interview. Write 150–200 words.

eighty-nine 89

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ALGEBRA 12

Proportion and graphs

You can use the symbol μ to show direct proportion. You can show quantities that are **directly proportional** or **inversely proportional** on a graph.

Direct proportion

$\mu \propto x$

$y = kx$ where k is a number

graph is a straight line passing through the origin

Inverse proportion

$\mu \propto \frac{1}{x}$

$y = \frac{k}{x}$ where k is a number

graph looks like a reciprocal graph

Q Electrical appliances in your home follow this rule:
Power (watts) μ Current (amps)
An electric drill uses 2.2 A and has a power of 528 W. Calculate the current used by a television with a power of 132 W.

A) 31 680 A B) 0.55 A
C) 1.82 A D) 8.8 A

Turn over for the answer

And the answer is... **B) 0.55 A**

$528 \div 132 = 4$

$2.2 \div 4 = 0.55$

The television uses 0.55 A

This method uses equivalent ratios:

$22 : 528$
 $\div 4$ $7 : 132$ $\div 4$

Watch out!

Your answer should make sense. If the quantities are in **direct proportion** then when one decreases the other should decrease as well.

If you only remember one thing...

Direct proportion: quantities change in the **same way**

Inverse proportion: quantities change in **opposite ways**.

STATISTICS 15

Translations and reflections

Translations

A translation is a **sliding** movement. You can describe a translation using a **vector**.

The transformation $A \rightarrow B$ is a translation by the vector

The top number describes horizontal movement
The bottom number describes vertical movement

Reflections

You can **reflect** a shape in a mirror line. To describe a reflection you need to give the **equation** of the mirror line.

The transformation $A \rightarrow B$ is a reflection in the line $x = 3$.

The mirror line is a line of symmetry.

Q Describe fully the single transformation that will map shape A onto shape B.

A) Translation $\begin{pmatrix} 1 \\ 1 \end{pmatrix}$
B) Reflection in the line $y = 1$
C) Translation $\begin{pmatrix} -1 \\ -1 \end{pmatrix}$
D) Reflection in the line $y = x$

Turn over for the answer

And the answer is... **D) Reflection in the line $y = x$**

You need to write the word 'reflection' and give the equation of the mirror line.

Draw the mirror line.

The distance from the line to each point on shape A is the same as the distance from the line to the corresponding point on shape B.

Watch out!

For both translations and reflections, the lengths of the sides and the angles in the shapes do not change.

If you only remember one thing...

Use the word **translation** and give the vector

Use the word **reflection** and give the equation of the mirror line.

NUMBER 8

Estimation

You can estimate the answer to a calculation by rounding each number to **1 significant figure**, and then doing the calculation. You can use this method to check your answers, or to estimate calculations on your **non-calculator** paper.

Here are two examples:

- $4.32 \times 18.09 = 4 \times 20 = 80$
The answer is approximately equal to 80.
- $3272 = 3002 = 32 \times 1002 = 90\,000$
The answer is approximately equal to 90\,000.

Q Work out an estimate for: $\frac{4.31 \times 278}{0.487}$

A) 1200
B) 2400
C) 240
D) 12000

Turn over for the answer

And the answer is... **(B) 2400**

$4.31 \times \frac{278}{0.487} \approx 4 \times \frac{300}{0.5}$

$= \frac{1200}{0.5}$

$= 2400$

Round all the numbers to **1 significant figure**.

Write out the calculation with the rounded values

Decimal division trick

You might have to divide by a decimal on your non-calculator paper. If you multiply both numbers in a division by the same amount the answer stays the same.

$\frac{1400}{0.05} = \frac{140\,000}{5} = 28\,000$

Watch out!

Take care when dividing by a decimal. Remember that dividing by 0.5 is the same as multiplying by 2, and dividing by 0.1 is the same as multiplying by 10.

If you only remember one thing...

Round all values to 1 significant figure to estimate answers.

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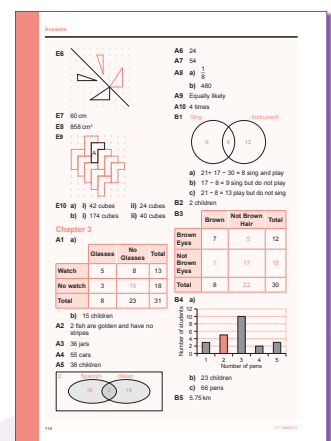
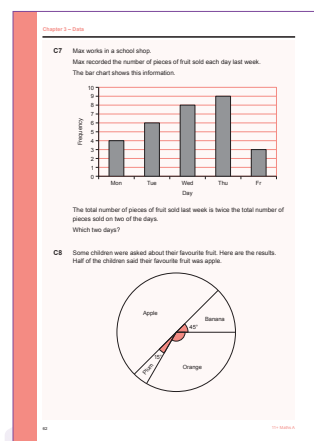
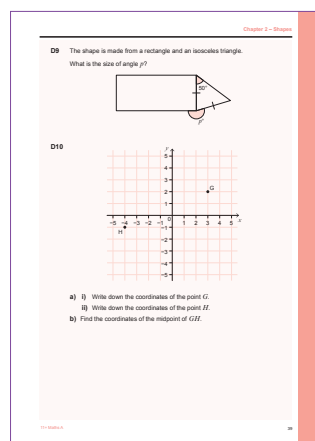
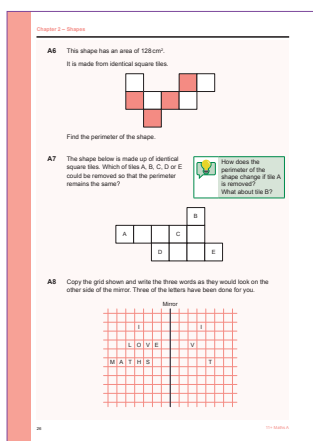
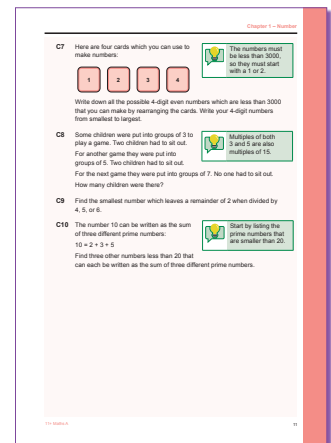
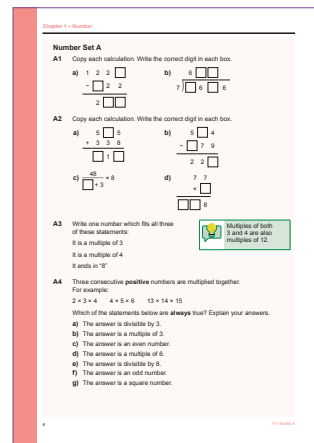
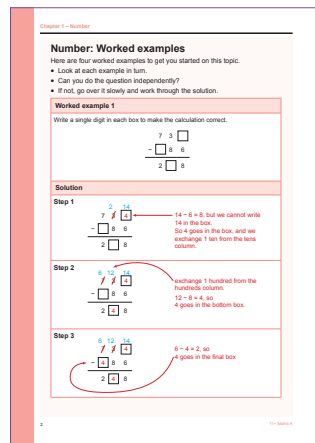
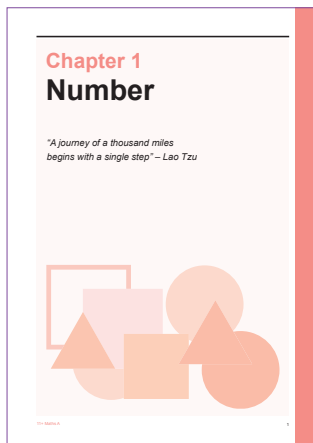
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1.4

FACTORS WHICH CAN IMPACT UPON THE POPULARITY OF SPORT IN THE UK

The popularity of some sports in the UK is largely affected by where you live and what you have access to, but there are several other factors.

Popularity factors

Number of people participating



Changes in popularity create a cycle of rise or decline – as sports become more popular, more people want to engage with them, so they become even more popular. As sports drop out of favour, people lose interest which decreases their popularity even further.

Provision of facilities

Living close to places that provide opportunity to watch or to take part in sport increases engagement with the sport.

➡ A town with a council-operated swimming pool will increase the relative popularity of swimming as it is more accessible to local residents.

➡ If the nearest swimming pool is far away, people are less likely to go, as access will be reduced.

Environmental or climatic conditions

Living close to places that provide opportunity to watch or to take part in sport increases engagement with the sport.

➡ Water sports, such as sailing, water skiing and rowing, would be more popular with those living in coastal areas or near large bodies of water.

➡ Skiing requires cold, snowy, and mountainous terrain. Those who live in Scotland have greater access to this environment, whereas people living in inner cities may have to make do with an indoor ski centre which does not replicate the natural environment.

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9

1.1

USER GROUPS

Physical activity and sport are popular to a wide range of people or **user groups**. However, different user groups face a variety of **barriers** that can impact their participation rate. It is important that **solutions** are made available to break these barriers down.

Different user groups who participate in sport

There is a wide range of people who take part in physical activity and sport. Those who chose to participate are categorised into a user group. An individual can belong to multiple user groups.

A user group is a specific group of people who share similar characteristics.

Gender

Different genders can have different needs, goals, and requirements for sport.

Traditionally, most sports are split into men's and women's categories. For example, football has male and female leagues. Men and women do not usually compete against each other or play in the same team.



People from different ethnic groups

An ethnic group shares a common background that could be based on culture, language, religion, traditions or heritage.



Traditionally, most sports are split into men's and women's categories. For example, football has male and female leagues. Men and women do not usually compete against each other or play in the same team.

Retired people/people over 60



As people get older and work less or retire, their leisure time will increase.

Retired people could be in receipt of a work or government pension.

Families with children

These are parents or carers that are raising children in their family of various ages.



Raising and caring for a young family takes up a lot of time. Some children may not be of school age.

Carers

Adults or children, caring for relatives, elderly, parents, or siblings.

Caring for loved ones can be very time consuming. A child may be the main carer for a parent or sibling when not in school.



People with family commitments

Some people may need to spend time with certain family members on a regular basis.



Family commitments may vary from person to person and could possibly link to other user groups above.

People with disabilities

Anyone with a physical or mental condition that affects their ability to complete certain day-to-day activities.



These are not just physical conditions or those that require the use of a wheelchair. It could be a neurological or learning condition such as autism.

Young children

A young child is a person aged from birth to the end of primary school.

Age 0 to 11.



Teenagers

A teenager is considered a person of compulsory secondary school age.



Age 11 to 18.

Parents (singles or couples)

People raising a child together or alone. Prioritising time to care for children is vital.

A single parent is an adult raising a child / children on their own. This is more difficult if they cannot share the responsibility.



People who work

Adults who are in employment and work to earn a living. The money earned is used for living costs and raising a family.



Those who work many hours or nightshifts have less opportunity to be physically active, and may be too tired to do so when not at work.

Unemployed/economically disadvantaged people

Adults without jobs are known as being unemployed and may be economically disadvantaged as a result. People who work low paid jobs can be economically disadvantaged too.



A lack of disposable income will reduce a person's ability to participate in physical activity and sport.

Identify **one** user group that is more likely to participate in golf. Explain your choice. [2]

Retired people^[1] as they do not work so they have more time on their hands to play a long round of golf.^[1] / People who work^[1] as they earn a living and can afford to pay for golf club membership.^[1]

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3

1.3

POSSIBLE BARRIER SOLUTIONS

To make physical activity and sport as inclusive as possible to all user groups, **solutions** should be made available to minimise barriers to all. It should not matter which user group or groups you fall into, nor where you live within the country.

Provision

Physical activity and sport facilities, such as leisure centres and swimming pools can offer alternative **provision** to accommodate and meet the needs of all user groups. This includes the type of programme, the sessions themselves and the timing of sessions.

Provision refers to what is provided. Provision should be adequate and equal to all user groups throughout the country.

Provision of:	Examples
Appropriate programmes	- Offer programmes for people over 60 with less strenuous exercise classes. Taster days to be held in schools to encourage wider participation out of school. - Businesses to work together with leisure facilities to provide employee discounts.
Sessions	- Respect diverse cultures by having female only swimming sessions. - Parent and child swim sessions encourage physical activity from a young age. - Exercise classes for parents with a creche facility.
Activities	- Offer differentiated activities, e.g., walking football for people over 60 and wheelchair basketball. - Fun activity sessions for parents and children to enjoy together, e.g., Change4Life, Healthy Steps activity.
Times for the different user groups	- Providers could open early or close late to allow for the employed to participate. - Online classes so the participant can access the class at a time that suits them around work. - Children only clubs at specific age groups to allow for more enjoyment and safety.

Paul is a retired 65 years old and would like to participate in sport. Using an example, suggest what provision a local leisure centre could offer to encourage Paul to participate in sport. [2]

Offer appropriate programmes,^[1] e.g., over 60s exercise classes.^[1]
Offer an appropriate session,^[1] e.g., low impact exercise classes.^[1]
Offer appropriate activities,^[1] e.g., walking football.^[1] Offer appropriate times,^[1] e.g., during the day / off-peak times.^[1]

Promotion strategies

Promotional strategies are used to inform the various user groups of the different activities available to them, in the hope to increase participation for all.

Promotion involves any form of advertising that is directed towards a specific audience or user group.

The use of targeted promotion

Targeted promotion is a form of advertising aimed at a particular user group to increase participation.

- A local fitness centre advertising in a college to encourage more teenagers to join.
- Women only sessions, e.g., women only swim advertised in a local mosque.

Role models

The use of a role model targeted at a particular user group to increase participation.

- Promoting the success of the England Women's Football team on the European and World stage to encourage more girls into local grass roots football teams.
- Jonnie Peacock and Ellie Simmonds became role models to many people with disabilities after their success at the Paralympic Games.

Initiatives

A series of campaigns to get user groups involved in sport and promote physical activity.

- Sport England 'This Girl Can' – A National Lottery funded campaign to celebrate a realistic vision of women and exercise in England and to tackle the gender activity gap.
- Sport England 'Join the Movement' – Another National Lottery funded campaign helping all user groups to find ways to get active.
- Chance to Shine – A national charity that aims to give all children the opportunity to play, learn and develop through cricket.

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7

Topic Area 1

EXAMINATION PRACTICE

Topic area 1: Issues which affect participation in sport

- 01 Young children, retired people and people from different ethnic backgrounds are types of user groups who may participate in physical activity and sport. Identify **three** other user groups that may participate in physical activity and sport. [3]
- 02 Draw a straight line to match each user group to the correct description. [3]
- | | |
|-------------------------------------|---|
| Young children | Those who do not work anymore due to their age. |
| Retired people | Share a common background that could be based on culture, language, religion, tradition, or heritage. |
| People from different ethnic groups | Aged from birth to the end of Primary School. |
| | Adults or children, caring for relatives, elderly, parents or siblings |
- 03 Which **one** of the following Sport England initiatives is used specifically to promote female participation in physical activity and sport. [1]
- ☐ A – Join the Movement
☐ B – Play Their Way
☐ C – This Girl Can
☐ D – We Are Undeatable
- 04 Hannah is a mother of two teenagers and works full time. Before having children, Hannah played a lot of sport. Hannah has decided that she wants to lose weight by playing sport once again. [3]
- (a) Identify **three** barriers that might prevent Hannah from regular participation in sport. [3]
 (b) Identify **three** solutions that could help Hannah to participate in more sport. [3]

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15

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2 Cell structure and function

Objectives

- Describe the use and limitations of optical microscopes, transmission electron microscopes and scanning electron microscopes.
- Explain the difference between magnification and resolution.
- Recognise cell structures from photomicrographs and electron micrographs and draw individual cell structures.
- Describe the principles of cell fractionation and ultracentrifugation, and explain why they are used.
- Measure the size of an object viewed with an optical microscope
- Calculate true size (in μm) and magnification, including using scale bars.
- Appreciate that there was a considerable period of time during which the scientific community distinguished between artefacts and cell organelles.

Unit introduction

This unit introduces cells as the simplest unit of life. It explores how the light microscope was developed and how it can be used in the school laboratory to view them. It also explores how electron micrographs provide us with further insight into the ultrastructure of cells, including the existence of organelles that are surrounded by a fluid-mosaic structure of cell membranes, which form an effective barrier that separates the contents of a cell from its external environment. Students will explore the difference between magnification and resolution and manipulate the calculation for magnification to work out the actual size of microscopic specimens and images, including practically by calibrating an eyepiece graticule using a stage micrometer. There are many practical opportunities in this unit and occasions for students to develop analytical, application and mathematical skills.

To introduce this unit to students, write the approximate number of cells in a human body on the board (to give students an idea of their size; see Figure 2.1). Ask students to read the features in the Big picture and Fact file and host a discussion about the reliability of evidence used to estimate the emergence of multicellular organisms, and the GAIA hypothesis.

A number of freely accessible sources of materials can be found online, to support teaching of this unit. Search for:

- *Cells Alive* and *Cell Image Library* for high-definition photomicrographs and electron micrographs of cells and organelles.
- *Big Picture Education*, which has videos and animations showing the use of light and electron microscopy. For higher-ability students, the imaging companies *Olympus* and *Zeiss* have educational resources on their websites for students to explore the technique of electron microscopy in more detail.
- *Phet Colorado* for a number of animations showing the different methods of molecular transport across cell membranes.

Prior learning

Students should be aware of the importance of cells to life and may know some of the structures that are found inside them. They will know that there are similarities and differences between plant and animal cells and that there are different types of cells such as sperm cells, red blood cells and root hair cells. Students may have used microscopes or hand lenses to study biological specimens and make drawings. Students will be aware of the importance of the exchange of materials between a cell and its environment, and that a membrane separates a cell from its surroundings. They will know that these materials include water and dissolved solutes.

To assess their prior knowledge and understanding before starting this unit, try hosting a brief round of closed true/false statements, which will also refresh previous learning of cell biology. Either ask students to hold up a piece of paper that has 'true' or 'false' printed on either side, or ask them to write down their answers for you to check in advance of the first lesson. Statements could include the following examples:

- 'Using a microscope, we can see all of the organelles in a cell.' (false)
- 'Animal cells have more different types of structure than plant cells.' (false)
- 'Plant cells can absorb more water than animal cells without bursting.' (true)

To extend this activity, ask higher-ability students to explain their answers.

Concept progression

The concept map shown in the opener spread illustrates the broad range of subtopics that students will encounter in this unit on cells. These include structures found within cells, and their functions, and how cells can be studied using microscopy. There are also some links with other topics that are studied in other units, such as stem cells, cell division and how cells are organised into tissues, organs and systems. Encourage students to consider other subtopics that could be added to this concept map. You could also suggest that they cross out or tick off the subtopics as they study them in the course of the unit.

TEACHERS GUIDE

Using photomicrographs and electron micrographs

Period objectives

- Make temporary preparations of cellular material suitable for viewing with a light microscope.
- Recognise cell structures from photomicrographs and electron micrographs and draw plant and animal cells from microscope slides and photomicrographs.
- Understand how cell fractionation and ultracentrifugation can be used to investigate the function of different cellular components.

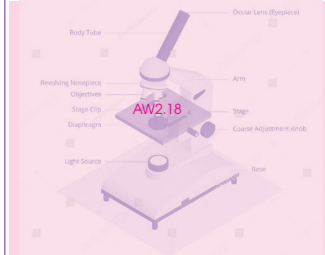
In this period, students study photomicrographs and electron micrographs, and develop their scientific drawing skills. Students learn how cell fractionation is used to purify samples of different structures in the cell, in order to study their function. A common mistake made by students is that they interchangeably use the terms photograph, photomicrograph and electron micrograph.

Period notes

Key learning	Guidance notes
Starter Ask students to describe the difference between a photomicrograph and a photograph. Examples of the two images could also be shown and students would need to identify the difference between them (e.g. see Figure 2.3).	Extend this activity by showing some highly visual images such as ileum epithelial cells with microvilli, muscle cells with myofibrils, and details of small cellular structures such as nuclear pores, centrioles and plasmodesmata.
Main Show students images of drawings by scientists such as Van Leeuwenhoek (e.g. display Figure 2.13) and challenge them to discuss the importance of drawing a scientific drawing accurately. Ask the students what they think makes a good scientific drawing and then show them examples of some students' drawings (e.g. Figure 2.15 (b)). Ask them to identify what is good about the diagrams and what could be improved.	Help students recognise the mistakes of others. Provide clear success criteria and set students the task of peer assessing each other's scientific drawings. These could be their drawings produced during the practical, or micrographs obtained online (e.g. Figure 2.14). This would also be a good time to help students recognise cell structures from electron micrographs. Examples of these images can be found throughout this unit.
It is impractical to undertake cell fractionation in the school laboratory: centrifuges can be very expensive. The process can be shown in a video, widely available online, or demonstrated by spinning a small bottle of water containing a suspension of raw brown rice, in order to illustrate how a pellet is formed by rotating it safely a few times over your shoulder.	Students can struggle to imagine the dynamic nature of a cell and how the different components interact. Show students video footage of actual living cells (not animations) with activities such as mitochondrial movement and division. Question 4 is of use here too.
Practical (60–90 minutes) The practical activity in this lesson involves preparing animal and plant cell specimens and examining them with the light microscope. Students develop their skills in producing scientific drawings from these microscope slides and photomicrographs.	The development of drawing skills is important as a means of assessing observational skills. A useful suggestion is to provide students with empty shapes, such as a circle divided into four quadrants, to help students draw components of an image in the correct positions and to scale. Provide clear success criteria and set students the task of peer assessing their drawings.
Plenary Select appropriate questions, such as those provided at the end of this lesson, for students to complete and pass to you as they leave the room.	This 'exit card' technique allows for formative assessment. This will enable you to judge if you need to revisit this material in the next lesson.

Unit 2 Chapter 1

Answers to activities & questions

Coverage & progression	Outcomes & answers
Activity: Cell theory Students should try to find out about all organisms that may not fit the pattern of cell theory.	There are a number of cells that, for various reasons, do not fully conform to the cell theory. These include muscle cells (myocytes) that contain multiple nuclei, and fungal hyphae, which consist of multiple cells that share their cytoplasm.
Activity: Accurate scientific drawings Students are asked to search for images online then produce a scientific drawing, which they must then self-assess using the seven criteria given in the textbook.	Students' answers will vary according to which electron micrograph they select. All drawings should be made in pencil with continuous lines and no shading. Use the checklist in the spread to give guidance and feedback to students. High achievers could be challenged to label their drawings or produce a second drawing of a more challenging image.
Question: Analysing scientific drawings Students are asked to assess the mistakes made in the three drawings shown.	In the drawing by Student A, more than one cell is drawn. The structures within the cell (sister chromatids) are not in the correct position relative to each other and the equator of the cell. Some labels are incorrect (e.g. cell wall label points to the cell membrane; chromosomes should be sister chromatids) and others are missing, for example the cell membrane. The drawing by Student B includes shading. Not all sister chromatids are drawn (one is missing from the right-hand side). The label lines have not been drawn using a ruler. In the drawing by Student C, the drawn lines are broken rather than continuous. Structures are not in proportion to the cell – they are too small (inaccurate representation). Key labels are missing (e.g. cell wall, sister chromatids). High achievers could be challenged to draw an improved scientific drawing of the plant cell.
Activity: Parts of a light microscope Students are asked to label the main parts of a light microscope in preparation for the practical activity.	Students may not be familiar with all the terms used here but will gain familiarity with them during the practical task. 

TEACHERS GUIDE

Unit 2 Chapter 1

Reflect & recall

1	This is a straightforward recall question about the process of cell fractionation.	Biological tissue must be homogenised in ice-cold solution because chemical reactions, which may occur in the homogenate and filtrate and which may result in a loss of organelle function, will occur at a reduced rate.
2	Students are asked to sketch a centrifuge tube to check understanding about the relative masses of cell organelles.	A centrifuge tube should be drawn that has three layers, which are in the order nuclei, mitochondria and then ribosomes (from bottom to top)
3	For a) a scientific diagram is required for one of the coronavirus particles pictured. For part b) students must apply their knowledge of viruses to the process of centrifugation.	a) A diagram of one virus particle should be drawn large and with good proportions, without shading and with clean, continuous lines. Labels are not required but higher-ability students could attempt some as an extension. b) Viruses have a very low mass and the centrifuge will not be able to spin at a high enough speed to cause them to sediment into a pellet.
4	a) Here students are asked to recall the main steps in differential centrifugation. For b) students are asked to try to explain the results shown in the graphs.	a) In order to obtain pure samples of these three types of organelle, the scientists should centrifuge the mixture at three different speeds (they need to use two fresh tubes between the different centrifugations). Higher-ability students could find out in which order the organelles will form pellets. b) The results show that radioactivity levels increase at first in the rough endoplasmic reticulum, before increasing in the Golgi apparatus, and finally in vesicles. This suggests that the radioactive molecules absorbed by the cell are transferred between these cell structures in this order.

Independent study, extension work and IT suggestions

Stains give contrast to microscopical images and can help to identify tissues viewed using microscopes. Staining techniques for use in light microscopy involve using coloured dyes, but have recently been supplemented with immunological techniques. In electron microscopy, heavy metal stains such as salts of osmium, lead and uranium, are incorporated into the specimen. Ask students to review the staining techniques available to modern biology and prepare a digital report explaining how these can enhance one area of study in biological science.

Making a temporary slide and drawing cells

Purpose/Objectives

- To make temporary preparations of cellular material (onion cells and human cheek cells) suitable for viewing with a light microscope.
- To draw diagrams of plant and animal cells from microscope slides and photomicrographs.

Equipment

- Iodine solution, 0.1 M
- Methylene blue
- Onion (red or white)
- Beaker
- Cotton buds
- Coverslips
- Disinfectant
- Distilled water
- Dropping pipette
- Eye protection
- Filter paper
- Forceps
- Glass slides
- Light microscope
- Mounted needle
- Sharp knife or scalpel
- White tile

Classroom organisation

Consider the following questions before you host this practical activity.

- Are students mature enough to safely use the knife and scalpels?
- Should students work in small groups, pairs or as individuals?
- Will microscopes be set out on the desks ready, or should students collect them?
- How much time is available? Should students prepare temporary slides of both onion and cheek cells, or just one or the other?

Setting up

Figure 2.21 shows how a temporary slide is prepared. In order to minimise the introduction of air bubbles, the coverslip should be lowered slowly at an angle using a mounted needle. Use filter paper to absorb excess water or stain.

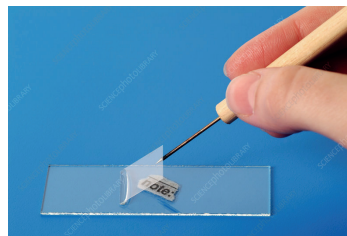


FIGURE 2.21 Preparing a temporary slide of plant tissue.

10

11

TEACHERS GUIDE

Preparing and viewing cheek cells

- Insert a cotton bud into your mouth and gently rub against the inside of your cheek.
- Smear the cotton bud onto a small area at the centre of the glass slide.
- Put the cotton bud straight into a beaker containing disinfectant.
- Add a very small drop of methylene blue to the area where the cheek cells were smeared, and leave this to soak for around 1 minute.
- Follow steps 5 to 14 as per the method for preparing onion cells.

Outcomes & writing up

Draw your observations at both lower and higher magnification.

Refer back to the period spread to remind yourself of the seven guidelines to follow when you produce a scientific drawing.

Taking it further

It is possible to use a special type of microscope slide called a cavity slide. Using this, it is possible to see living microscopic organisms that move around in drops of water. Although you are unlikely to find anything living that is visible in a drop of tap water, try using a drop of pond water or even seawater. It will be difficult to make a scientific drawing of your observations. Instead, try holding your mobile phone camera lens very still over the eyepiece of the microscope. You may even be able to record a short video and play it back in slow motion to see some detail of the organisms.

1 Unit review

Checkpoint

Competency statements	Review questions
Microscopes - I know that microscopes are used in cell biology. - I can distinguish between the different types of microscope (light microscopes, transmission electron microscopes and scanning electron microscopes). - I understand the advantages and disadvantages of using different types of microscope.	1 The structures of some organelles are only visible with an electron microscope. Explain why.
Studying cells - I know that temporary preparations of cellular material are suitable for viewing with a light microscope. - I can draw diagrams of plant and animal cells from microscope slides and photomicrographs. - I understand how cell fractionation can be used to investigate the function of different cellular components.	2 Describe how a sample consisting only of chloroplasts could be obtained from homogenised plant tissue.
True size and magnification - I know how to use and rearrange the magnification formula to calculate magnifications and true size. - I can use the appropriate units to measure cells and their structures: millimetre (mm), micrometre (µm) and nanometre (nm). - I understand how eyepiece gratings and stage micrometer scales can be used to make measurements of objects seen through microscopes.	3 Describe how a student can prepare a temporary microscope slide to view a piece of plant tissue.

16

17

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Unit

2

Cell structure and function

Big picture

What is a living cell? This question is harder to answer than you might think.

One definition of a cell is the smallest unit of life. However, there are structures in cells without which a cell could not live. Are these 'alive' too? And how do we evaluate the difference between unicellular organisms, which consist of only one cell, and multicellular organisms, which have very many (Figure 2.1)?

Factfile

Professor Lynn Margulis was one of the key microbiologists of the 20th century. Early in her career, she was intrigued by some of her observations of plant and animal cells, called eukaryotic cells. Mitochondria, internal structures that provide eukaryotic cells with energy, and chloroplasts, which are responsible for photosynthesis, reminded her of bacteria, called prokaryotic cells. Could it be that, billions of years ago, bacteria may have been taken in by another, larger cell? Perhaps, instead of being digested, the bacterium could have survived inside it and formed a highly interactive partnership. Professor Margulis's theory became known as the endosymbiotic theory (endo means 'within', and 'symbiosis' is defined as 'of mutual benefit'). Controversial at first, this theory is widely accepted today.

In her later years, Professor Margulis extended her thinking and helped to advance the GAIA hypothesis (Figure 2.2). First proposed by a space scientist working for NASA, this attested that life, through its interactions with rocks, oceans and atmosphere, stabilises our planet's conditions. Many examples will be familiar to you: organisms are able to make new rocks such as limestone, change the composition of our atmosphere by producing oxygen, and cycle elements such as carbon and nitrogen. Perhaps the wide variety of habitats for life on Earth were borne of life itself.

Link to

It is possible to link the content of this unit with your studies of other academic subjects. Here are some examples:

- Ask your language teacher to help you consider the derivation of words used to describe structures found within cells. Examples include cytoplasm (derived from 'cyto-' which is the Ancient Greek for 'container') and 'nucleus' (derived from the Latin for 'seed'). What about 'prokaryotic' and 'vacuole'?
- Compare the specialisation of cells with the specialisation of different woodwork tools or cooking utensils.
- The skills that you will develop in this unit, such as using a microscope, are required for observations of blood smears and the gross structure of blood vessels in animals, as well as observing root hair cells and locating the position of xylem and phloem in plants.

Progression map

Prior learning	In this unit	Later learning
All living things are composed of cells	- The use and limitations of optical microscopes - The difference between magnification and resolution - Calculating true size (in μm)	Gas exchange across cell membranes
Cells are too small to be seen with the naked eye		Adaptations of cells in the digestive system
Calculating magnification for a light microscope		Genetics and cell mutations

Figure 2.1

In 2019, scientists working in the Arctic discovered the earliest evidence of multicellular life. Microscopic fossils of a new fungus, given the name *Oursaphria glaciaria*, show cells that are attached and appeared to have been working together. Today, multicellular organisms are familiar to us: the latest estimate suggests that the body of an adult human contains around 37 trillion cells – that is 37,000,000,000,000!

1

Microscopy

Unit 2 Chapter 1

Objectives

- Describe the use and limitations of optical microscopes, transmission electron microscopes and scanning electron microscopes.
- Explain the difference between magnification and resolution.
- Recognise cell structures from photomicrographs and electron micrographs and draw individual cell structures.
- Describe the principles of cell fractionation and ultracentrifugation, and explain why they are used.
- Measure the size of an object viewed with an optical microscope
- Calculate true size (in μm) and magnification, including using scale bars.
- Appreciate that there was a considerable period of time during which the scientific community distinguished between artefacts and cell organelles.

Lesson 1:
Microscopes and cell structures

Lesson 2:
Cell Membranes

Lesson 3:
Transport through cell membranes

Lesson 4:
Movement of water between cells and solutions

Lesson 5:
Active Transport and Co-Transport

We've added lessons from subsequent chapters in order to visually show how this design works with more than 1 chapter. - Design

Chapter 1 Microscopy

Hooke's work coincided with that of Antonie Van Leeuwenhoek in the Netherlands. He was a draper, and had no scientific background. His love of microscopy is thought to have been inspired by *Micrographia*. Van Leeuwenhoek learned how to grind lenses, the parts used to magnify the specimen, and make simple microscopes. His microscopes were small – they were only 80 mm to 100 mm long – but they were powerful. One magnified up to around 270 times (Figure 2.5).

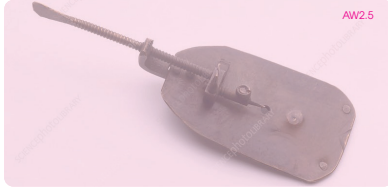


FIGURE 2.5 A replica of one of Van Leeuwenhoek's microscopes. He is known to have made over 500 microscopes, but fewer than 10 have survived.

By the early part of the 19th century, there were major improvements in lens quality and in the mechanisms needed to adjust the moving parts of microscopes. The light microscopes we use today are based on the same principles as the early **compound microscopes** of Hooke and Van Leeuwenhoek. The quality of lenses is, of course, far superior. The image produced by a compound microscope is the product of magnification using two lenses – an **objective lens** and an **eyepiece lens**. With most microscopes, there is normally a choice of objective lenses – or simply, 'objectives' – depending on the magnification required (Figure 2.6).

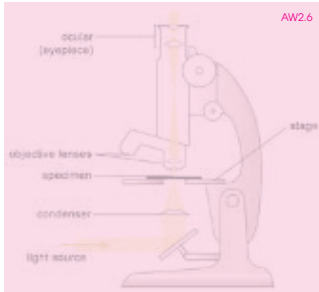


FIGURE 2.6 This light microscope uses visible light as a medium to magnify a specimen. You will explore how to use one of these in the next period.



Hint

Lenses focus light or other types of radiation to produce an image.



Did you know?

If an object is transparent, it will allow light waves to pass through it and therefore will still not be visible. This is why many biological structures have to be treated with special chemicals to **stain** them before they can be seen.



Try this

It is possible to make a very simple microscope using equipment found around the house. Using scissors, cut a hole in the bottom of a transparent plastic cup. Stretch a piece of cling film over the top of the cup and secure it with a rubber band. Find a small specimen, perhaps a piece of plant material, and place it through your cut-out hole in the bottom of the cup. Pour a small volume of water on top of the cling film so that it sits in a small pool. Look at your specimen through the water. The water acts as a lens and makes your specimen look larger. Can you suggest how the magnification and resolving power of your microscope could be improved?



Did you know?

There are two types of microscope slide. A **temporary slide** can be made by mounting a thin piece of tissue in a drop of water. Temporary slide preparation is a useful technique for viewing living specimens quickly. The slide will, of course, dry out in a short space of time and the cell structure will change. In time, the specimen would decay. Sometimes, a **permanent slide** is required as a permanent record of the cells or tissue, for instance in the pathology department of a hospital.



Hint

Magnification relates to size; resolution relates to detail.



Try this

To consider resolution, find at a digital photograph on your computer or phone. If you keep enlarging it, the magnification increases. However, when you start to see the separate pixels, then greater magnification will not lead to greater resolution. You will not be able to see any more detail.

The reason microscopes are used is because they produce images larger than the original objects. This is called **magnification**. This is how many times bigger an image is than the original object, which is called the **specimen**. Although in theory there is no limit to how many times an image can be magnified, at some point it will not be possible to see any more detail. The ability to see detail is a measure of the microscope's **resolution** (or **resolving power**) and is the shortest distance between two separate objects that can still be seen separately (Figure 2.7).

So, what is the smallest specimen that can be magnified by these different types of microscope? In Period 3, you will become familiar with the micrometre (1000 times smaller than a millimetre) and nanometre (1000 times smaller than a micrometre).



FIGURE 2.7 Example to show how two points in a cell might look when viewed through different resolution lenses.

Different types of microscope; different types of image

As you saw in Figure 2.3, there are two fundamentally different types of microscope image. Images produced using a microscope are called **micrographs**. Specifically, images produced by a **light (optical) microscope** are called **photomicrographs**. Images produced by an **electron microscope** are called **electron micrographs**.

Both types of microscope use a form of radiation in order to see the specimen being examined. The light microscope uses **visible light** as a source of radiation, whereas the electron microscope uses **electron beams**. The advantage of electron microscopes is that they can achieve a much greater magnification than light microscopes: more than $\times 1$ million, versus a maximum of $\times 1500$. For example, the structure of viruses, which are much smaller than cells, was first seen using an electron microscope. However, despite this, light microscopes do have some advantages over electron microscopes, as you will see later.

Specimens smaller than 200 nm cannot be seen with a light microscope. To view smaller objects, we must use radiation of a shorter wavelength than visible light. One option is to use ultraviolet light or X-rays. A much better idea, however, is to use electrons. Electrons are negatively charged particles, which in some cases behave like waves. These electron beams have an incredibly short wavelength (about 1 nm). Using an electron microscope, a resolution of 0.5 nm can be obtained, 400 times better than a light microscope. In addition, the negative charge of electrons means that electron beams can be focused using **electromagnets**, which improves resolution. The inside of an electron microscope is shown in Figure 2.8.

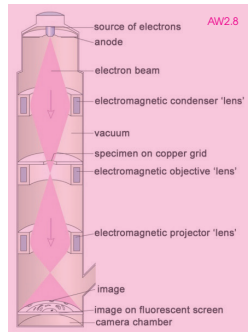


FIGURE 2.8 The workings of an electron microscope. Heating a metal filament cathode in a vacuum tube emits electrons. The electrons are accelerated by applying a voltage. The electrons will tend to follow a straight path, with properties similar to those of light, but the beam of electrons is deflected by electromagnetic fields in the same way as a lens would reflect light rays. Two or more electromagnets are used in the electron microscope to produce magnified images.

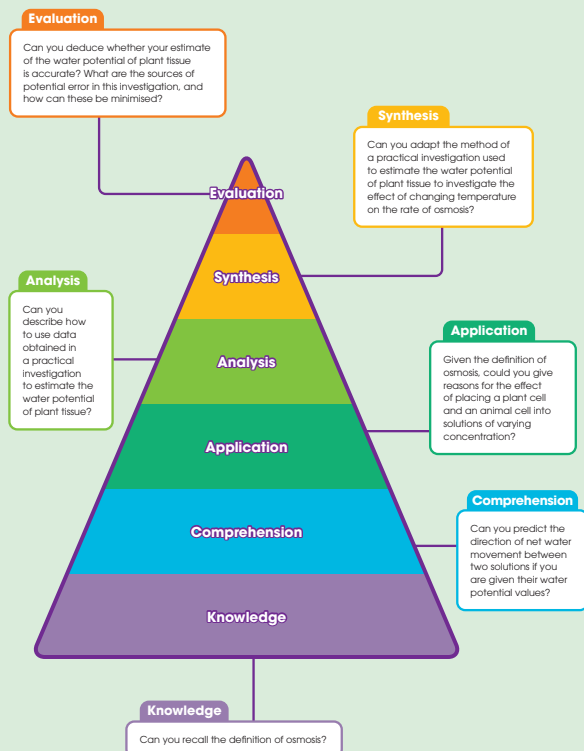
8

9

Unit 2 Review

Unit 2 Review

Skills progression pyramid



Key term definitions

Term	Definition
buffer	A solution which has a pH that changes very little despite being mixed with acid or alkali.
cell biology	The study of living organisms at the level of cells.
cell fractionation	A process used to separate cellular components (organelles) for analysis of their functions.
cell theory	The theory that all living things are made up of cells.
centrifugation	A technique that involves the application of centrifugal force to separate organelles from a mixture according to their mass.
centrifuge	A piece of laboratory equipment that applies centrifugal force to separate organelles from a mixture according to their mass.
compound microscope	A device used to view specimens at increased magnification using two lenses: the objective lens and the eyepiece lens.
electromagnet	A type of magnet in which the magnetic field is produced by an electric current.
electron beams	A stream of electrons, which can be made using a number of different methods.
electron micrograph	An image captured using an electron microscope.
electron microscope	A microscope that uses electron beams as a medium.
eyepiece lens	The part of a microscope down which you view a specimen; its magnification is usually $\times 10$.
filtrate	The solution remaining when a substance is filtered.
filtration	The process of separating particles from a mixture using filter paper.
homogenate	A suspension of cell fragments obtained when tissue is homogenised.
homogenisation	The blending of biological tissue to form a paste-like material, ready for filtration. This is a step in cell fractionation.
homogeniser	The piece of laboratory equipment, likened to a blender which forms a paste-like material from biological material in cell ultracentrifugation.
isotonic	Having the same water potential as a particular fluid.
light (optical) microscope	A microscope that uses visible light as a medium.
magnification	The number of times an object is enlarged in size to be viewed as an image.
micrograph	An image created/captured using a microscope: photomicrographs are created using a light microscope whereas electron micrographs are made using an electron microscope.
micrometre (μm)	A unit for measuring length equivalent to one thousandth of a millimetre ($1 \times 10^{-3} \text{ mm}$).
microscope	Device used to view an object in greater detail using a light source or electron beams for magnification.
millimetre (mm)	A unit for measuring length equivalent to one thousandth of a metre ($1 \times 10^{-3} \text{ m}$).
nanometre (nm)	A unit for measuring length equivalent to one millionth of a millimetre ($1 \times 10^{-9} \text{ m}$).
objective lens	The lens closest to the slide holding the specimen that is being viewed.
pellet	A mass of organelles, sedimented from a mixture by cell ultracentrifugation.
permanent slide	A preparation of a specimen in which the specimen is preserved, dehydrated, embedded in wax, sectioned, stained and mounted in a resin, to produce a slide that will last for many years.
photomicrograph	An image captured using a light (optical) microscope.
resolution	The ability to distinguish two objects from each other.
resolving power	The ability of a microscope to distinguish small or closely adjacent images.
scanning electron microscope (SEM)	A type of electron microscope that produces images of a specimen by scanning the surface with a focused beam of electrons, and which gives information on the surface structure of the specimen.
section	A thin slice of tissue prepared for viewing with a microscope.
specimen	An object to be viewed under a microscope, usually mounted onto a slide.
stain	A coloured chemical, used in solution, to dye the cell so that the microscopical image has contrast.
supernatant	The volume of liquid left in a tube that has been centrifuged.
temporary slide	A preparation of a specimen for microscopy containing living tissue that is not meant to be permanent.
transmission electron microscope (TEM)	A microscopy technique in which a beam of electrons is transmitted through a specimen to form an image.
ultracentrifugation	A specialised technique used to spin samples at exceptionally high speeds in an attempt to separate the organelles in cells.
vacuum	A space that is devoid of matter.
visible light	The portion of the electromagnetic spectrum that is visible to the human eye.

18

19

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White Rose Science Worksheets Year 1 Autumn term
Typesetting and Page Design

Explore materials – wood, plastic, glass and metal



1 Use the key words to label the materials.

metal

plastic

glass

wood









2 What is the same about these objects?



Complete the sentence.

All of the objects are made from _____.

3 What is different about these forks?



Complete the sentence.

They are made from _____.

_____.

4 Help! Diddy is stuck in the ice!



Diddy needs to get out of the ice.

a) How can you help Diddy get out of the ice?

b) What will happen to the ice?

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Typesetting and Poster Design

Connect

How do people demonstrate intelligence?

1

Big Idea

Intelligence

examples:
show empathy

jobs:
dancers work as a team

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Connect

What can sharing knowledge allow us to do?

12

Big Idea

Knowledge

Shared knowledge	Results
Michiko's language	Tobio was able to communicate.

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Connect

What happens when we change our perspective?

4

Big Idea

Perspective

Perspective A	Perspective B
Brigida saw lines.	Brigida learned the lines were pictures that ancient people drew.

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Family and Friends 2 Kazakhstan Edition, Pupil's Book
Resizing Layout to new page dimensions

Kazakhstan Edition

Family and Friends 2

Pupil's Book



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1 All about me

Lesson One Words: I can understand greetings and family words.

- Ask and answer.

Hello, I'm Saken. What's your name? My name's Marzhan.
How are you? I'm fine, thank you.
How old are you? I'm nine.
- Listen and sing. **Let's sing!** Welcome song
Welcome back To all our friends.
Fun and learning A day for learning.
Never end! Billy Tim
- Sing and do. **Let's sing!** Welcome song
Welcome back To all our friends.
Fun and learning A day for learning.
Never end! Billy Tim
- Listen and number. mum dad brother sister grandma grandpa aunt uncle cousin

Unit 1 Hello again

Lesson Four Grammar: I can use can and can't to talk about ability.

- Listen to the story again and repeat. Act.
- Look and say.

Let's learn!

I can skate. I can't skateboard. Can she play tennis? Yes, she can. Can he ride a bike? No, he can't.
- Write. He She They can can't

ride a bike. ride a horse. play football. skate. play tennis. skateboard.
- Point, ask and answer.

Can he ride a bike? Yes, he can.

Let's learn!
I can't You can
He, she, it can They can We can

I can ... Unit 1 7

Lesson Five Song: I can sing a song about clothes and where something is.

- Listen, point and repeat.

skirt scarf gloves jeans boots shirt
- Listen and sing. **Let's sing!** Where is my teddy bear?
Where is my teddy bear?
Where is he?
I can't find him anywhere!
Look behind the bedroom door.
Is he hiding there?
Look behind the bedroom door.
I can't find him anywhere!
Look in front of the sofa...
Look between the bed and chair...
Is he hiding there?
Look next to the big toy box.
Yes, my teddy's hiding there!

Let's learn!
boot = boots
skirt = skirts
scarf = scarves
- Sing and do. **Let's sing!** Where is my teddy bear?
Where is he?
I can't find him anywhere!
Look behind the bedroom door.
Is he hiding there?
Look behind the bedroom door.
I can't find him anywhere!
Look in front of the sofa...
Look between the bed and chair...
Is he hiding there?
Look next to the big toy box.
Yes, my teddy's hiding there!
- Choose skirt, scarf or shirt and sing again.

Unit 1 My clothes and things

Lesson Three Song: I can sing a song about feelings.

- Listen, point and repeat.

tired angry scared brave nervous
- Listen and sing. **Let's sing!** If you're tired and you know it...
If you're tired and you know it,
Go to sleep! [Snore, snore]
If you're tired and you know it,
Go to sleep! [Snore, snore]
If you're tired and you know it,
Go to sleep! [Snore, snore]
If you're scared and you know it,
Hug yourself! [Hug, hug] ...
If you're angry and you know it,
Stamp your feet! [Stamp, stamp] ...
If you're brave and you know it,
Say, 'I can!' [I can!] ...
- Sing and do. **Let's sing!** If you're tired and you know it...
If you're tired and you know it,
Go to sleep! [Snore, snore]
If you're tired and you know it,
Go to sleep! [Snore, snore]
If you're tired and you know it,
Go to sleep! [Snore, snore]
If you're scared and you know it,
Hug yourself! [Hug, hug] ...
If you're angry and you know it,
Stamp your feet! [Stamp, stamp] ...
If you're brave and you know it,
Say, 'I can!' [I can!] ...
- Talk about your friends and family members. mum dad brother sister grandma grandpa cousin uncle aunt friend
This is my friend, Aizere. She's cold.

Unit 2 People I know

Review 1 Lesson Three I can make plans with friends.

Everyday English

- Listening Listen, read and say.

Kate: Are you free after school today?
Ellie: Sorry, I'm not free today.
Kate: How about on Tuesday?
Ellie: Yes, that's fine.

Kate: We can play with my doll's house.
Ellie: Great. I'll ask my mum.
Mrs Smith: Oh! ... Thank you, Ellie.
Ellie: Sorry, Mrs Smith.
- Listen and number.

Monday Tuesday Wednesday mum dad grandpa
- Speaking Ask and answer.

Are you free after school on Tuesday?
Sorry, I'm not free on Tuesday.
How about Wednesday?
Yes, that's fine. I'll ask my dad.

Watch!

Review 1 Lesson Four I can make a mini book and talk about it with my friends.

Project

- Project Make a mini book.

Fold the paper in half. Cut along the top of the book. Your book now has 8 pages.

Colour and stick the pictures. Or draw your own activities.
- Speaking Use the mini book and say.

Are you free on Friday?
Sorry, I'm not free. I go swimming on Friday.
How about Sunday?
Yes, that's fine.
We can listen to music.

Project a mini book

Customer: Westchester

Hathaway Readers
Typesetting and Page Design

GERMS

WHAT IS A GERM?

A germ is a very small thing. Germs can make you sick. Germs get on your hands when you carry things. These things can look clean, but germs are on them.

That is why we wash our hands before we eat. That is why we wash our hands after we go to the bathroom. That is why we wash our hands after we play in the park. That is why we wash when we hurt our bodies. We must try to be clean.

CAN WE SEE GERMS?

Germs are very small and our eyes cannot see them. We need a **microscope** to see them. A microscope makes very small things look bigger. When we look at germs with a microscope, we see there are many kinds. Two kinds of germs are viruses and bacteria. We see a lot of these. Two other kinds of germs are fungi and protozoans. We do not see as many of these.

microscope

A long time ago, people thought that they got sick because of bad **air**. They didn't know about germs before Zacharias Janssen **invented** the microscope in 1590.

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Series redesign and typesetting

1 Higher 10

NEED TO KNOW Find the missing y -values by substituting each x -value in the equation. The roots of the equation are the x -values on the curve at $y=0$

TIP The curve should be smooth and pass through all the marked points

CAUTION Be careful with negative:
 $-x - = +$ $- - = +$
 $-x + = -$ $- + = -$

10 (a) Complete the table of values for $y = x^3 - 5x + 3$

x	-3	-2	-1	0	1	2	3
y	-9		7		-1		

(2)

(b) On the grid, draw the graph of $y = x^3 - 5x + 3$ for the values of x from -3 to 3.

(1)

(c) Using your graph, find all the roots of the equation $x^3 - 5x + 3 = 0$

$x =$ _____ (2)

(5 marks)

1 Higher 14

NEED TO KNOW Describing an enlargement requires the co-ordinates of the centre of enlargement and the scale factor.

TIP If a shape gets larger or smaller and turns upside down, the scale factor will be negative.

CAUTION If a shape gets smaller, the scale factor will be a fraction (<1).

14

Shape P is transformed into shape Q by a simple transformation. Describe fully the transformation.

(3 marks)

Higher 13 1

NEED TO KNOW

area = $\frac{\theta}{360} \times \pi r^2$
 arc length = $\frac{\theta}{360} \times 2\pi r$

TIP Use sector area to find the radius.

CAUTION Do not mix up the radius and diameter. Perimeter is the length around the whole outside

13

The area of sector ACD is $24\pi \text{ cm}^2$.
 $AC : AB = 3 : 4$
 Work out the total perimeter of shape ABCD.
 Leave the answer in terms of π .

(5 marks)

Higher 15 1

NEED TO KNOW For similar solids, if length ratio = $1 : k$ then
 area ratio = $1 : k^2$
 volume ratio = $1 : k^3$

TIP Square root the area ratio to get the length ratio. Use this to find the volume ratio.

CAUTION Have you subtracted the smaller volume to get the final answer?

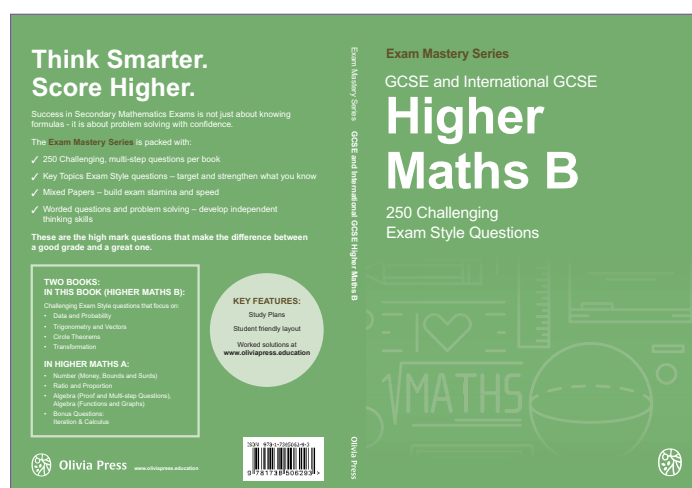
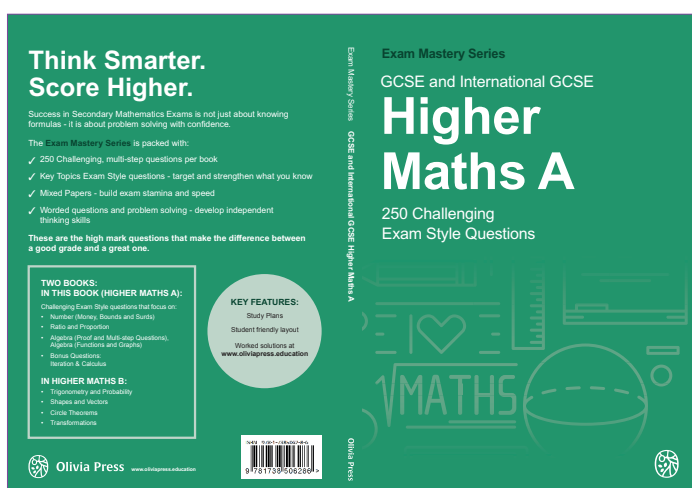
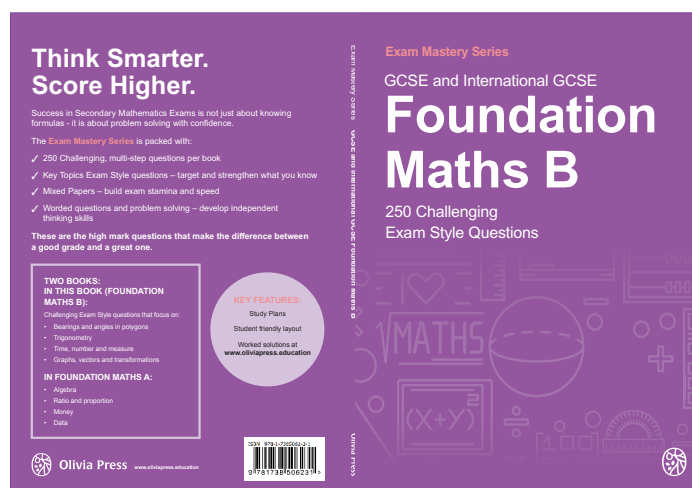
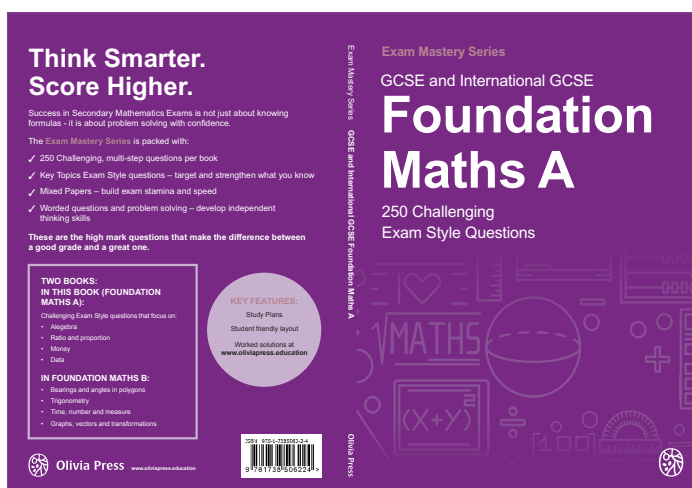
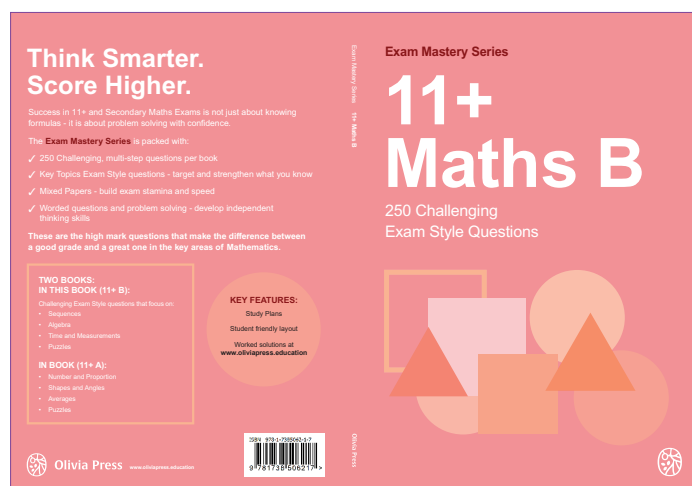
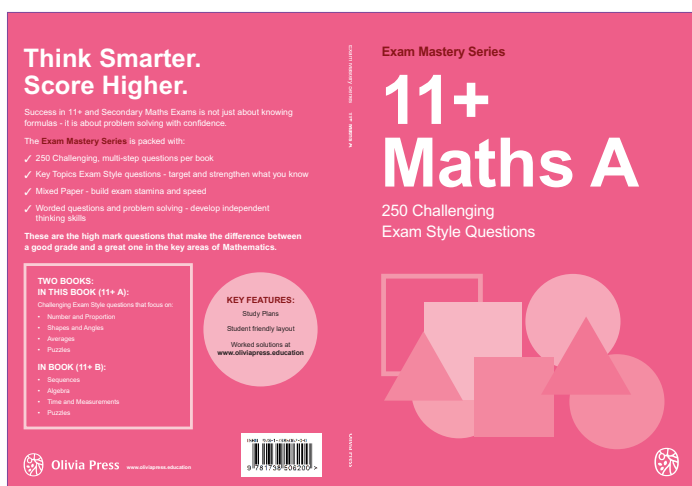
15 A small metal frustum is removed from a larger metal frustum. The two frustums are similar.

The smaller frustum has volume 9 cm^3 and the total surface area $x \text{ cm}^2$.
 The larger frustum has total surface area $16x^2 \text{ cm}^2$.
 Find an expression, in terms of x , for the volume of the larger frustum after the smaller frustum has been removed.

(4 marks)

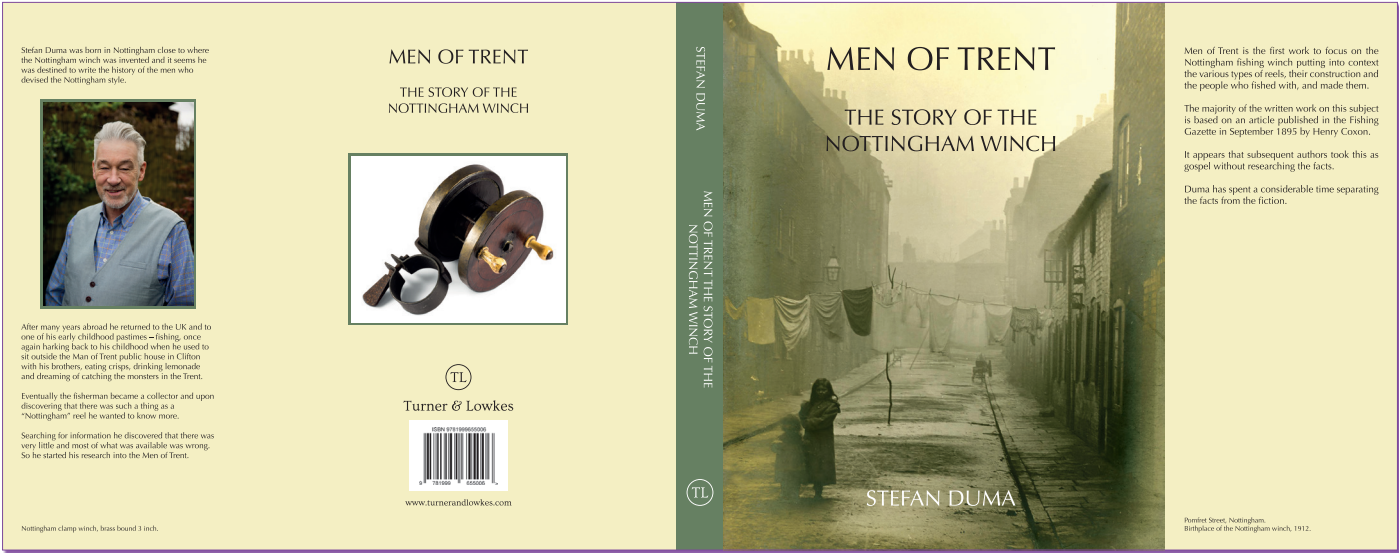
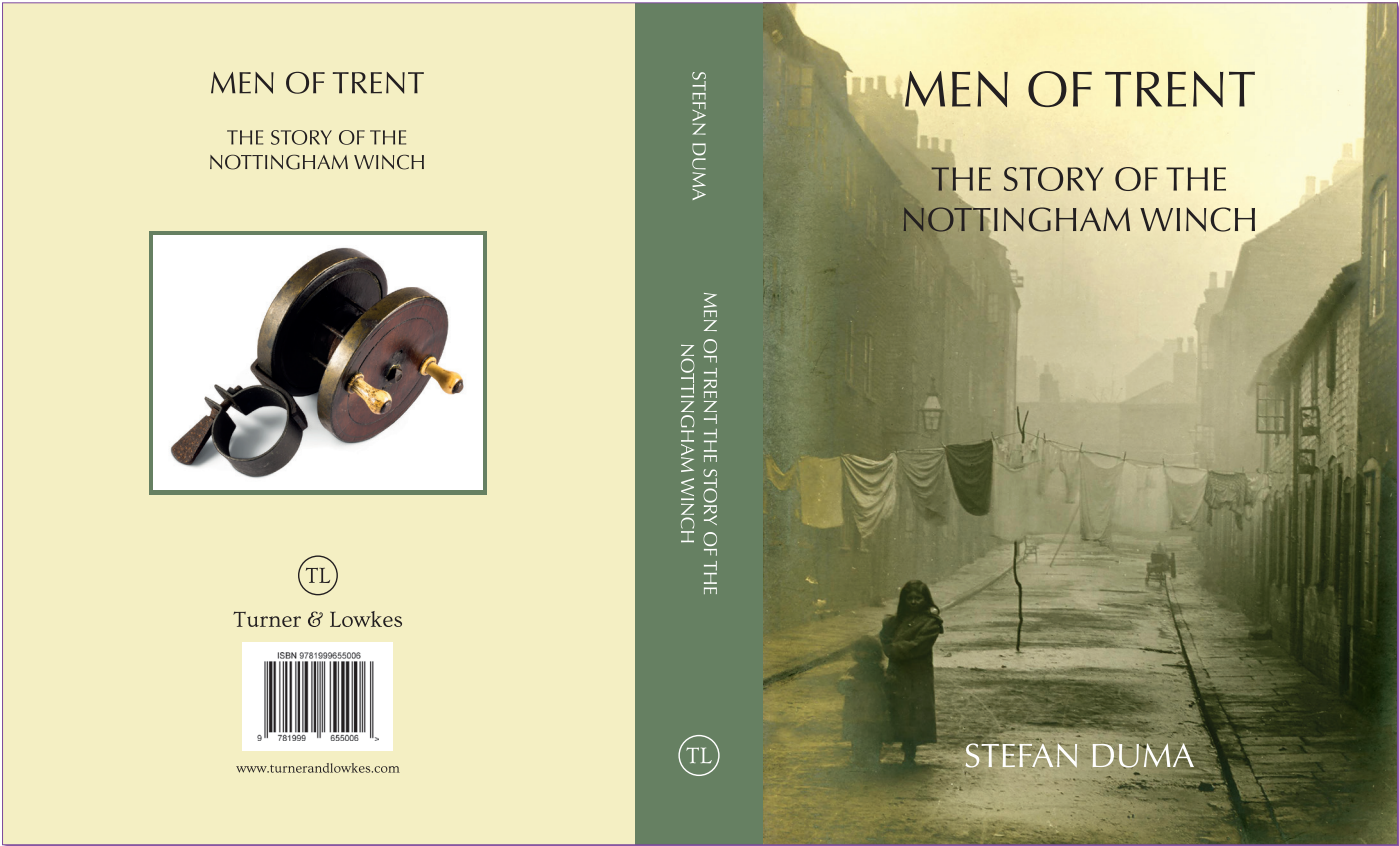
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