Scheme of Work

Cambridge O Level
Mathematics 4024

For examination from 2025

Contents

Introduction

This scheme of work has been designed to support you in your teaching and lesson planning. Making full use of this scheme of work will help you to improve both your teaching and your learners' potential. It is important to have a scheme of work in place in order for you to guarantee that the syllabus is covered fully. You can choose what approach to take and you know the nature of your institution and the levels of ability of your learners. What follows is just one possible approach you could take and you should always check the syllabus for the content of your course.

Suggestions for independent study **(I)** and formative assessment **(F)** and areas where sustainability may be addressed are included. Throughout the scheme of work we have included reference to the Sustainability Development Goals **(SDGs)** sdgs.un.org/goals in the first column, if and where they are relevant and applicable.

Opportunities for differentiation are indicated as extension activities **(E)**; there is the potential for differentiation by resource, grouping, expected level of outcome, and degree of support by teacher, throughout the scheme of work. Timings for activities and feedback are left to the judgement of the teacher, according to the level of the learners and size of the class. Length of time allocated to a task is another possible area for differentiation.

Guided learning hours

Guided learning hours give an indication of the amount of contact time you need to have with your learners to deliver a course. Our syllabuses are designed around 130 hours for Cambridge O Level courses. The number of hours may vary depending on local practice and your learners' previous experience of the subject. The table below give some guidance about how many hours we recommend you spend on each topic area.

Topic	Suggested teaching time (hours / % of the course)	Suggested teaching order
Introduction to mathematics I	13hrs/10%	1
Introduction to mathematics II	13hrs/10%	2
Further algebra, Pythagoras' theorem, surds and appropriate accuracy	13hrs/10%	3
Coordinate Geometry I, Ratio and Scale Drawing	13hrs/10%	4
Probability I, geometry and graphs	13hrs/10%	5
Circles, 3D mensuration, vectors and cumulative frequency	13hrs/10%	6
Standard form, similarity, trigonometry I and probability II	13hrs/10%	7

Topic	Suggested teaching time (hours / % of the course)	Suggested teaching order
Coordinate geometry II, accuracy and trigonometry II	13hrs/10%	8
Sets, scatter diagrams, 3D trig and vector geometry	10hrs/8% (include time for exam preparation)	9
Functions, histograms (& differentiation)	10hrs/8% (include time for exam preparation)	10

Resources

You can find the endorsed resources to support Cambridge O Level Mathematics on the Published resources tab of the syllabus page on our website https://www.cambridgeinternational.org/programmes-and-qualifications/cambridge-o-level-mathematics-d-4024/.

Endorsed textbooks have been written to be closely aligned to the syllabus they support, and have been through a detailed quality assurance process. All textbooks endorsed by Cambridge International for this syllabus are the ideal resource to be used alongside this scheme of work as they cover each learning objective. Throughout this scheme of work we refer to our Cambridge O Level Mathematics 4024 past papers. In addition to reading the syllabus, teachers should refer to the updated specimen assessment materials.

Tools to support remote teaching and learning – to find out about and explore the various online tools available for teachers and learners.

School Support Hub

The School Support Hub www.cambridgeinternational.org/support is a secure online resource bank and community forum for Cambridge teachers, where you can download specimen and past question papers, mark schemes and other teaching and learning resources. We also offer online and face-to-face training; details of forthcoming training opportunities are posted online. This scheme of work is available as PDF and an editable version in Microsoft Word format; both are available on the School Support Hub at www.cambridgeinternational.org/support. If you are unable to use Microsoft Word you can download Open Office free of charge from www.openoffice.org

Websites

This scheme of work includes website links providing direct access to internet resources. Cambridge Assessment International Education is not responsible for the accuracy or content of information contained in these sites. The inclusion of a link to an external website should not be understood to be an endorsement of that website or the site's owners (or their products/services).

The website pages referenced in this scheme of work were selected when the scheme of work was produced. Other aspects of the sites were not checked and only the particular resources are recommended.

Scheme of Work

How to get the most out of this scheme of work – integrating syllabus content, skills and teaching strategies

We have written this scheme of work for the Cambridge O Level Mathematics syllabus and it provides some ideas and suggestions of how to cover the content of the syllabus. We have designed the following features to help guide you through your course.

Learning objectives help your learners by making clear the knowledge they are trying to build. Pass these on to your learners by expressing them as 'We are learning to / about…'.

Suggested teaching activities give you lots of ideas about how you can present learners with new information without teacher talk or videos. Try more active methods which get your learners motivated and practising new skills.

Independent study (I) gives your learners the opportunity to develop their own ideas and understanding without direct input from you.

Sustainability Development Goals (SDG) references and links to further classroom activities.

Extension activities provide your more able learners with further challenge beyond the basic content of the course. Innovation and independent learning are the basis of these activities.

Formative assessment (F) is ongoing assessment which informs you about the progress of your learners. Don't forget to leave time to review what your learners have learnt, you could try question and answer, tests, quizzes, 'mind maps', or 'concept maps'. These kinds of activities can be found in the scheme of work.

Resource Plus provides ready built, multi-media rich Teaching Packs with lesson plans. Access these through the School Support Hub syllabus page www.cambridgeinternational.org/support

Past papers, specimen papers and **mark schemes** are available for you to download at: www.cambridgeinternational.org/support

Using these resources with your learners allows you to check their progress and give them confidence and understanding.

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
		between life expectancy and average height for different countries.
6.4 Pythagoras' theorem and trigonometry in 3D	Carry out calculations and solve problems in three dimensions using Pythagoras' theorem and trigonometry, including calculating the area between a line and a plane.	Use a flagpole supported by wires or similar situation to introduce a problem in three dimensions needing the use of trigonometry or Pythagoras' theorem, revising the work as necessary. Show learners how the right-angled triangle required and teach them to draw a sketch of this triangle, showing the right its true size to assist in the solution. Learners often find it difficult to visualise the triangle required. One method is to use pieces of wire spaghetti with small pieces of poster mounting putty or non-hardening modelling clay to make 3D and highlight the triangles that are used in solving questions. Alternatively, use cardboard models sections cut away to show the section required. (I) Give practice in solving problems. (I) (F) Ask learners to design a net for a pyramid-shaped gift box with a given height a Learners consider the level of accuracy for a practical problem, e.g. finding the mountain. How accurate are the measurements? What are the upper and lower effect will this have on the final answer? Giving values for sin, cos or tan that ar common error in examinations; the results of this activity should demonstrate th measurement can have a significant impact on the result. (E) Reinforce or assess understanding of this topic using this workbook on 3D geom http://www.cimt.org.uk/projects/mepres/allgcse/bkc18.pdf (I) (F) SDG 9 Consider using trigonometry for working out railway inclines.
7.3 Magnitude of a vector	Calculate the	Use diagrams to help illustrate how to calculate the magnitude of a vector; link t theorem from topic 6.1. **Resource Plus** Teaching Pack: Vectors The Teaching Pack includes lessons on: • properties of vectors • vectors and translations • adding and subtracting vectors • vectors in real life contexts • vector geometry.

Past and specimen papers

Past/specimen papers and mark schemes are available to download at www.cambridgeinternational.org/support (F)

1. Introduction to mathematics I

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
1.1 Types of number	Identify and use: • natural numbers • integers (positive, negative and zero) • prime numbers • square numbers • cube numbers • common factors • common multiples • rational and irrational numbers • reciprocals.	As a useful starting point, revise positive and negative numbers using a number line and explain the difference between natural numbers and integers. Provide learners with definitions of the listed terms (e.g. factor, multiple, square number) which are on the Maths Revision website (www.mathsrevision.net). If the link doesn't work: from the home page, select 'GCSE > number > numbers'. **(I)** A fun activity is to allocate a number to each learner in the class and ask them to stand up if their number exhibits a property that you call out. For example, you might call out "a multiple of 4"; "a factor of 18", etc. Use this to show interesting facts, such as prime numbers will have 2 people standing up (this emphasises that 1 is not prime); and square numbers will have an odd number of people standing up. You can use this activity to highlight common factors / common multiples for pairs of numbers. This could be extended to highest common factors (HCF) and lowest common multiples (LCM). Don Steward has posted a challenge to identify pairs of numbers from the HCF and LCM which is available at [donsteward.blogspot.co.uk\search\label\LCM and HCF](donsteward.blogspot.co.uk\search\label\LCM and HCF) **(E)** As a follow-on activity, learners identify a number from a description of its properties. For example, say to the class "which number less than 50 has 3 and 5 as factors and is a multiple of 9?" You could also ask learners to make up their own descriptions and test one another. **(I)** The Strange Bank Account from NRICH provides a starting point for an interesting investigation: nrich.maths.org/9923 **(I) (E)** Another interesting task is to look a Fermat's discovery, which shows that some prime numbers are the sum of two squares, e.g. $29 = 25 + 4 = 5^2 + 2^2$. Ask learners to find what other prime numbers they can form in this way, and any they can't form in this way. Then ask if they can formulate a rule that tests if a prime can be made like this. **(E)** Look at how to write any integer as a product of prime numbers. Demonstrate the factor tree method to your learners (you can find this online), then ask them to practise using this method to write other numbers as products of primes. Then ask learners to find the product of primes of other numbers, for example 60, 450, 42, 315, but this time, ask them to look for alternative methods, for example by researching on the internet; another useful method is the repeated division method. **(I)** Give learners a definition of the terms rational, irrational and real numbers, which you can find on the Maths is

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
		Fun website (www.mathsisfun.com). If the link doesn't work, from the home page: click on 'Index > 10 upwards > numbers > Irrational Numbers. The website also includes questions on rational and irrational numbers for learners to try. These start simple and soon become more challenging. **(I) (F)**
1.6 The four operations	Use the four operations for calculations with integers, fractions and decimals, including correct ordering of operations and use of brackets.	As a starter activity, ask learners to work in groups to use four 4s and the four rules for calculations to obtain all the whole numbers from 1 to 20, e.g. 4 + 4 × 4 – 4 = 16. Next look at long multiplication, and short and long division. You can see repeated subtraction (chunking) examples on the 3 Minute Maths channel at www.youtube.com/. (If the link doesn't work, search for 'Chunking division 3 Minute Maths' on You Tube.) Or go to www.bbc.co.uk/schools/gcsebitesize/maths. If the link doesn't work, search for 'Long multiplication and division' on the BBC Bitesize website. This should be revision for most but is worth spending a bit of time on to ensure learners are confident in the methods. Clarify the order of operations, including the use of brackets. Highlight common errors such as working from left to right instead of using the order of operations rule, BIDMAS (Brackets Indices Division Multiplication Addition and Subtraction). Give learners some examples that illustrate the rules for multiplying and dividing with negative numbers. Extend this to using the four rules with fractions (including mixed numbers) and decimals. It is important that learners can do these calculations both with and without the use of a calculator as they may be expected to show working. Ask a variety of questions using 'Would you rather..?' that require learners to use mathematical calculations, e.g. Would you rather have a stack of coins (use a small local currency, e.g. 25 cents) from the floor to the top of your head OR $225? **(I) (E)** To check their understanding learners can try past paper questions. **(I)**
1.7 Indices I	1. Understand and use indices (positive, zero, negative and fractional). 2. Understand and use the rules of indices.	Start by revising the meaning of positive indices and the basic rules of indices such as $3^3 × 3^5 = 3^8$, $5^4 ÷ 5^3 = 5^1 = 5$, etc. Give learners simple examples to revise writing an integer as a product of prime numbers, including writing answers using index notation. Try to avoid using 2 as the number you work with initially as learners may think, incorrectly, that 2^3 means 2 × 3 because of the exception that is 2^2. You can discuss this exception once learners understand the concept. An interesting challenge for learners is the puzzle 'Power Crazy' on the Nrich website (nrich.maths.org). Ask learners to work in groups to complete the challenge. This can be extended to 'Excel investigation: Power Crazy' on the same website. This example also illustrates that although a spreadsheet can be used as a tool to make calculations, we need our brains to solve the problem using reasoning. **(E)**

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
		Move on to negative, zero and fractional indices. Useful examples are $2^{-1}=2^{(2-3)}=\frac{2^2}{2^3}=\frac{1}{2}$ and $2^0=2^{(3-3)}=\frac{2^3}{2^3}=1$ You can move on to introducing fractional indices by relating them to roots (of positive integers), for example $4^{\frac{1}{2}}\times 4^{\frac{1}{2}}=4^1=4$ so $4^{\frac{1}{2}}=\sqrt{4}=2$. Use the rules of indices to show how values such as $16^{\frac{3}{4}}$ can be simplified. Learners should try lots of examples and questions. **(I)**
1.3 Powers and roots	Calculate with the following: • squares • square roots • cubes • cube roots • other powers and roots of numbers.	Using simple examples, illustrate squares, square roots, cubes and cube roots of integers. Extend this by asking more able learners to find the square and cube of fractions and decimals without using a calculator; you might need to cover topic 1.7 Indices I first to help with this. Show how to find the square root of an integer by repeated subtraction of consecutive odd numbers until you reach zero. For example, for 25 subtract in turn 1, 3, 5, 7, and then 9 to get to 0. Five odd numbers have been subtracted so the square root of 25 is 5. Ask learners to investigate this method for other, larger, square numbers. **(I)** Explain to learners that the square number 121 is palindromic (when the digits are reversed it is the same number). Challenge learners to find all the palindromic square numbers less than 1000. **(I)** To check their understanding, learners can then try an past paper question. **(F)**
1.14 Using a calculator	1. Use a calculator efficiently. 2. Enter values appropriately on a calculator. 3. Interpret the calculator display appropriately.	Start this topic by using examples to show how to estimate the answer to a calculation by rounding each figure in the calculation to 1 significant figure. Learners then check their estimates by doing the original calculation using a calculator. Find good exercises and ask learners to practise. **(I)** As an interesting extension activity to link this work to percentages, learners investigate the percentage error produced by rounding calculations using addition/subtraction and multiplication/division. (Make sure you explain percentage error beforehand.) **(E)**
2.1 Introduction to algebra	1. Know that letters can be used to represent	An effective start to this topic is revising basic algebraic notation. For example, $a + a = 2a$, $b \times c = bc$ (emphasising that cb is the same as bc but that the convention is to write letters in alphabetical order). Also look at simple examples with indices $d \times d = d^2$ and $e \times e \times e \times e = e^4$. Explain to learners how to substitute

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
	generalised numbers. 2. Substitute numbers into expressions and formulas.	numbers into a formula, including formulae that contain brackets. Ask learners to work in groups to look at the difference between simple algebraic expressions which are often confused. For example, 'Find the difference between $2x$, $2 + x$ and x^2 for different values of x'. Ask learners "is there a number that makes them all equal?" Move on to more complicated formulae when substituting, for example those with many orders of operations to consider. You can link the work on transforming formulae to the work on solving equations, asking learners to think about the balance method used in both.
2.2 Algebraic manipulation	1. Simplify expressions by collecting like terms. 2. Expand products of algebraic expressions. 3. Factorise by extracting common factors. 4. Factorise expressions of the form: • $ax + bx + kay + kby$ • $a^2x^2 - b^2y^2$ • $a^2 + 2ab + b^2$ • $ax^2 + bx + c$ • $ax^3 + bx^2 + cx$ 5. Complete the square for expressions in the	Start by revising all aspects of directed numbers with all four operations and link this to positive and negative algebraic terms with the four operations. Make sure learners can work with negative numbers as this is important in algebraic work. You will need to use examples, with both positive and negative numbers, to illustrate expanding brackets. Start simply with a single term being multiplied over a bracket containing two or more terms. Extend this technique to multiplying two simple linear brackets together for example $(x - 3)(x + 7)$. It may be useful to build on the grid method of multiplication linked to the partitioning of numbers. You could use a 2×2 algebraic multiplication grid to help with learners' understanding. The next step is to use examples, with both positive and negative numbers, to illustrate factorising simple expressions with one bracket. Explain that factorising is the reverse of expanding. Follow on with examples where learners will need to find the products of algebraic expressions, for example $(x^2 + 3x - 4)(x - 5)$. Building on the earlier factorising work, use examples to show learners how to factorise three-term quadratic equations, initially where the coefficient of x^2 is 1. Include examples of simple difference of two squares, such as $x^2 - 16$, emphasising that these can be solved using the same method as three-term quadratics bearing in mind that the coefficient of the x term is 0. There are some good questions to get your learners practising factorising simple quadratics on slide 5 of the PowerPoint presentation 'Factorising quadratic expressions' on the TES website (www.tes.co.uk). A really challenging topic is that of factorising quadratics where the coefficient of x^2 is **not** 1. It is worth spending a considerable amount of time on this topic, including revisiting it throughout the course to make sure learners remember the methods. A higher-order thinking skill is to ask learners to compare different methods for tackling a question. This is particularly useful for more able learners. Ask them to compare the two different methods for factorising quadratics of the form $ax^2 + bx + c$, where $a \neq 1$. The first method is on slide 16 of the

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
	form $ax^2 + bx + c$	PowerPoint presentation above, (which uses splitting the x term into two terms and then factorising by grouping). The second method is on Mr Barton Maths website (mrbartonmaths.com) in the eBook 'The Maths E-Book of Notes and Examples' in the section 'More factorising quadratics' (which uses a trial and error approach). To support learners' understanding, the Maths is Fun website (www.mathsisfun.com) has a good explanation of completing the square that uses multiple representations. (If the link doesn't work, search 'Completing the square'.) Finally, give learners example problems requiring them to factorise the difference of two squares, for example $16x^2 – 25y^2$. Discuss two-term quadratic factorising examples such as $18x^2 – 24x$. Emphasise that these are often poorly answered. Point out that because they are quadratics learners often try to use two sets of brackets instead of just the one set of brackets required.
9.1 Classifying statistical data	Classify and tabulate statistical data.	Use simple examples to revise collecting data and presenting it in a frequency (tally) chart. For example, record the different makes of car in a car park, or record the number of words on the first page of a series of different books. Ask learners to conduct an experiment of this type, tabulating their data. Use examples to classify data using statistical terminology, e.g. discrete, continuous, numerical (quantitative), non-numerical (qualitative). Use examples to show how to draw simple inferences from statistical diagrams, and tables including two-way tables. Resource Plus Teaching Pack: Statistics The Teaching Pack includes lessons on: • predicting trends, considering data models and effective questioning • bar charts and histograms • representations, restrictions and relationships between data • cumulative frequency and box-and-whisker plots. **SDG 11 / 13** Consider collecting and presenting local data such as **distance** travelled to school or annual rainfall over time.

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
4.2 Geometrical constructions	1. Measure and draw lines and angles. 2. Construct a triangle, given the three sides, using a ruler and pair of compasses only. 3. Draw, use and interpret nets.	Reinforce accurate measurement of lines and angles through various exercises. For example, each learner draws two lines that intersect. Measure the length of each line to the nearest millimetre and one of the angles to the nearest degree. Each learner should then measure another learner's drawing and compare answers. Ask learners to draw any triangle and then measure the three angles and check that they add up to 180°. Show how to construct a triangle using a ruler and a pair of compasses only, given the lengths of all three sides. The Maths is fun website (www.mathsisfun.com) has a useful animation, 'Constructing a triangle with 3 known sides', to demonstrate. Explore some geometric solids and their properties on the Illuminations website (illuminations.nctm.org); search for 'Geometric solids'. **(I) (E)**
1.15 Time	1. Calculations involving time: seconds (s), minutes (min), hours (h), days, weeks, months, years, including the relationship between units. 2. Calculate times in terms of the 24-hour and 12-hour clock. 3. Read clocks and timetables.	Revise the units used for measuring time, with examples showing how to convert between hours, minutes and seconds. It is useful to use television schedules and bus/train timetables to help with calculations of time intervals, and conversions between 12-hour and 24-hour clock formats. Ask learners to work in pairs or small groups to create a timetable for buses or trains running between two local towns. To extend a topic that is relatively easy for more able learners, there is an interesting case study online called 'Scheduling an aircraft' on the Centre for Innovation in Mathematics Teaching website (www.cimt.org.uk). It is useful for learners to look at world time differences and the different time zones. You could ask them to research and annotate a world map with times in various cities assuming it is 12:00 pm where you live. Learners can find times at www.timeanddate.com by searching for the worldclock. **(I)** A common error associated with time calculations occurs when learners use a calculator and are given a decimal answer, e.g. '5.3'. Make sure your learners understand that this means '5 hours 18 minutes' not '5 hours 3 minutes' or '5 hours 30 minutes'. You can illustrate this using the decimal time converter at www.springfrog.com; search for the 'Convert between hours minutes & seconds and decimal time' page.
5.1 Units of measure	Use metric units of mass, length, area, volume and capacity in practical situations and convert quantities into larger and smaller units.	First, use practical examples to illustrate how to convert between: millimetres, centimetres, metres and kilometres; grams, kilograms and tonnes; millilitres, centilitres and litres, for example, by looking at various measuring scales. Then learners investigate connections between non-linear units, for example by drawing a variety of squares and rectangles, marking key dimensions using mm, cm and m and using these to find areas in mm, cm and m. Use their results to deduce conversion factors for these square units.

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
		Extend this work to look at converting between units of area mm^2, cm^2 and m^2 and volume mm^3, cm^3 and m^3. More able learners may find it interesting to explore the link between the work on converting between area units and the work on ratio (topic 1.11) and similar shapes (topic 4.4), and can look at using scales on maps to work with areas. **(E)** Resource Plus Teaching Pack: Unit conversions The Teaching Pack includes lessons on: - converting between simple units of measure - area and volume - compound measures - interpreting travel and conversion graphs. **SDG 14/15** Consider using units related to sustainability topics.

Past and specimen papers
Past/specimen papers and mark schemes are available to download at www.cambridgeinternational.org/support **(F)**

2. Introduction to mathematics II

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
1.4 Fractions, decimals and percentages	1. Use the language and notation of the following in appropriate contexts: • proper fractions • improper fractions • mixed numbers • decimals • percentages. 2. Recognise equivalence and convert between these forms.	Give learners a definition of the relevant terms (e.g. numerator, denominator, equivalent fractions, simplify, proper fraction, improper fraction, mixed number, decimal and percentage). Ask learners to produce a crossword with the terms defined. Ask them to add any other terms that they can think of to do with fractions, decimals and percentages. Learners can easily create crosswords using the excellent online software at EclipseCrossword.com (www.eclipsecrossword.com) **(I)** Use clear examples and questions to cover converting between fractions, decimals and percentages. Learners should understand how to use place value (units, tenths, hundredths, etc.) to change a simple decimal into a fraction. For example 0.3 has 3 in the tenths column so it is $\frac{3}{10}$. Look at the online lesson 'converting repeating decimals to fractions' at Basic-Mathematics.com (www.basic-mathematics.com) to demonstrate how to convert recurring decimals to fractions. It uses the following method: $x = 0.15151515\ldots.$ $100x = 15.15151515\ldots$ subtract these to get $99x = 15$ so $x = \frac{15}{99} = \frac{5}{33}$ Emphasise the appropriate recurring decimal notation, e.g. $0.1\dot{7}=0.1777\ldots, 0.1\dot{2}\dot{3}=0.1232323\ldots, 0.\overline{123}=0.123123\ldots$. To check their understanding, learners can then try a past paper question. **(F)**
1.13 Percentages	1. Calculate a given percentage of a quantity.. 2. Express one quantity as a percentage of another. 3. Calculate percentage	The best starting point is to revise converting between percentages and decimals. You can use examples that require learners to find percentages of quantities, such as: to find 15% of $24, calculate 0.15 × 24 = 3.6 so the answer is $3.60. (Remind learners that in money calculations it is conventional to use 2 d.p. for dollar answers). Encourage learners to practise mental arithmetic methods too, for example: divide by 10 to find 10%, halve this to find 5% and add these results to find 15%. Then, use examples to show how to express one quantity as a percentage of another including where there is a mixture of units. Extend the work on finding percentages of quantities to looking at how to calculate percentage increases and decreases. For example, to increase something by 15% you need to multiply by 1.15; to decrease something

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
	increase or decrease. 4. Calculate with simple and compound interest. 5. Calculate using reverse percentages.	by 15% you need to multiply by 0.85. Provide practice examples. **(I)** Make sure learners don't have the common misunderstanding that increasing a quantity by 50% and then decreasing the resulting quantity by 50% leads back to the original value. Introduce the formula $I = PRT$, where I = interest earned, P is the investment, R is the percentage rate and T is the time. Use this formula to solve a variety of problems involving simple interest, including those requiring learners to use rearranged versions of the formula. Learners are required to calculate compound interest, ideally in a single calculation, using the formula: Value of investment = $P(1+\frac{r}{100})^n$ where P is the amount invested, r is the percentage rate of interest and n is the number of years of compound interest. For example, the compound interest earned on an investment of \$500 over 4 years at a rate of 3% interest is 500×1.03^4. An interesting task is to ask learners to research the cost of borrowing money from different banks. Move on to calculations involving reverse percentages. There are two good videos explaining two different approaches for reverse percentages questions: • 'Reverse percentages' on YouTube by 'MrArnoldsMaths' (www.youtube.com/watch?v=OQ9T1-0Up6I) • 'Reverse percentages' on the B Grade Maths website (bgrademaths.blogspot.co.uk) Ask learners to compare these methods and to decide which method they think is easier. The STEM learning website (www.stem.org.uk/resources) has an excellent lesson on reverse percentages; search for 'Using Percentages to Increase Quantities N7.' The resource makes links between percentages, decimals and fractions, represents percentage increase and decrease as a multiplication and recognises the inverse relationship between increase and decrease. This material tackles the misconception that an increase of 50% followed by a decrease of 50% will take you back to the original value. 'Singapore Maths' bar modelling can be used effectively to visualise reverse percentage problems. The Great Maths Teaching Ideas website (www.greatmathsteachingideas.com) includes an introduction on how to use a bar model with basic proportional reasoning problems; search for 'Bar modelling – a powerful visual approach for introducing number topics'. This can be easily extended to include reverse percentage problems. **(E)** **SDG 7 / 9** Consider the efficient production/transmission of energy, or using resources efficiently with waste % being calculated e.g., how much food is not eaten on 1 day as a % of food prepared
1.16 Money	1. Calculate with	Use examples to show how to solve straightforward problems involving exchange rates. It is useful for

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
	money. 2. Convert from one currency to another.	learners if you link this work to syllabus section 2.9 (conversion graphs). Find up-to-date exchange rates from a daily newspaper or online. Learners compare offers, or investigate offers that do not represent good value for money. They could collect their own information from websites or local retailers, or use images. **(E)** To check their understanding, learners can then try past paper questions. **(F)** Resource Plus Teaching Pack: Unit conversions The Teaching Pack includes lessons on: • converting between simple units of measure • area and volume • compound measures • interpreting travel and conversion graphs. **SDG 5** Consider comparing wages, either in different countries, or male/female, or any other suitable local discriminant.
9.2 Interpreting statistical data	1. Read, interpret and draw inferences from tables and statistical diagrams. 2. Compare sets of data using tables, graphs and statistical measures. 3. Appreciate restrictions on drawing conclusions from	Explore the Gapminder website (https://www.gapminder.org/) for some interesting ways of displaying data and access to a wide range of data sets. Encourage learners to bring in examples of data used in the media. Discuss how the data is represented. Is it designed to be informative, or to deliver a particular message, or to sell something? 'Interpreting Bar Charts, Pie Charts, Box and Whisker Plots S5' on the STEM learning website (www.stem.org.uk) gives learners the opportunity to interpret bar charts and pie charts, and helps them appreciate the benefits and limitations of these representations. The second part of the resource also compares box-and-whisker plots, which is useful for topic 9.6. **(E)** Resource Plus Teaching Pack: Statistics The Teaching Pack includes lessons on: • predicting trends, considering data models and effective questioning • bar charts and histograms • representations, restrictions and relationships between data

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
	given data.	• cumulative frequency and box-and-whisker plots. **SDG 11 / 13** Consider interpreting local data such as distance travelled to school or annual rainfall over time.
9.3 Averages and measures of spread	1. Calculate the mean, median, mode and range for individual data and distinguish between the purposes for which these are used. 2. Calculate an estimate of the mean for grouped discrete or grouped continuous data 3. Identify the modal class from a grouped frequency distribution.	Show how to work out the mean, the median and the mode from a list of data or from a frequency table. Explain that if there are two middle values, learners need to find the half-way point for the median, because there can only be one median, but there can be more than one mode or no mode. Use simple examples to highlight how these averages may be used. For example, in a discussion about average salaries the owner of a company with a few highly paid managers and a large work force may wish to quote the mean wage rather than the median. 'Mean, median and mode' at www.mathsteacher.com has examples of when to use the different averages for different situations. Use the 'Life Expectancy' PowerPoint and resources on the Gapminder website (www.gapminder.org/) to explore averages in a topical real-life situation. Include examples where the mean is given and the number of people, total or an individual value needs to be found. Ask learners to work out how adding or removing a piece of data would change the mean of a distribution. **(I)** An interesting challenge where learners decide which of two poems is easier to read is at donsteward.blogspot.co.uk/2012/10/two-poems.html **(E)** Explain how the mode can be recognised from a frequency diagram. Use examples to show how to calculate an estimate for the mean of data in a grouped frequency table using the mid-interval values. Look at the examples and questions on the Centre for Innovation in Mathematics Teaching website (www.cimt.org.uk/) **(I)** A good explanation of how to estimate the mean for grouped data, including identifying the modal class is at www.mathsisfun.com. See 'Mean, Median and Mode from Grouped Frequencies'. Explain how to find the interval that contains the median; for more able learners you could show them the

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
		idea of linear interpolation. **(E)** Investigate the differences between calculating the mean from a list of values and using the same data in different grouped frequency distributions to estimate the mean. **(E)** Resource Plus Teaching Pack: Statistics The Teaching Pack includes lessons on: • predicting trends, considering data models and effective questioning • bar charts and histograms • representations, restrictions and relationships between data • cumulative frequency and box-and-whisker plots. **SDG 3** Consider calculating statistics for life expectancy in your country and other countries.
9.4 Statistical charts and diagrams	Draw and interpret: • bar charts • pie charts • pictograms • simple frequency distributions.	Use the data collected in the activity recommended for topic 9.1 to construct a pictogram, a bar chart and a pie chart. Point out that the bars in a bar chart can be drawn apart. Investigate the length of words used in two different newspapers and present the findings using statistical diagrams (links to newspapers are at onlinenewspapers.com). **(I)** Resource Plus Teaching Pack: Statistics The Teaching Pack includes lessons on: • predicting trends, considering data models and effective questioning • bar charts and histograms • representations, restrictions and relationships between data • cumulative frequency and box-and-whisker plots.
5.2 Area and perimeter	Carry out calculations involving the perimeter and area of a rectangle, triangle, parallelogram and trapezium.	Begin this topic by reminding learners how to calculate the perimeter and area of a rectangle, square and a triangle. Extend to looking at how to calculate the area of a parallelogram and a trapezium, and a variety of compound shapes. An interesting investigation is to look at using isometric dot paper to find the area of shapes that have a perimeter of 5, 6, 7, ... , units.

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
24		Ask learners to find out what shape quadrilateral has the largest area when the perimeter is, for example 24 cm. **(E)** Challenge learners to use graph paper to make a shape that has a million squares – this could form the basis of a classroom display. You could use 'Viva las Colas!' to generate a variety of interesting questions about volume: www.101qs.com/112-viva-las-colas **(E)**
4.1 Geometrical terms	1. Use and interpret the following geometrical terms: • point • vertex • line • plane • parallel • perpendicular • perpendicular bisector • bearing • right angle • acute, obtuse and reflex angles • interior and exterior angles • similar • congruent • scale factor. 2. Use and interpret the vocabulary of: • Triangles • special quadrilaterals • polygons	Use flashcards at Quizlet (quizlet.com) to look at the geometrical terminology. Introduce the terminology for bearings, similarity and congruence briefly as similar shapes and three-figure bearings will be studied in more detail in topics 4.3 Scale drawings and 6.2 Right-angled triangles. A good extension activity is for learners to investigate how to determine congruence (showing that two shapes are congruent is not required). **(E)** Illustrate common solids, e.g. cube, cuboid, tetrahedron, cylinder, cone, sphere, prism, pyramid. Define the terms vertex, edge and face. **Resource Plus** Teaching Pack: Understanding Bearings The Teaching Pack includes lessons on: • angle facts • bearings, compass points and angle facts • trigonometry and bearings. **Resource Plus** Teaching Pack: Circle theorems The Teaching Pack includes a lesson on drawing and describing circles.

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
	• nets • solids. 3. Use and interpret the vocabulary of a circle.	

Past and specimen papers
Past/specimen papers and mark schemes are available to download at www.cambridgeinternational.org/support **(F)**

3. Further algebra, Pythagoras' theorem, surds and appropriate accuracy

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
1.5 Ordering	Order quantities by magnitude and demonstrate familiarity with the symbols $=, \neq, >, <, \geq$ and $\leq$	Give learners a set of cards with the symbols $=, \neq, >, <, \geq, \leq$. Ask them to choose which card should go between pairs of quantities that you give them. For example, 400 m and 4000 cm; 20% and 0.2; –8 and –10, etc. Extend this by asking learners to consider when, or if, more than one card can be used (e.g. $\neq$ can be used in place of > or <). Give learners a list of fractions, decimals and percentages. Ask them to order these by magnitude using the inequality signs. To check their understanding, learners can then try a past paper question. **(F)**
1.9 Estimation	1. Round values to a specified degree of accuracy. 2. Make estimates for calculations involving numbers, quantities and measurements. 3. Round answers to a reasonable degree of accuracy in the context of a given problem.	As a starter, revise rounding numbers to the nearest 10, 100, 1000, etc., or to a set number of decimal places. Show learners how to round a number to a given number of significant figures, explaining the differences and similarities between significant figures and decimal places. It is helpful to explain common misconceptions such as 43.98 to 1 d.p. is 44.0 not 44. Emphasise that for this syllabus, non-exact answers are required to three significant figures unless the question says otherwise. Revision of estimating and rounding can be found on the Math.com website (www.math.com); if the link doesn't work, search for 'Estimating and rounding decimals'.
2.3 Algebraic fractions	1. Manipulate algebraic fractions.	Building on the work on factorising in topic 2.2, show learners how to factorise and simplify rational expressions such as $\frac{x^2-2x}{x^2-5x+6}$.

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
	2. Factorise and simplify rational expressions.	Provide learners with plenty of examples and questions. It is worth linking this work on simplifying rational expressions to the work on using the four rules with algebraic fractions, so that learners always give the most simplified answer. **(I)** You will need to spend time revising adding and subtracting simple fractions with learners, for example $\frac{2}{5}+\frac{3}{8}$. Explain the process of finding a common denominator by, in this case, multiplying the two denominators. Ask learners to discuss when the lowest common denominator doesn't need to be the product of the two denominators, e.g. $\frac{3}{10}+\frac{5}{8}$. The next step is to move on to algebraic fractions starting with numerical denominators, for example $\frac{x}{3}+\frac{x-4}{2}$, $\frac{2x}{3}-\frac{3(x-5)}{2}$ then extending this to algebraic denominators such as $\frac{1}{x-2}+\frac{2}{x-3}$. You will need to emphasise common errors that learners make when subtracting algebraic fractions. For example, in $\frac{3}{x-5}-\frac{4}{x+2}$ explain that learners often make sign errors on the numerator when $x-5$ is multiplied by -4. Move on to examples demonstrating multiplying and dividing with numerical fractions, reminding learners that instead of dividing by a fraction you multiply by its reciprocal. Extend this by looking at algebraic fractions such as $\frac{3a}{4}\times\frac{9a}{10}$, $\frac{3a}{4}\div\frac{9a}{10}$. Provide example questions for learners to practise. A possible formative task is at kutasoftware.com. If the link breaks, visit the website and navigate to 'Free worksheets; Infinity Algebra 1; Simplifying Rational Expressions'. **(I) (F)**
2.5 Equations	1. Construct expressions, equations and formulas. 2. Solve linear equations in one unknown. 3. Solve fractional equations with	Begin this work with revising how to solve simple linear equations, including those with negatives, for example $3x + 2 = -1$. You should also include examples showing how to solve linear equations with brackets such as $5(x + 4) = 3(x + 10)$. For a fun active learning resource, ask learners to work in groups to complete the 'Simple equations jigsaw' activity from the TES website (www.tes.com . Many more jigsaws are available at Mr Barton Maths website (mrbartonmaths.com). You can also download the Tarsia software to view the jigsaws from this website. Next ask learners to invent a 'think of a number' puzzle, for example, think of a number, add 7, double your answer, etc. Challenge them to use algebra to help them create a puzzle that always gives a certain answer. 'Performing Number Magic', a resource from the UK Department for Education's Standards Unit, asks learners to analyse simple number 'tricks', and then use algebra to explain how they work, before going on to

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
	numerical and linear algebraic denominators. 4. Solve simultaneous linear equations in two unknowns. 5. Solve quadratic equations by factorisation, completing the square and by use of the quadratic formula. 6. Change the subject of formulas.	create their own 'tricks' (www.nationalstemcentre.org.uk/elibrary/resource/2022/performing-number-magic-a9). If the link does not work, visit www.stem.org.uk and search for 'Performing Number Magic A9'. **(I)** A good introduction to simultaneous equations is to use a non-algebraic approach that builds on learners' informal approaches to real-life problems. For example, 3 coffees and 2 teas cost \$6.50, and 5 coffees and 2 teas cost \$9.50. Show learners how the simultaneous equation from these statements can be formed and emphasise that the cost of tea and coffee does not change. You can start with concrete examples and visual images to build on learners' informal understanding. It is important for learners to understand that to solve problems that involve **two** unknowns it is necessary for them to have **two** equations. The aim of solving simultaneous equations is to remove one of the unknowns – then they can approach the problem using what they already know about solving simple linear equations in one unknown. Don Stewart has collated some word puzzles that can be solved by forming equations (donsteward.blogspot.com/2013/06/puzzles-that-you-could-use-algebra-to.html) **(E)** Extend this by looking at examples to illustrate how to solve simultaneous linear equations with two unknowns by elimination, substitution and finding approximate solutions using graphical methods (linking to topic 2.10). You can use software packages such as Desmos (www.desmos.com) or GeoGebra Graphing Calculator (www.GeoGebra.org) to allow learners to explore the solutions of simultaneous equations graphically. **(I)** Challenge learners to apply these skills to solve three-variable problems. Don Steward has some three-variable problems (donsteward.blogspot.co.uk/2013/08/three-variable-simultaneous-equations.html) **(E)** Then explore all the different methods for solving quadratic equations: by factorisation, using the quadratic formula and completing the square. The Maths is Fun website (www.mathsisfun.com) has a good explanation of completing the square that uses multiple representations to help reinforce learners' understanding of the process. (If the link breaks, search 'Completing the square'.) The best starting point is exercises using the form $ax^2 + bx + c = 0$ then extend this to equations requiring rearranging into this form first. **(F) (I)** Move on to exercises where learners need to construct their own equations from information given and then solve them to find the unknown quantity or quantities. This could involve the solution of linear equations, simultaneous equations or quadratic equations. Mathematics teacher William Emeny has a card-sorting task that summarises all methods for solving quadratics and asks learners to consider when each method should be used: www.greatmathsteachingideas.com/2012/02/16/quadratic-equations-the-main-ideas-a-card-sort-to-support-

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
		conceptual-understanding/ **(F)**
2.8 Proportion	Express direct and inverse proportion in algebraic terms, and use this form of expression to find unknown quantities.	Learners will need to be able to solve a variety of problems involving direct or inverse variation. Encourage learners to use efficient notation that moves from the question to each step in turn. For example, • y varies directly with x (or y is directly proportional to x) to $y \propto x \Rightarrow y = kx$ • t varies inversely as the square of v to $v \Rightarrow t \propto \frac{1}{v^2} \Rightarrow t = \frac{k}{v^2}$ where k is a constant. Emphasise the common error of reversing direct and inverse variation. Once the formula has been established ask learners to use given values to work out the value of the constant, k, and then use the formulae with the evaluated k. **SDG 7** Consider looking at energy production e.g., hydroelectricity – volume of water and working head (direct). Wind power – more wind, less other energy emissions (inverse).
1.18 Surds	1. Understand and use surds, including simplifying expressions. 2. Rationalise the denominator.	Give learners exercises to revise their knowledge of indices and then develop skills in manipulating surds. Use examples that can be shown to be true using the index laws, in order to convince your learners. **(I)** Use the 'Surds' exercise (www.mathsisfun.com/surds.html) to reinforce the concept of a surd and give learners some quick practice. Use either as a starter activity with an advanced group, or as a teacher-led activity with a group that needs more support. Make sure learners understand algebraically as well as numerically that $\sqrt{a} \times \sqrt{b} = \sqrt{ab}$ and vice versa and also $\frac{\sqrt{a}}{\sqrt{b}} = \sqrt{\frac{a}{b}}$ and vice versa. Explain to learners that rationalising the denominator is a new skill and is mathematical convention. Revise the difference of two squares to show why, for example $1+\sqrt{3}$ is the multiplier to use to rationalise $1-\sqrt{3}$. Make sure that learners appreciate that multiplying both the numerator and the denominator by the 'same' number with opposite sign ('the square root conjugate') means that the original expression is being multiplied by a strategic form of 1 and therefore identity is maintained. Use an investigative approach, so that learners discover what rationalising the denominator is all about and why we do it, as well as manipulating expressions with surds. Start with questions such as: simplify $\sqrt{18}$, $4\sqrt{18}-3\sqrt{18}$, $2\sqrt{75}$ to lowest terms. Then gradually build up the level of difficulty to consider how to simplify

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
		terms such as $\sqrt{2}(5-\sqrt{8})$ and then to simplification of expressions such $(2+\sqrt{8})^2$ A good summary of the properties of surds is available on the BBC Bitesize website (www.bbc.co.uk/bitesize/guides/zg6gk2p/revision/1). If the link does not work search for 'Surds – Higher – OCR' on the BBC Bitesize website. To reinforce their understanding, learners can try the worksheet available on the TES website (www.tes.com/teaching-resource/maths-surds-worksheet-6160541). If the link does not work, search for 'maths: surds worksheet' on the TES website. **(I)** Some of the activities in *Manipulating Surds*, a resource from the UK Department for Education's Standards Unit, are suitable for this level: www.nationalstemcentre.org.uk/elibrary/resource/1968/ **(F)**
6.1 Pythagoras' theorem	Know and use Pythagoras' theorem.	Revise squares and square roots. Use simple examples involving right-angled triangles to illustrate Pythagoras' theorem. Start with finding the length of the hypotenuse then move on to finding the length of one of the shorter sides. See 'Pythagoras' theorem' examples on the Maths is fun website (www.mathsisfun.com) Explore some of the 'Pythagoras proofs' on the Nrich website (nrich.maths.org) **(E)** Extend this work to cover diagrams where the right-angled triangle isn't explicitly drawn, or the problem is presented without a diagram, e.g. 'find the diagonal length across a rectangular field or the height of a building'. You could also use examples of triangles in different orientations and where the labels are different, for example, where the hypotenuse is labelled *a* not *c*. This will check whether students really understand the theorem or whether they are just following a prescribed routine. **(F)**
Past and specimen papers		
Past/specimen papers and mark schemes are available to download at www.cambridgeinternational.org/support **(F)**		

4. Coordinate geometry I, ratio and scale drawing

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
3.1 Coordinates	Use and interpret Cartesian coordinates in two dimensions.	Revise coordinates in two dimensions. Draw a picture by joining dots on a square grid. Draw x and y axes on the grid and write down the coordinates of each dot. **(I)** Ask other learners to draw these pictures from a list of coordinates only.
3.2 Drawing linear graphs	Draw straight line graphs for linear equations.	Show learners how to construct tables of values and use them to draw a straight line graph. It is worth going through the process of finding values and converting these to coordinates to model the process for your learners. A surprisingly common error is to plot the points, but then fail to draw the line, so remind learners about this. Another common problem is a lack of accuracy, so remind learners that points must be plotted accurately and that lines should pass through all points. You can use graphical packages to support introductory work; they will allow you to plot points when modelling the process for your learners, before entering the function to draw the final line. Ask groups of learners to draw families of graphs and compare the results e.g. one group draws $y = x$, $y = 2x$, $y = 3x$, etc, another draws $y = x$, $y = x + 1$, $y = x − 2$, another draws $y = 2x$, $y = −0.5x$, $y = −4x$, $y = 0.25x$, etc. as a lead-in to work on the equation of a straight line, gradient, intercept, and parallel (and perpendicular) lines. If possible, use computers for this activity, using graph-drawing programs such as GeoGebra, Autograph or Desmos.
3.3 Gradient of linear graphs	1. Find the gradient of a straight line. 2. Calculate the gradient of a straight line from the coordinates of two points on it.	Use a diagram to help you define a line with a positive gradient as one sloping upwards, and a line with a negative gradient as one sloping downwards. Use simple examples to show how to calculate the gradient (positive, negative or zero) of a straight line from a graph using vertical distance divided by horizontal distance in a right-angled triangle: $$\text{gradient} = \frac{\text{change in } y \text{ coordinates}}{\text{change in } x \text{ coordinates}}$$ Extend this to consider the gradient of the line x = constant. Use examples to show how to calculate the gradient of a straight line from the coordinates of two points on it,

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
		first by drawing the line and then without drawing the line. Use gradient $= \frac{\text{change in } y \text{ coordinates}}{\text{change in } x \text{ coordinates}}$. Explain the common error of subtracting the coordinates the opposite way around on the numerator to the denominator causing the sign to be incorrect. The Maths is Fun website (www.mathsisfun.com) has a clear explanation for this objective. Search 'Equation of a line from two points'. The underground maths website (undergroundmathematics.org) uses an interactive applet to help learners explore how to calculate the gradient of a straight line from the coordinates of two points. You can use this to arrive at the general formula $y - y_1 = m(x - x_1)$. The link includes a clear explanation and examples, and links it to the work learners have already done on transformations of graphs (2.10). Search for 'The equation of a straight line'. **(I)** Resource Plus Teaching Pack: Straight line graphs The Teaching Pack includes a lesson on finding the gradient of a straight line.
3.4 Length and midpoint	1. Calculate the length of a line segment. 2. Find the coordinates of the mid-point of a line segment.	Revise Pythagoras' theorem (topic 6.1). Show how to calculate the length of a straight line segment from the coordinates of its end points using a sketch. To challenge learners, do this using the formula $\sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$. **(E)** Show how to find the coordinates of the midpoint of a straight line from the coordinates of its end points. Include examples working backwards, e.g. when an end point and a midpoint are known, find the other end point. **(I)**
3.5 Equations of linear graphs	Interpret and obtain the equation of a straight line graph.	Revise drawing a graph of $y = mx + c$ from a table of values. Interpret the meaning of m and c from the equation using the terms gradient and intercept. Starting with a straight line graph, show how its equation $(y = mx + c)$ can be obtained. Emphasise that learners should present equations of a line in fully simplified form. **(I)** To interpret the meaning of an equation, explain how an equation simply gives the relationship between the x and y coordinates on the line, e.g. for the equation $y = 2x$ this means the y ordinate is always double the x ordinate. Use this to identify if a point lies on the line, e.g. which of these points: (2, 8), (–4, 8), (7, 14), (20, 10), (0, 0) lies on the line $y = 2x$? Ask learners to write similar questions. **(I)** Then give these questions to others in a group to identify which points do not lie on a given line.

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
		Move on to graphs where the equation is given in different forms such as $ax + by = c$. are Learners can investigate different features of graphs using software drawing packages such as GeoGebra (www.GeoGebra.org). GeoGebra is free to download. **(I)** Resource Plus Teaching Pack: Straight line graphs The Teaching Pack includes a lesson on interpreting and obtaining the equation of a straight line graph.
1.11 Ratio and proportion	Understand and use ratio and proportion, to: • give ratios in their simplest form • divide a quantity in a given ratio • use proportional reasoning and ratios in context.	Explain the meaning of ratio with a practical demonstration, for example the ratio of different coloured beads on a necklace. Give learners exercises on dividing a quantity into a number of unequal parts. For example: 'Share $360 in the ratio 2 : 3 : 7'. Move on to writing ratios in an equivalent form, e.g. 6 : 8 can be written as 3 : 4, leading on to the form 1 : n. An interesting alternative to exercise questions is the ratio jigsaw called 'Tarsia – ratio (general)' on the TES website (www.tes.co.uk) which learners can work in groups to complete. A fun task would be for learners to produce their own 'ratio' jigsaw. They can produce their own jigsaw using blank equilateral triangles and paper. However, they could use Tarsia software if they prefer to do this task electronically. **(I)** The next step is to look at ratio problems where you are not given the total. For example, 'Two lengths are in the ratio 4 : 7. if the shorter length is 48 cm, how long is the longer length?' Extend this to exercises where you are given the difference. For example, 'The masses of two objects are in the ratio 2 : 5. One object is 36 g heavier than the other, what is the mass of each object? The Nrich website (nrich.maths.org) has a series of problems of different levels of difficulty. Search for 'ratio and proportion' to obtain a list. It also has a set of problems on 'Ratio, proportion and rates of change' as well as some short problems; search for 'Ratio proportion and rates of change – short problems'. **(I)** Films often use giant insects or giant or miniaturised people. Learners could work out the weight of an insect or person that has been transformed in this way. **(E)** The Maths Is Fun website (www.mathsisfun.com) has a good summary of the difference between direct and inverse proportion; search for 'Directly proportional and inversely proportional'. Two variables are **proportional** if there is always a constant ratio between them. The constant is called

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
		the [constant](#) of proportionality. To express the statement "y is directly proportional to x" mathematically, write $y = cx$, where c is the proportionality constant. This can also be written as $y \propto x$. To express the statement "y is inversely proportional to x" mathematically, write an equation $y = \frac{c}{x}$ or "y is directly proportional to $\frac{1}{x}$. Demonstrate this visually by drawing a graph of y against $\frac{1}{x}$, as in the example at www.desmos.com/calculator/audngjzwg8 Provide some good examples and questions on increasing and decreasing a quantity by a given ratio. Investigating the 'Golden Ratio' can generate an interesting display. **(E)**
1.12 Rates	1. Use common measures of rate. 2. Apply other measures of rate. 3. Solve problems involving average speed.	Formally define speed and use it to solve problems involving constant speeds. (This may be combined with the work on travel graphs in the next section.) Ask learners to solve a variety of problems involving direct proportion by either the ratio method or the unitary method. Look at quantities in inverse proportion, for example, the number of days to perform a job and the number of people working on the job. You will be able to link proportion to measures of rate and scales, for example exchange rates, average speed, density, map scales and other practical examples. For some ideas, read the online blog '*It started with a map*, November 2012' from colinbillett (https://colinbillett.wordpress.com). Use problems involving other rates, for example, the volume of water per minute that is flowing through a tap. Please note – there is further work on rates, including finding acceleration, in 2.9 of this scheme. Using a Tarsia puzzle is a good end-of-topic consolidation task (www.tes.com/teaching-resource/compound-measures-tarsia-jigsaw-11671826).If the link does not work, search the TES website for 'Compound Measures - tarsia jigsaw' **(I)** As an extension, learners work out whether top sprinters, such as Usain Bolt, would be breaking local speed limits. Alternatively, they could time themselves running 100m, then work out how far in front Usain Bolt would be when he crossed the finish line. **(E)** **SDG 7 / 9** Consider the efficient use of resources or efficient energy production / transmission – using local data
4.3 Scale drawings	1. Draw and interpret scale	Use an example to revise the topic of scale drawing.

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
	drawings. 2. Use and interpret three-figure bearings.	Show how to calculate the scale of a drawing given a length on the drawing and the corresponding real length. Tell learners that measurements do not need to be included on a scale drawing and that many scale drawings usually have a scale written in the form 1 : *n*. Draw various situations to scale and interpret results. For example, ask learners to draw a plan of a room in their house to scale and use it to determine the area of carpet needed to cover the floor, plan an orienteering course, etc. **(I)** Explore the set of resources on the Khan Academy website (www.khanacademy.org/) by searching for 'scale drawings'. Introduce three-figure bearings and use examples of measuring and drawing involving bearings. Use examples to show how to calculate bearings, e.g. calculate the bearing of B from A if you know the bearing of A from B. Use a map to determine distance and direction (bearing) between two places, e.g. learners' home and school, etc. Maps from around the world are at maps.google.com **(I)** Resource Plus Teaching Pack: Understanding Bearings The Teaching Pack includes lessons on: - angle facts - bearings, compass points and angle facts - trigonometry and bearings.

Past and specimen papers

Past/specimen papers and mark schemes are available to download at www.cambridgeinternational.org/support **(F)**

5. Probability I, geometry and graphs

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
8.1 Introduction to probability	1. Understand and use the probability scale from 0 to 1. 2. Understand and use probability notation. 3. Calculate the probability of a single event. 4. Understand that the probability of an event not occurring = 1 – the probability of the event occurring.	Discuss probabilities of 0 and 1, leading to the outcome that a probability lies between these two values. Revise the language of probability associated with the probability scale. Use the probability scale by estimating frequencies of events occurring based on probabilities. Ask learners to produce their own probability scale with events marked on it. Fix a string across the room. On one end, attach a card that says 'Certain' and on the other end attach a card that says 'Impossible'. In between, attach cards, 'Very likely', 'Fairly likely', 'Equally likely', 'Not very likely' and others, if wanted. Pre-prepare cards that refer to each of the learners in the group and some to events that are either topical or of interest to your learners. It is useful if one card refers to an event that is almost certain and another to something that is almost impossible. Attach the topical event cards anywhere on the string between 'Certain' and 'Impossible'. Ask learners to discuss among themselves the order in which they should appear. Next, label the 'Impossible' card as 'Probability 0' and the 'Certain' card as 'Probability 1' and explain that probabilities are measured between 0 and 1. Ask for suggestions for numerical values (in decimals or fractions) for the topical events. Write these values on blank cards and attach them above the event cards. Ask learners to find out the meaning of mutually exclusive and exhaustive. **(E)** Use theoretical probability to predict the likelihood of a single event. For example, find the probability of choosing the letter M from the letters of the word MATHEMATICS. Use the formula: $$\text{probability} = \frac{\text{favourable outcomes}}{\text{possible outcomes}}$$ Discuss when fractions, decimals or percentages are preferable for representing probabilities, e.g. if the probability is $\frac{2}{3}$ then a fraction is preferable because it is exact. Use examples to show that the 'probability of an event occurring = 1 – the probability of the event not occurring', including where there are only two outcomes and where there are more than two outcomes. Learners do example questions that you've prepared or from textbooks. **(I)**
8.2 Relative and expected frequencies	1. Understand relative frequency as an estimate of	Compare estimated experimental probabilities, or relative frequency, with theoretical probabilities. Learners need to recognise that when experiments are repeated different outcomes may result, and increasing the number of times an experiment is repeated generally leads to better estimates of probability.

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
	probability. 2. Calculate expected frequencies.	Conduct a class experiment into rolling dice 300 times, e.g. 15 pairs of learners rolling a dice 20 times each. Collect and combine results from groups to create a large sample set. Show how estimates change as more data is added to the set. Repeat the experiment where the theoretical probability is not known, e.g. the chance of a drawing pin landing point down when thrown in the air. Try 'Buffon's Needle' activity on the Maths is fun website (www.mathsisfun.com) **(E)** Carry out experiments to sample the number of unknown coloured counters in a bag. Ask learners to suggest how many of each type of coloured counter there are in the bag, given the known total. **(E)** Another extension activity is to solve problems where the final probability of an outcome is given and learners work backwards from this to work out information such as how many counters of each colour are in a bag. **(E)**
4.5 Symmetry	1. Recognise line symmetry and order of rotational symmetry in two dimensions. 2. Recognise symmetry properties of prisms, cylinders, pyramids and cones.	Define the terms line of symmetry and order of rotational symmetry for two-dimensional shapes. Revise the symmetries of triangles (equilateral, isosceles) and quadrilaterals (square, rectangle, rhombus, parallelogram, trapezium, kite) including considering diagonal properties. Discuss the infinite symmetry properties of a circle. Use classifying and 'odd-one-out' activities to engage learners with comparing and contrasting the properties of these shapes related to their symmetries. An example of this type of activity is at www.stem.org.uk; search for 'Classifying shapes SS1'. Define the terms plane of symmetry and order of rotational symmetry for 3-dimensional shapes. Use diagrams to illustrate the symmetries of cuboids (including a cube), prisms (including a cylinder) and pyramids (including a cone). Look at diagrams for the symmetry properties of circles paying attention to chords and tangents.
4.6 Angles	1. Calculate unknown angles and give simple explanations using the following geometrical properties: • sum of angles	Revise basic angle properties by drawing simple diagrams that illustrate angles at a point; angles on a straight line and intersecting lines; angles formed within parallel lines and angle properties of triangles and quadrilaterals. Define the terms irregular polygon, regular polygon, concave and convex. Use examples that include: triangles, quadrilaterals, pentagons, hexagons and octagons. Show that each exterior angle of a regular polygon is $\frac{360°}{n}$, where n is the number of sides, and that the interior angle is 180° minus the exterior angle. Give learners a variety of problems that use these formulae. Draw a table of information for regular polygons.

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
	at a point = 360° - sum of angles at a point on a straight line = 180° - vertically opposite angles are equal - angle sum of a triangle = 180° and angle sum of a quadrilateral = 360° 2. Calculate unknown angles and give geometric explanations for angles formed within parallel lines: - corresponding angles are equal - alternate angles are equal - co-interior (supplementary) angles sum to 180°. 3. Know and use angle properties	Use as headings: number of sides, name, exterior angle, sum of interior angles, interior angle. **(I)** A challenging problem involving two polygons is at NRICH: nrich.maths.org/5642 **(E)** Move on to look at angle properties of irregular polygons. By dividing an *n*-sided polygon into several triangles, show that the sum of the interior angles is $180(n - 2)°$ and that the interior and exterior angles sum to 180°. The topic can be extended by learners considering which regular polygons will tessellate, based on the sizes of their interior angles. Interactive tessellation tool from NRICH: nrich.maths.org/6069 Alternatively, they investigate convex polygons, for example considering how many acute angles are possible. Convex polygons from NRICH: nrich.maths.org/1972 **(E)** Resource Plus Teaching Pack: Understanding Bearings The Teaching Pack includes lessons on: - angle facts - bearings, compass points and angle facts - trigonometry and bearings.

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
	of regular and irregular polygons.	
4.7 Circle theorems I	Calculate unknown angles and give explanations using the following geometrical properties of circles: • angle in a semi-circle = 90° • angle between tangent and radius = 90° • angle at the centre is twice the angle at the circumference • angles in the same segment are equal • opposite angles of a cyclic quadrilateral sum to 180° (supplementary) • alternate segment theorem.	Use diagrams to show the angle in a semicircle and the angle between tangent and radius of a circle are 90°. Learners can see the circle theorems come to life on dynamic pages at timdevereux.co.uk Provide the solution to an exam-style question on the topic of angles that contains a mistake in the working. Ask learners to identify the mistake. Explain the theory that angles in opposite segments are supplementary. Investigate cyclic quadrilaterals. For example, explain why all rectangles are cyclic quadrilaterals. What other quadrilateral is always cyclic? Is it possible to draw a parallelogram that is cyclic?, etc. Use examples to show that the angle at the centre of a circle is twice the angle at the circumference and that angles in the same segment are equal. Introduce learners to the process of proof by demonstrating one of the circle theorems and then asking them to reproduce the proof independently, or by creating a proof and then cutting it up and asking learners to reconstruct it. You can make this second approach more challenging by leaving steps out of the proof for learners to identify and complete. You could also ask learners to provide feedback on exemplar proofs. **(I)** Give learners a variety of problems using all the circle theorems. Making sure that they know the correct language for describing their reasoning. Some of the tasks in 'Discovering circle theorems', an activity from the National Centre for Excellence in Teaching Mathematics (NCETM) can challenge learners to consider fully these theorems. **(E)** Resource Plus Teaching Pack: Circle theorems The Teaching Pack includes lessons on: • drawing and describing circles • angle in a semi-circle • angle at the centre of a circle • angle in the same and opposite segments • other circle theorems

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
2.9 Graphs in practical situations	1. Use and interpret graphs in practical situations including travel graphs and conversion graphs. 2. Draw graphs from given data. 3. Apply the idea of rate of change to simple kinematics involving distance–time and speed–time graphs, acceleration and deceleration. 4. Calculate distance travelled as area under a speed–time graph.	Start by giving learners exercises to draw and use straight line graphs to convert between different units, for example between metric and imperial units, or between different currencies. You can find exchange rates online and use them for setting questions. Learners need to be confident in solving problems using compound measures. It will be useful to link this work to topics 1.11 Ratio and proportion and 1.17 Money. It is important for learners to be able to draw a variety of graphs from given data, for example to determine whether two quantities are in proportion, e.g. y and x (or for more able learners y and x2). You will be able to link this to the work in topic 2.8 on direct and inverse proportion. Provide examples of how to draw and use distance–time graphs to calculate average speed (linking this to the calculating gradients work in topic 3.3). Learners should be able to interpret the information shown in travel graphs and be able to draw travel graphs from given data. Ask learners to draw a travel graph for an imaginary journey and write a set of questions about this journey. For example, "What was the average speed?" **(I)** When learners have drawn their graphs and written their questions, they can then give these to other members of a group to answer. The STEM learning e-library (www.stem.org.uk/resources) has a lesson that can be used to deepen or assess learners' understanding in this section. Search for 'Interpreting distance–time graphs A6'. **(I) (F)** Make sure that learners have studied topic 4.2 Geometrical constructions and that they can confidently calculate areas of rectangles, triangles, trapeziums and compound shapes derived from these. Extend this work by looking at examples of using speed–time graphs to find acceleration and deceleration and to calculate distance travelled as area under a linear speed–time graph. Provide challenge by looking at examples where learners are required to convert between different units. For example, where different units are being used in the question and in the graph. Resource Plus Teaching Pack: Unit conversions The Teaching Pack includes lessons on: • converting between simple units of measure • area and volume • compound measures • interpreting travel and conversion graphs. **SDG 11 / 12** Consider travel arrangements in the local area to generate distance/time graphs, or the amount of material required to generate given items for conversion graphs

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
2.10 Graphs of functions	1. Construct tables of values and draw, recognise and interpret graphs for functions of the following forms: • ax^n (includes sums of no more than three of these) • $ab^x + c$. where n = –2, –1, $-\frac{1}{2}$, 0, $\frac{1}{2}$, 1, 2, 3; a and c are rational numbers; and b is a positive integer. 2. Solve associated equations graphically, including finding and interpreting roots by graphical methods. 3. Draw and interpret graphs representing exponential growth and decay problems. 4. Estimate gradients of curves by	Software drawing packages such as GeoGebra (www.GeoGebra.org) are useful for learners to use to investigate different features of graphs. GeoGebra is free to download. Start by asking learners to draw functions of the form $\frac{a}{x^2}$; $\frac{a}{x}$; ax^3; a^x; where a is a constant, using a graph drawing package like GeoGebra. Ask learners to work in groups to use the software to gain an awareness of what each of the different type of graphs look like. Learners should recognise common types of functions from their graphs, for example the parabola, hyperbola, quadratic, cubic and exponential graphs. Use the Maths is Fun website (www.mathsisfun.com) to explore the effect of transforming graphs. Search for 'Function transformations'. This page explains how all transformations can be done in one go using the arrangement: a f$(b(x + c)) + d$. Remind learners that for quadratic equations, completing the square arranges the quadratic function in this form. Learners explore transformations of functions independently, using GeoGebra. You can also find existing examples in the resource section of the GeoGebra website. **(I) (E)** Once learners understand the effect of transforming a quadratic equation written in the form a f$(b(x + c)) + d$, they will be able to derive how they find the turning point for different quadratic equations by completing the square and relate this to a transformation of the graph of x^2. A good resource to consolidate or assess learners' understanding of how to use transformations of the graph of x^2 to identify key properties such as turning points is in the STEM learning e-library (www.stem.org.uk); it is called 'Linking the properties and forms of quadratic functions C1'. **(I) (F)** The Maths is Fun website (www.mathsisfun.com) also has a useful page describing different asymptotes. This includes questions for learners to explore on their own, including detailed explanations to support the solutions. Learners could explore these questions alongside the use of GeoGebra graphing calculator package. **(I)** Move on to asking learners to draw graphs from tables of values. A useful video 'Exponential function graph' is on the Khan academy website (www.khanacademy.org). Extend the work to include simple sums of not more than three functions in the form ax^n, where a is a rational constant, and n = –2, –1, 0, 1, 2, 3. Ask learners to solve associated equations approximately using these graphs. Ensure learners have studied topic 3.3 (finding the gradient of a straight line) before beginning this topic. Learners should already be able to confidently find the gradient of a straight line. Give learners a definition of the term tangent. Move on to looking at examples that show how to find the gradient at a point on a curve by

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
	drawing tangents.	drawing a tangent at that point. **SDG 14 / 15** Consider conservation for exponential graphs.
2.11 Sketching curves	Recognise, sketch and interpret graphs of the following functions: (a) linear (b) quadratic (c) cubic (d) reciprocal (e) exponential.	Encourage learners to sketch a range of graphs by recognising key points on these graphs. They should realise that sketching a graph is different from drawing a graph and that both are useful; they may be asked to do both. Learners should understand that a sketch of a graph does not need to be 100% accurate and to scale; it is important however, that the most important features are there and clearly labelled. Questions that they could ask themselves should include: • What happens when $x = 0$? When $y = 0$? • What happens when x tends towards infinity? • Are there any asymptotes? Horizontal? Vertical? Oblique? • They could also link this to trigonometrical functions by considering whether the graph is going to be periodic. The final step is to look at examples of how to draw and interpret graphs representing exponential growth and decay problems. It will be useful to link this to the work on exponential growth and decay from topic 1.14.
1.17 Exponential growth and decay	Use exponential growth and decay.	Khan Academy (www.khanacademy.org/) provides some good examples to introduce the topic of exponential growth and decay; search for 'Exponential growth & decay word problems'. This site uses the approach $n = ak^t$ where n = number at time t, a is the initial value and k is the rate. Ask learners to compare the similarities between this exponential growth formula and the compound interest formula. **SDG 15** Consider investigating population growth/decline e.g., investigating growth of bacteria etc.
Past and specimen papers		
Past/specimen papers and mark schemes are available to download at www.cambridgeinternational.org/support **(F)**		

6. Circles, 3D mensuration, vectors and cumulative frequency

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
5.3 Circles, arcs and sectors	1. Carry out calculations involving the circumference and area of a circle. 2. Carry out calculations involving arc length and sector area as fractions of the circumference and area of a circle.	Revise how to calculate the circumference and area of a circle, using straightforward examples. Learners are expected to know the formulae. Extend this by looking at how to find compound areas involving circles, for example, a circle with the radius of 5.3 cm is drawn touching the sides of a square. Ask learners "What area of the square is not covered by the circle?" You could extend the question to consider the area of waste material when cutting several circles of this size out of an A4 sheet of paper. **(I)** The Khan academy website (www.khanacademy.org) includes a good explanation of arc length and sector area. Search 'Arc length from subtended angle' and 'Area of a sector'. The quiz for arc length includes challenge questions to check learners' understanding. **(F)** The next step is to use examples to illustrate how to calculate the arc length and the sector area by using fractions of full circles.
2.4 Indices II	1. Understand and use indices (positive, zero, negative and fractional). 2. Understand and use the rules of indices.	Start by giving learners examples that revise the rules of indices work from Unit 1 topic 1.7. Extend this to using and interpreting positive, negative and zero indices and using the rules of indices with algebraic terms. For example, simplify: $6x^7y^4 \times 5x^{-5}y$, $12a^3 \div 3a^{-2}$, $(5x^3)^2$ and solve simple equations such as $2^x = 32$. Move on to looking at fractional indices, for example, simplify: $3x^{-4} \times \frac{2}{3}x^{\frac{1}{2}}$, $\frac{2}{5}x^{\frac{1}{2}} \div 2x^{-2}$, $\left(\frac{2x^5}{3}\right)^3$; and solving simple exponential equations such as, $32^x = 2$, $5^{x+1} = 25^x$. (Knowledge of logarithms is **not** required.)
5.4 Surface area and volume	Carry out calculations and solve problems involving the surface area and volume of	Starting with simple examples, draw the nets of a variety of solids, asking learners if they are able to identify the solid from the net. It is useful for learners to understand that there are many different right and wrong ways to draw the net of a cube. Less able learners could work in groups to draw nets on card and use these to make various geometrical shapes.

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
	a: • cuboid • prism • cylinder • sphere • pyramid • cone.	Next, demonstrate a purpose and use for drawing nets. For example, in the packaging industry there are many different interesting nets used to create boxes, particularly those that require little or no glue. An interesting activity would be to ask learners to collect lots of different packaging boxes to investigate the nets used to create them. **(I)** Next, ask learners to look at how to calculate the surface area of a cuboid and a cylinder, using the nets to help. Extend this to showing how to calculate the volume of a cuboid and a variety of prisms, including cylinders. Learners will need to know the formula: volume of prism = cross-sectional area × length. A useful resource on this topic is on the Annenberg learner website (www.learner.org); if the link breaks, search for 'Geometry 3D shapes > surface area'. Move on to using nets to illustrate how to calculate the surface area of a triangular prism, a pyramid and a cone. It will be useful for learners to understand how to obtain the formula $\pi r(r + s)$ for the surface area of a cone (where s = slant length). Also explain how to calculate the surface area of a sphere using the formula $4\pi r^2$. Use examples to illustrate how to calculate the volume of a pyramid (including a cone) using the formula: $\frac{1}{3}$ × area of base × perpendicular height. Also look at how to calculate the volume of a sphere using the formula $\frac{4}{3} \pi r^3$. Diagrams and formulae are at www.thoughtco.com; search for 'Math Formulas for Geometric Shapes'. Emphasise to learners that they should know which formulae to learn and which will be given. You could challenge those with good memories to learn the given formulae too. Ask learners to create a set of designs for a container with a certain volume. Which design uses the least card? **(I)** Challenge learners to investigate practical problems , for example, designing a dipstick for a cylindrical tank: **(E)** Learners apply their ideas to making nets of cones or frustums. Ask learners to make a conical party hat of a given height that will fit the circumference of their head. This is a fun but challenging activity that also involves some trigonometry in 3D (introduced formally in the next unit). **(E)** **SDG 9** Consider working out efficient use of packaging material.

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
5.5 Compound shapes and parts of shapes	1. Carry out calculations and solve problems involving perimeters and areas of: • compound shapes • parts of shapes. 2. Carry out calculations and solve problems involving surface areas and volumes of: • compound solids • parts of solids.	The final section extends the work from topics 5.1 to 5.4 to find the surface area and volume of a wide variety of composite shapes. Learners complete a project in which they calculate the cost of redecorating a room. They need to decide what measurements they require, find areas and use them to calculate paint or wallpaper quantities, costs of flooring, etc. **(E)** **SDG 3/4** Consider calculations involving designing suitable housing / schools / classrooms.
7.1 Transformations	Recognise, describe and draw the following transformations: 1. Reflection of a shape in a straight line. 2. Rotation of a shape about a centre through multiples of 90°. 3. Enlargement of a shape from a centre by a scale factor. 4. Translation of a shape by a vector	Draw an arrow shape on a squared grid. Use this to illustrate the following: reflection in a line (mirror line); rotation about any point (centre of rotation) through multiples of 90° (in both clockwise and anti-clockwise directions); and translation by a vector. Show several different examples of each transformation . Use the word image appropriately. Learners investigate how transformations are used to make tessellations and produce an Escher-type drawing. For inspiration and step-by-step guides, see www.tessellations.org. **(I)** Ask learners to research the work of Maurits Cornelis Escher linked to tessellations. **(E)** Ask learners to investigate traditional designs which use transformations, or create some designs of their own. **(E)** Use a pre-drawn shape on (x, y) coordinate axes to complete several transformations using the equations of lines to represent mirror lines and coordinates to represent centres of rotation. Work with (x, y) coordinate axes to show how to find: the equation of a simple mirror line given a shape and its (reflected) image; the centre and angle of rotation given a shape and its (rotated) image; and the vector of a translation. Emphasise

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
	$\begin{pmatrix} x \\ y \end{pmatrix}$.	all the detail that is required to describe each of the transformations. Draw a triangle on a squared grid. Use this to illustrate enlargement by a positive integer scale factor about any point (centre of enlargement). Use both methods: counting squares and drawing rays. Show how to find the centre of enlargement given a shape and its (enlarged) image. **Resource Plus** Teaching Pack: Vectors The Teaching Pack includes lessons on: • properties of vectors • vectors and translations • adding and subtracting vectors • vectors in real-life contexts • vector geometry.
7.2 Vectors in two dimensions	1. Describe a translation using a vector represented by $\begin{pmatrix} x \\ y \end{pmatrix}$, $\overrightarrow{AB}$, or **a**. 2. Add and subtract vectors. 3. Multiply a vector by a scalar.	Use the concept of translation to explain a vector. Use simple diagrams to illustrate column vectors in two dimensions, explaining the significance of positive and negative numbers. Introduce the various forms of vector notation. Show how to add and subtract vectors algebraically by making use of a vector triangle. Show how to multiply a column vector by a scalar and illustrate this with a diagram. Learners can explore the use of vectors with the 'vector journeys' problem on the Nrich website (nrich.maths.org). There are support and extension activities linked to this resource. **Resource Plus** Teaching Pack: Vectors The Teaching Pack includes lessons on: • properties of vectors • vectors and translations • adding and subtracting vectors • vectors in real-life contexts • vector geometry.

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
2.6 Inequalities	1. Represent and interpret inequalities, including on a number line. 2. Construct, solve and interpret linear inequalities. 3. Represent linear inequalities in two variables graphically. 4. List inequalities that define a given region.	To introduce the topic of solving linear inequalities, it is a good idea to start with just numbers, for example $7 > 5$, showing that multiplying or dividing an inequality by a negative number reverses the inequality sign, i.e. $-7 < -5$. Use examples to illustrate how to solve simple linear inequalities including representing the inequality on a number line. Interpretation of results may be required. You can use software packages such as GeoGebra (www.GeoGebra.org) to create interactive activities for learners to explore and demonstrate their understanding of inequalities on a number line. You can also explore the resources on the GeoGebra website by searching for inequalities on a number line. **(I) (F)** The most challenging inequalities for learners to solve are those where the inequality needs to be split into two parts and each part solved separately. The TES website has a useful inequalities worksheet (www.tes.com/teaching-resource/representing-and-solving-inequalities-11812747) . Search for 'representing and solving inequalities' if the link breaks. **(F)** Ask learners to draw several straight lines on a set of axes, possibly on mini whiteboards, for example $y = 2$, $x = -5$, $y = 3x$ and $x + 2y = 10$. Ask learners to consider a point on one side of each of these lines, the origin if possible, and use substitution to see if the inequalities $y < 2$, $x > -5$, $y < 3x$ and $x + 2y > 10$ are true for their chosen point. Ask learners to work in groups to do their own examples. Finally, learners will need to understand how to construct inequalities to define a given region using the convention of broken lines for strict inequalities and solid lines for inclusive inequalities. Unwanted regions should be shaded. (Linear programming problems are not included.) Mathematics teacher William Emeny has a card-sorting task that summarises all methods for solving quadratics and asks learners to consider when each method should be used: www.greatmathsteachingideas.com/2012/02/16/quadratic-equations-the-main-ideas-a-card-sort-to-support-conceptual-understanding/ **(F)**
9.6 Cumulative frequency diagrams	1. Draw and interpret cumulative frequency tables and diagrams.	Explain cumulative frequency and use an example to illustrate how a cumulative frequency table is constructed. Draw the corresponding cumulative frequency curve emphasising that points are plotted at upper class limits; the curve must always be increasing; and highlight its distinctive shape. Explain that this can be approximated by a cumulative frequency polygon. Use a cumulative frequency curve to help explain and interpret percentiles. Introduce the names given to the

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
	2. Estimate and interpret the median, percentiles, quartiles and interquartile range from cumulative frequency diagrams.	25th, 50th and 75th percentiles and show how to estimate these from a graph. Show how to estimate the inter-quartile range from a cumulative frequency diagram. Explain how to use a cumulative frequency curve to complete a frequency table.

Learners can interpret simple frequency distributions and cumulative frequency diagrams, to display the median, percentiles, quartiles and inter-quartile range on the Stem learning website (www.stem.org.uk). If the link breaks, search for 'Interpreting frequency graphs, cumulative frequency graphs, box and whisker plots S6'.

The second part of the 'Interpreting Bar Charts, Pie Charts, Box and Whisker Plots S5' on the STEM learning website (www.stem.org.uk) compares box-and-whisker plots. **(E)**

Ask learners to consider how cumulative frequency data can be used to estimate probabilities. Why would this only be an estimate? How reliable would the estimate be? **(E)**

Resource Plus
Teaching Pack: Statistics
The Teaching Pack includes lessons on:
- predicting trends, considering data models and effective questioning
- bar charts and histograms
- representations, restrictions and relationships between data
- cumulative frequency and box-and-whisker plots

SDG 11
Consider using cumulative frequency diagrams for distance travelled to school by learners in the class/year. |

Past and specimen papers
Past/specimen papers and mark schemes are available to download at www.cambridgeinternational.org/support **(F)**

7. Standard form, similarity, trigonometry I and probability II

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
1.8 Standard form	1. Use the standard form $A \times 10^n$ where n is a positive or negative integer, and $1 \le A < 10$. 2. Convert numbers into and out of standard form. 3. Calculate with values in standard form.	Give learners a range of examples showing how to write numbers in standard form and to convert standard form to numbers. Emphasise to learners that different calculators display standard form in different ways and check that they know how to input numbers in standard form into **their** calculator. Use the Maths Is Fun website (www.mathsisfun.com) to make links between the rules of indices and standard notation. Search for 'Index notation and powers of 10' . Learners could explore the f following problem: Using $a = 6 \times 10^3$ and $b = 3 \times 10^2$ determine which of these calculations gives the largest solution and which gives the smallest. $$\boxed{a \times b} \qquad \boxed{a \div b} \qquad \boxed{b \times a} \qquad \boxed{b \div a}$$ It is important that learners understand that standard form is a way of writing very large and very small numbers. For example, it is used on a scientific calculator when a number is too large or too small to fit on the screen. Being able to write numbers in standard form depends on learners having a secure understanding of place value. This understanding is fundamental in manipulating large and small numbers, both mentally and in written form. The video 'Powers of ten and the relative size of things in the universe' is very good for helping learners to understand the concept of magnitude. It is available on the Eames Office website (www.eamesoffice.com) or on YouTube (www.youtube.com/watch?v=0fKBhvDjuy0). The next step is to give learners a range of exercises on writing numbers in standard form and converting standard form to numbers.. Extend this by using the four rules of calculation with numbers in standard form, both with and without a calculator. Emphasise common errors, for example, for the problem: write $2.4 \times 10^4 - 2 \times 10^4$ in standard form learners often give the (incorrect) answer 0.4×10^4. Point out that although $2.4 \times 10^4 - 2 \times 10^4 = 0.4 \times 10^4$ the answer is not in standard form, since 0.4 is less than 1. Ask learners to try the 'Standard form worksheet' from the TES website (www.tes.com). **(F)**

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
		A challenge could be to research sizes of very large or very small objects and produce some comparisons, for example, how many trips to the moon would be needed to cover the same distance as travelling from the Earth to one of the outer planets. **(E)**
4.4 Similarity	1. Calculate lengths of similar shapes. 2. Use the relationships between lengths and areas of similar shapes and lengths, surface areas and volumes of similar solids. 3. Solve problems and give simple explanations involving similarity.	If necessary, revise what is meant by 'similar' and provide examples. Give learners practice of calculating lengths in similar figures. Then expand on calculating lengths of similar figures to exercises using the relationships between areas, surface areas and volumes of similar shapes and solids. Identify the conditions for two triangles to be similar and investigate the geometric justification for similarity. This could be extended to other shapes. **(E)**
6.2 Right-angled triangles	1. Know and use the sine, cosine and tangent ratios for acute angles in calculations involving sides and angles of a right-angled triangle. 2. Solve problems in two dimensions using Pythagoras'	When introducing trigonometry, spend some time on labelling the sides of triangles with a marked angle: adjacent, hypotenuse and opposite. Ask learners to work in groups to draw right-angled triangles with a 30° angle of various sizes. Learners work out the ratio 'opposite side ÷ adjacent side' for all the different triangles to find they should all be a similar value. Then use examples involving the sine, cosine and tangent ratios to calculate the length of an unknown side of a right-angled triangle given an angle and the length of one side. Use a mix of examples: some examples where division is required and some where multiplication is required. For learners who struggle with rearranging the trigonometrical ratios it is possible to use the 'formula triangle approach'. For more able learners, encourage the 'rearranging' approach. Move on to examples involving inverse ratios to calculate an unknown angle given the length of two sides of a right-angled triangle. Give learners a wide variety of problems in context using Pythagoras' theorem and trigonometric ratios

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
	theorem and trigonometry. 3. Know that the perpendicular distance from a point to a line is the shortest distance to the line. 4. Carry out calculations involving angles of elevation and depression.	(include work with any shape that may be partitioned into right-angled triangles). **(I)** Use examples to show how to solve problems involving bearings using trigonometry. **(F)** Define angles of elevation and depression. Use examples to show how to solve problems involving angles of elevation and depression using trigonometry. Resource Plus Teaching Pack: Understanding Bearings The Teaching Pack includes lessons on: • angle facts • bearings, compass points and angle facts • trigonometry and bearings.
8.3 Probability of combined events	Calculate the probability of combined events using, where appropriate: • sample space diagrams • Venn diagrams • tree diagrams.	Roll two different dice, or spin two spinners, and list all the outcomes. Use simple examples to illustrate how sample space diagrams and tree diagrams can help to organise data. Use sample space diagrams and tree diagrams to help calculate probabilities of simple combined events, paying close attention to how diagrams are labelled. The article 'Probability calculations from tree diagrams' on the Nrich website (nrich.maths.org/9648) suggests a set of activities that introduce learners to combined events in an intuitive way using tree diagrams to record and visualise the outcomes of combined events. The examples are set at different levels of complexity. The article 'Tree diagrams, 2-way Tables and Venn Diagrams' on the Nrich website (nrich.maths.org/9861) considers a range of diagrammatic representations for probability. The resources include some detailed examples of how different representations could be used to support the solution to example problems. You could use these to stimulate discussion with learners. **(E)** Resource Plus Teaching Pack: Probability of combined events The Teaching Pack includes lessons on: • sample space diagrams • area and volume • drawing and interpreting tree diagrams

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
		• conditional probability • tree diagrams & more complex probabilities. Resource Plus Teaching Pack: Venn diagrams This Teaching Pack includes lessons that cover the following: • using Venn diagrams • formal notation used with Venn diagrams • constructing Venn diagrams to solve problems • calculating simple probabilities using Venn diagrams.
2.7 Sequences	1. Continue a given number sequence or pattern. 2. Recognise patterns in sequences, including the term-to-term rule and relationships between different sequences. 3. Find and use the nth term of sequences.	Give learners the definition of a sequence of numbers. Ask them to work in groups to investigate some simple sequences, such as finding the next two numbers in a sequence of even, odd, square, triangle or Fibonacci numbers. Extend this to looking at finding the term-to-term rule for a sequence. For example, the sequence 3, 9, 15, 21, 27, ..., has a term-to-term rule of +6; the sequence 40, 20, 10, 5, 2.5, …, has a term to term rule of ÷2. Learners will need to have some understanding of the limitations of a term-to-term rule, i.e. that they are not very useful for finding terms that are a long way down the sequence. This leads on to finding the position-to-term rule for a sequence by examining the common difference, for example the nth term in the sequence 3, 9, 15, 21, 27, …, is $6n - 3$. The Nrich website (nrich.maths.org) has a nice activity called 'Seven squares – group worthy task' that challenges learners to describe generic patterns verbally, numerically and algebraically. It does not assume prior knowledge of algebra and could be a good way for you to introduce, practise or assess algebraic fluency. You could use mini whiteboards or coloured matchsticks to support this activity. **(F)** An interesting investigation is to look at square tables placed in a row so that 4 people can sit around one table, 6 people can sit around 2 tables joined, 8 people can sit around 3 tables joined, and so on. Ask learners to work out how many people can sit around n tables. To add an extra challenge, ask learners to investigate tables of different shapes and sizes, and to try to relate the nth term formula to the practical situation, explaining how the numbers in the formula relate to the arrangements of the tables. **(I)** With more able learners you could look at deriving the formula for a linear sequence with nth term = $a + (n - 1)d$ where a is the first term and d is the common difference. This formula is not essential knowledge. **(E)**

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
		Another approach is looking at patterns and relationships between different sequences. For example, the sequence 2, 5, 10, 17, 26, …, is the square numbers + 1. You can give learners several examples of these, asking them to find the nth term, using just simple quadratic and cubic sequences, i.e. of the form $an^2 \pm c$ or $an^3 \pm c$. **(I)**
		Continue by looking at examples of finding the nth term of harder quadratic sequences. A useful resource is the video and applet listed below. Learners can work in groups using the applet to investigate finding the nth term of harder quadratic sequences.
		• Quadratic sequences 1 video: www.waldom. aths.com/video/QuadSeq01/QuadSeq01.jsp • 'nth term of quadratic sequences' applet: www.waldomaths.com/QuadSeq2L.jsp
		For even greater challenge, you can extend this to investigating cubic sequences: • 'Cubic sequences 1 – finding the nth term' video: www.waldomaths.com/video/CubSeq01/CubSeq01.jsp • 'nth term of cubic sequences' applet: www.waldomaths.com/CubSeq1L.jsp
		Other methods for finding nth terms are possible. Ask learners to search online for alternative methods. **(I)**
		For an explanation of subscript notation, go to the introduction to sequences on the Maths is Fun website (www.mathsisfun.com). Search for 'Sequences'.
		Finally, learners will need to look at exponential sequences with a common multiplier (or ratio) instead of a common difference.
		Learners can use the nth term to solve problems. For example, if they are told that the first and second terms of a sequence with the nth term $ax^2 + b/x$ are 7 and 14, they should be able to form and solve equations to find the values of a and b. **(E)**
		Alternatively, learners could investigate or research sequences such as the Fibonacci sequence. With more able learners, derive the formula for the nth term $= ar^{(n-1)}$ where a is the first term and r is the common ratio. This formula is not essential knowledge. **(E)**

Past and specimen papers

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8. Coordinate geometry II, accuracy and trigonometry II

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
4.8 Circle theorems II	Use the following symmetry properties of circles: • equal chords are equidistant from the centre • the perpendicular bisector of a chord passes through the centre • tangents from an external point are equal in length.	Ask learners to draw a circle with two tangents meeting at a point. Join this point to the centre and draw in the radii to the points of contact of the tangent, and the chord joining these points. Discuss the symmetries of this diagram and hence obtain and explain the required symmetry and angle properties. Give learners angle and length problems to solve using these properties. For instance, Pythagoras' theorem (topic 6.1) can be used to find the length of a chord, given the radius and its distance from the centre. Some of the tasks in 'Discovering circle theorems', an activity from the National Centre for Excellence in Teaching Mathematics (NCETM) can challenge learners to consider fully these theorems. **(E)**
3.6 Parallel lines	Find the gradient and equation of a straight line parallel to a given line.	Use examples to show that parallel lines have the same gradient. Include examples where the equation is given implicitly, e.g. which of these lines are parallel? $y = 2x$, $y + 2x = 10$, $y - 2x + 3$, $2y = 2x + 7$, etc. Use an odd-one-out activity with three or more examples, where one of the lines is not parallel to the others and ask learners to identify which one is the odd-one-out and why. Ask learners to come up with their own set of odd-one-out examples. You could use the following resource to assess learners' understanding of this topic (along with topic 3.3, 3.4, 3.5 and 3.7) **(I) (F)**: Parallel lines: www.mathsisfun.com/algebra/line-parallel-perpendicular.html Resource Plus Teaching Pack: Straight line graphs The Teaching Pack includes a lesson on finding the gradient of parallel and perpendicular lines.

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
3.7 Perpendicular lines	Find the gradient and equation of a straight line perpendicular to a given line.	Find the gradient of perpendicular lines by using the fact that if two lines are perpendicular the product of their gradients is –1, e.g. find the gradient of a line perpendicular to $y = 3x + 1$. Use a variety of examples linking to earlier topics from this unit, e.g. find the equation of a line perpendicular to one passing through the coordinates (1, 3) and (–2, –9). To support topics 3.6 and 3.7 learners could do the tasks 'Enclosing Squares': http://nrich.maths.org/763 and 'Painting Between the Lines': http://nrich.maths.org/7031 **(E)** You could use the following resources to assess learners' understanding of this topic (along with topics 3.3, 3.4, 3.5 and 3.6) **(I) (F)**: • Parallel lines: www.mathsisfun.com/algebra/line-parallel-perpendicular.html • Lots of lines!: undergroundmathematics.org/geometry-of-equations/lots-of-lines Resource Plus Teaching Pack: Straight line graphs The Teaching Pack includes a lesson on finding the gradient of parallel and perpendicular lines.
1.10 Limits of accuracy	1. Give upper and lower bounds for data rounded to a specified accuracy. 2. Find upper and lower bounds of the results of calculations which have used data rounded to a specified accuracy.	Start this topic by giving learners problems to determine upper and lower bounds for data. Use simple examples and then progressively harder ones, such as: 'a length, l, measured as 3 cm to the nearest millimetre has lower bound 2.95 cm and upper bound 3.05 cm'. Emphasise that the bounds, in this case, are not 2.5 and 3.5, which would be a common misconception. Show learners how this information can be written using inequality signs, e.g. 2.95 cm ≤ l < 3.05 cm. Move on to looking at upper and lower bounds for quantities calculated from given formulae. To check their understanding, learners try past paper questions. **(F)** Resource Plus Teaching Pack: Accuracy and bounds This Teaching Pack includes lessons that cover the following: • accuracy and bounds to the nearest 10, 100 or 1000 • … to 3 decimal places • … to significant figures • substituting bounds into formulae.

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
6.3 Non-right-angled triangles	1. Use the sine and cosine rules in calculations involving lengths and angles for any triangle. 2. Use the formula area of triangle = $\frac{1}{2} ab \sin C$.	Rearrange the formula for the area of a triangle $\frac{1}{2} bh$ to the form $\frac{1}{2} ab \sin C$ (regentsprep.org has a useful resource to support this). Illustrate its use with a few simple examples. Explain that the letters in the formula may change from problem to problem, so learners should try to remember the pattern of two sides and the sine of the included angle. Move on to see if learners can use the formula to work out other problems, e.g. 'calculate the area of a segment of a circle given the radius and the sector angle' (using their knowledge of sector area work from topic 5.3) or 'calculate the area of a parallelogram given two adjacent side lengths and any angle'. **(I)** Use examples to show how to solve problems using the sine rule, explaining that the version $\frac{a}{\sin A} = \frac{b}{\sin B}$ is preferable for finding a side and the version $\frac{\sin A}{a} = \frac{\sin B}{b}$ is preferable for finding an angle. Use examples to show how to solve problems using the cosine rule. Make sure that learners either learn both rearrangements of the formula: • to find a side $a^2 = b^2 + c^2 - 2bc \cos A$ • to find an angle $\cos A = \frac{b^2 + c^2 - a^2}{2bc}$ or can confidently rearrange from one to the other. Give learners a set of questions where they can either use the sine rule or the cosine rule. Ask them not to work out the answers but instead to decide which rule to use. Explain how learners can tell whether they need the sine rule or the cosine rule, i.e. use the cosine rule when you know all three sides in a triangle or an enclosed angle and two sides, otherwise use the sine rule. The Maths is Fun website (www.mathsisfun.com) has a useful page on 'Area of triangles without right angles'.**(I)**

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9. Sets, scatter diagrams, 3D trig and vector geometry

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
1.2 Sets	Understand and use set language, notation and Venn diagrams to describe sets and represent relations between sets Example definition of sets: A = {x: x is a natural number} B = {(x,y): $y = mx + c$} C = {$x : a \le x \le b$} D = {$a, b, c…$} Union of A and B; $A \cup B$ Intersection of A and B; $A \cap B$	It is useful to start with revising simple Venn diagrams. For example, group learners who wear glasses in one circle and learners with brown hair in another circle, and ask learners to describe those in the overlapping region. Extend this to general Venn diagrams concentrating more on the shading of the regions representing the sets $A \cup B$, $A \cap B$, $A' \cup B$, $A \cup B'$, $A' \cap B$, $A \cap B'$, $A' \cup B'$ and $A' \cap B'$ helping learners to understand the notation. Show learners that $(A \cup B)'$ is the same as $A' \cap B'$ and that $(A \cap B)'$ is the same as $A' \cup B'$. Make sure that learners understand the language associated with sets and Venn diagrams. The work on Venn diagrams can be extended to look at unions and intersections when there are three sets. **Resource Plus** Teaching Pack: Venn diagrams This Teaching Pack includes lessons that cover the following: • using Venn diagrams • formal notation used with Venn diagrams • constructing Venn diagrams to solve problems • calculating simple probabilities using Venn diagrams.
9.5 Scatter diagrams	1. Draw and interpret scatter diagrams. 2. Understand what is meant by positive, negative and zero correlation. 3. Draw by eye,	Explain how to draw scatter diagrams with a simple example. Use simple examples of scatter diagrams to explain the terms and meanings of positive, negative and zero correlation. Practise drawing scatter diagrams and describe the resulting correlation. Discuss why and where scatter graphs are useful, e.g. in making predictions. Explore the Gapminder website (www.gapminder.org/) for innovative approaches to scatter diagrams and videos that you could use to engage learners using some real-life topical contexts.

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
	interpret and use a straight line of best fit.	Ask learners to collect some bivariate data of their choice and to predict the correlation, if any, that they expect to find, for example, height and arm span for members of the class. Use collected data to draw a scatter diagram and then look for the expected correlation. Discuss the results. Use the 'How does income relate to life expectancy' presentation on the Gapminder website (www.gapminder.org/) to demonstrate the use of correlation to explore social problems. Explain that if there are too few points on a scatter diagram, there may appear to be a correlation when in fact there is no real relationship between the variables. Learners should understand that a correlation does not prove cause and effect it just provides evidence to support a potential relationship and/or identify an area for further research. For example, a third unidentified variable may be causing the apparent correlation. Learners could do a web search for the 'Televisions, Physicians, and Life Expectancy' problem to demonstrate this phenomenon. **(E)** Explain, with diagrams, that the purpose of a good line of best fit is to have the sum of the vertical distances from each point to the line as small as possible. In simpler terms, ask learners to aim for a similar number of points on each side of the line and as many points as possible on the line or as close to it as possible. Draw diagrams showing bad lines of best fit explaining what is wrong with them. For example, a common error made by learners is to draw the line of best fit through the origin when that doesn't fit with the trend of the data. Extend the work with learners finding equations for their line of best fit. If using data from e.g. their science experiments this could be interpreted in terms of the two variables. **(E)** Resource Plus Teaching Pack: Statistics The Teaching Pack includes lessons on: • predicting trends, considering data models and effective questioning • bar charts and histograms • representations, restrictions and relationships between data • cumulative frequency and box-and-whisker plots **SDG 3** Teach correlation using data on social problems such as income and life expectancy. **SDG 11** Consider looking at the correlation between cost and distance to travel (for journeys from your location), or

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
		between life expectancy and average height for different countries.
6.4 Pythagoras' theorem and trigonometry in 3D	Carry out calculations and solve problems in three dimensions using Pythagoras' theorem and trigonometry, including calculating the area between a line and a plane.	Use a flagpole supported by wires or similar situation to introduce a problem in three dimensions needing the use of trigonometry or Pythagoras' theorem, revising the work as necessary. Show learners how to identify the right-angled triangle required and teach them to draw a sketch of this triangle, showing the right angle at its true size to assist in the solution. Learners often find it difficult to visualise the triangle required. One method is to use pieces of wire or spaghetti with small pieces of poster mounting putty or non-hardening modelling clay to make 3D models and highlight the triangles that are used in solving questions. Alternatively, use cardboard models with sections cut away to show the section required. **(I)** Give practice in solving problems. **(I) (F)** Ask learners to design a net for a pyramid-shaped gift box with a given height and base dimension. **(I) (E)** Learners consider the level of accuracy for a practical problem, e.g. finding the height of a tree, building or mountain. How accurate are the measurements? What are the upper and lower bounds in each case? What effect will this have on the final answer? Giving values for sin, cos or tan that are insufficiently accurate is a common error in examinations; the results of this activity should demonstrate that small errors in measurement can have a significant impact on the result. **(E)** Reinforce or assess understanding of this topic using this workbook on 3D geometry: http://www.cimt.org.uk/projects/mepres/allgcse/bkc18.pdf **(I) (F)** **SDG 9** Consider using trigonometry for working out railway inclines.
7.3 Magnitude of a vector	Calculate the magnitude of a vector $\begin{pmatrix} x \\ y \end{pmatrix}$ as $\sqrt{x^2 + y^2}$	Use diagrams to help illustrate how to calculate the magnitude of a vector; link this to the work on Pythagoras' theorem from topic 6.1. Resource Plus Teaching Pack: Vectors The Teaching Pack includes lessons on: • properties of vectors • vectors and translations • adding and subtracting vectors • vectors in real life contexts • vector geometry.

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
7.4 Vector geometry	1. Represent vectors by directed line segments. 2. Use position vectors. 3. Use the sum and difference of two or more vectors to express given vectors in terms of two coplanar vectors. 4. Use vectors to reason and to solve geometric problems	Explain the notation required, i.e. $\overrightarrow{AB}$ or **a** for vectors and for their magnitudes $\left|\overrightarrow{AB}\right|$ or $\|a\|$ (with modulus signs). Define a position vector and give learners various problems in vector geometry. Explain to learners that in their answers to questions, they are expected to indicate **a** in some definite way, e.g. by an arrow or by underlining, thus $\overrightarrow{AB}$ or <u>a</u>. Use vectors to solve problems and demonstrate some properties of plane figures, e.g. that the diagonals of a parallelogram bisect each other, or that the medians of a triangle intersect, dividing the medians in the ratio 2:1. There are some more challenging questions and extension work on the Centre for Innovation in Mathematics Teaching website: www.cimt.org.uk/projects/mepres/allgcse/bkc19.pdf **(I) (E)** Resource Plus Teaching Pack: Vectors The Teaching Pack includes lessons on: - properties of vectors - vectors and translations - adding and subtracting vectors - vectors in real life contexts - vector geometry.

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10. Functions, histograms (& differentiation)

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
9.7 Histograms	1. Draw and interpret histograms. 2. Calculate with frequency density.	Use an example to show how discrete data can be grouped into equal classes. Draw a histogram to illustrate the data (i.e. with a continuous scale along the horizontal axis). Point out that this information could also be displayed in a bar chart (i.e. with bars separated) because data is discrete. Record sets of continuous data, e.g. heights, masses, etc., in grouped frequency tables. Use examples that illustrate equal class widths and unequal class widths. Draw the corresponding histograms. Emphasise that for continuous data, bars of a histogram must touch. Use the section on bar charts and histograms at mrbartonmaths.com ('The Maths E-Book of Notes and Examples'), to illustrate why frequency density is a fairer way to represent data than frequency on the vertical axis. Label the vertical axis of a histogram as 'frequency density' and show that the area of each bar is proportional to the frequency. Show how to calculate frequency densities from a frequency table with grouped data and how to calculate frequencies from a given histogram. Ask learners to consider how they could estimate the median value from a histogram. **(E)** Resource Plus Teaching Pack: Statistics The Teaching Pack includes lessons on: • predicting trends, considering data models and effective questioning • bar charts and histograms • representations, restrictions and relationships between data • cumulative frequency and box-and-whisker plots. **SDG 12/15** Consider using histograms for the distribution of size of a local food product.
2.12 Functions	1. Understand functions, domain and range, and use function notation. 2. Understand	Give learners a definition of a function, $f(x)$: that it is a rule applied to values of x. Look at evaluating simple functions for specific values, for example linear functions, describing the functions using $f(x)$ notation and mapping notation. The next step is to introduce the inverse function as an operation which 'undoes' the effect of a function. Demonstrate how learners can evaluate simple inverse functions for specific values, describing the functions using the $f^{-1}(x)$ notation and mapping notation. Link this to the work on transforming formulae

Syllabus ref. and SDGs	Learning objectives	Suggested teaching activities
	and find inverse functions f^{−1}(x). 3. Form composite functions as defined by gf(x) = g(f(x)).	from topic 2.5. Explain to learners that to find the inverse of the function $f(x) = 2x - 5$, a useful method is to rewrite this as $y = 2x - 5$, then to interchange the x and y to get $x = 2y - 5$, then to make y the subject: $y = (x + 5)/2$ and finally to rewrite using the inverse function notation as $f^{-1}(x) = (x + 5)/2$. Using linear and/or quadratic functions, $f(x)$ and $g(x)$, show learners how to form composite functions such as $gf(x)$, and how to evaluate them for specific values of x. Ask learners to investigate for a variety of different functions $gf(x)$ and $fg(x)$ to see that these are often not the same. Emphasise that it is important that learners know the correct order to apply the functions. Provide learners with examples and questions, either prepared yourself or from textbooks. The video 'Finding inverse functions: linear' on the Khan academy website (www.khanacademy.org) also talks about what the graph of an inverse function looks like. Knowing that the graph of an inverse function is a reflection in the line $y = x$ is a useful extension for more able learners. **(E)** Learners investigate or research functions to find examples where the inverse function does not work for all values. **(E)**

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