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# Mathematics resources



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# WELCOME TO THE MATHEMATICS CATALOGUE

Inside this catalogue you will find our broad range of resources for secondary level mathematics.

Covering a wide range of UK and international curricula, our resources draw on the best current practices in mathematics education to support teaching and learning worldwide.

Our A Level Mathematics and Further Mathematics series have been developed for the **OCR A** and **AQA** specifications and are written by an experienced author team. These resources ensure a strong focus on the development of problem-solving skills, mathematical reasoning and fluency, equipping students and teachers with exactly what they need to face the challenges of the A Level curriculum.

Also included is our GCSE Mathematics series specifically written for the **AQA**, **Edexcel** and **OCR** specifications. This comprehensive suite also includes the innovative GCSE Mathematics Online – our digital resource that provides an interactive and flexible enhancement to your class. With a strong focus on the development of problem-solving skills, mathematical reasoning and fluency, our resources support the navigation of the assessment objectives and exams, and help prepare students for the specifications.

You can also explore our Cambridge IGCSE™ Mathematics and Cambridge International AS & A Level Mathematics resources which have been developed for first examination from 2020.

For more information, please contact your local sales consultant, who will be happy to answer your questions or visit [cambridge.org/education](https://cambridge.org/education).

Best wishes,

**The Mathematics Team**

### Key to icons



Print book



Digital resource



Print book and digital resource bundle

**Order your A Level Mathematics approval copies for OCR A and AQA**

Contact your local consultant for more details.

# GCSE Mathematics Online

## The complete online resource for GCSE Mathematics

GCSE Mathematics Online is our interactive teaching and learning subscription service available for the AQA, Edexcel and OCR 2015 GCSE Mathematics specifications. This tablet-friendly resource supports both independent learning and whole-class teaching through a suite of flexible resources that includes lesson notes, interactive walkthroughs, explanatory animations, games, worksheets, quick quizzes and levelled assessments.

Sign up for a  
**30-DAY  
FREE TRIAL**  
and access to **FREE** Year 9  
Transition Units.  
Find out more  
[gcsemaths.cambridge.org](http://gcsemaths.cambridge.org)



- Allows teachers to set tasks, create tests, auto-mark and compile reports to review student performance.
- A test generator to compile your own assessments
- Interactive widgets to visually demonstrate concepts
- Worksheets offering practical activities, discussion points, investigations, games and further practice
- Walkthroughs that take students through a question step by step, with feedback
- Quick-fire quizzes with leaderboards, providing an opportunity for question practice
- Levelled questions that assess understanding of each topic

- Covers both Foundation and Higher, offering flexibility for moving students between tiers
- Resources organised into chapters corresponding to the student books, with explanatory notes for all topics
- Contains material for all types of classroom set-up, including interactive whiteboards, projectors and tablets
- Includes a digital PDF version of both the Foundation and Higher student books

**Whole-  
school site  
licence  
AVAILABLE\***

\*UK schools only, an unlimited number of teachers and students within the same school.

## Launchpad

A flow chart of concepts covered in the chapter. Each step tests a different skill, progressing from least to most advanced. Students can assess their most appropriate starting point in the chapter, encouraging them to take ownership of their learning.

### What you will learn

Short objectives to show the content and mathematical skills covered in the chapter.

## 41 Transformations of curves and their equations

In this chapter you will learn how to ...

- Identify transformations and reflections of a given graph or equation.
- Sketch the graphs of these types of transformation.

For more resources relating to this chapter, visit the OCR Mathematics Online.

### Using mathematics: real-life applications

Many people study the graphs of curves in the course of their work. Sound engineers are a good example. They mix and balance sounds by looking at curves made by sound waves.



Tip  
Use ICT when studying this chapter. You can draw your own graphs so you can study them quickly and accurately, comparing values and comparing results.

### Before you start...

Ch 18: You should be able to recognise the graphs of standard functions.

$y = x^2 + c$

$y = mx + c$

$y = \frac{1}{x}$

Sketch each function to show its general shape.

Ch 33: You should be able to sketch the trigonometric functions.

$y = \sin x$

$y = \cos x$

$y = \tan x$

Sketch and label the third trigonometric function.

Ch 8: You should be able to complete the square on a quadratic equation.

1. Which of these functions would result in a curved graph and which would produce a linear graph?

a  $y = x^2 + 9$

b  $y = x^2 - 9$

c  $y = \frac{2}{x}$

d  $y = (x - 7)^2 - 2$

Sketch each function to show its general shape.

2. Which trigonometric functions are represented by these graphs?

a

b

c

Sketch and label the third trigonometric function.

3. Rewrite  $y = 3x^2 + 6x + 7$  in the form  $a(x - h)^2 + k$ .

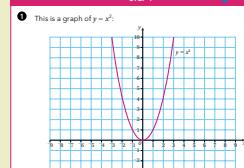
4. Solve  $y = 3x^2 + 6x + 7$  in the form  $a(x - h)^2 + k$ .

746

### 41 Transformations of curves and their equations

Assess your starting point using the Launchpad

STEP 1



Sketch

a  $y = x^2 + 2$

b  $y = x^2 - 2$

c Write the equation of the reflection of this graph about the x-axis.

d What happens to the graph when it is reflected about the y-axis?

GO TO  
Section 1  
Quadratic functions and parabolas

STEP 2

a What are the values of  $\sin 90^\circ$  and  $\cos 90^\circ$ ?

For what values of  $\theta$  does  $\cos \theta = 1$ ?

b Sketch graphs of  $y = \sin x + 2$  and  $y = \cos(x + 90^\circ)$ .

GO TO  
Section 2  
Trigonometric functions

STEP 3

The Launchpad continues on the next page ...

GO TO  
Step 3

Find answers at: [cambridge.org/schools/ocr-maths-student-book-answers](http://cambridge.org/schools/ocr-maths-student-book-answers)

### Tip

General hints and reminders to aid students, sometimes including questions to prompt their knowledge.

### Before you start...

Lists the prerequisite knowledge for the chapter. Includes questions on each concept to assess whether students can recall the necessary knowledge and skills.

Sample pages from OCR Foundation student book.

## Student books



- Written from scratch and approved for the 2015 OCR (J560) GCSE Mathematics specification
- A 'Launchpad' feature at the beginning of each chapter directs students to their best starting point to optimise progress and allows for both independent and personalised learning

- Topics and problems are introduced through a wide variety of contexts, showing how maths relates to the real world
- Thousands of questions cover all assessment objectives, offering extensive opportunity to master key skills
- A 'Work it out' feature encourages students to explore and discuss common errors, helping to draw out misconceptions

## Problem-solving books



- Approved for the 2015 OCR GCSE Mathematics qualification.
- Questions with worked solutions draw out the reasoning, interpreting, estimating and communication skills required to effectively solve problems
- Each chapter focuses on a different technique to equip students with a problem-solving toolkit that they can apply to any question, encouraging students to develop problem-solving 'muscle memory'
- All questions have star ratings to show the level of difficulty, allowing students to track their progress
- Questions are colour-coded to show which strands of maths they cover, with questions covering multiple topics to prepare students for the synoptic nature of the exams

## Homework books



- Approved for the 2015 OCR GCSE Mathematics specification
- Offer practice questions for students across the full GCSE Mathematics curriculum
- Contain exercises that correspond to each section of the student book, offering hundreds of additional questions for further practice
- Questions assess a variety of skills, including recall, interpretation, problem-solving and mathematical reasoning
- Ideally sized for school bags

## Teacher's resource



Our FREE digital teacher's resource for both the Foundation and Higher tiers contains everything necessary to plan and deliver the 2015 OCR (J560) GCSE Mathematics qualification.

## GCSE Mathematics for OCR course structure



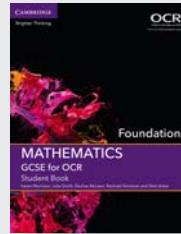
### Student books

Student books have a strong focus on the development of problem-solving skills, mathematical reasoning and fluency.

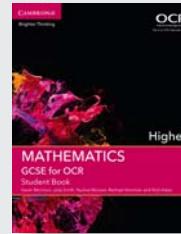
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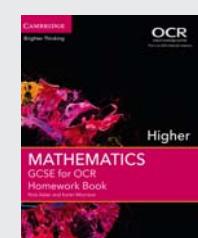
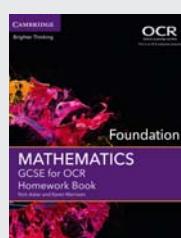
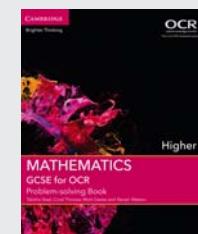
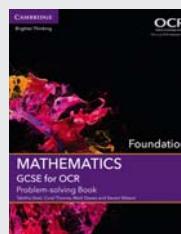
### GCSE Mathematics Online

GCSE Mathematics Online for OCR is packed with flexible resources that include lesson notes, walkthroughs, animations, games, worksheets, quick quizzes and levelled assessments.

Site Licence (1 Year)\* 9781316507858; 1 Year 9781107449909  
2 Years 9781107449855; 3 Years 9781107569386



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### Homework books

Homework books are affordable standalone resources and ideal companions to the student books.

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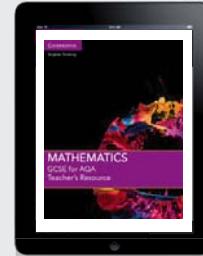
Higher: 9781107496927



### Teacher's resource

Our FREE digital teacher's resource for both the Foundation and Higher tiers is full of teaching ideas and advice. Available from [cambridge.org/education](http://cambridge.org/education).

9781107468221



FREE

Editable GCSE  
Mathematics for OCR  
1, 2 and 3 year schemes  
of work, available at  
[cambridge.org/education](http://cambridge.org/education)

\*UK schools only, an unlimited number of teachers and students within the same school.

# GCSE Mathematics for Edexcel

## What you will learn

Short objectives to show the content and mathematical skills covered in the chapter.

## Using mathematics

Shows how the content of the chapter relates to the world of work, making maths relevant beyond the classroom.

## Launchpad

A flow chart of concepts covered in the chapter. Each step tests a different skill, progressing from least to most advanced. Students can assess their most appropriate starting point in the chapter, encouraging them to take ownership of their learning.

### 8 Powers and roots

In this chapter you will learn how to ...

- use integers and fractions to represent numbers in index notation.
- apply the rules for multiplying and dividing indices.

For more resources visit [Cambridge GO! Mathematics Online](#).

Using mathematics: real-life applications

Financial advisors and investors have to perform calculations involving powers and roots to work out the value of investments. They may use computer technology (apps) to work out different options to help their clients invest their money wisely.

**Calculator tip**

Make sure you know which buttons to use on your calculator to multiply and find different roots of numbers.

I need to be able to understand, calculate and evaluate different formulas to find the best investment. Many of these formulas involve fractional powers and different roots. (Personal financial advisor)

Before you start ...

Ch 1	You should be able to quickly add and subtract pairs of integers mentally.	1 Choose the correct sign: $c_1$ or $c_2$ . a $-3 - 4 = 2$ b $6 - 7 = 3$ c $4$ d $-2 + 6 = 5$
Ch 4	You need to be able to find the squares, cubes, square roots and cube roots of numbers.	2 Choose the correct answer. a The area of a square with sides of 6 cm. b $6\text{cm}^2$ c $6\text{cm}^3$ d $36\text{cm}^2$ e $36\text{cm}^3$ f $36\text{cm}^4$ g $\sqrt{10000}$ h $\sqrt{5}$ i $\sqrt{3}$
Ch 6	You need to be able to find the reciprocal of a number or fraction.	3 Find the reciprocal of each number. Choose from the values in the box. a $\frac{1}{2}$ b $12$ c $\frac{1}{12}$ d $\frac{1}{3}$ e $\frac{1}{2}$ f $\frac{1}{12}$ g $\frac{1}{3}$ h $\frac{1}{2}$

Find answers at: [cambridge.org/uk/schools/gcse/mathematics-student-book/answers](#)

## GCSE Mathematics for Edexcel (Higher)

Assess your starting point using the Launchpad

**STEP 1**

1 Write each of these numbers in index notation.

- a  $4 \times 4 \times 4 \times 4$
- b  $8^3$  (eight cubed)
- c  $4^6$  (four to the power of 6)
- d nine to the power of seven
- e the reciprocal of 3 to the power of 4
- f the reciprocal of 2 to the power of 3

**GO TO** [Section 1: Index notation](#)

**STEP 2**

2 Evaluate these without a calculator. Give the answer in index form and show your working out.

- a  $3^3 \times 3^2$
- b  $4^2 \times 4^4$
- c  $\frac{5^3}{5^2}$
- d  $\frac{6^3}{6^2}$
- e  $(2^3)^2$

**GO TO** [Chapter review](#)

## Key vocabulary

index: a power or exponent, indicating how many times a base number is multiplied by itself. For example, in  $5^3$ , the index is 3 because it means the number 5 is multiplied by itself 3 times:  $(5 \times 5 \times 5)$ .

index notation: writing a number as a base and index, for example  $2^3$ .

**Tip**

Any number to the power of 1 stays the same number so you don't usually write powers of 1.

The plural of index is indices.

## Tip

General hints and reminders to aid students, sometimes including questions to prompt their knowledge.

Sample pages from Edexcel Foundation student book.

## Student books



- Written from scratch and approved for the 2015 Edexcel (1MA1) GCSE Mathematics specification
- A 'Launchpad' feature at the beginning of each chapter directs students to their best starting point to optimise progress and allows for both independent and personalised learning

- Topics and problems are introduced through a wide variety of contexts, showing how maths relates to the real world
- Thousands of questions cover all assessment objectives, offering extensive opportunity to master key skills
- A 'Work it out' feature encourages students to explore and discuss common errors, helping to draw out misconceptions

## Problem-solving books



- Approved for the 2015 Edexcel GCSE Mathematics specification
- Questions with worked solutions draw out the reasoning, interpreting, estimating and communication skills required to effectively solve problems
- Each chapter focuses on a different technique to equip students with a problem-solving toolkit that they can apply to any question, encouraging students to develop problem-solving 'muscle memory'
- All questions have star ratings to show the level of difficulty, allowing students to track their progress
- Questions are colour-coded to show which strands of maths they cover, with questions covering multiple topics to prepare students for the synoptic nature of the exams

## Homework books



- Approved for the 2015 Edexcel GCSE Mathematics specification
- Offer practice questions for students across the full GCSE Mathematics curriculum
- Contain exercises that correspond to each section of the student book, offering hundreds of additional questions for further practice
- Questions assess a variety of skills, including recall, interpretation, problem-solving and mathematical reasoning
- Ideally sized for school bags

## Teacher's resource



Our FREE digital teacher's resource for both the Foundation and Higher tiers contains everything necessary to plan and deliver the 2015 Edexcel (1MA1) GCSE Mathematics qualification.

## GCSE Mathematics for Edexcel course structure



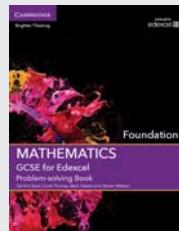
### Student books

Student books have a strong focus on the development of problem-solving skills, mathematical reasoning and fluency.

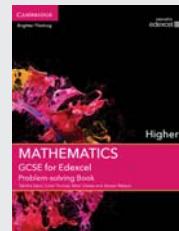
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Higher: 9781107448001

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### GCSE Mathematics Online

GCSE Mathematics Online for Edexcel is packed with flexible resources that include lesson notes, walkthroughs, animations, games, worksheets, quick quizzes and levelled assessments.

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2 Years 9781107449671; 3 Years 9781107569256



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### Student book and online subscription bundle

Contains our print student book and GCSE Mathematics Online subscription service for Edexcel.

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Higher: 2 Years 9781107447851; 3 Years 9781107557642

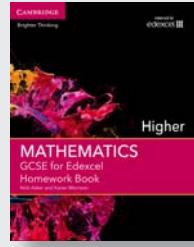
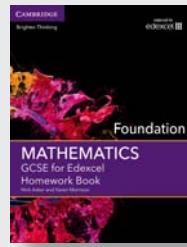
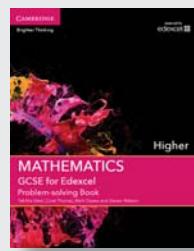
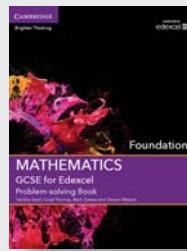


### Problem-solving books

Problem-solving books contain a variety of questions to develop students' problem-solving and reasoning skills within the context of the GCSE curriculum.

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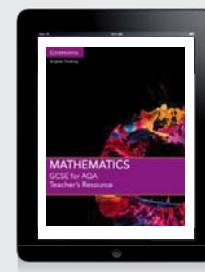


### Homework books

Homework books are affordable standalone resources and ideal companions to the student books.

Foundation: 9781107496859

Higher: 9781107496828



FREE

Editable GCSE Mathematics for Edexcel 1, 2 and 3-year schemes of work, available at [cambridge.org/education](http://cambridge.org/education)



### Teacher's resource

Our FREE digital teacher's resource for both the Foundation and Higher tiers is full of teaching ideas and advice. Available from [cambridge.org/education](http://cambridge.org/education).

9781107468146

\*UK schools only, an unlimited number of teachers and students within the same school.

# GCSE Mathematics for AQA

**Launchpad**

A flow chart of concepts covered in the chapter. Each step tests a different skill, progressing from least to most advanced. Students can assess their most appropriate starting point in the chapter, encouraging them to take ownership of their learning.

**What you will learn**

Short objectives to show the content and mathematical skills covered in the chapter.

**Using mathematics**

Shows how the content of the chapter relates to the world of work, making maths relevant beyond the classroom.

**26 Ratio**

**Using mathematics: real-life applications**

Ratio is used in many different real-life situations. Comparing between different quantities, the greater the ratio is to the best value for money, mixing large quantities of cement and scaling up a recipe to cater for more people all involve reasoning using ratios.

**Before you start ...**

CB 5 You need to be able to identify and simplify fractions.

CB 5 You need to be able to find a fraction of a quantity.

CB 5 You need to be able to find an original amount given a fraction.

CB 5 You need to be able to identify and simplify fractions.

CB 5 You need to be able to find a fraction of a quantity.

CB 5 You need to be able to find an original amount given a fraction.

**Assess your starting point using the Launchpad**

**STEP 1**

1 Write the ratio 12:21 in its simplest form.  
2 In a class of 34 girls and 14 boys what is the ratio of boys to girls?  
3 In every 80 minutes of television broadcast, a quarter of an hour of adverts is shown.  
What is the ratio of adverts to programmes?

**STEP 2**

1 Share 35 in the ratio 2:5.  
2 The dry ingredients for chocolate brownies are dark chocolate, vegetable oil, caster sugar and self-raising flour. In the ratio 17:5:17:20:10. I have 85 grams of dark chocolate. What weight of dried mixture can I make?

**GO TO Section 1 Introducing ratios**

**GO TO Section 2 Sharing in a given ratio**

**GO TO Chapter review**

**Key vocabulary**

Key terms are highlighted for ease of learning, and gathered in a glossary at the back of the student book for quick reference.

Sample pages from AQA Foundation student book.

## Student books



- Written from scratch and approved for the 2015 AQA (8300) GCSE Mathematics specification
- A 'Launchpad' feature at the beginning of each chapter directs students to their best starting point to optimise progress and allows for both independent and personalised learning

- Topics and problems are introduced through a wide variety of contexts, showing how maths relates to the real world
- Thousands of questions, including multiple-choice questions, cover all assessment objectives, offering extensive questions to master key skills
- A 'Work it out' feature encourages students to explore and discuss common errors, helping to draw out misconceptions

## Problem-solving books



- Questions with worked solutions draw out the reasoning, interpreting, estimating and communication skills required to effectively solve problems
- Each chapter focuses on a different technique to equip students with a problem-solving toolkit that they can apply to any question, encouraging students to develop problem-solving 'muscle memory'
- All questions have star ratings to show the level of difficulty, allowing students to track their progress
- Questions are colour-coded to show which strands of maths they cover, with questions covering multiple topics to prepare students for the synoptic nature of the exams

## Homework books



- Offer practice questions for students across the full GCSE Mathematics curriculum
- Contain exercises that correspond to each section of the student book, offering hundreds of additional questions for further practice
- Questions assess a variety of skills, including recall, interpretation, problem-solving and mathematical reasoning
- Questions increase in difficulty throughout each exercise and chapter to build confidence and allow for progression
- Ideally sized for school bags

## Teacher's resource



Our FREE digital teacher's resource for both the Foundation and Higher tiers contains everything necessary to plan and deliver the 2015 AQA (8300) GCSE Mathematics qualification.

## GCSE Mathematics for AQA course structure



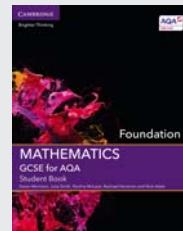
### Student books

Student books have a strong focus on the development of problem-solving skills, mathematical reasoning and fluency.

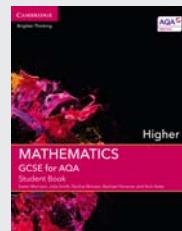
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2 Years 9781107449770; 3 Years 9781107569317



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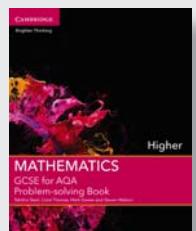
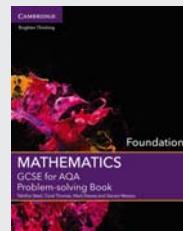


### Student book and online subscription bundle

Contains our print student book and GCSE Mathematics Online subscription service for AQA.

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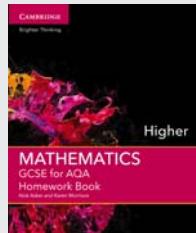
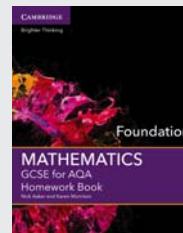
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Problem-solving books contain a variety of questions to develop students' problem-solving and reasoning skills within the context of the GCSE curriculum.

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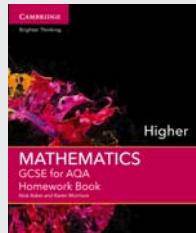


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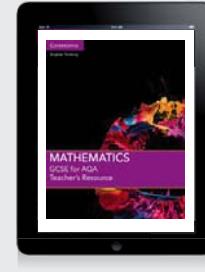
Higher: 9781107496866



### Teacher's resource

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FREE

Editable GCSE Mathematics for AQA 1, 2 and 3-year schemes of work, available at [cambridge.org/education](http://cambridge.org/education)

\*UK schools only, an unlimited number of teachers and students within the same school.

# AS/A Level Mathematics & Further Mathematics for OCR A

OCR'S  
PUBLISHER  
PARTNER  
FOR  
MATHEMATICS

## The resources

These OCR resources provide detailed coverage of the linear specifications, supporting teachers and students every step of the way by offering a firm foundation for study beyond A Level. In particular, the resources include:

- A structured pedagogical approach, assisting teachers in delivering expanded content in a clear and effective way

- A deeper, more synoptic understanding of mathematics that helps students to develop essential skills in problem-solving, modelling and proof to help meet the new requirements
- Cambridge Elevate editions which encourage adaptations of the student book, alongside other useful resources

## Student books

### Colour-coded exercises

Exercises are colour-coded and designed to provide careful progression, ranging from basic fluency to practice questions.

### Tip

Offers useful guidance to students, including ways of calculating or checking and using technology.

A Level Mathematics for OCR A Student Book 1

#### EXERCISE 5A

- Find the coordinates of intersection of the given curve and the given straight line.
  - $y = x^2 + 2x - 3$  and  $y = x - 1$
  - $y = x^2 - 4x + 3$  and  $y = 2x - 6$
- Solve the following simultaneous equations:
  - $y = -x^2 + 3x + 9$  and  $2x - y = 3$
  - $y = x^2 - 2x + 8$  and  $x - y = 6$
- Find the coordinates of the points of intersection of  $y = \frac{1}{x}$  and  $y = 2x$ .
- Solve simultaneously:
$$3^2 + 2^2 = 13 \quad 3^2 - 2^2 = 5$$
- Solve simultaneously:
$$y = 2^2 \quad 4^2 + y = 72$$
- The sum of two numbers is 8 and their product is 9.75.
  - Show that this information can be written as a quadratic equation.
  - What are the two numbers?
- Solve the equations  $xy + x = 0$ ,  $x^2 + y^2 = 4$ .
- The equations  $y = (x-2)(x-3)^2$  and  $y = k$  have one solution for all  $k < m$ . Find the largest value of  $m$ .

#### Section 2: The discriminant revisited

Sometimes you only want to know how many intersection points there are, rather than to find their actual coordinates. The discriminant can be used to determine the number of intersections.

#### WORKED EXAMPLE 5.2

Find the set of values of  $k$  for which the line with equation  $x + y = k$  intersects the curve with equation  $x^2 - 4x + y^2 + 6y = 12$  at two distinct points.

Line equation:  $y = k - x$

Substitute into the equation:

$$x^2 - 4x + (k - x)^2 + 6(k - x) = 12$$
$$\Rightarrow x^2 - 4x + k^2 - 2kx + x^2 + 6k - 6x = 12$$
$$\Rightarrow 2x^2 - (10 + 2k)x + k^2 + 6k - 12 = 0$$

This is a quadratic equation, so write it with one side equal to zero.

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Two solutions:  $\therefore \Delta > 0$

$$\Delta = (10 + 2k)^2 - 8(k^2 + 6k - 12) > 0$$

$$\Rightarrow 100 + 40k + 4k^2 - 8k^2 - 48k + 96 > 0$$

$$\Rightarrow -4k^2 - 8k + 196 > 0$$

$$\Rightarrow k^2 + 2k - 49 < 0$$

$$\Delta = k^2 + 2k - 49$$

$$\text{Roots: } k^2 + 2k - 49 = 0$$

$$k = \frac{-2 \pm \sqrt{4 + 4 \times 49}}{2}$$

$$= \frac{-2 \pm 2\sqrt{1 + 49}}{2}$$

$$= -1 \pm \sqrt{50} = -1 \pm 5\sqrt{2}$$

$$\therefore -1 - 5\sqrt{2} < k < -1 + 5\sqrt{2}$$

You know that the discriminant tells you the number of solutions of a quadratic equation.

Divide both sides by -4. Remember that this reverses the inequality.

$$A$$

$$-1 - 5\sqrt{2}$$

$$O$$

$$-1 + 5\sqrt{2}$$

$$\Delta = k^2 + 2k - 49$$

$$\text{Roots: } k^2 + 2k - 49 = 0$$

$$k = \frac{-2 \pm \sqrt{4 + 4 \times 49}}{2}$$

$$= \frac{-2 \pm 2\sqrt{1 + 49}}{2}$$

$$= -1 \pm \sqrt{50} = -1 \pm 5\sqrt{2}$$

$$\therefore -1 - 5\sqrt{2} < k < -1 + 5\sqrt{2}$$

This is a quadratic inequality. To solve it, find where LHS = 0 and sketch the graph.

The graph shows that the required interval is between the roots.

### Tip

Questions which talk about the number of intersections are often solved using the discriminant.

#### EXERCISE 5B

- Show that the line with equation  $x - y = 6$  is a tangent to the curve with equation  $x^2 - 6x + y^2 + 2y + 2 = 0$ .
- Find the exact values of  $m$  for which the line  $y = mx + 3$  is a tangent to the curve with equation  $y = 3x^2 - x + 5$ .
- Let  $C$  be the curve with equation  $4x^2 + 9y^2 = 36$ . Find the exact values of  $k$  for which the line  $2x + 3y = k$  is a tangent to  $C$ .

### Fast forward

The equation  $x^2 - 4x + y^2 + 6y = 12$  in Worked example 5.2 actually represents a circle. You will study circles in Chapter 6.

### Tip

A tangent touches the curve but does not cross at that point. With quadratic equations this means that there are repeated roots so the discriminant is zero. After studying Chapter 13 you will find another way of finding the tangent to a curve. However, this type of question is still best done using the discriminant.

Pages from A Level Mathematics for OCR A Student Book 1

### Worked examples

The left-hand side shows students how to set out their working. The right-hand side explains the more difficult steps and helps them to better understand why a particular method was chosen.

### Fast forward

Links to topics that students may cover in greater detail later on in their studies.

# AS/A Level Mathematics & Further Mathematics for OCR A

## Student books



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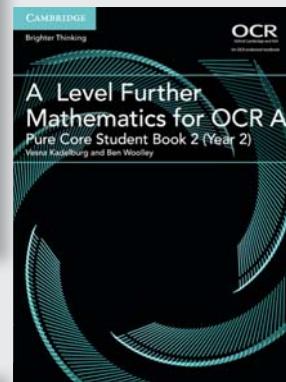
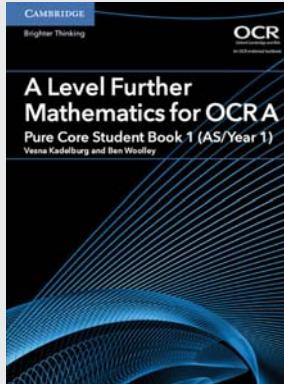
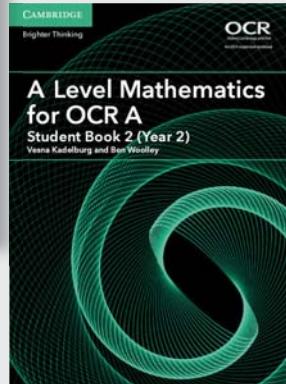
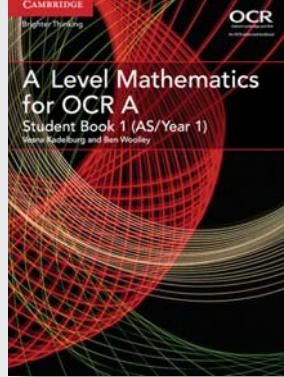
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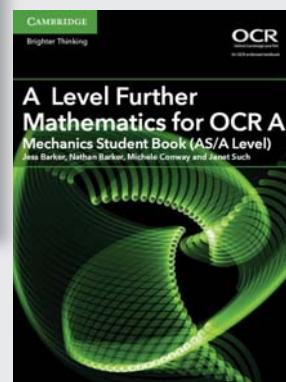
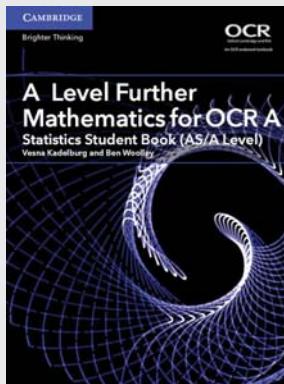
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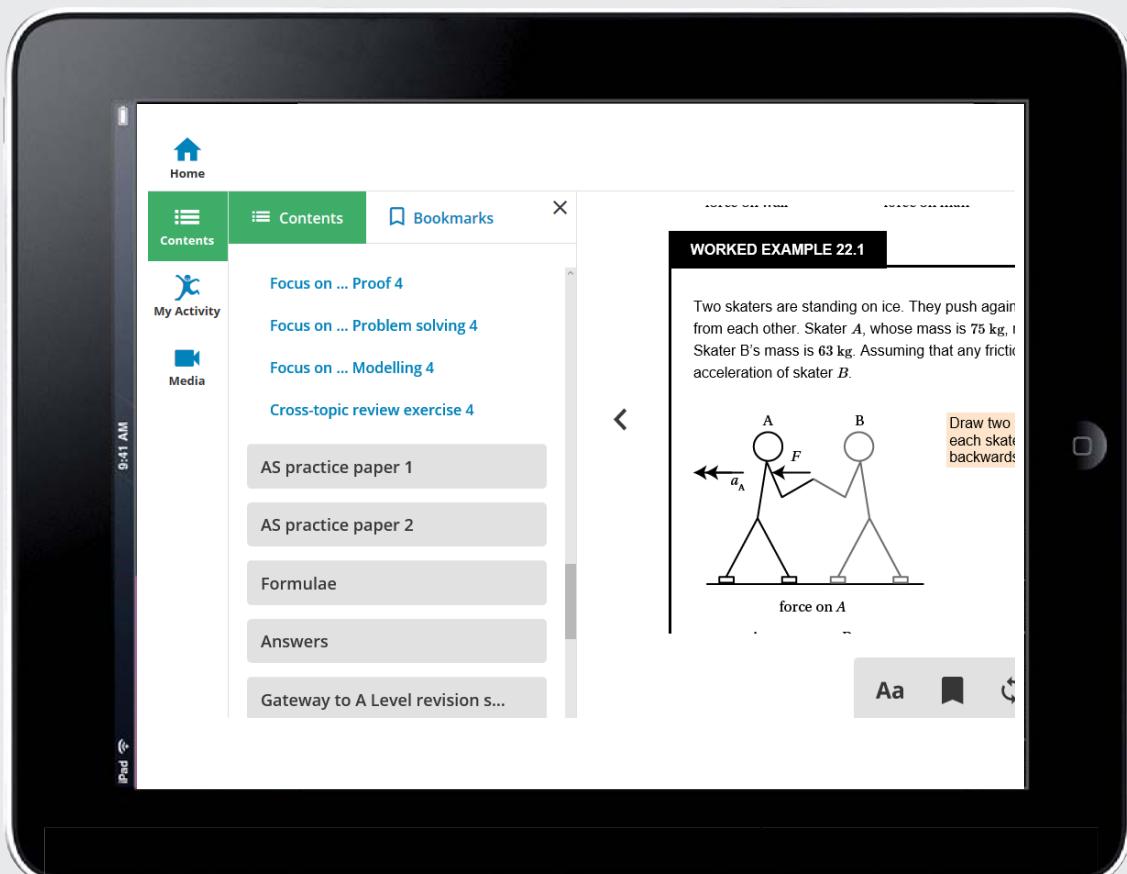
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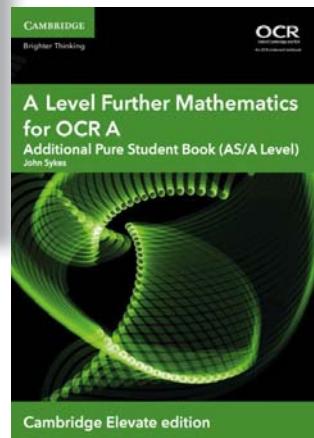
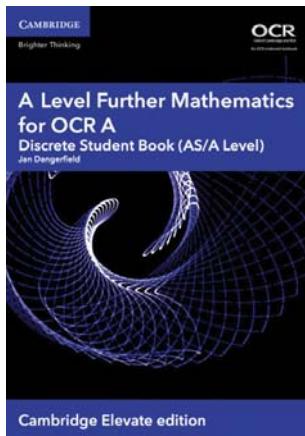
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- A structured pedagogical approach, assisting teachers in delivering expanded content in a clear and effective way

- A deeper, more synoptic understanding of mathematics that helps students to develop essential skills in problem-solving, modelling and proof to help meet the new requirements
- Cambridge Elevate editions which encourage adaptations of the student book, alongside other useful resources

## Student books

### Worked example

The left-hand side shows students how to set out their working. The right-hand side explains the more difficult steps and helps them to better understand why a particular method was chosen.

### Proof

Provides step-by-step walkthroughs of standard proofs and methods of proof.

### Key point

Provides a summary of the most important methods, facts and formulae for students.

A Level Mathematics for AQA Student Book 1

#### WORKED EXAMPLE 12.2

Prove, using differentiation from first principles, that for  $f(x) = x^3 + x$ ,  $f'(x) = 3x^2 + 1$ .

$$\begin{aligned}f'(x) &= \lim_{h \rightarrow 0} \frac{f(x+h) - f(x)}{h} \\&= \lim_{h \rightarrow 0} \frac{(x+h)^3 + (x+h) - (x^3 + x)}{h} \\&= \lim_{h \rightarrow 0} \frac{x^3 + 3x^2h + 3xh^2 + h^3 + x + h - x^3 - x}{h} \\&= \lim_{h \rightarrow 0} \frac{3x^2h + h^3 + x + h}{h} \\&= \lim_{h \rightarrow 0} (3x^2 + h^2 + 1) \\&= 3x^2 + 1\end{aligned}$$

Use the formula with  $f(x) = x^3 + x$ , so that  $f(x+h) = (x+h)^3 + (x+h)$ .

Expand  $(x+h)^3$  and simplify the expression.

Then divide top and bottom by  $h$ .

Finally, let  $h \rightarrow 0$ .

#### EXERCISE 12B

1 Prove from first principles that the derivative of  $y = 8$  is zero.

2  $f(x) = -4x$

Use differentiation from first principles to find  $f'(x)$ .

3  $y = 3x^2$

Find  $\frac{dy}{dx}$  from first principles.

4 Using differentiation from first principles, prove that the derivative of  $x^2 + 1$  is  $2x$ .

5 Differentiate  $f(x) = x^2 - 6x$  from first principles.

6  $y = x^2 - 3x + 4$

Using differentiation from first principles, find  $y'$ .

7 a Expand  $(x+h)^2$ .

b Hence find from first principles the derivative of  $y = x^2$ .

8  $f(x) = 3x^2 + 2$

Find  $f'(x)$  from first principles.

9 a Expand  $(x+h)^3$ .

b Hence prove from first principles that if  $f(x) = x^3$ , then  $f'(x) = 3x^2$ .

10 a Find an expression for the gradient of the chord between the points  $A$  and  $B$  on the curve  $y = f(x)$  with  $x$ -coordinates  $x$  and  $x+h$  respectively.

b Explain why, in the limit as  $h \rightarrow 0$ , the expression in part a becomes  $f'(x)$ .

#### Elevate

See Extension Sheet 12 for some harder questions on differentiation from first principles.

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Pages from A Level Mathematics for AQA Student Book 1

### Colour-coded exercises

Exercises are colour-coded and designed to provide careful progression, ranging from basic fluency to practice questions.

### Elevate

A support sheet for each chapter contains further worked examples and exercises on the most common question types. Extension sheets provide further challenges for the most ambitious.

12. Differentiation

11 Given that  $k$  is a constant, prove that the derivative of  $kf(x)$  is  $kf'(x)$ .

12 If  $y = f(x) + g(x)$ , prove that  $y' = f'(x) + g'(x)$ .

#### Section 3: Rules of differentiation

By now, you may have noticed a pattern emerging for differentiation.

#### Key point 12.4

If  $y = x^n$  then:

$$\frac{dy}{dx} = nx^{n-1}$$

The result in Key point 12.4 is proved here for positive integers, using differentiation from first principles, but the result is true (and you will need to use it) for all rational powers - positive and negative.

#### PROOF 6

$$\begin{aligned}\frac{dy}{dx} &= \lim_{h \rightarrow 0} \frac{(x+h)^n - x^n}{h} \quad \text{Use the formula with } f(x) = x^n. \\&= \lim_{h \rightarrow 0} \frac{x^n + \binom{n}{1}x^{n-1}h + \binom{n}{2}x^{n-2}h^2 + \dots + h^n - x^n}{h} \quad \text{Expand } (x+h)^n \text{ using the binomial expansion.} \\&= \lim_{h \rightarrow 0} \frac{\binom{n}{1}x^{n-1}h + \binom{n}{2}x^{n-2}h^2 + \dots + h^n}{h} \quad \text{Simplify...} \\&= \lim_{h \rightarrow 0} \left[ \binom{n}{1}x^{n-1} + \binom{n}{2}x^{n-2}h + \dots + h^{n-1} \right] \quad \dots \text{and then divide top and bottom by } h. \\&= \binom{n}{1}x^{n-1} \quad \text{Let } h \rightarrow 0. \\&= nx^{n-1} \quad \binom{n}{1} = n\end{aligned}$$

#### WORKED EXAMPLE 12.3

$$\begin{aligned}y &= x^3. \text{ Find } \frac{dy}{dx}. \\&\frac{dy}{dx} = 3x^{2.1} \quad \text{Use } \frac{dy}{dx} = nx^{n-1}. \\&= 3x^2\end{aligned}$$

#### Fast forward

In Student Book 2, Chapter 10, you will learn a method called implicit differentiation, which will allow you to extend Proof 6 to all rational powers.

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## Student books



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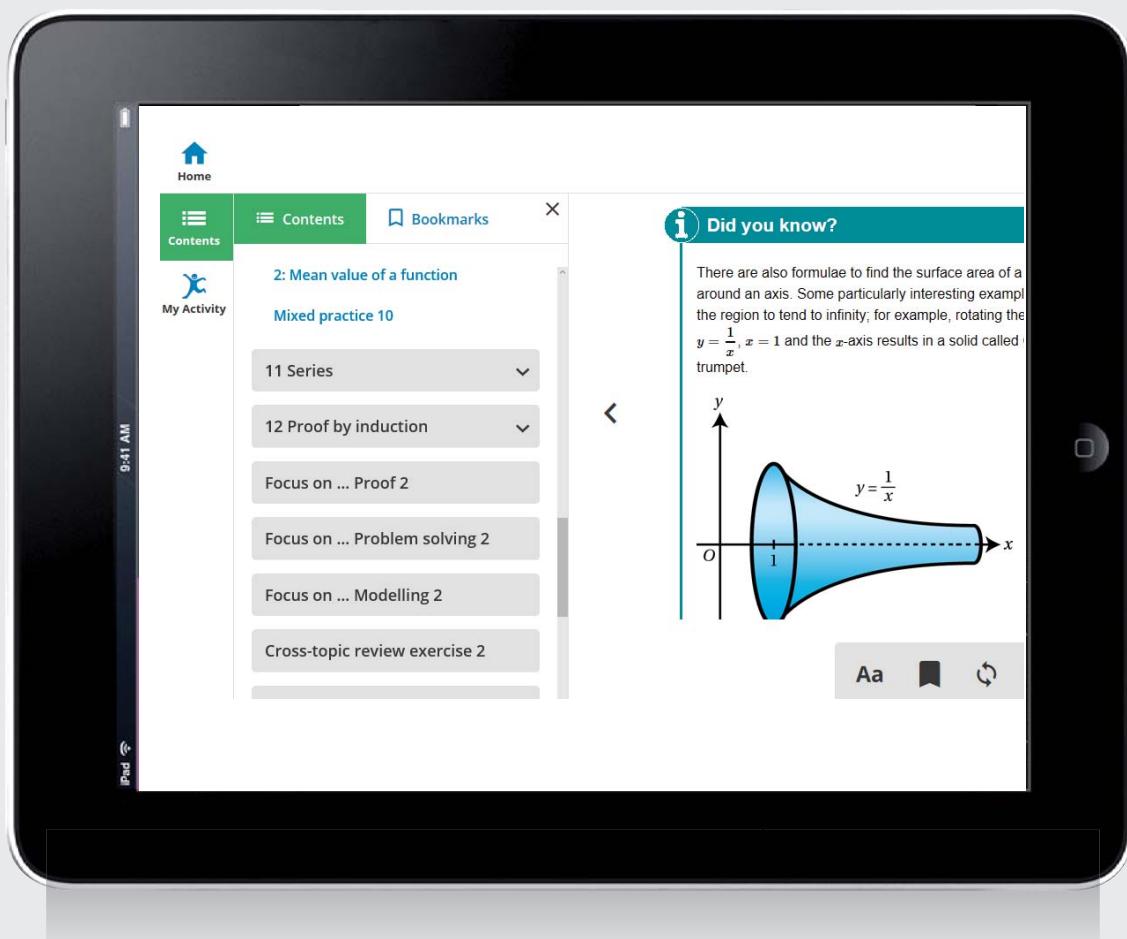
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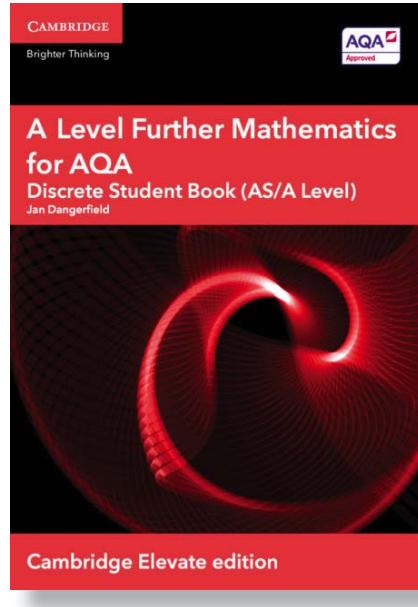
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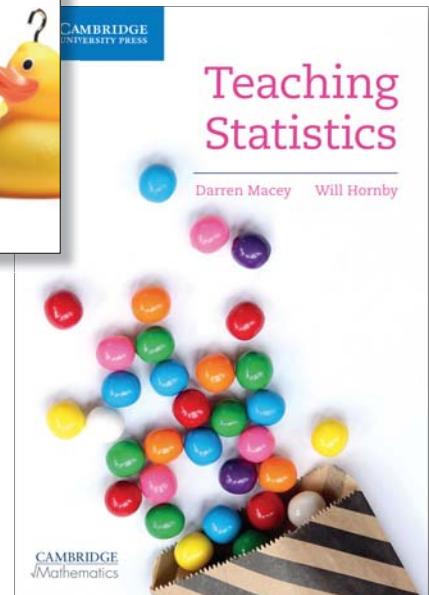
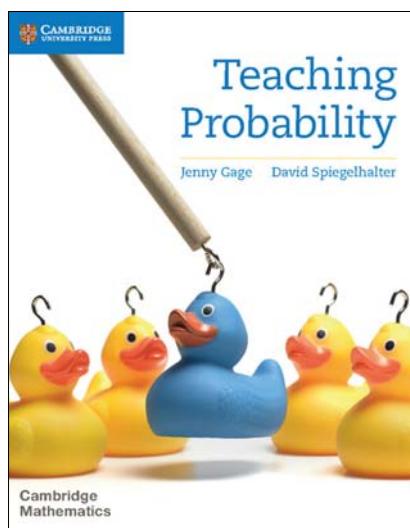


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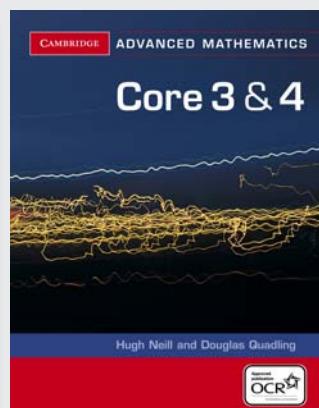
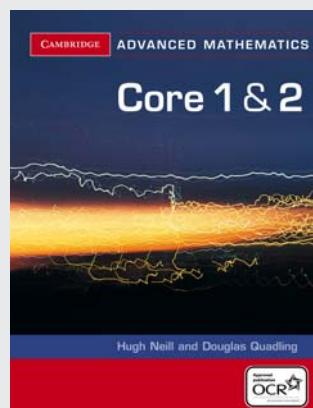
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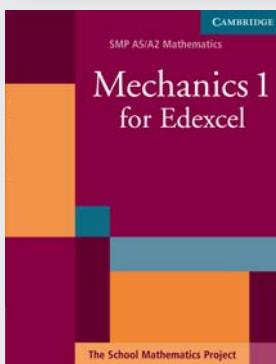
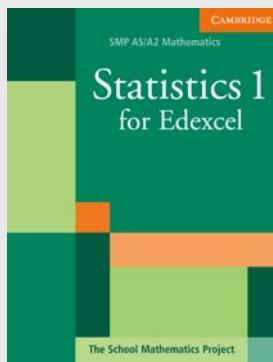
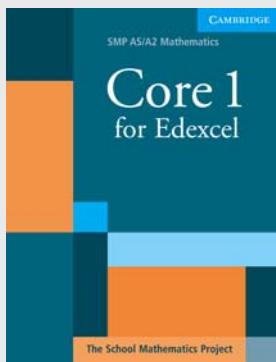


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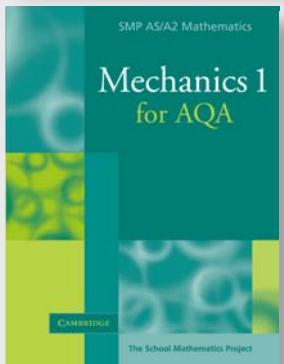
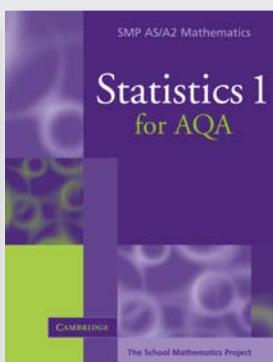
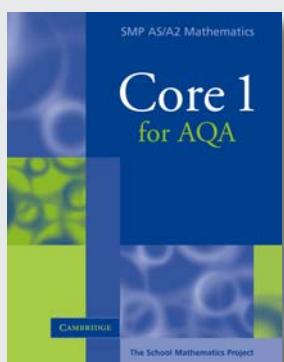
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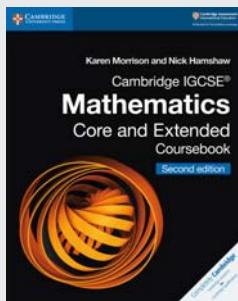
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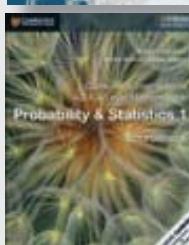
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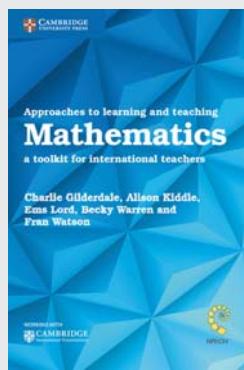
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