

Pearson Edexcel AS and A level Mathematics

Pure Mathematics

Year 1/AS

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Year 1/AS

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Overarching themes

The following three overarching themes have been fully integrated throughout the Pearson Edexcel AS and A level Mathematics series, so they can be applied alongside your learning and practice.

1. Mathematical argument, language and proof

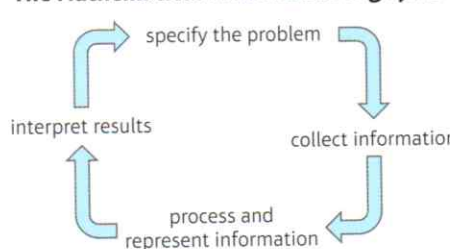
- Rigorous and consistent approach throughout
- Notation boxes explain key mathematical language and symbols
- Dedicated sections on mathematical proof explain key principles and strategies
- Opportunities to critique arguments and justify methods

2. Mathematical problem solving

- Hundreds of problem-solving questions, fully integrated into the main exercises
 - Problem-solving boxes provide tips and strategies
 - Structured and unstructured questions to build confidence
 - Challenge boxes provide extra stretch
-
- ```

graph TD
 A[specify the problem] --> B[collect information]
 B --> C[process and]
 C --> D[interpret results]
 D --> A

```

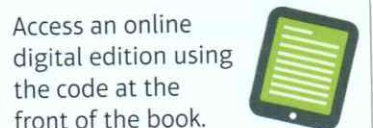


### 3. Mathematical modelling

- Dedicated modelling sections in relevant topics provide plenty of practice where you need it
- Examples and exercises include qualitative questions that allow you to interpret answers in the context of the model
- Dedicated chapter in Statistics & Mechanics Year 1/AS explains the principles of modelling in mechanics

Finding your way around the book

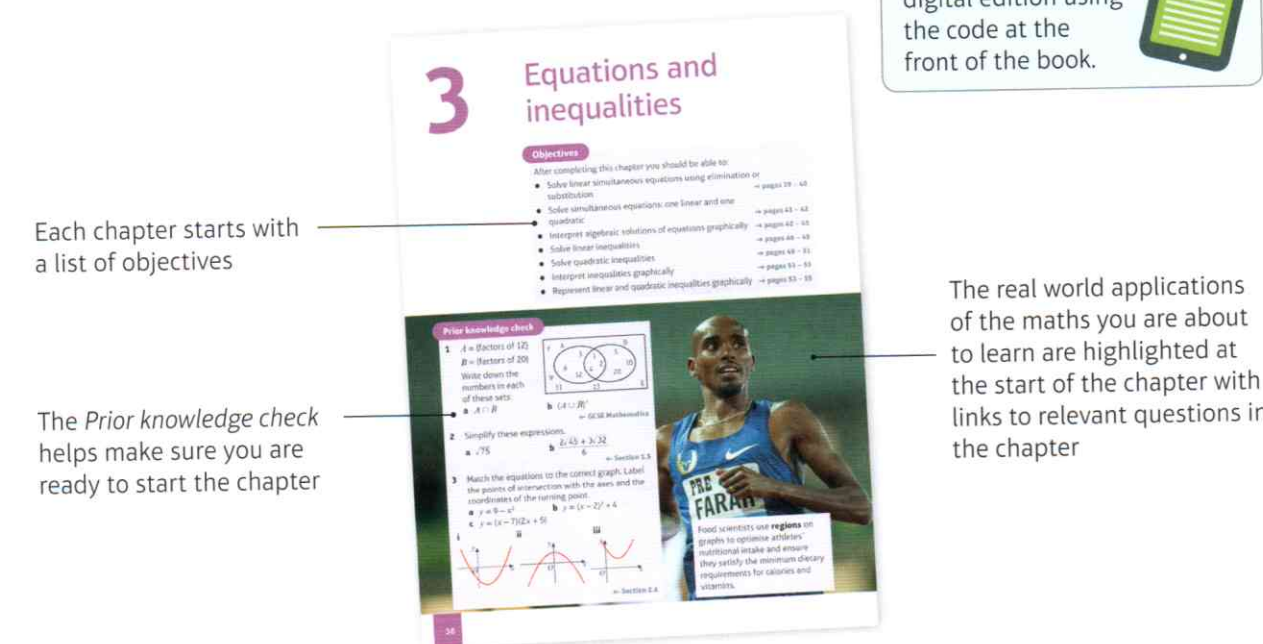
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Each chapter starts with a list of objectives

- Solve simultaneous equations using various methods → pages 43 – 47
- Graphically → pages 48 – 54
- Interpret algebraic solutions of equations graphically → pages 46 – 55
- Solve linear inequalities → pages 60 – 71
- Solve quadratic inequalities → pages 74 – 84

The *Prior knowledge check* helps make sure you are ready to start the chapter



The real world applications of the maths you are about to learn are highlighted at the start of the chapter with links to relevant questions in the chapter

Exercise questions are carefully graded so they increase in difficulty and gradually bring you up to exam standard

Challenge boxes give you a chance to tackle some more difficult questions

Each section begins with explanation and key learning points

Step-by-step worked examples focus on the key types of questions you'll need to tackle

Exam-style questions are flagged with **E**

Problem-solving questions are flagged with **P**

Chapter 14

Exponentials and logarithms

1. Solve the following equations:

a  $\log_3 3 + \log_3 x = 2$     b  $\log_2 12 - \log_2 x = 3$   
 c  $2 \log_2 x = 1 + \log_2 6$     d  $2 \log_2 (x+1) = 2 \log_2 (2x-3) + 1$

2. Given that  $\log_2 (x+1) + 2 \log_2 (x-1) = 5$ , show that  $3x^2 - 7x + 2 = 0$ . (5 marks)

3. Hence, or otherwise, solve  $\log_2 (x+1) + 2 \log_2 (x-1) = 1$ . (2 marks)

4. Given that  $a$  and  $b$  are positive constants, and that  $a > b$ , solve the simultaneous equations  $a + b = 13$  and  $\log_2 a + \log_2 b = 2$ .

**Challenge**  
 By setting  $\log_2 a = x$  and  $\log_2 b = y$ , prove that  $\log_2 x = \log_2 y$ .

**14.6 Solving equations using logarithms**  
 You can use logarithms and your calculator to solve equations of the form  $ax^b = c$ .

**Example 14**  
 Solve the following equations, giving your answers to 3 decimal places:

a  $3^x = 20$     b  $5^{x-1} = 6$

Use the **log** button on your calculator.

You can evaluate the final answer in one step on your calculator.

**Example 15**  
 Solve the equation  $5^{2x} - 12(5^x) + 20 = 0$ , giving your answer to 3 significant figures.

$5^{2x} - 12(5^x) + 20 = 0$  is a quadratic function of  $5^x$ .

An alternative method is to rewrite the equation using the substitution  $y = 5^x$ :  $y^2 - 12y + 20 = 0$ .

$y^2 - 12y + 20 = 0$   
 $(y-10)(y-2) = 0$   
 $y = 10$  or  $y = 2$   
 $5^{2x} = 10$  or  $5^{2x} = 2$  or  $5^x = \sqrt{10}$  or  $5^x = \sqrt{2}$   
 $x = \frac{1}{2} \log_5 10$  or  $x = \frac{1}{2} \log_5 2$   
 $x \approx 0.464$  or  $x \approx 0.433$

**Watch out** Solving the quadratic equation gives you two possible values for  $5^x$ . Make sure you calculate both corresponding values of  $x$  for your final answer.

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You can solve more complicated equations by 'taking logs' of both sides.

• Whenever  $f(x) = g(x)$ ,  $\log_2 f(x) = \log_2 g(x)$

**Example 16**  
 Find the solution to the equation  $3^x = 2^{x+1}$ , giving your answer to four decimal places.

$3^x = 2^{x+1}$   
 $\log_2 3^x = \log_2 2^{x+1}$   
 $x \log_2 3 = (x+1) \log_2 2$   
 $x \log_2 3 = x + 1$   
 $x \log_2 3 - x = 1$   
 $x(\log_2 3 - 1) = 1$   
 $x = \frac{1}{\log_2 3 - 1} \approx 1.7095$

This step is called 'taking logs of both sides'. The logs on both sides must be to the same base. Here 'log' is used to represent  $\log_2$ .

Use the power law.

Move all the terms in  $x$  to one side then factorise.

**Exercise 14F**

1. Solve, giving your answers to 3 significant figures:

a  $2^x = 75$     b  $3^x = 10$     c  $5^x = 2$     d  $4^x = 100$   
 e  $9^{x+1} = 50$     f  $2^{x-1} = 23$     g  $11^{x-2} = 65$     h  $2^{x-1} = 89$

2. Solve, giving your answers to 3 significant figures:

a  $2^{x^2} = 62$     b  $3^{x^2} = 15(3^x) + 44$     c  $5^{x^2} = 625$     d  $3^{x^2} = 3^{x+1} - 10$     e  $7^{x^2} = 12$     f  $2^{x^2} = 3(2^x) - 4$     g  $4^{x^2} = 25(4^x) - 9$     h  $4^{x^2} = 17(4^x) - 7$

3. Solve the following equations, giving your answers to 3 significant figures where appropriate:

a  $3^{x^2} = 2000$     b  $\log_2 (x-3) = 0$

4. a Sketch the graph of  $y = 4^x$ , stating the coordinates of any points where the graph crosses the axes. (2 marks)  
 b Solve the equation  $4^{x^2} = 16(4^x) + 16$ . (2 marks)

5. Solve the following equations, giving your answers to four decimal places:

a  $5^x = 2^{x+1}$     b  $3^{x^2} = 8^x$     c  $7^{x^2} = 3^{x+1}$

**Hint**  $3^{x^2} = 3^x \times 3^x = 3^{2x}$

**Problem-solving** Consider these equations as functions of  $x$ . Part a is equivalent to  $x^2 - 8x + 5 = 0$ , with  $a = 2$ .

**Watch out** Take logs of both sides.

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Each chapter ends with a *Mixed exercise* and a *Summary of key points*

Exercises are packed with exam-style questions to ensure you are ready for the exams

Problem-solving boxes provide hints, tips and strategies, and *Watch out* boxes highlight areas where students often lose marks in their exams

Every few chapters a *Review exercise* helps you consolidate your learning with lots of exam-style questions

**Review exercise 1**

1. Write down the value of  $b$ .  
 2. Find the value of  $8^{\frac{1}{3}}$ .  
 3. Express  $\sqrt{80}$  in the form  $a\sqrt{b}$ , where  $a$  is an integer.  
 4. Express  $(4 - \sqrt{3})^2$  in the form  $a + b\sqrt{3}$ , where  $a$  and  $b$  are integers.  
 5. Expand and simplify  $(4 + \sqrt{3})(4 - \sqrt{3})$ .  
 6. Express  $\frac{28}{4 + \sqrt{3}}$  in the form  $a + b\sqrt{3}$ , where  $a$  and  $b$  are integers.  
 7. Here are three numbers:  $1 - \sqrt{2}$ ,  $2 + \sqrt{3}$ , and  $2 + \sqrt{5}$ . Given that  $k$  is a positive integer, find:  
 a the mean of the three numbers.  
 b the range of the three numbers.  
 8. Given that  $y = \frac{1}{25^{x-1}}$ , express each of the following in the form  $kx^a$ , where  $k$  and  $a$  are constants:  
 a  $y^2$   
 b  $3y^3$   
 9. Find the area of this trapezium in  $\text{cm}^2$ . Give your answer in the form  $a + b\sqrt{2}$ , where  $a$  and  $b$  are integers to be found.  
 10. Given that  $p = 3 - 2\sqrt{2}$  and  $q = 2 - \sqrt{2}$ , find the value of  $\frac{p+q}{p-q}$ . Give your answer in the form  $m + n\sqrt{2}$ , where  $m$  and  $n$  are rational numbers to be found.  
 11. Factorise the expression  $x^2 - 10x + 16$ .  
 12. Hence, or otherwise, solve the equation  $8x^2 - 108x + 16 = 0$ .  
 13.  $x^2 - 3x - 29 = 0$  ( $x = a^2$ ), where  $a$  and  $b$  are constants.  
 14. Find the value of  $a$  and the value of  $b$ .  
 15. Hence, or otherwise, show that the roots of  $x^2 - 8x - 29 = 0$  are  $\pm \frac{1}{2} \pm \sqrt{5}$ , where  $x$  and  $y$  are integers.

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## Exam-style practice

### Mathematics AS Level

#### Paper 1: Pure Mathematics

Time: 2 hours

You must have: Mathematical Formulae and Statistical Tables, Calculator

1. Given that  $4 = 64^k$ , find the value of  $n$ .  
 2. Write  $150$  in the form  $k \times 2$  where  $k$  is an integer to be determined.  
 3. Find the equation of the line parallel to  $2x - 3y + 4 = 0$  that passes through the point  $(5, 8)$ .  
 4. A student is asked to evaluate the integral  $\int_1^4 \left(x^2 - \frac{3}{x} + 2\right) dx$ . The student's working is shown below:
- $$\int_1^4 \left(x^2 - \frac{3}{x} + 2\right) dx = \left[\frac{x^3}{3} - 3 \ln x + 2x\right]_1^4$$
- $$= \left[\frac{4^3}{3} - 2 \ln 4 + 2(4)\right] - \left[\frac{1^3}{3} - 2 \ln 1 + 2(1)\right]$$
- $$= \left[\frac{64}{3} - 2 \ln 4 + 8\right] - \left[\frac{1}{3} - 2 \ln 1 + 2\right]$$
- $$= \frac{63}{3} - 2 \ln 4 + 6 = 21 - 2 \ln 4$$
5. Identify two errors made by the student.  
 6. Evaluate the definite integral, giving your answer correct to 3 significant figures.  
 7. Find all the solutions in the interval  $0 \leq x < 180^\circ$  of  $\sin(2x) - \sin(2x) - 1 = 0$  giving each solution in degrees.

A full AS level practice paper at the back of the book helps you prepare for the real thing



## Extra online content

Whenever you see an *Online* box, it means that there is extra online content available to support you.



### SolutionBank

SolutionBank provides a full worked solution for every question in the book.

**Online** Full worked solutions are available in SolutionBank.



Download all the solutions as a PDF or quickly find the solution you need online

Pure Mathematics Year 1/AS SolutionBank

**Differentiation 12A**

1 a Examples of estimates of gradients:  
Gradient of tangent at  $x = -1$  is  
 $\frac{f_2 - f_1}{x_2 - x_1} = \frac{3 - 1}{(-1) - (-0.5)}$   
 $= -4$   
Gradient of tangent at  $x = 0$  is  
 $\frac{f_2 - f_1}{x_2 - x_1} = \frac{1 - (-1)}{(-0.5) - (-0.5)}$   
 $= -2$   
Gradient of tangent at  $x = 1$  is  
 $\frac{f_2 - f_1}{x_2 - x_1} = \frac{(-1) - (-1)}{2 - 0}$   
 $= 0$   
Gradient of tangent at  $x = 2$  is  
 $\frac{f_2 - f_1}{x_2 - x_1} = \frac{(1) - (-1)}{1.5 - 2.5}$   
 $= 2$   
Gradient of tangent at  $x = 3$  is  
 $\frac{f_2 - f_1}{x_2 - x_1} = \frac{3 - 1}{3 - 2.5}$   
 $= 4$

| x-coordinate                   | -1 | 0  | 1 | 2 | 3 |
|--------------------------------|----|----|---|---|---|
| Estimate for gradient of curve | -4 | -2 | 0 | 2 | 4 |

b The gradient of the curve at the point where  $x = p$  is  $2p - 2$ .

c Gradient of tangent at  $x = 1.5$  is  
 $\frac{f_2 - f_1}{x_2 - x_1} = \frac{(-1.7) - 0.5}{0.5 - 2.5}$   
 $= 1$   
 $2p - 2 = 2(1.5) - 2 = 1$

2 a Substituting  $x = 0.6$  into  $y = \sqrt{1 - x^2}$ :  
 $y = \sqrt{1 - 0.6^2} = \sqrt{0.64} = 0.8$ , therefore the point on the curve is  $(0.6, 0.8)$ .

2 a i Gradient of AD =  $\frac{f_2 - f_1}{x_2 - x_1}$   
 $= \frac{0.8 - \sqrt{0.19}}{0.6 - 0.9}$   
 $= -1.21$  (3 s.f.)

ii Gradient of AC =  $\frac{f_2 - f_1}{x_2 - x_1}$   
 $= \frac{0.8 - 0.6}{0.6 - 0.8}$   
 $= -1$

iii Gradient of AB =  $\frac{f_2 - f_1}{x_2 - x_1}$   
 $= \frac{0.8 - \sqrt{0.81}}{0.6 - 0.7}$   
 $= -0.859$  (3 s.f.)

d As the points move closer to A, the gradient tends to  $-0.75$ .

3 a i Gradient =  $\frac{16 - 9}{4 - 3} = 7$

ii Gradient =  $\frac{12.25 - 9}{3.5 - 3} = 6.5$

iii Gradient =  $\frac{9.61 - 9}{3.1 - 3} = 6.1$

iv Gradient =  $\frac{9.0601 - 9}{3.01 - 3} = 6.01$

v Gradient =  $\frac{(3 + h)^2 - 9}{(3 + h) - 3}$

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**Differentiation, Mixed Exercise 12**

1  $f(x) = 10x^2$   
 $f'(x) = \lim_{h \rightarrow 0} \frac{f(x+h) - f(x)}{h}$   
 $= \lim_{h \rightarrow 0} \frac{10(x+h)^2 - 10x^2}{h}$   
 $= \lim_{h \rightarrow 0} \frac{10x^2 + 20xh + 10h^2 - 10x^2}{h}$   
 $= \lim_{h \rightarrow 0} \frac{20xh + 10h^2}{h}$   
 $= \lim_{h \rightarrow 0} (20x + 10h)$   
As  $h \rightarrow 0$ ,  $20x + 10h \rightarrow 20x$   
So  $f'(x) = 20x$

2 a A has coordinates (1, 4).  
The y-coordinate of B is  
 $(1 + 6x^2 + 3x) = 6x^2 + 3x + 4$   
 $= (6x^2 + 3x) + 4$   
Gradient of AB  
 $= \frac{f_2 - f_1}{x_2 - x_1}$   
 $= \frac{(6x^2 + 3x) + 4 - 4}{(1 + 6x^2 + 3x) - 1}$   
 $= \frac{6x^2 + 3x}{6x^2 + 3x}$   
 $= 1$   
b As  $h \rightarrow 0$ ,  $(6x^2 + 3x) + 4 \rightarrow 4$   
Therefore, the gradient of the curve at point A is 1.

3  $y = 3x^2 + 3 + \frac{1}{x} = 3x^2 + 3 + x^{-1}$   
 $\frac{dy}{dx} = 6x - 2x^{-2} = 6x - \frac{2}{x^2}$   
When  $x = 1$ ,  $\frac{dy}{dx} = 6 - 2 = 4$

3 When  $x = 2$ ,  $\frac{dy}{dx} = 6 + 2 - \frac{2}{2^2}$   
 $= 12 - \frac{1}{2}$   
 $= 11\frac{1}{2}$   
When  $x = 3$ ,  $\frac{dy}{dx} = 6 + 3 - \frac{2}{3^2}$   
 $= 18 - \frac{2}{9}$   
 $= 17\frac{2}{9}$

The gradients at points A, B and C are 4,  $11\frac{1}{2}$  and  $17\frac{2}{9}$ , respectively.

4  $y = 7x^2 - x^3$   
 $\frac{dy}{dx} = 14x - 3x^2$   
 $\frac{dy}{dx} = 16$  when  
 $14x - 3x^2 = 16$   
 $3x^2 - 14x + 16 = 0$   
 $(3x - 8)(x - 2) = 0$   
 $x = \frac{8}{3}$  or  $x = 2$

5  $y = x^3 - 11x + 1$   
 $\frac{dy}{dx} = 3x^2 - 11$   
 $\frac{dy}{dx} = 1$  when  
 $3x^2 - 11 = 1$   
 $3x^2 = 12$   
 $x^2 = 4$   
 $x = 2$   
When  $x = 2$ ,  $y = 2^3 - 11(2) + 1 = -13$   
When  $x = -2$ ,  $y = (-2)^3 - 11(-2) + 1 = 15$   
The gradient is 1 at the points (2, -13) and (-2, 15).

6 a  $f(x) = x + \frac{9}{x} = x + 9x^{-1}$   
 $f'(x) = 1 - 9x^{-2} = 1 - \frac{9}{x^2}$

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## Use of technology

Explore topics in more detail, visualise problems and consolidate your understanding. Use pre-made GeoGebra activities or Casio resources for a graphic calculator.

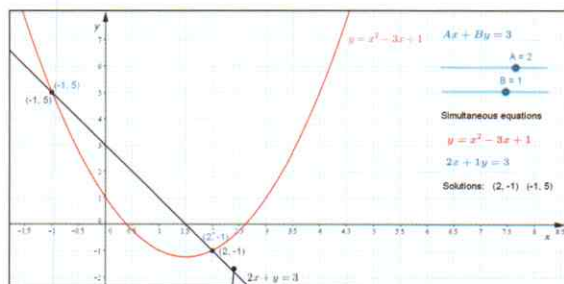


### Online

Find the point of intersection graphically using technology.

# GeoGebra

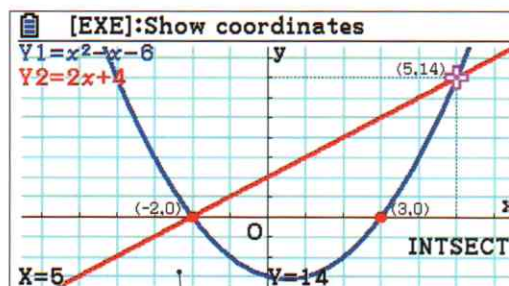
GeoGebra-powered interactives



Interact with the maths you are learning using GeoGebra's easy-to-use tools

# CASIO

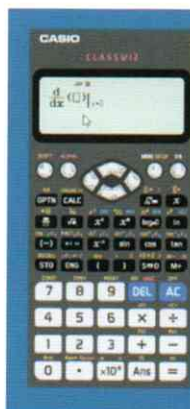
Graphic calculator interactives



Explore the maths you are learning and gain confidence in using a graphic calculator

## Calculator tutorials

Our helpful video tutorials will guide you through how to use your calculator in the exams. They cover both Casio's scientific and colour graphic calculators.



### Finding the value of the first derivative

to access the function press:



MENU 1 SHIFT

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### Online

Work out each coefficient quickly using the  ${}^nC_r$  and power functions on your calculator.



Step-by-step guide with audio instructions on exactly which buttons to press and what should appear on your calculator's screen

Published by Pearson Education Limited, 80 Strand, London WC2R 0RL.

www.pearsonschoolsandcolleges.co.uk

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Edited by Tech-Set Ltd, Gateshead  
Typeset by Tech-Set Ltd, Gateshead  
Original illustrations © Pearson Education Limited 2017  
Cover illustration Marcus@kja-artists

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First published 2017

20  
10 9 8

#### British Library Cataloguing in Publication Data

A catalogue record for this book is available from the British Library

ISBN 978 1 292 18339 8

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Printed in Great Britain by Bell and Bain Ltd, Glasgow

#### Acknowledgements

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