Free Practice Workbook

2027 Edition

Written and taught by **Leonard Shen**

TOPICS

1 Function Basics
2 Transformations
3 Polynomials
4 Coordinate Geometry
5 Exponentials and Logarithms
6 Circular Functions
7 Composite and Inverse Functions
8 Curve Sketching
9 Differentiation
10 Integration
11 Probability and Statistics
12 Miscellaneous

USING THIS SET

A free sample of the CoastEd **Question Workbook**: a spread of questions from every topic, from the basics to a separator, copied unchanged from the full book. The full workbook has 582 questions, and with the **Notes** and **Worked Solutions** it comes with every CoastEd course (coasted.org). Notes references (for example "Notes 9.4") point to sections of the CoastEd Notes.

The topics match the **Notes**, in the same order. Every topic has **Section A** (technology free: shorter questions done by hand, like Examination 1), **Section B** (technology active: the questions that need the CAS and the long extended-response questions, like Section B of Examination 2) and **Section C** (multiple choice, like Section A of Examination 2), then a **Short answers** page. Later topics build on earlier ones, so expect to use old skills in new places.

Tick **Done**, **Marked** and **Redo** at the top of each question as you go. Anything marked Redo goes in your mistake log.

Worked solutions are in the separate **Free Practice Worked Solutions**, with the other methods that work listed for each question. You may use the VCAA formula sheet. **Read "How to use this workbook" before you start.**

⋆ and ⋆⋆	The basics: these should be automatic
⋆⋆⋆	Standard exam questions
⋆⋆⋆⋆ and ⋆⋆⋆⋆⋆	Hard questions and separators

This workbook contains **108** questions.

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How to use this workbook

Every question has a level, shown by the stars after its number. The levels tell you what to expect of yourself. Work through a topic in order the first time. After that, use the stars: the one- to three-star questions until they are automatic, then the four- and five-star questions until none of them surprise you.

Level	What it is	What you should be able to do
⋆ and ⋆⋆	The basics	Do them **straight away, with no mistakes, like clockwork**. No looking at the notes, no long pause to remember the method.
⋆⋆⋆	Standard exam questions	Get them right with care. A slip now and then is normal; the same slip twice goes in your mistake log.
⋆⋆⋆⋆ and ⋆⋆⋆⋆⋆	Hard questions and separators	Expect to get stuck. These are the question types that decide the top marks.

If the easy ones weren't clockwork

If a one- or two-star question took you more than about a minute per mark, if you had to look something up, or if you made *any* mistake, you are rusty on that skill and one go at it here is not enough practice. The hard questions are built out of the easy ones, so fix it before moving on:

- **Textbook:** each topic in the Notes ends with a *Textbook questions* list. Do every second question of the matching exercise until they feel automatic.
- **Ask an AI for more:** type in the question and ask for ten more like it, the same difficulty, with worked answers at the end. Do them on paper before you look. Then redo the workbook question, and tick **Redo** until you get it right first time.

The hard questions are where the marks are decided

Give each four- or five-star question a proper attempt (about two minutes per mark) before you open the solutions, because working out *how to start* is the skill being tested. Most rely on one idea that is easy to miss, and that idea will come back in a different disguise in your exam. Study the worked solution, then **redo the question from a blank page a week later**.

What is in each topic

- **Section A** is technology free: shorter questions done by hand, like Examination 1. **Section B** is technology active: the questions that need the CAS and the long extended-response questions, like Section B of Examination 2. **Section C** is multiple choice, like Section A of Examination 2. Each section starts easy and gets harder. Question 4A.9 is Topic 4, Section A, Question 9.
- Between them, the questions cover every style of question in the course, from one-mark basics to the last part of an extended-response question, including the rare ones. The styles were checked against a large bank of past exam, trial exam and SAC questions, and every question here is an original written in those styles.
- The workbook shows only the question. Its title, and the notes section it tests, are in the Worked Solutions, so that nothing on the page tells you which method to use. There is a **Short answers** page at the end of each topic for a quick check.
- The **question index** at the back lists the questions under the idea or style they practise, for when you want more practice on one thing.
- A question marked ◊ **non-essential** goes past what the exam usually asks, or is a style that rarely appears. Leave it until the rest of the topic is solid.

How to read the solutions

The Worked Solutions follow this workbook with the same question numbers, and each solution shows the workbook page of its question. A solution can have up to four parts:

- the **full working**, set out the way you should set it out for full marks, with the marks at the right: **M1** is a method mark and **A1** is an answer mark;
- **The trick** (on the harder questions): the one idea that unlocks the question;
- **Watch out**: a detail that was put there to catch you (a domain, a sign, a rounding instruction, a solution that has to be rejected), for your mistake log if it caught you;
- **Another way** or **Ways to do it**: the other techniques that work for that question, by hand and on the TI-Nspire. Read these even when you got the question right, then redo the question with one of the other methods. Knowing two ways is how you check your own answers in an exam.

On the CAS, start a new problem for every question in Sections B and C (doc, 4 Insert, 1 Problem), so an old $f(x)$ or stored value can't quietly change the next answer (see the CAS Guide at the back of the Notes).

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1 Function Basics

Section A – Technology free

Question 1A.1* (6 marks) ☐ Done ☐ Marked ☐ Redo

State the maximal domain of each function.

a. $f(x) = \sqrt{6-3x}$ 1 mark

b. $g(x) = \log_e(2x+5)$ 1 mark

c. $h(x) = \dfrac{3}{x^2-4}$ 1 mark

d. $k(x) = \tan(2x)$ 1 mark

e. $p(x) = \sqrt{x+1} + \log_e(3-x)$ 2 marks

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Question 1A.2** (3 marks) ☐ Done ☐ Marked ☐ Redo

a. Show that $f(x) = x^4 - 3x^2$ is an even function. 1 mark

b. Show that $g(x) = \dfrac{x}{x^2+1}$ is an odd function. 1 mark

c. Is $h(x) = x^3 + 1$ odd, even or neither? Justify your answer. 1 mark

Question 1A.3*** (4 marks) ☐ Done ☐ Marked ☐ Redo

Two functions are **equal** only if they have the same rule *and* the same domain.

a. Let $f(x) = \dfrac{x^2-4}{x-2}$ and $g(x) = x+2$, each with its maximal domain. Explain why f and g are not equal, and state the range of f. 2 marks

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b. Let $p(x) = \log_e(x^2)$ and $q(x) = 2\log_e(x)$, each with its maximal domain. State both domains, and the largest set on which $p(x) = q(x)$. 2 marks

Question 1A.4**** (5 marks) ☐ Done ☐ Marked ☐ Redo

Find the maximal domain of each function.

a. $f(x) = \log_e\left(\dfrac{x+1}{3-x}\right)$ 2 marks

b. $g(x) = \sqrt{2-\sqrt{x}}$ 1 mark

c. $h(x) = \dfrac{\sqrt{x+2}}{\log_e(x)}$ 2 marks

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Section B – Technology active

Question 1B.1*** (6 marks) ☐ Done ☐ Marked ☐ Redo

The depth of water, D metres, in a reservoir t hours after midnight is modelled by

$$D(t) = \begin{cases} 2 + \frac{1}{2}t, & 0 \leq t < 4 \\ a(t-6)^2 + 3, & 4 \leq t \leq 10 \end{cases}$$

where a is a real constant and D is continuous over $[0, 10]$.

a. Find the value of a. 2 marks

b. State the range of D. 2 marks

c. Find all times when the depth is 5 metres. Give your answers correct to two decimal places. 2 marks

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Question 1B.2**** (5 marks) ☐ Done ☐ Marked ☐ Redo

Let $f(x) = \log_e(x^2 - 2kx + 9)$, where k is a real constant.

a. Find the values of k for which the maximal domain of f is R. 2 marks

b. Find the maximal domain of f when $k = 5$. 2 marks

c. Find the maximal domain of f when $k = 3$. 1 mark

Another way: $\log_e\left((x-3)^2\right)$ only fails where $(x-3)^2 = 0$, i.e. $x = 3$.

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Section C – Multiple choice (technology active)

Question 1C.1** (1 mark) ☐ Done ☐ Marked ☐ Redo

A graph has asymptotes $x = 0$ and $y = 0$ and lies entirely above the x-axis. Its rule could be

A. $y = \dfrac{1}{x}$ **B.** $y = \dfrac{1}{x^2}$

C. $y = \sqrt{x}$ **D.** $y = -\dfrac{1}{x}$

Answer: (A) (B) (C) (D)

Question 1C.2*** (1 mark) ☐ Done ☐ Marked ☐ Redo

Let $f(x) = \sqrt{x+3}$ and $g(x) = \log_e(2-x)$. The maximal domain of $f+g$ is

A. $[-3, 2]$ **B.** $(-3, 2)$

C. $[-3, 2)$ **D.** $[-3, \infty)$

Answer: (A) (B) (C) (D)

Question 1C.3**** (1 mark) ☐ Done ☐ Marked ☐ Redo

Let $f(x) = \begin{cases} x^2, & x \leq 1 \\ 3-x, & x > 1 \end{cases}$. The equation $f(x) = p$ has exactly two solutions when

A. $0 < p < 1$ **B.** $p = 0$ or $1 \leq p < 2$

C. $p = 0$ or $1 < p < 2$ **D.** $p \geq 2$

Answer: (A) (B) (C) (D)

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Function Basics – Short answers

Final answers only. Full working is in the Worked Solutions. The grey column shows the notes section each question tests: if you got it wrong, reread that section first.

1A.1	a. $(-\infty, 2]$	Notes 1.3 Finding the maximal domain
1A.1	b. $\left(-\frac{5}{2}, \infty\right)$	Notes 1.3 Finding the maximal domain
1A.1	c. $R \setminus \{-2, 2\}$	Notes 1.3 Finding the maximal domain
1A.1	d. $R \setminus \left\{\frac{\pi}{4} + \frac{n\pi}{2} : n \in Z\right\}$	Notes 1.3 Finding the maximal domain
1A.1	e. $[-1, 3)$	Notes 1.3 Finding the maximal domain
1A.2	a. $f(-x) = f(x)$	Notes 1.7 Odd and even functions
1A.2	b. $g(-x) = -g(x)$	Notes 1.7 Odd and even functions
1A.2	c. Neither, e.g. $h(-1) = 0$ but $h(1) = 2$	Notes 1.7 Odd and even functions
1A.3	a. Different domains; $\operatorname{ran} f = R \setminus \{4\}$	Notes 1.2 Writing a function in full: domain, codomain and range
1A.3	b. $\operatorname{dom} p = R \setminus \{0\}$, $\operatorname{dom} q = (0, \infty)$; equal on $(0, \infty)$	Notes 1.2 Writing a function in full: domain, codomain and range
1A.4	a. $(-1, 3)$	Notes 1.3 Finding the maximal domain
1A.4	b. $[0, 4]$	Notes 1.3 Finding the maximal domain
1A.4	c. $(0, 1) \cup (1, \infty)$	Notes 1.3 Finding the maximal domain
1B.1	a. $a = \frac{1}{4}$	Notes 1.6 Piecewise (hybrid) functions
1B.1	b. $[2, 7]$	Notes 1.6 Piecewise (hybrid) functions
1B.1	c. $t \approx 8.83$	Notes 1.6 Piecewise (hybrid) functions
1B.2	a. $k \in (-3, 3)$	Notes 1.3 Finding the maximal domain
1B.2	b. $(-\infty, 1) \cup (9, \infty)$	Notes 1.3 Finding the maximal domain
1B.2	c. $R \setminus \{3\}$	Notes 1.3 Finding the maximal domain
1C.1	B	Notes 1.8 The base graph library
1C.2	C	Notes 1.3 Finding the maximal domain
1C.3	C	Notes 1.6 Piecewise (hybrid) functions

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2 Transformations

Section A – Technology free

Question 2A.1* (4 marks) ☐ Done ☐ Marked ☐ Redo

Describe a sequence of transformations that maps the graph of the first function onto the graph of the second.

a. $y = x^2$ onto $y = 3(x-2)^2 + 1$ 1 mark

b. $y = \sqrt{x}$ onto $y = -2\sqrt{x+1}$ 1 mark

c. $y = \dfrac{1}{x}$ onto $y = \dfrac{1}{3x} - 4$ 1 mark

d. $y = \log_e x$ onto $y = \log_e(2-x)$ 1 mark

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Question 2A.2*** (4 marks) ☐ Done ☐ Marked ☐ Redo

Let $T(x,y) = (2x+3,\ 3y-6)$.

a. Describe T as a sequence of transformations with the dilations first. 1 mark

b. By factorising each coordinate of T, describe T with the translations first. 2 marks

c. The graph of $y = f(x)$ is translated 1 unit left, then dilated by a factor of 3 from the y-axis. By writing this in mapping form and expanding, describe the same transformation with the dilation first. 1 mark

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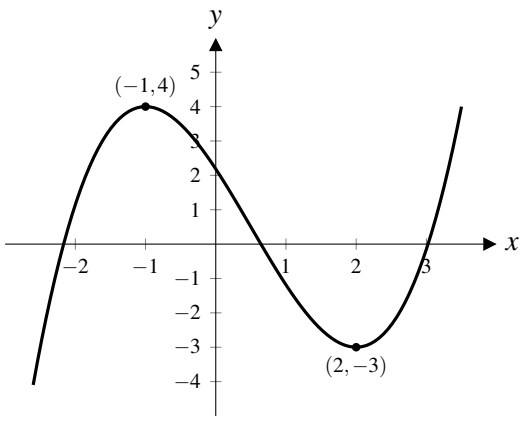
Question 2A.3** (3 marks) ☐ Done ☐ Marked ☐ Redo

The graph of a cubic $y = f(x)$ is shown below. Its turning points are $(-1, 4)$ and $(2, -3)$.



Find the values of k for which the equation $f(x) + k = 0$ has

a. exactly three solutions 1 mark

b. exactly two solutions 1 mark

c. exactly one solution 1 mark

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Question 2A.4**** (5 marks) ☐ Done ☐ Marked ☐ Redo

The transformation $T(x,y) = (ax+b,\ cy+d)$ maps $(1,2)$ onto $(5,1)$ and $(3,6)$ onto $(9,-7)$.

a. Find the values of a, b, c and d. 2 marks

b. Both points lie on the line $y = 2x$. Find the equation of the image of this line under T. 2 marks

c. Find the coordinates of the point that T maps onto itself. 1 mark

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Section B – Technology active

Question 2B.1*** (4 marks) ☐ Done ☐ Marked ☐ Redo

Let $f:[-1,3]\to R,\ f(x)=x^2-2x$. The graph of $y=f(x)$ is transformed by $T(x,y)=(1-2x,\ 3y+2)$.

a. Find the rule of the image in the form $y=3f(\ldots)+2$, and its domain. 2 marks

b. State the range of the image. 2 marks

Question 2B.2***** (3 marks) ☐ Done ☐ Marked ☐ Redo

Let $f:R\to R,\ f(x)=x(x-3)(x-8)$ and $g:R\to R,\ g(x)=(x-a)^2(x-b)$, where $g(x)=f(x)+k$ and $a,b,k\in R$.

Find all possible values of a and b. 3 marks

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Section C – Multiple choice (technology active)

Question 2C.1*** (1 mark) ☐ Done ☐ Marked ☐ Redo

The function f has domain $[-2,4]$ and range $[0,3]$. The function $g(x) = 1 - f\left(\frac{x}{2}\right)$ has

A. domain $[-1,2]$ and range $[-2,1]$

B. domain $[-4,8]$ and range $[-2,1]$

C. domain $[-4,8]$ and range $[1,4]$

D. domain $[-4,8]$ and range $[-3,0]$

Answer: (A) (B) (C) (D)

Question 2C.2** (1 mark) ☐ Done ☐ Marked ☐ Redo

The circle $x^2 + y^2 = 4$ is translated 3 units right and 1 unit down. The image has equation

A. $(x+3)^2 + (y-1)^2 = 4$

B. $(x-3)^2 + (y-1)^2 = 4$

C. $(x-3)^2 + (y+1)^2 = 4$

D. $(x+3)^2 + (y+1)^2 = 4$

Answer: (A) (B) (C) (D)

Question 2C.3**** (1 mark) ☐ Done ☐ Marked ☐ Redo

The transformation $(x,y) \to \left(\frac{x}{2}+1,\ -y\right)$ maps the graph of $y = f(x)$ onto a graph that passes through $(4,3)$. Which point must lie on the graph of $y = f(x)$?

A. $(3,-3)$

B. $(6,3)$

C. $(6,-3)$

D. $(10,-3)$

Answer: (A) (B) (C) (D)

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Transformations – Short answers

Final answers only. Full working is in the Worked Solutions. The grey column shows the notes section each question tests: if you got it wrong, reread that section first.

2A.1	a.	Dilation by factor 3 from the x-axis, then translation 2 right and 1 up	Notes 2.4 The inspection method (use this one)
2A.1	b.	Dilation by factor 2 from the x-axis, reflection in the x-axis, translation 1 left	Notes 2.4 The inspection method (use this one)
2A.1	c.	Dilation by factor $\frac{1}{3}$ from the y-axis, translation 4 down	Notes 2.4 The inspection method (use this one)
2A.1	d.	Reflection in the y-axis, then translation 2 right	Notes 2.4 The inspection method (use this one)
2A.2	a.	Dilate by 2 from the y-axis and by 3 from the x-axis, then translate 3 right and 6 down	Notes 2.3 The order of transformations: DRT
2A.2	b.	Translate $\frac{3}{2}$ right and 2 down, then dilate by 2 from the y-axis and by 3 from the x-axis	Notes 2.3 The order of transformations: DRT
2A.2	c.	Dilate by 3 from the y-axis, then translate 3 left	Notes 2.3 The order of transformations: DRT
2A.3	a.	$-4 < k < 3$	Notes 2.7 Sketching using transformations
2A.3	b.	$k = -4$ or $k = 3$	Notes 2.7 Sketching using transformations
2A.3	c.	$k < -4$ or $k > 3$	Notes 2.7 Sketching using transformations
2A.4	a.	$a = 2,\ b = 3,\ c = -2,\ d = 5$	Notes 2.5 The mapping (dash) method
2A.4	b.	$y = 11 - 2x$	Notes 2.5 The mapping (dash) method
2A.4	c.	$\left(-3, \frac{5}{3}\right)$	Notes 2.5 The mapping (dash) method
2B.1	a.	$y = 3f\left(\frac{1-x}{2}\right) + 2 = \frac{3}{4}x^2 + \frac{3}{2}x - \frac{1}{4}$, domain $[-5, 3]$	Notes 2.5 The mapping (dash) method
2B.1	b.	$[-1, 11]$	Notes 2.5 The mapping (dash) method
2B.2		$a = 6,\ b = -1$ or $a = \frac{4}{3},\ b = \frac{25}{3}$	Notes 2.7 Sketching using transformations
2C.1		B	Notes 2.7 Sketching using transformations
2C.2		C	Notes 2.2 What happens to the equation: the opposite
2C.3		C	Notes 2.8 From a sequence of transformations to the equation

Notes

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3 Polynomials

Section A – Technology free

Question 3A.1* (5 marks) ☐ Done ☐ Marked ☐ Redo

a. Solve $2x^2 - 5x - 3 = 0$. 1 mark

b. Solve $x^2 - 4x - 1 = 0$, giving exact answers. 2 marks

c. Find the values of k for which $x^2 + kx + 9 = 0$ has two distinct real solutions. 2 marks

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Question 3A.2** (4 marks) ☐ Done ☐ Marked ☐ Redo

Let $f(x) = \dfrac{2x+7}{x+3}$.

a. Write $f(x)$ in the form $a + \dfrac{b}{x+c}$. 2 marks

b. State the equations of the asymptotes and the axis intercepts of $y = f(x)$. 2 marks

Question 3A.3*** (3 marks) ☐ Done ☐ Marked ☐ Redo

Solve $x^3 - 4x^2 + x + 6 \geq 0$. 3 marks

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Question 3A.4**** (3 marks) ☐ Done ☐ Marked ☐ Redo

Divide $x^4 + 2x^3 - x + 5$ by $x^2 + 1$. State the quotient and the remainder. 3 marks

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Section B – Technology active

Question 3B.1*** (3 marks) ☐ Done ☐ Marked ☐ Redo

$P(x) = x^3 + ax^2 + bx + 2$ has $(x-1)^2$ as a factor. Find a and b, and hence factorise $P(x)$. 3 marks

Question 3B.2***** (4 marks) ☐ Done ☐ Marked ☐ Redo

Let $f(x) = x^4 - 4x^3$.

a. Using technology, find the coordinates of the stationary points of the graph of f and state their nature. 2 marks

b. Find the values of k for which the equation $x^4 - 4x^3 + k = 0$ has two solutions, both positive. 2 marks

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Section C – Multiple choice (technology active)

Question 3C.1** (1 mark) ☐ Done ☐ Marked ☐ Redo

$x-2$ is a factor of x^3+ax^2-4x+4. The value of a is

A. -2 **B.** -1

C. 0 **D.** 1

Answer: (A) (B) (C) (D)

Question 3C.2*** (1 mark) ☐ Done ☐ Marked ☐ Redo

The number of real solutions of $x^4-2x^2-8=0$ is

A. 0 **B.** 1

C. 2 **D.** 3

Answer: (A) (B) (C) (D)

Question 3C.3**** (1 mark) ☐ Done ☐ Marked ☐ Redo

The equation $x^3-3x+k=0$ has three distinct real solutions when

A. $k>2$ **B.** $k<-2$

C. $-2<k<2$ **D.** $k=\pm 2$

Answer: (A) (B) (C) (D)

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Polynomials – Short answers

Final answers only. Full working is in the Worked Solutions. The grey column shows the notes section each question tests: if you got it wrong, reread that section first.

3A.1	a. $x = -\frac{1}{2}$ or $x = 3$	Notes 3.2 Quadratics
3A.1	b. $x = 2 \pm \sqrt{5}$	Notes 3.2 Quadratics
3A.1	c. $k \in (-\infty, -6) \cup (6, \infty)$	Notes 3.2 Taking the formula apart: the discriminant
3A.2	a. $f(x) = 2 + \dfrac{1}{x+3}$	Notes 3.10 Division into inspection form
3A.2	b. Asymptotes $x = -3$, $y = 2$; intercepts $\left(-\frac{7}{2}, 0\right)$, $\left(0, \frac{7}{3}\right)$	Notes 3.10 Division into inspection form
3A.3	$[-1, 2] \cup [3, \infty)$	Notes 3.3 Cubics
3A.4	Quotient $x^2 + 2x - 1$, remainder $-3x + 6$	Notes 3.8 Dividing polynomials: the language
3B.1	$a = 0$, $b = -3$; $P(x) = (x-1)^2(x+2)$	Notes 3.11 Equating coefficients
3B.2	a. $(0, 0)$ stationary point of inflection; $(3, -27)$ local minimum	Notes 3.4 Quartics
3B.2	b. $0 < k < 27$	Notes 3.4 Quartics
3C.1	B	Notes 3.9 Factorising polynomials: the one question to know
3C.2	C	Notes 3.5 How many solutions? Removing solutions
3C.3	C	Notes 3.3 Cubics

Notes

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4 Coordinate Geometry

Section A – Technology free

Question 4A.1* (2 marks) ☐ Done ☐ Marked ☐ Redo

Solve $3x-2y=12$ and $x+4y=-10$ simultaneously. 2 marks

Question 4A.2*** (3 marks) ☐ Done ☐ Marked ☐ Redo

Let $A=(-1,2)$ and $B=(5,6)$.

a. Find the equation of the perpendicular bisector of AB. 2 marks

b. Find the point on the x-axis that is the same distance from A as from B. 1 mark

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Question 4A.3**** (4 marks) ☐ Done ☐ Marked ☐ Redo

Find the shortest distance from the point $P(4,5)$ to the line $y=2x+2$, and the point on the line that is closest to P. 4 marks

Question 4A.4** (6 marks) ☐ Done ☐ Marked ☐ Redo

a. A line has x-intercept 4 and y-intercept -3. Write its equation in intercept form, and in the form $ax+by=c$ where a, b and c are integers. 2 marks

b. Find the equation of the line through $(2,-5)$ that is (i) parallel to the line $x=7$ (ii) perpendicular to the line $x=7$. 2 marks

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c. Find the value of m for which the line $y = mx + 1$ is (i) parallel to $2x - 3y = 6$ (ii) perpendicular to $2x - 3y = 6$.

2 marks

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Section B – Technology active

Question 4B.1*** (5 marks) ☐ Done ☐ Marked ☐ Redo

The points $A(1,1)$, $B(5,3)$, $C(7,7)$ and $D(3,5)$ are the vertices of a quadrilateral.

a. Show that $ABCD$ is a rhombus. 2 marks

b. Show that the diagonals are perpendicular. 1 mark

c. Find the area of $ABCD$. 2 marks

Question 4B.2***** (6 marks) ☐ Done ☐ Marked ☐ Redo

The line with equation $y = mx - 2$, where $m > 0$, can be tangent to the circle with equation

$$(x-1)^2 + \left(y - \left(\sqrt{3}-2\right)\right)^2 = 2 - \sqrt{3}$$

for two distinct values of m.

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a. Find the two values of m and the corresponding points of tangency with the circle. 3 marks

b. Find the area of the region bounded by the two tangent lines and the minor arc of the circle. 3 marks

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Section C – Multiple choice (technology active)

Question 4C.1*** (1 mark) ☐ Done ☐ Marked ☐ Redo

The simultaneous equations $x+ky=2$ and $kx+4y=4$ have a unique solution when

A. $k=2$

B. $k \in R \setminus \{2\}$

C. $k=\pm 2$

D. $k \in R \setminus \{-2,2\}$

Answer: (A) (B) (C) (D)

Question 4C.2** (1 mark) ☐ Done ☐ Marked ☐ Redo

If $ax+b=cx+d$, where $a \neq c$, then x equals

A. $\dfrac{d-b}{a-c}$

B. $\dfrac{b-d}{a-c}$

C. $\dfrac{d-b}{a+c}$

D. $\dfrac{d+b}{a-c}$

Answer: (A) (B) (C) (D)

Question 4C.3**** (1 mark) ☐ Done ☐ Marked ☐ Redo

The distance between the parallel lines $y=2x+1$ and $y=2x+6$ is

A. 5

B. $\sqrt{5}$

C. $\frac{5}{2}$

D. $2\sqrt{5}$

Answer: (A) (B) (C) (D)

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Coordinate Geometry – Short answers

Final answers only. Full working is in the Worked Solutions. The grey column shows the notes section each question tests: if you got it wrong, reread that section first.

4A.1	$x = 2, y = -3$	Notes 4.4 Simultaneous linear equations
4A.2	a. $3x + 2y = 14$	Notes 4.1 Equations of lines
4A.2	b. $\left(\frac{14}{3}, 0\right)$	Notes 4.1 Equations of lines
4A.3	$\sqrt{5}$, at the point $(2, 6)$	Notes 4.5 General tips for coordinate geometry
4A.4	a. $\frac{x}{4} - \frac{y}{3} = 1;\ 3x - 4y = 12$	Notes 4.1 Equations of lines
4A.4	b. (i) $x = 2$ (ii) $y = -5$	Notes 4.1 Equations of lines
4A.4	c. (i) $\frac{2}{3}$ (ii) $-\frac{3}{2}$	Notes 4.1 Equations of lines
4B.1	a. Opposite sides parallel and all four sides $\sqrt{20}$	Notes 4.2 The formula sheet you should already know
4B.1	b. $m_{AC} m_{BD} = -1$	Notes 4.2 The formula sheet you should already know
4B.1	c. 12 square units	Notes 4.2 The formula sheet you should already know
4B.2	a. $m = 1$ at $\left(\frac{\sqrt{3}+1}{2}, \frac{\sqrt{3}-3}{2}\right)$; $m = 2 + \sqrt{3}$ at $\left(\frac{1}{2}, \frac{\sqrt{3}}{2} - 1\right)$	Notes 4.3 The angle between two lines
4B.2	b. $1 - \frac{5\pi(2-\sqrt{3})}{12} \approx 0.649$ square units	Notes 4.3 The angle between two lines
4C.1	D	Notes 4.4 Simultaneous linear equations
4C.2	A	Notes 4.5 General tips for coordinate geometry
4C.3	B	Notes 4.5 General tips for coordinate geometry

Notes

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5 Exponentials and Logarithms

Section A – Technology free

Question 5A.1* (3 marks) ☐ Done ☐ Marked ☐ Redo

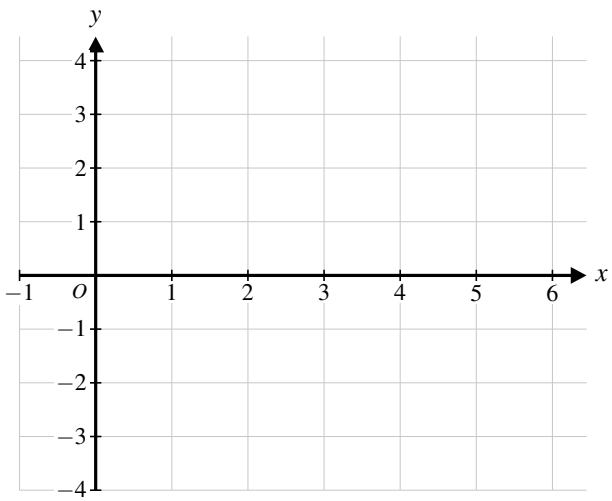
Simplify each expression, writing your answer with positive indices.

a. $\dfrac{(8x^6y^3)^{\frac{2}{3}}}{4x^2y}$ 2 marks

b. $\dfrac{3^{n+2}-3^n}{8\times 3^n}$ 1 mark

Question 5A.2** (3 marks) ☐ Done ☐ Marked ☐ Redo

Sketch $y=2\log_e(x-1)$ on the axes below, labelling the asymptote with its equation and the x-intercept with its coordinates. 3 marks



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Question 5A.3**** (5 marks) ☐ Done ☐ Marked ☐ Redo

a. Solve $\log_2(x) = \log_4(x+6)$. 3 marks

b. Solve $2\log_3(x) - \log_3(x+6) = 1$. 2 marks

Question 5A.4*** (3 marks) ☐ Done ☐ Marked ☐ Redo

a. Solve $2^{x+y} = 32$ and $3^{x-y} = 27$ simultaneously. 1 mark

b. Solve $\log_2(x) + \log_2(y) = 5$ and $\log_2(x) - \log_2(y) = 1$ simultaneously. 2 marks

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Section B – Technology active

Question 5B.1***** (5 marks) ☐ Done ☐ Marked ☐ Redo

The concentration of a medicine in the blood t hours after one dose is $C(t) = 10te^{-\frac{t}{2}}$ mg/L.

a. Using technology, find the maximum concentration from a single dose and the time at which it occurs. Give the concentration exactly. 2 marks

b. A second identical dose is taken 6 hours after the first, so for $t \geq 6$ the concentration is $C(t) + C(t-6)$. Find the maximum concentration after the second dose and the time at which it occurs, each correct to two decimal places. 3 marks

Question 5B.2*** (4 marks) ☐ Done ☐ Marked ☐ Redo

The mass of a radioactive substance is $m(t) = m_0 e^{-kt}$ grams after t days. Its half-life is 8 days.

a. Show that $k = \frac{1}{8}\log_e 2$. 1 mark

b. Find the fraction of the original mass that remains after 24 days. 1 mark

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c. Find the exact time taken for 90% of the substance to decay. 2 marks

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Section C – Multiple choice (technology active)

Question 5C.1** (1 mark) ☐ Done ☐ Marked ☐ Redo

A population is modelled by $P = 200e^{0.1t}$. The time taken for the population to triple is

A. $10\log_e(3)$ **B.** $\frac{1}{10}\log_e(3)$

C. $\log_e(30)$ **D.** $10\log_e(600)$

Answer: (A) (B) (C) (D)

Question 5C.2*** (1 mark) ☐ Done ☐ Marked ☐ Redo

The solution of $e^{-2x} < 4$ is

A. $x < -\log_e(2)$ **B.** $x > -\log_e(2)$

C. $x > \log_e(2)$ **D.** $x < \log_e(2)$

Answer: (A) (B) (C) (D)

Question 5C.3**** (1 mark) ☐ Done ☐ Marked ☐ Redo

The solution of $\log_{\frac{1}{2}}(x) > 3$ is

A. $x > \frac{1}{8}$ **B.** $x < \frac{1}{8}$

C. $0 < x < \frac{1}{8}$ **D.** $x > 8$

Answer: (A) (B) (C) (D)

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Exponentials and Logarithms – Short answers

Final answers only. Full working is in the Worked Solutions. The grey column shows the notes section each question tests: if you got it wrong, reread that section first.

5A.1	a. x^2y	Notes 5.1 Index laws
5A.1	b. 1	Notes 5.1 Index laws
5A.2	Asymptote $x = 1$; x-intercept $(2, 0)$	Notes 5.6 Graphs: growth and decay
5A.3	a. $x = 3$	Notes 5.5 Changing the base
5A.3	b. $x = 6$	Notes 5.5 Changing the base
5A.4	a. $x = 4$, $y = 1$	Notes 5.2 Solving exponential equations
5A.4	b. $x = 8$, $y = 4$	Notes 5.2 Solving exponential equations
5B.1	a. $20e^{-1}$ mg/L at $t = 2$	Notes 5.8 Applications: it's just transformations
5B.1	b. 8.90 mg/L at $t \approx 7.72$	Notes 5.8 Applications: it's just transformations
5B.2	a. Shown	Notes 5.8 Applications: it's just transformations
5B.2	b. $\frac{1}{8}$	Notes 5.8 Applications: it's just transformations
5B.2	c. $\dfrac{8\log_e 10}{\log_e 2}$ days $(= 8\log_2 10 \approx 26.6)$	Notes 5.8 Applications: it's just transformations
5C.1	A	Notes 5.8 Applications: it's just transformations
5C.2	B	Notes 5.9 Solving non-linear inequalities: sketch it
5C.3	C	Notes 5.9 Solving non-linear inequalities: sketch it

Notes

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6 Circular Functions

Section A – Technology free

Question 6A.1* (3 marks) ☐ Done ☐ Marked ☐ Redo

Find the exact value of each.

a. $\sin\left(\frac{5\pi}{6}\right)$ 1 mark

b. $\cos\left(-\frac{2\pi}{3}\right)$ 1 mark

c. $\tan\left(\frac{7\pi}{4}\right)$ 1 mark

Question 6A.2** (2 marks) ☐ Done ☐ Marked ☐ Redo

Solve $2\sin(x) = \sqrt{3}$ for $x \in [0, 2\pi]$. 2 marks

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Question 6A.3**** (5 marks) ☐ Done ☐ Marked ☐ Redo

a. Solve $2\sin^2(x) - \sin(x) - 1 = 0$ for $x \in [0, 2\pi]$. 2 marks

b. Solve $2\cos^2(x) + 3\sin(x) - 3 = 0$ for $x \in [0, 2\pi]$. 3 marks

Question 6A.4*** (3 marks) ☐ Done ☐ Marked ☐ Redo

Solve $\sin(2x) = \sqrt{3}\cos(2x)$ for $x \in [0, \pi]$. 3 marks

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Section B – Technology active

Question 6B.1***** (7 marks) ☐ Done ☐ Marked ☐ Redo

The number of hours of daylight in a city on day t of the year is modelled by $D(t) = 12 + 2.4\sin\left(\dfrac{2\pi(t-80)}{365}\right)$, for $1 \leq t \leq 365$.

a. State the greatest and least number of hours of daylight. 1 mark

b. Find the number of days in the year with more than 13.5 hours of daylight. 3 marks

c. A second city is modelled by $E(t) = 12 + a\sin\left(\dfrac{2\pi(t-80)}{365}\right)$, $a > 0$. Each year, the interval of time during which it has more than 13.5 hours of daylight is exactly 150 days long. Find a, correct to two decimal places. 3 marks

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Question 6B.2**** (4 marks) ☐ Done ☐ Marked ☐ Redo

A carriage on a Ferris wheel is $h(t) = 12 - 10\cos\left(\dfrac{\pi t}{15}\right)$ metres above the ground t seconds after it starts.

a. For how many seconds in each rotation is the carriage more than 17 m above the ground? 2 marks

b. A second wheel has $H(t) = 12 - 10\cos(nt)$. Its carriage is more than 17 m above the ground for exactly 8 seconds in each rotation. Find n. 2 marks

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Section C – Multiple choice (technology active)

Question 6C.1*** (1 mark) ☐ Done ☐ Marked ☐ Redo

The general solution of $\tan(2x) = 1$ is

A. $x = \frac{\pi}{4} + n\pi,\ n \in Z$ **B.** $x = \frac{\pi}{8} + n\pi,\ n \in Z$

C. $x = \frac{\pi}{8} + \frac{n\pi}{2},\ n \in Z$ **D.** $x = \frac{\pi}{8} + 2n\pi,\ n \in Z$

Answer: (A) (B) (C) (D)

Question 6C.2** (1 mark) ☐ Done ☐ Marked ☐ Redo

If $\cos(x) = -\frac{5}{13}$ and $\pi < x < \frac{3\pi}{2}$, then $\sin(x)$ is equal to

A. $\frac{12}{13}$ **B.** $-\frac{12}{13}$

C. $\frac{8}{13}$ **D.** $-\frac{8}{13}$

Answer: (A) (B) (C) (D)

Question 6C.3**** (1 mark) ☐ Done ☐ Marked ☐ Redo

The equation $\cos\left(ax + \frac{\pi}{6}\right) = 1$, where $a > 0$, has exactly one solution for $x \in [0, 2]$ when

A. $a < \frac{11\pi}{12}$ **B.** $\frac{11\pi}{12} \leq a < \frac{23\pi}{12}$

C. $a \geq \frac{23\pi}{12}$ **D.** $\frac{11\pi}{6} \leq a < \frac{23\pi}{6}$

Answer: (A) (B) (C) (D)

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Circular Functions – Short answers

Final answers only. Full working is in the Worked Solutions. The grey column shows the notes section each question tests: if you got it wrong, reread that section first.

6A.1	a. $\frac{1}{2}$	Notes 6.3 Quadrants and the reference angle
6A.1	b. $-\frac{1}{2}$	Notes 6.3 Quadrants and the reference angle
6A.1	c. -1	Notes 6.3 Quadrants and the reference angle
6A.2	$x = \frac{\pi}{3},\ \frac{2\pi}{3}$	Notes 6.6 Solving trig equations
6A.3	a. $x = \frac{\pi}{2},\ \frac{7\pi}{6},\ \frac{11\pi}{6}$	Notes 6.6 Solving trig equations
6A.3	b. $x = \frac{\pi}{6},\ \frac{\pi}{2},\ \frac{5\pi}{6}$	Notes 6.6 Solving trig equations
6A.4	$x = \frac{\pi}{6},\ \frac{2\pi}{3}$	Notes 6.6 Solving trig equations
6B.1	a. 14.4 hours and 9.6 hours	Notes 6.8 Sketching circular functions
6B.1	b. 104 days	Notes 6.8 Sketching circular functions
6B.1	c. $a \approx 5.43$	Notes 6.8 Sketching circular functions
6B.2	a. 10 seconds	Notes 6.9 Trig inequalities
6B.2	b. $n = \frac{\pi}{12}$	Notes 6.9 Trig inequalities
6C.1	C	Notes 6.7 General solutions
6C.2	B	Notes 6.10 The Pythagorean identity
6C.3	B	Notes 6.7 General solutions

Notes

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7 Composite and Inverse Functions

Section A – Technology free

Question 7A.1* (3 marks) ☐ Done ☐ Marked ☐ Redo

Let $f(x) = x^2 + 1$ and $g(x) = 2x - 3$.

a. Find $f\big(g(x)\big)$. 1 mark

b. Find $g\big(f(x)\big)$. 1 mark

c. Evaluate $f\big(g(2)\big)$. 1 mark

Question 7A.2** (3 marks) ☐ Done ☐ Marked ☐ Redo

Let $f(x) = 3e^{2x} - 1$.

Find the rule and domain of f^{-1}. 3 marks

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Question 7A.3*** (4 marks) ☐ Done ☐ Marked ☐ Redo

Let $f : (-\infty, a] \to R,\ f(x) = x^2 + 2x - 3$.

a. Find the largest value of a for which f has an inverse function. 1 mark

b. For this value of a, find the rule and domain of f^{-1}. 3 marks

Question 7A.4**** (4 marks) ☐ Done ☐ Marked ☐ Redo

Let $f(x) = \sqrt{x-1}$ with its maximal domain, and $g : R \to R,\ g(x) = 4 - x^2$.

a. Explain why $f \circ g$ is not defined. 1 mark

b. Find the largest domain D for g so that $f \circ g$ is defined. 2 marks

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c. With this domain, state the rule and range of $f \circ g$. 1 mark

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Section B – Technology active

Question 7B.1***** (8 marks) ☐ Done ☐ Marked ☐ Redo

Let $f(x) = e^{ax} - b$, where $a, b > 0$, over its maximal domain.

a. Find the rule and domain of the inverse function f^{-1}. 2 marks

b. Find b in terms of a such that the graphs of $y = f(x)$ and $y = f^{-1}(x)$ are tangent to each other. 2 marks

c. For $a = 1$ and a certain value of b, the graphs of $y = f(x)$ and $y = f^{-1}(x)$ intersect at $x = 1$. Find the area of the region bounded by the graphs, correct to four decimal places. 3 marks

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d. Let C be the circle that circumscribes the region described in part c. Find the area of C, correct to two decimal places. 1 mark

Question 7B.2*** (7 marks) ☐ Done ☐ Marked ☐ Redo

The functions f and g both have domain $\{1,2,3,4,5\}$. Their rules are not given, but all of their values are in the table.

x	1	2	3	4	5
$f(x)$	3	5	2	3	1
$g(x)$	4	1	5	2	3

a. Evaluate (i) $f\big(g(2)\big)$ (ii) $g\big(f(f(1))\big)$. 2 marks

b. Find all values of x for which $f\big(g(x)\big) = 3$. 2 marks

c. The function g is one-to-one, so it has an inverse. Find $g^{-1}\big(f(5)\big)$. 1 mark

d. Explain why f does not have an inverse function, and state the number of solutions of $g\big(f(x)\big) = 2$. 2 marks

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Section C – Multiple choice (technology active)

Question 7C.1**** (1 mark) ☐ Done ☐ Marked ☐ Redo

The number of points of intersection of the graphs of $f(x) = -x^3$ and its inverse is

A. 0 **B.** 1

C. 2 **D.** 3

Answer: (A) (B) (C) (D)

Question 7C.2*** (1 mark) ☐ Done ☐ Marked ☐ Redo

A one-to-one function f has $f(2) = 5$ and $f'(2) = 4$. The gradient of the graph of $y = f^{-1}(x)$ at $x = 5$ is

A. 4 **B.** -4

C. $\frac{1}{4}$ **D.** $\frac{1}{5}$

Answer: (A) (B) (C) (D)

Question 7C.3** (1 mark) ♢ non-essential ☐ Done ☐ Marked ☐ Redo

Which one of the following has maximal domain R?

A. $y = x^{\frac{1}{2}}$ **B.** $y = x^{-1}$

C. $y = x^{\frac{1}{3}}$ **D.** $y = x^{-\frac{1}{2}}$

Answer: (A) (B) (C) (D)

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Composite and Inverse Functions – Short answers

Final answers only. Full working is in the Worked Solutions. The grey column shows the notes section each question tests: if you got it wrong, reread that section first.

7A.1	a. $(2x-3)^2+1$	Notes 7.1 Composite functions and the rule
7A.1	b. $2x^2-1$	Notes 7.1 Composite functions and the rule
7A.1	c. 2	Notes 7.1 Composite functions and the rule
7A.2	$f^{-1}:(-1,\infty)\to R,\ f^{-1}(x)=\frac{1}{2}\log_e\left(\frac{x+1}{3}\right)$	Notes 7.4 Inverse functions
7A.3	a. $a=-1$	Notes 7.4 Inverse functions
7A.3	b. $f^{-1}(x)=-1-\sqrt{x+4}$, domain $[-4,\infty)$	Notes 7.4 Inverse functions
7A.4	a. $\operatorname{ran} g \not\subseteq \operatorname{dom} f$	Notes 7.2 Finding the domain and range of a composite
7A.4	b. $D=[-\sqrt{3},\sqrt{3}]$	Notes 7.2 Finding the domain and range of a composite
7A.4	c. $\sqrt{3-x^2}$, range $[0,\sqrt{3}]$	Notes 7.2 Finding the domain and range of a composite
7B.1	a. $f^{-1}:(-b,\infty)\to R,\ f^{-1}(x)=\frac{1}{a}\log_e(x+b)$	Notes 7.6 Inverses in calculus: tangency, gradients and areas
7B.1	b. $b=\dfrac{1+\log_e(a)}{a}$ (which needs $a>\frac{1}{e}$ so that $b>0$)	Notes 7.6 Inverses in calculus: tangency, gradients and areas
7B.1	c. ≈ 2.3511 square units	Notes 7.6 Inverses in calculus: tangency, gradients and areas
7B.1	d. ≈ 9.77 square units	Notes 7.6 Inverses in calculus: tangency, gradients and areas
7B.2	a. (i) 3 (ii) 1	Notes 7.1 Composite functions and the rule
7B.2	b. $x=1$ or $x=2$	Notes 7.1 Composite functions and the rule
7B.2	c. 2	Notes 7.1 Composite functions and the rule
7B.2	d. f is many-to-one ($f(1)=f(4)$); no solutions	Notes 7.1 Composite functions and the rule
7C.1	D	Notes 7.5 Intersections of f and f^{-1}
7C.2	C	Notes 7.6 Inverses in calculus: tangency, gradients and areas
7C.3	C	Notes 7.7 Power functions (reference)

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8 Curve Sketching

Section A – Technology free

Question 8A.1** (4 marks) ☐ Done ☐ Marked ☐ Redo

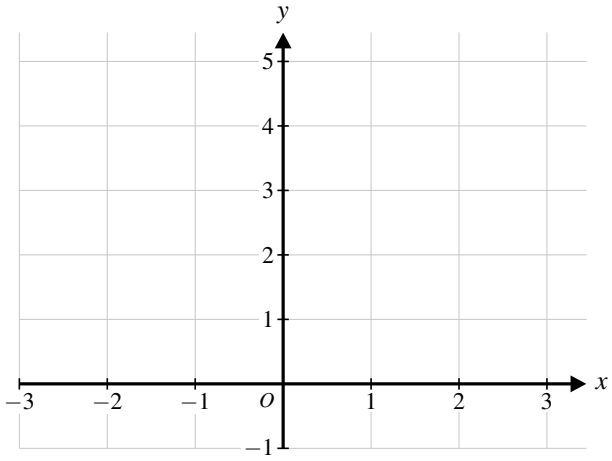
State the equations of all asymptotes of each graph.

a. $y = \dfrac{3}{x^2-4}+1$ 2 marks

b. $y = \dfrac{x^2+1}{x}$ 2 marks

Question 8A.2** (3 marks) ◊ non-essential ☐ Done ☐ Marked ☐ Redo

Sketch $y = |x^2-4|$, labelling all axis intercepts and any points where the graph is not smooth. 3 marks



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Question 8A.3*** (3 marks) ☐ Done ☐ Marked ☐ Redo

Let $f(x) = x^2 - 1$.

Without sketching it accurately, describe the key features of the graph of $y = \dfrac{1}{f(x)}$: its asymptotes, where it is positive and negative, and its turning point. 3 marks

Question 8A.4**** (3 marks) ☐ Done ☐ Marked ☐ Redo

The graph of $y = \dfrac{ax+b}{x+c}$ has asymptotes $x = 2$ and $y = 3$, and passes through $(0,1)$. Find a, b and c. 3 marks

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Section B – Technology active

Question 8B.1*** (5 marks) ☐ Done ☐ Marked ☐ Redo

Let $f(x) = x^2 e^{-x}$.

a. Find the coordinates of the stationary points, giving exact values. 2 marks

b. Find the x-coordinates of the points of inflection, giving exact values. 2 marks

c. State the equation of the asymptote. 1 mark

Question 8B.2***** (7 marks) ☐ Done ☐ Marked ☐ Redo

Let $f(x) = \dfrac{\log_e(x)}{x}$.

a. State the maximal domain of f, its x-intercept, and the equations of its asymptotes. 2 marks

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b. Find the exact coordinates of the turning point and the point of inflection. 2 marks

c. Hence find the values of k for which the equation $\log_e(x) = kx$ has (i) two solutions, (ii) exactly one solution. 3 marks

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Section C – Multiple choice (technology active)

Question 8C.1** (1 mark) ☐ Done ☐ Marked ☐ Redo

Let $h(x) = f(x) + g(x)$. If $f(2) = 3$ and $g(2) = -3$, then the graph of h must

A. have a turning point at $x = 2$

B. have an asymptote at $x = 2$

C. have an x-intercept at $x = 2$

D. pass through $(2, 3)$

Answer: (A) (B) (C) (D)

Question 8C.2*** (1 mark) ☐ Done ☐ Marked ☐ Redo

The graph of $y = f(x)$ has x-intercepts at $x = -1$ and $x = 2$ only. The graph of $y = \dfrac{1}{f(x)}$ has

A. x-intercepts at $x = -1$ and $x = 2$

B. vertical asymptotes at $x = -1$ and $x = 2$

C. x-intercepts at $x = -1$ and $x = \frac{1}{2}$

D. turning points at $x = -1$ and $x = 2$

Answer: (A) (B) (C) (D)

Question 8C.3*** (1 mark) ☐ Done ☐ Marked ☐ Redo

The graph of $y = x\log_e(x)$ has a local minimum at

A. $(1, 0)$

B. $(e,\ e)$

C. $\left(\frac{1}{e},\ -\frac{1}{e}\right)$

D. $\left(\frac{1}{e},\ -1\right)$

Answer: (A) (B) (C) (D)

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Curve Sketching – Short answers

Final answers only. Full working is in the Worked Solutions. The grey column shows the notes section each question tests: if you got it wrong, reread that section first.

8A.1	a. $x = 2$, $x = -2$, $y = 1$	Notes 8.2 Asymptotes, properly
8A.1	b. $x = 0$ and $y = x$	Notes 8.2 Asymptotes, properly
8A.2	W shape: corners at $(\pm 2, 0)$, local max $(0, 4)$	Notes 8.3 Other techniques
8A.3	Asymptotes $x = \pm 1$, $y = 0$; positive for $\lvert x \rvert > 1$, negative between; local max $(0, -1)$	Notes 8.3 Other techniques
8A.4	$a = 3$, $b = -2$, $c = -2$	Notes 8.2 Asymptotes, properly
8B.1	a. $(0, 0)$ and $(2, 4e^{-2})$	Notes 13.7 CAS Guide: sketching on the CAS
8B.1	b. $x = 2 \pm \sqrt{2}$	Notes 13.7 CAS Guide: sketching on the CAS
8B.1	c. $y = 0$ (as $x \to \infty$)	Notes 13.7 CAS Guide: sketching on the CAS
8B.2	a. $(0, \infty)$; $(1, 0)$; asymptotes $x = 0$ and $y = 0$	Notes 13.7 CAS Guide: sketching on the CAS
8B.2	b. Maximum $\left(e, \frac{1}{e}\right)$; inflection $\left(e^{\frac{3}{2}}, \frac{3}{2}e^{-\frac{3}{2}}\right)$	Notes 13.7 CAS Guide: sketching on the CAS
8B.2	c. (i) $0 < k < \frac{1}{e}$ (ii) $k = \frac{1}{e}$ or $k \leq 0$	Notes 13.7 CAS Guide: sketching on the CAS
8C.1	C	Notes 8.3 Other techniques
8C.2	B	Notes 8.3 Other techniques
8C.3	C	Notes 8.4 Worked example: piecing the clues together

Notes

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9 Differentiation

Section A – Technology free

Question 9A.1* (5 marks) ☐ Done ☐ Marked ☐ Redo

Differentiate each with respect to x.

a. $3x^4 - \dfrac{2}{x} + \sqrt{x}$ 1 mark

b. $(2x+1)^5$ 1 mark

c. $x^2 \log_e x$ 1 mark

d. $\dfrac{\cos x}{x}$ 2 marks

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Question 9A.2** (3 marks) ☐ Done ☐ Marked ☐ Redo

The height of a plant is $h(t) = 2\sqrt{t}$ cm after t weeks.

a. Find the average rate of change of the height over the first 9 weeks. 1 mark

b. Find the instantaneous rate of change of the height when $t = 9$. 2 marks

Question 9A.3*** (5 marks) ☐ Done ☐ Marked ☐ Redo

A particle moves in a straight line so that its position is $x(t) = t^3 - 6t^2 + 9t$ metres at time t seconds, $t \geq 0$.

a. Find the times at which the particle is at rest, and its acceleration at each of those times. 2 marks

b. State the values of t for which the particle is moving in the negative direction. 1 mark

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c. Find the total distance travelled in the first 4 seconds. 2 marks

Question 9A.4**** (5 marks) ☐ Done ☐ Marked ☐ Redo

A closed cylindrical can must hold 16π cm^3.

a. Show that the surface area is $A = 2\pi r^2 + \dfrac{32\pi}{r}$, where r cm is the radius. 2 marks

b. Find the radius and height that minimise the surface area, and the minimum surface area. 3 marks

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Section B – Technology active

Question 9B.1*** (3 marks) ☐ Done ☐ Marked ☐ Redo

Use Newton's method with $x_0 = 2$ to find x_2 for $f(x) = x^3 - 2x - 5$. Give x_2 correct to four decimal places.

3 marks

Question 9B.2***** (2 marks) ☐ Done ☐ Marked ☐ Redo

Let $f(x) = x^2 + k\sin(x)$ over its maximal domain, where $k \in R$. Find the minimum value of k, correct to two decimal places, for which all roots of $f(x) = 0$ are non-negative. 2 marks

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Section C – Multiple choice (technology active)

Question 9C.1** (1 mark) ☐ Done ☐ Marked ☐ Redo

The tangent to the graph of $y = \sqrt{x}$ at $x = 4$ has equation

A. $y = \frac{1}{4}x + 1$ **B.** $y = \frac{1}{4}x + 2$

C. $y = \frac{1}{2}x$ **D.** $y = 4x - 14$

Answer: (A) (B) (C) (D)

Question 9C.2*** (1 mark) ☐ Done ☐ Marked ☐ Redo

The absolute maximum value of $f : [-2, 3] \to R,\ f(x) = x^3 - 3x$ is

A. 2 **B.** -2

C. 3 **D.** 18

Answer: (A) (B) (C) (D)

Question 9C.3**** (1 mark) ☐ Done ☐ Marked ☐ Redo

The graphs of $y = e^x$ and $y = x + k$ touch when k equals

A. 0 **B.** 1

C. e **D.** -1

Answer: (A) (B) (C) (D)

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Differentiation – Short answers

Final answers only. Full working is in the Worked Solutions. The grey column shows the notes section each question tests: if you got it wrong, reread that section first.

9A.1	a. $12x^3 + \frac{2}{x^2} + \frac{1}{2\sqrt{x}}$	Notes 9.2 The differentiation toolkit
9A.1	b. $10(2x+1)^4$	Notes 9.2 The differentiation toolkit
9A.1	c. $2x\log_e x + x$	Notes 9.2 The differentiation toolkit
9A.1	d. $-\frac{x\sin x + \cos x}{x^2}$	Notes 9.2 The differentiation toolkit
9A.2	a. $\frac{2}{3}$ cm/week	Notes 9.1 What is a derivative?
9A.2	b. $\frac{1}{3}$ cm/week	Notes 9.1 What is a derivative?
9A.3	a. $t = 1$ ($a = -6$) and $t = 3$ ($a = 6$)	Notes 9.1 What is a derivative?
9A.3	b. $1 < t < 3$	Notes 9.1 What is a derivative?
9A.3	c. 12 m	Notes 9.1 What is a derivative?
9A.4	a. Shown	Notes 9.9 Absolute maximums and minimums (optimisation)
9A.4	b. $r = 2$ cm, $h = 4$ cm, $A = 24\pi$ cm^2	Notes 9.9 Absolute maximums and minimums (optimisation)
9B.1	$x_2 \approx 2.0946$	Notes 9.12 Approximating x-intercepts
9B.2	$k = -20.17$ (all roots are non-negative for $-20.1748\ldots < k \leq 0$)	Notes 9.11 Families of functions (slider questions)
9C.1	A	Notes 9.8 Tangents and normals
9C.2	D	Notes 9.9 Absolute maximums and minimums (optimisation)
9C.3	B	Notes 9.10 Tangential graphs

Notes

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10 Integration

Section A – Technology free

Question 10A.1* (3 marks) ☐ Done ☐ Marked ☐ Redo

Find an antiderivative of each.

a. $6x^2 - \dfrac{4}{x^2}$ 1 mark

b. e^{2x+1} 1 mark

c. $\dfrac{1}{3x-2}$ 1 mark

Question 10A.2** (2 marks) ☐ Done ☐ Marked ☐ Redo

Use the trapezium rule with two strips of equal width to estimate $\displaystyle\int_1^3 \frac{1}{x}\,dx$. 2 marks

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Question 10A.3*** (3 marks) ☐ Done ☐ Marked ☐ Redo

a. Find the value of $a > 1$ for which $\int_1^a (2x-3)\,dx = 6$. 2 marks

b. Find the exact value of k for which $\int_0^k e^{2x}\,dx = 4$. 1 mark

Question 10A.4**** (3 marks) ☐ Done ☐ Marked ☐ Redo

Let $F(x) = \int_0^x \left(t^2 - 4t + 3\right) dt$.

Find $F'(x)$, and hence find the coordinates of the local maximum of the graph of F. 3 marks

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Section B – Technology active

Question 10B.1***** (6 marks) ☐ Done ☐ Marked ☐ Redo

Water flows into a reservoir at a rate of $I(t) = 20 + 10\sin\left(\dfrac{\pi t}{12}\right)$ ML per hour and is released at a constant 24 ML per hour, for $0 \leq t \leq 24$. The reservoir holds 500 ML when $t = 0$.

a. Find the times at which the volume of water stops decreasing and starts increasing, and stops increasing and starts decreasing, correct to two decimal places. 2 marks

b. Find the maximum volume of water in the reservoir, correct to the nearest megalitre. 2 marks

c. Find the minimum volume of water in the reservoir during the 24 hours. 2 marks

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Question 10B.2*** (3 marks) ☐ Done ☐ Marked ☐ Redo

Use the trapezium rule with four strips of equal width to estimate $\int_0^2 e^{-x^2} dx$, correct to four decimal places. Find the percentage error in this estimate, correct to two decimal places. 3 marks

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Section C – Multiple choice (technology active)

Question 10C.1** (1 mark) ☐ Done ☐ Marked ☐ Redo

The area enclosed by the graphs of $y = x^2$ and $y = 2x$ is

A. $\frac{2}{3}$ **B.** $\frac{4}{3}$

C. $\frac{8}{3}$ **D.** 4

Answer: (A) (B) (C) (D)

Question 10C.2*** (1 mark) ☐ Done ☐ Marked ☐ Redo

If $\int_1^5 f(x)\,dx = 7$ and $\int_3^5 f(x)\,dx = 2$, then $\int_1^3 \big(f(x)+2\big)\,dx$ is equal to

A. 5 **B.** 7

C. 9 **D.** 11

Answer: (A) (B) (C) (D)

Question 10C.3**** (1 mark) ☐ Done ☐ Marked ☐ Redo

$\frac{d}{dx}\left(\int_1^x \sqrt{1+t^3}\,dt\right)$ is equal to

A. $\sqrt{1+x^3}$ **B.** $\sqrt{1+x^3}-\sqrt{2}$

C. $\dfrac{3x^2}{2\sqrt{1+x^3}}$ **D.** $\sqrt{1+t^3}$

Answer: (A) (B) (C) (D)

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Integration – Short answers

Final answers only. Full working is in the Worked Solutions. The grey column shows the notes section each question tests: if you got it wrong, reread that section first.

10A.1 a.	$2x^3 + \frac{4}{x}$	Notes 10.2 Integration formulas
10A.1 b.	$\frac{1}{2}e^{2x+1}$	Notes 10.2 Integration formulas
10A.1 c.	$\frac{1}{3}\log_e \lvert 3x-2 \rvert$	Notes 10.2 Integration formulas
10A.2	$\frac{7}{6}$	Notes 10.5 Estimating areas
10A.3 a.	$a = 4$	Notes 10.3 The fundamental theorem of calculus
10A.3 b.	$k = \log_e 3$	Notes 10.3 The fundamental theorem of calculus
10A.4	$F'(x) = x^2 - 4x + 3$; local maximum $\left(1, \frac{4}{3}\right)$	Notes 10.3 The fundamental theorem of calculus
10B.1 a.	$t \approx 1.57$ and $t \approx 10.43$	Notes 10.3 The fundamental theorem of calculus
10B.1 b.	531 ML	Notes 10.3 The fundamental theorem of calculus
10B.1 c.	404 ML (at $t = 24$)	Notes 10.3 The fundamental theorem of calculus
10B.2	0.8806; error $\approx 0.17\%$	Notes 10.5 Estimating areas
10C.1	B	Notes 10.6 Exact areas
10C.2	C	Notes 10.7 Manipulating integrals
10C.3	A	Notes 10.3 The fundamental theorem of calculus

Notes

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11 Probability and Statistics

Section A – Technology free

Question 11A.1** (3 marks) ☐ Done ☐ Marked ☐ Redo

a. How many different arrangements are there of the letters of LEVEL? 1 mark

b. A committee of 3 is chosen from 5 boys and 4 girls. How many committees have at least one girl? 2 marks

Question 11A.2** (2 marks) ☐ Done ☐ Marked ☐ Redo

X is normally distributed with mean 50 and standard deviation 4. Use the 68–95–99.7% rule to estimate:

a. $\Pr(X > 58)$ 1 mark

b. $\Pr(46 < X < 58)$ 1 mark

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Question 11A.3*** (3 marks) ☐ Done ☐ Marked ☐ Redo

In a game, a fair die is rolled once. The player wins \$12 for a six, \$3 for a four or a five, and nothing otherwise.

a. It costs \$5 to play. Find the player's expected profit per game. 2 marks

b. The prize for a six is changed to \$$w$ so that the game is fair at \$5 to play. Find w. 1 mark

Question 11A.4**** (6 marks) ☐ Done ☐ Marked ☐ Redo

The continuous random variable X has probability density function $f(x) = kx(4-x^2)$ for $0 \leq x \leq 2$, and $f(x) = 0$ elsewhere.

a. Show that $k = \frac{1}{4}$. 1 mark

b. Find the mode of X. 2 marks

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c. Find the exact median of X. 3 marks

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Section B – Technology active

Question 11B.1*** (3 marks) ☐ Done ☐ Marked ☐ Redo

Forty different researchers each take their own random sample from the same population and each calculates a 95% confidence interval for the same proportion p.

a. How many of the 40 intervals would you expect *not* to contain p? 1 mark

b. Find the probability that all 40 intervals contain p, correct to four decimal places. 2 marks

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Question 11B.2***** (12 marks) ☐ Done ☐ Marked ☐ Redo

A machine fires tennis balls from ground level at the origin. The path of a ball is modelled by

$$y = x - \frac{10x^2}{v^2}, \qquad x \geq 0,$$

where x metres is the horizontal distance from the machine, y metres is the height of the ball and v metres per second is the launch speed.

a. Find, in terms of v, how far from the machine the ball lands. 1 mark

b. Find the maximum height of the ball, in terms of v. 2 marks

A net 2 metres high stands 30 metres from the machine. A shot is *in* if the ball passes over the net and lands no more than 45 metres from the machine.

c. Find the exact interval of values of v for which a shot is in. 3 marks

d. The launch speed is a normally distributed random variable V with a mean of 20 and a standard deviation of 2.

Find the probability that a shot is in, correct to four decimal places. 2 marks

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e. Ten balls are fired, independently. Find the probability that at least eight of the shots are in, correct to four decimal places. 2 marks

f. The mean launch speed can be changed, while the standard deviation stays at 2. Find the mean, correct to two decimal places, that makes the probability of a shot being in as large as possible. 2 marks

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Section C – Multiple choice (technology active)

Question 11C.1**** (1 mark) ☐ Done ☐ Marked ☐ Redo

X has pdf $f(x) = 2x$ for $0 \leq x \leq 1$ (and 0 elsewhere). $\Pr(X > 0.5 \mid X > 0.25)$ is equal to

A. 0.75 **B.** 0.8

C. 0.5 **D.** 0.9375

Answer: (A) (B) (C) (D)

Question 11C.2*** (1 mark) ☐ Done ☐ Marked ☐ Redo

A box holds 5 red and 5 blue pens. Two are chosen at random without replacement, and $\hat{P}$ is the proportion of red pens in the sample. $\Pr\left(\hat{P} = \frac{1}{2}\right)$ is equal to

A. $\frac{1}{2}$ **B.** $\frac{5}{9}$

C. $\frac{2}{9}$ **D.** $\frac{1}{4}$

Answer: (A) (B) (C) (D)

Question 11C.3** (1 mark) ☐ Done ☐ Marked ☐ Redo

X takes the values 1, 2 and 3 with probabilities 0.2, 0.5 and 0.3. $E\left(X^2\right)$ is equal to

A. 4.41 **B.** 4.9

C. 2.1 **D.** 14

Answer: (A) (B) (C) (D)

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Probability and Statistics – Short answers

Final answers only. Full working is in the Worked Solutions. The grey column shows the notes section each question tests: if you got it wrong, reread that section first.

11A.1 a. 30 — Notes 11.2 Counting methods

11A.1 b. 74 — Notes 11.2 Counting methods

11A.2 a. 0.025 — Notes 11.8 The normal distribution

11A.2 b. 0.815 — Notes 11.8 The normal distribution

11A.3 a. $-\$2$ — Notes 11.5 Discrete random variables

11A.3 b. $w = 24$ — Notes 11.5 Discrete random variables

11A.4 a. Shown — Notes 11.7 Continuous random variables

11A.4 b. $\frac{2}{\sqrt{3}} = \frac{2\sqrt{3}}{3}$ — Notes 11.7 Continuous random variables

11A.4 c. $m = \sqrt{4 - 2\sqrt{2}}$ — Notes 11.7 Continuous random variables

11B.1 a. 2 — Notes 11.9 Sampling

11B.1 b. 0.1285 — Notes 11.9 Sampling

11B.2 a. $\dfrac{v^2}{10}$ metres — Notes 11.8 The normal distribution

11B.2 b. $\dfrac{v^2}{40}$ metres — Notes 11.8 The normal distribution

11B.2 c. $\dfrac{15\sqrt{70}}{7} < v \leq 15\sqrt{2}$ — Notes 11.8 The normal distribution

11B.2 d. 0.5778 — Notes 11.8 The normal distribution

11B.2 e. 0.1341 — Notes 11.8 The normal distribution

11B.2 f. $\mu = 19.57$ (the probability rises to 0.5885) — Notes 11.8 The normal distribution

11C.1 B — Notes 11.7 Continuous random variables

11C.2 B — Notes 11.9 Sampling

11C.3 B — Notes 11.10 Expected value of a function of X

Notes

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12 Miscellaneous

Section A – Technology free

Question 12A.1** (2 marks) ☐ Done ☐ Marked ☐ Redo

What value does this algorithm print?

```
s ← 0
for i from 1 to 4
    s ← s + i^2
end for
print s
```

2 marks

Question 12A.2*** (3 marks) ☐ Done ☐ Marked ☐ Redo

The bisection method is applied to $f(x) = x^2 - 3$ starting with the interval $[1, 2]$. Find the interval after three iterations.

```
a ← 1, b ← 2
for i from 1 to 3
    m ← (a + b)/2
    if f(a)*f(m) < 0 then
        b ← m
    else
        a ← m
    end if
end for
```

3 marks

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Question 12A.3*** (1 mark) ☐ Done ☐ Marked ☐ Redo

Which one of the following functions satisfies $f(x+y) = f(x)f(y)$ for all real x and y?

A. $f(x) = 3x$ **B.** $f(x) = x^3$

C. $f(x) = e^{3x}$ **D.** $f(x) = 3e^x$

1 mark

Question 12A.4**** (2 marks) ☐ Done ☐ Marked ☐ Redo

Let $f(x) = kx + c$, where $k, c \in R$. Show that $f(x+y) = f(x) + f(y)$ for all x, y only if $c = 0$. 2 marks

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Section B – Technology active

Question 12B.1**** (3 marks) ☐ Done ☐ Marked ☐ Redo

```
count ← 0
for i from 1 to 10000
  d1 ← random integer from 1 to 6
  d2 ← random integer from 1 to 6
  if d1 + d2 ≥ 10 then count ← count + 1
end for
print count/10000
```

a. State what the algorithm estimates, and the value you would expect it to print, correct to three decimal places. 2 marks

b. Explain why running the algorithm twice is likely to print two different values. 1 mark

Question 12B.2*** (6 marks) ☐ Done ☐ Marked ☐ Redo

A population is modelled by $P(t) = 500e^{kt}$, where t is in years, and $P(3) = 800$.

a. Find the exact value of k, and find $P(20)$ correct to the nearest whole number. 2 marks

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b. A student rounds k to 0.16 first. Find the value they get for $P(20)$, and the size of their error. 2 marks

c. Find the time at which the population reaches 2000. Give your answer in years, correct to two decimal places. 2 marks

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Section C – Multiple choice (technology active)

Question 12C.1*** (1 mark) ☐ Done ☐ Marked ☐ Redo

The algorithm below should carry out Newton's method. The missing line is

```
x ← 1
for i from 1 to 5
    ____________
end for
print x
```

A. `x ← f(x)/df(x)`

B. `x ← x − df(x)/f(x)`

C. `x ← x − f(x)/df(x)`

D. `x ← x + f(x)/df(x)`

Answer: (A) (B) (C) (D)

Question 12C.2** (1 mark) ☐ Done ☐ Marked ☐ Redo

A question says: "Find the x-intercept of the graph of $y = e^x - 2$." Which answer gets the mark?

A. 0.69

B. 0.693

C. $\log_e(2)$

D. $\log(2)$

Answer: (A) (B) (C) (D)

Question 12C.3**** (1 mark) ☐ Done ☐ Marked ☐ Redo

Consider the algorithm below, written in pseudocode.

```
define f(x)
    return x^3 − 2x − 5
define df(x)
    return 3x^2 − 2
x ← 2
n ← 0
while |f(x)| > 0.01
    x ← x − f(x)/df(x)
    n ← n + 1
end while
print n, x
```

The values printed by the algorithm, with `x` correct to four decimal places, are

A. `1, 2.1000`

B. `2, 2.0946`

C. `3, 2.0946`

D. `2, 2.1000`

Answer: (A) (B) (C) (D)

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Miscellaneous – Short answers

Final answers only. Full working is in the Worked Solutions. The grey column shows the notes section each question tests: if you got it wrong, reread that section first.

12A.1	30	Notes 12.1 Pseudocode
12A.2	$[1.625,\ 1.75]$	Notes 12.1 Pseudocode
12A.3	C	Notes 12.2 Functional equations
12A.4	Shown	Notes 12.2 Functional equations
12B.1 a.	$\Pr(\text{sum} \geq 10)$; about 0.167	Notes 12.1 Pseudocode
12B.1 b.	Random variation between runs	Notes 12.1 Pseudocode
12B.2 a.	$k = \frac{1}{3}\log_e(1.6);\ P(20) \approx 11\,475$	Notes 12.3 Exam conventions
12B.2 b.	$\approx 12\,266$, which is about 791 too high	Notes 12.3 Exam conventions
12B.2 c.	8.85 years	Notes 12.3 Exam conventions
12C.1	C	Notes 12.1 Pseudocode
12C.2	C	Notes 12.3 Exam conventions
12C.3	B	Notes 12.1 Pseudocode

Notes

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