CAMBRIDGE ADVANCED NATIONALS

OCR
Oxford Cambridge and RSA

Sample question paper and mark scheme

DRAFT

LEVEL 3 CAMBRIDGE ADVANCED NATIONAL (AAQ) IN

ENGINEERING

Extended Certificate H127

For first teaching in 2025

F138: Mathematics for engineering

Version 1.0 (September 2023)

Introduction

This is Sample Assessment Material (SAM). It is an example exam paper that we publish alongside a new specification to help illustrate the intended style and structure of our question papers.

During the lifetime of the qualification, updates to the question paper template may happen. We always recommend you look at the most recent set of past papers where available.

We also produce two further specific resources to support you with using this SAM:

- An assessment story. We explain the research we have undertaken during the development of the qualification and how consultation with teachers, students and schools have helped shape our assessment approach.
- Annotated SAMs. We take you through the key points of the assessment and highlight the different types of questions your students will experience in the exam.

Tell us what you think

Your feedback plays an important role in how we develop, market, support and resource qualifications now and into the future. Here at OCR, we want teachers and students to enjoy and get the best out of our qualifications and resources, but to do that we need honest opinions to tell us whether we're on the right track or not. That's where you come in.

You can email your thoughts to **ProductDevelopment@OCR.org.uk** or visit the **OCR feedback page** to learn more about how you can help us improve our qualifications.

Designed and tested with teachers and students

Helping young people develop an ethical view of the world

Equality, diversity, inclusion and belonging (EDIB) are part of everything we do

Summary of updates

Date	Version	Page number	Summary of change
July 2023	1 DRAFT	All	Creation of document

Teacher support

We have a range of support services to help you at every stage, from preparation to delivery.

Our teacher support is designed to make teaching our qualifications straightforward, whether you are an experienced teacher, new to teaching, new to OCR, or not a subject specialist of the qualification you are teaching.

We offer free access to services such as Access to Scripts, ExamBuilder and ActiveResults, and you'll find comprehensive teaching resources and a range of professional development courses on our teacher website, Teach Cambridge.

Our OCR subject advisors provide support and information to centres, including:

- Specification and non-exam assessment advice
- Updates on resource developments and training opportunities
- Information on our subject networks giving an opportunity to share ideas and expertise.

Further help and support

Visit our subject pages to find out more about the assessment and request trial access to **Teach Cambridge**.

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Have more questions about teaching OCR qualifications? Explore our **Online Support Centre** or contact our **Customer Support team**.

Contact details are available on the **final page** of the SAM.

Work with us

As one of the major UK exam boards, OCR is responsible for creating and marking exams taken by over a million students each year. We work with over 10,000 professionals to create, check, mark and moderate our assessments.

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Our equality, diversity, inclusion and belonging principles are that we:

- are respectful and considerate
- celebrate differences and promote positive attitudes to belonging
- include perspectives that reflect the diverse cultural and lifestyle backgrounds of our society
- challenge prejudicial views and unconscious biases
- promote a safe and supportive approach to learning
- are accessible and fair, creating positive experiences for all
- provide opportunities for everyone to perform at their best
- are contemporary, relevant and equip everyone to live and thrive in a global, diverse world
- create a shared sense of identity in a modern mixed society with one humanity.

To learn more, including our work on accessibility in our assessment materials, visit our People and planet page.

If you prefer to use a printed copy of the SAMs, consider printing a selection of pages.
The following are the pages which you might find useful to print:

Question paper pages 5-18

Mark scheme pages 19-28

Oxford Cambridge and RSA

Level 3 Cambridge Advanced National (AAQ) in Engineering (Extended Certificate)

H127 F138: Mathematics for engineering

Sample Assessment Material (SAM)

Time allowed: 1 hour 15 minutes

You must have:

- the Formula Booklet for Unit F138 (inserted)
- a ruler (cm/mm)
- a scientific calculator

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

Date of birth | D | D | M | M | Y | Y | Y | Y |

INSTRUCTIONS

- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. You can use extra paper if you need to, but you must clearly show your candidate number, the centre number and the question numbers.
- In the live exam there might be lined pages at the end of the question paper for you to use if you need extra space. Remember, you must clearly show the question numbers.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.
- Give non-exact numerical answers correct to 3 significant figures unless a different degree of accuracy is specified in the question.

INFORMATION

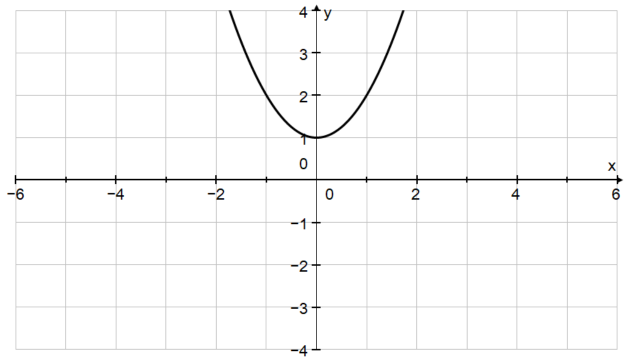
The total mark for this paper is **55**.
The marks for each question are shown in brackets **[ ]**.
This document consists of **14** pages.

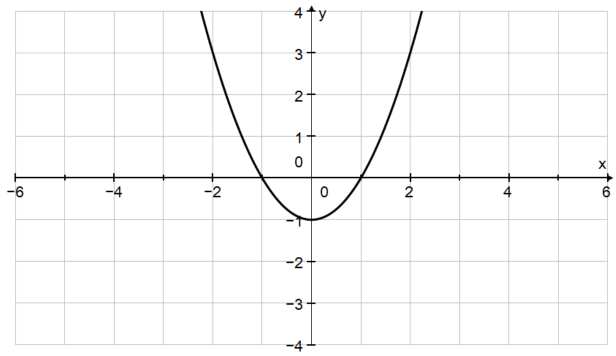
ADVICE

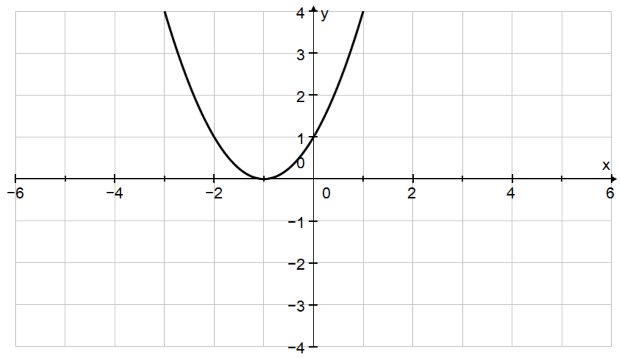
Read each question carefully before you start your answer.

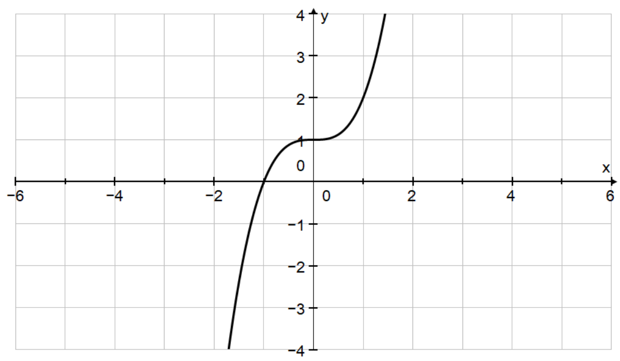
1 Which graph is a representation of the curve with equation $y = x^2 + 1$?

Tick (✓) **one** box.









[1]

2 Which of these is the simplified expression for a^3 x a^4?

Tick (✓) **one** box.

a^{-1} ☐

a^7 ☐

a^{12} ☐

a^{34} ☐

[1]

3 **(a)** You are given that $P = \begin{pmatrix} 2 & 1 & -2 \\ 3 & 0 & 1 \end{pmatrix}$ and $Q = \begin{pmatrix} 3 & 1 \\ 1 & 2 \\ 4 & -1 \end{pmatrix}$

Calculate PQ.

[2]

(b) You are then given that $Q = \begin{pmatrix} 3 & 1 \\ 1 & 2 \\ 4 & -1 \end{pmatrix}$ and $P = \begin{pmatrix} 2 & 1 & -2 \\ 3 & 0 & 1 \end{pmatrix}$.

Calculate QP.

[3]

4 **(a)** You are given that $A = \begin{pmatrix} 3 & 1 \\ 7 & 4 \end{pmatrix}$.

Find DetA.

[2]

(b) You are given that $B = \begin{pmatrix} 1 & 3 \\ 4 & x \end{pmatrix}$.

Find the value of x such that DetB = 0.

[3]

5 **(a)** Write the following as a single logarithm.

$3\log x + \log x - \log 4$

[3]

(b) Solve the equation $3^x = 12$.

[3]

(c) When a capacitor is charged in an electrical circuit the voltage (V) volts at time (t) seconds is given by the formula $V = 12\left(1 - e^{-\frac{t}{6}}\right)$.

At time t = 0 the capacitor is fully discharged, and a constant electrical voltage is applied.

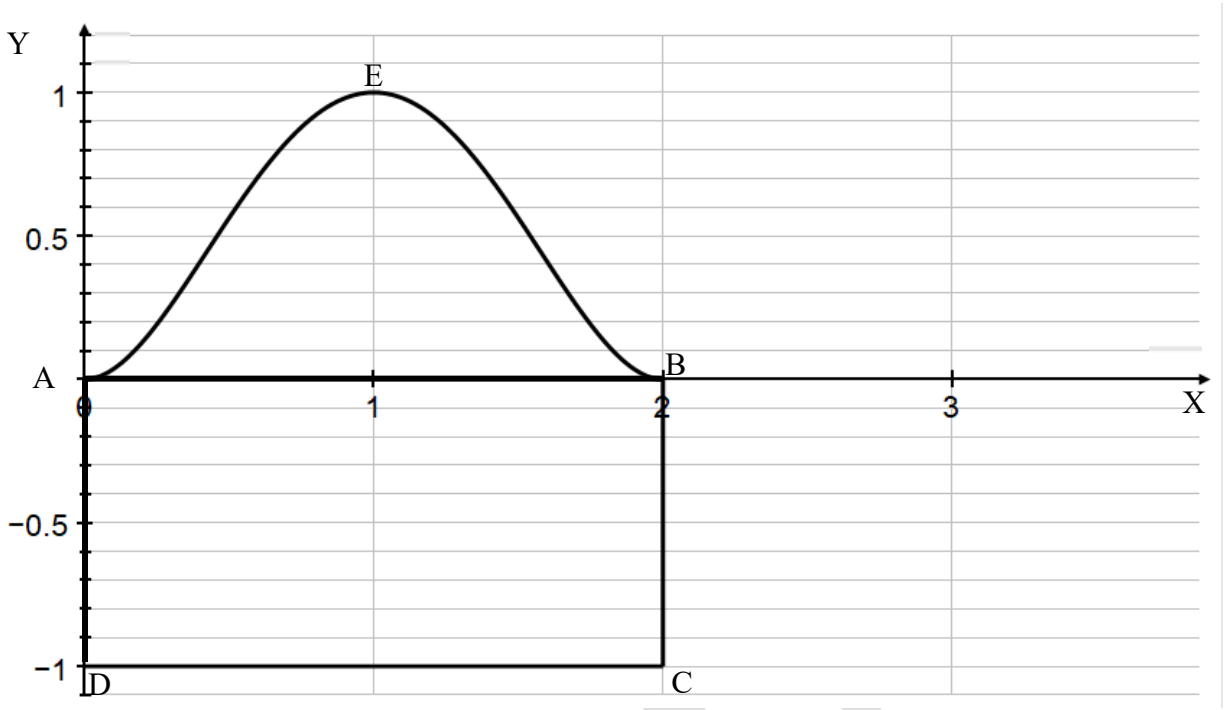
Determine the time when the voltage reaches 11 volts.

You must show your working.

t = ...seconds

[4]

6 An engineer is designing a seal for an automotive application. The cross-section of the seal is placed in a coordinate system below. Units are in centimetres.



The section ABCDA is a rectangle with dimensions 1 cm by 2 cm.

The edge of the section AEBA is part of the curve $y = x^4 - 4x^3 + 4x^2$.

Using integration, determine the cross-sectional area of the seal.

You must show your working.

Cross-sectional area = ... cm^2

[5]

7 A machine on an engineering production line should operate all day.

The machine has two identical components and will stop if either component fails.

The probability of one component failing during the course of the day is 0.1, and this probability is independent of whether the other component fails or not.

Determine the probability that the machine fails during the day.

You must show your working.

Answer = ...

[4]

8 An industrial machine produces metal bars that should be 200 mm in length. A quality control engineer chooses a sample of 40 bars at random and measures their length.

The results are summarised in this table.

Length, x cm	$197.5 < x \leq 198.5$	$198.5 < x \leq 199.5$	$199.5 < x \leq 200.5$	$200.5 < x \leq 201.5$	$201.5 < x \leq 202.5$
Frequency	4	6	20	6	4

(a) State how you can tell that the mean length is 200 mm without doing any calculations.

.....

.....

[1]

(b) Determine whether there are any outliers in the sample.

You must show your working.

[4]

9 **(a)** Differentiate the following functions:

(i) $2e^{3x}$

[2]

(ii) $(2x - 3)^3$

You must show your working.

[4]

(b) An engineer is investigating the path of a roller coaster. A section of its path is modelled by the equation $y = x^3 - 9x^2 + 24x - 7$.

(i) Show that there is a stationary value at (2, 13).

You must show your working.

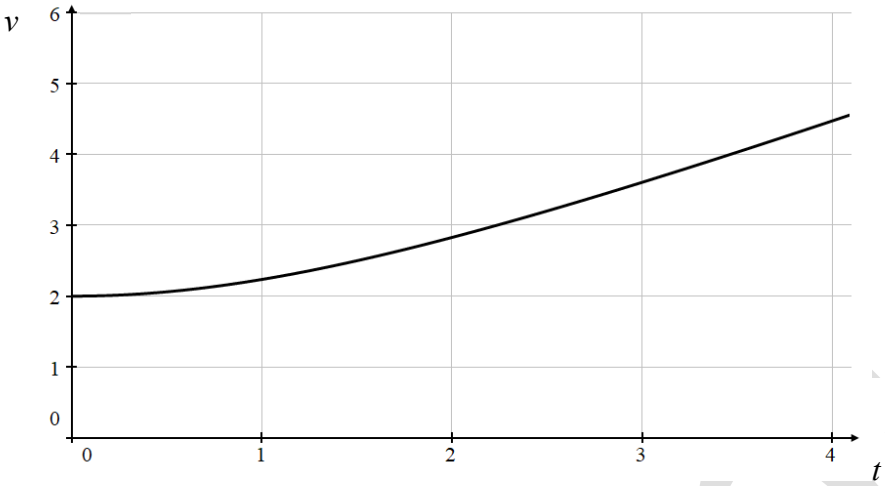
[5]

(ii) Show that this stationary value is a maximum.
You must show your working.

[3]

10 A car is being driven at a constant 2 ms^{-1}. At a certain point the driver accelerates the car.

The velocity of the car is modelled by the equation $v = \sqrt{t^2 + 4}$ where t is measured in seconds and v in metres per second. The graph for $0 \leq t \leq 4$ is shown below.



Use Simpson's rule with 4 strips to determine the distance travelled by the car between $t = 0$ and $t = 4$.

You must show your working.

[5]

END OF QUESTION PAPER

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This is sample assessment material for our specification. It is to help show how the live assessment materials will look. During the lifetime of the qualification you might see small adjustments to the assessment materials. This is part of continuous improvement, designed to help you and your students. We recommend you look at the most recent set of past papers where available.

OCR
Oxford Cambridge and RSA

Level 3 Cambridge Advanced National (AAQ) in Engineering (Extended Certificate)

F138 Mathematics for engineering

SAMPLE ASSESSMENT MATERIAL

Mark scheme

Last updated: 20/07/2023

This document has **10** pages.

MARKING INSTRUCTIONS

Crossed-out answers

If a student has crossed out an answer and written a clear alternative, do **not** mark the crossed-out answer.

If a student has crossed out an answer and **not** written a clear alternative, give the student the benefit of the doubt and mark the crossed-out answer if it's readable.

Multiple choice question answers

When a multiple choice question has only one correct answer and a student has written two or more answers (even if one of these answers is correct), you should **not** award a mark.

When a student writes more than one answer

1. Questions that ask for a set number (including 1) of short answers or points

If a question asks for a set number of short answers or points (e.g. **two** reasons for something), mark only the **first set number** of answers/points.

First mark the answers/points against any printed numbers on the answer lines, marking the **first** answer/point written against each printed number. **Then**, if students have not followed the printed numbers, mark the answers/points from left to right on each line and **then** line by line until the set number of answers/points have been marked. Do **not** mark the remaining answers/points.

2. Questions that ask for a single developed answer

If a student has written two or more answers to a question that only requires a single (developed) answer, and has **not** crossed out unintended answers, mark only the first answer.

3. Contradictory answers in points-based questions

When a student has written contradictory answers, do **not** award any marks, even if one of the answers is correct.

Levels of Response marking

1. To determine the level start at the highest level and work down until you reach the level that best describes the answer

2. To determine the mark within the level, consider the following:

Quality of the answer	Award mark
Consistently meets the criteria for this level	At the top of the level (6 and 9 mark questions)
Meets the criteria but with some inconsistency	At the middle of the level (9 mark questions)
On the borderline of this level and the one below	At the bottom of the level (6 and 9 mark questions)

Mark scheme abbreviations

Annotation	Meaning
soi	Seen or implied in subsequent workings
ecf	Allow error carried forward from another question/item
ft	Allow follow through of an incorrect calculation within a question/item

Categorisation of marks (for questions other than MCQs)

B marks

These are awarded as independent marks, which do not depend on other marks. For a **B**-mark to be scored, the point to which it refers must be seen specifically in the candidate's answers.

M marks

These are method marks upon which **A**-marks (accuracy/answer marks) later depend. For an **M**-mark to be scored, the point to which it refers must be seen in the candidate's answers. If a candidate fails to score a particular **M**-mark, then none of the dependent **A**-marks can be scored.

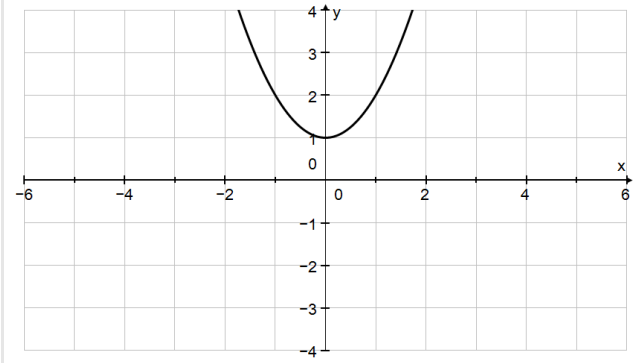
C marks

These are compensatory method marks which can be scored even if the points to which they refer are not written down by the candidate, providing subsequent working gives evidence that they must have known it. For example, if an equation carries a **C**-mark and the candidate does not write down the actual equation but does correct working which shows the candidate knew the equation, then the **C**-mark is given.

A marks

These are accuracy or answer marks, which either depend on an M-mark, or are independent of/allow a **C**-mark to be scored.

MARK SCHEME

1		
Max mark	1	
Answer & mark allocation		First box ticked
Guidance	Correct answer only (MCQ)	

2		
Max mark	1	
Answer & mark allocation	a^7	Second box ticked
Guidance	Correct answer only (MCQ)	

3 (a)		
Max mark	2	
Answer & mark allocation	$PQ = \begin{pmatrix} -1 & 6 \\ 13 & 2 \end{pmatrix}$	B1 for top row B1 for second row
Guidance	Only accept answers that are in a 2 × 2 matrix	

3 (b)		
Max mark	3	
Answer & mark allocation	$QP = \begin{pmatrix} 9 & 3 & -5 \\ 8 & 1 & 0 \\ 5 & 4 & -9 \end{pmatrix}$	B1 for top row B1 for middle row B1 for bottom row
Guidance	Only accept answers that are in a 3 × 3 matrix	

4 (a)		
Max mark	2	
Answer & mark allocation	$\text{Det}A = 3 \times 4 - 7 \times 1$ $= 5$	C1 Substitution A1 Answer
Guidance	Award full marks if correct answer seen	

4 (b)		
Max mark	3	
Answer & mark allocation	$\text{DetB} = 1 \times x - 4 \times 3 = x - 12$ $\text{DetB} = 0 \text{ if } x - 12 = 0$ $\Rightarrow x = 12$	C1 Multiplication of elements C1 Formation of algebraic equation A1 Answer
Guidance	Award full marks if correct answer seen	

5 (a)		
Max mark	3	
Answer & mark allocation	$= log\, x^3 + log\, x - log\, 4$ $= log\, x^4 - log\, 4$ $= log \frac{x^4}{4}$	C1 Sight of one log law C1 Sight of second log law A1 Answer
Guidance	Award full marks if correct answer seen	

5 (b)		
Max mark	3	
Answer & mark allocation	$3^x = 12 \Rightarrow x\, log\, 3 = log\, 12$ $\Rightarrow x = \frac{log\, 12}{log\, 3} = 2.26$	C1 Take logs both sides of the equation C1 Rearrange A1 Answer (3SF)
Guidance	Accept answers that round to 2.26 Award full marks if correct answer seen	

5 (c)		
Max mark	4	
Answer & mark allocation	$11 = 12\left(1 - e^{-\frac{t}{6}}\right)$ $\Rightarrow \frac{11}{12} = 1 - e^{-\frac{t}{6}}$ $\Rightarrow e^{-\frac{t}{6}} = \frac{1}{12}$ $\Rightarrow -\frac{t}{6} = ln\left(\frac{1}{12}\right) = -2.485$ $\Rightarrow t = 14.9$	M1 Substitute $V = 11$ and initial rearrange M1 Rearranging to $e^{-\frac{t}{6}} = \frac{1}{12}$ M1 Take logs A1 Answer
Guidance	Accept correct answers stated in other appropriate units of measure.	

6		
Max mark	5	
Answer & mark allocation	Edge of the section AEBA $A = \int_0^2 (x^4 - 4x^3 + 4x^2)dx$ $= \left[\frac{x^5}{5} - x^4 + \frac{4x^3}{3}\right]_0^2$ $= \left(\frac{32}{5} - 16 + \frac{32}{3}\right)(-0)$ $= \frac{16}{15} (= 1.07)$ Rectangular section ABCDA = 2 Total area = $3\frac{1}{15} (= 3.07)$	M1 Integrate; ignore limits (soi) A1 Indefinite integral correct (soi) M1 Substitute $x = 2$. Ignore 0 A1 Correct area under curve A1 Adding rectangle to give final value (ft for their area under the curve)
Guidance		

7		
Max mark	4	
Answer & mark allocation	P (one component does not fail) = 0.9 P (neither component will fail) = (=0.9 ×0.9) = 0.81 **or** P (machine runs to end of day) = 0.81 P (Machine will stop during the day) = 1 – 0.81 = 0.19	B1 first line, seen anywhere. M1 Multiplication of probabilities M1 Use of 1 (certainty) to find the probability of an event occurring A1 answer
Guidance	Accept answer as 19 percent/%. Accept alternative methods of working.	

8 (a)		
Max mark	**1**	
Answer & mark allocation	Symmetry (of the data about midpoint which is 200 mm)	B1 mention of symmetry
Guidance		

8 (b)		
Max mark	4	
Answer & mark allocation	SD = 1.06 2SD = 2.12 200 ±2.12 = [197.88, 202.12] Since the upper range of items in the top group could be as great as 202.5 there could be items > 202.12 and likewise the bottom group	B1 SD by calculator: 1.049 if divisor of n is used instead of $n - 1$ M1 Finding 2SD A1 Range A1 Answer
Guidance		

9 (a) (i)		
Max mark	2	
Answer & mark allocation	$6e^{3x}$	B1 for 6 B1 for e^{3x}
Guidance		

9 (a) (ii)		
Max mark	4	
Answer & mark allocation	$y = (2x-3)^3$ $y = u^3$ and $u = (2x-3)$ $\frac{dy}{du} = 3u^2$ and $\frac{du}{dx} = 2$ $\frac{dy}{dx} = 6(2x-3)^2$	M1 sight of function of function rule A1 and A1 for differentiation of separate parts If $\frac{dy}{dx} = 3u^2 \times 2$ seen award M1 A2 (3 marks) A1 Answer
Guidance		

9 (b) (i)		
Max mark	**5**	
Answer & mark allocation	$y = x^3 - 9x^2 + 24x - 7$ $\Rightarrow \frac{dy}{dx} = 3x^2 - 18x + 24$ $= 0$ when $x^2 - 6x + 8 = 0$ $\Rightarrow (x-2)(x-4) = 0$ $\Rightarrow x = 2$ is a stationary point $x = 2 \Rightarrow y = 8 - 36 + 48 - 7$ $= 13$	M1 A1 for correct differentiation M1 for setting = 0 A1 Correct quadratic A1 Value for *y*
Guidance		

9 (b) (ii)		
Max mark	3	
Answer & mark allocation	$\frac{dy}{dx} = 3x^2 - 18x + 24$ $\Rightarrow \frac{d^2y}{dx^2} = 6x - 18$ When $x = 2, \frac{d^2y}{dx^2} = 12 - 18 = -6 < 0$ So maximum	M1 Differentiation again A1 Correct expression A1 Sub $x = 2$ and interpretation
	Alternative 1 $y_{1.9} = 12.97 < 13$ $y_{12.1} = 12.97 < 13$ $\Rightarrow y < 13$ either side of $x = 2$ $\Rightarrow$ maximum at $x = 2$	M1 Finding y either side of $x = 2$ A1 Correct values A1 Interpretation
	Alternative 2 $\frac{dy}{dx_{1.9}} = (1.9 - 4)(1.9 - 2) = -2.1 \times -0.1 = 0.21 > 0$ $\frac{dy}{dx_{2.1}} = (2.1 - 4)(2.1 - 2) = -1.9 \times 0.1 = -0.19 < 0$ $\Rightarrow \frac{dy}{dx}$ goes from a +ve value through 0 to a -ve value So is a maximum	M1 Finding $\frac{dy}{dx}$ either side of $x = 2$ A1 Correct values A1 interpretation
Guidance	Accept answers using any method above For alternatives 1 and 2 the values chosen for the test can be any value for x in range [1.8,2.2]	

<table>
<tr><td>10</td><td colspan="2"></td></tr>
<tr><td>Max mark</td><td colspan="2">5</td></tr>
<tr><td>Answer & mark allocation</td><td>
<table>
<tr><td>x</td><td>y</td></tr>
<tr><td>0</td><td>2</td></tr>
<tr><td>1</td><td>2.2361</td></tr>
<tr><td>2</td><td>2.8284</td></tr>
<tr><td>3</td><td>3.6056</td></tr>
<tr><td>4</td><td>4.4721</td></tr>
</table>
$A = \frac{h}{3}(y_0 + 4y_1 + 2y_2 + 4y_3 + y_4)$
$= \frac{1}{3}(2 + 4 \times 2.2361 + 2 \times 2.8284 + 4 \times 3.6056 + 4.4721)$
$= 11.8$
</td><td>B2 Values in table, B1 for 1 error

M1 Correct formula soi by correct answer

A1 substitution into formula (ft)

A1 answer (ft)</td></tr>
<tr><td>Guidance</td><td colspan="2">Accept answers that round to 11.8</td></tr>
</table>

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- Enhance subject knowledge
- Great for professional development

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