Pearson Edexcel

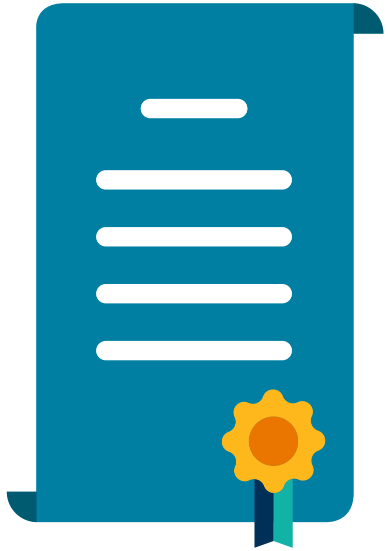
A level Mathematics

A guide to our question paper improvements

Pearson Edexcel

PEUK B0214

Following the **Summer 2019 exam series for A level Mathematics**, we have been continuing to gather feedback from teachers, parents and students. Building on this and our analysis of students' performance in the exams, we have been taking steps to refine our papers to improve the exam experience for all students



The improvements have focused on these key principles:

- **ensuring early questions are accessible to all** and then steadily ramp in demand to encourage engagement and help build students' confidence through the papers.
- **dividing questions into parts** so students are clear where marks can be achieved and can attempt the question in smaller parts
- **using clear, concise language** to better enable all students to access the questions and understand the type of response expected
- **increasing the number of marks** that students find most accessible

The **Autumn 2020 exam series** for A level Mathematics presented what these improvements like in practice and what you can expect in future exam papers. To support you and your students, we have created this guide to exemplify how these principles are guiding the development of our assessments. It shows how modifying questions can enable students to better access and engage with papers and show what they know and can do.

Analysis of performance data

We worked with our A level Mathematics Senior Examining team to review our summer 2019 A level papers and analyse the exam performance data. This data has given our question paper writing committee valuable insight into the accessibility of our questions.

Key findings

The transition from a modular to linear course structure has had a significant impact on how students approach questions

Some of the requirements of the new Assessments Objectives (AOs) are proving to be demanding for students

Students now need to retain much more information for each assessment

Although we are unable to change the assessment requirements, we have identified steps we can take to make our A level Mathematics papers more accessible and improve the assessment experience for students.

Ensuring accessibility of early questions

Our analysis of students' performance has shown which types of questions contain the most accessible marks. That is why we will order questions in our exam papers to ensure that early questions are accessible to all, then steadily ramp in demand. Helping students get off to a good start will encourage engagement and help build their confidence.

1. Weed is completely covering the surface of a pond.

Fish are introduced into the pond in an effort to control the weed.

The surface area of the pond, $A\,\mathrm{m}^2$, covered by the weed, t days after the fish are introduced is modelled by the equation

$$A = 105 - 12e^{0.08t} \qquad t \in \mathbb{R}, t \geqslant 0$$

According to the model,

(a) state the surface area of the pond covered by the weed at the start of the investigation,
(1)

(b) find the time taken in days, to one decimal place, for the surface area of the pond covered by the weed to fall to $40\,\mathrm{m}^2$
(3)

Stuart wants to predict the surface area of the pond covered by the weed 30 days after the fish are introduced.

(c) Explain why he should not use this model.
(2)

This question on the exponential model is a good starter at the beginning of a paper as it contains at least 4 marks that should be accessible to most students.

2. $$\mathrm{f}(x) = 3x^4 + 2x^2 - 12x + 8$$

Given that $y = \mathrm{f}(x)$ has a single turning point at $x = \alpha$,

(a) show that α is a solution of the equation

$$x = \sqrt[3]{1 - \frac{x}{3}}$$
(3)

The iterative formula

$$x_{n+1} = \sqrt[3]{1 - \frac{x_n}{3}}$$

is used with $x_1 = 1$ to find an approximate value for α.

(b) Calculate the value of x_2 and the value of x_5, giving each answer to 4 decimal places.
(3)

(c) Using a suitable interval and a suitable function that should be stated, show that to 3 decimal places α is 0.889
(2)

A question like this on differentiation and iteration methods is a good starter question. Analysis of past performance on similar GCE Maths questions has shown that this is a very accessible topic.

Dividing questions into parts

Where possible, our exam papers will include questions divided into parts so students are clear where marks can be achieved and can attempt the question in smaller parts, hence providing more restart opportunities.

By scaffolding this question and adding the part (a) as a "show that" gives an opportunity for students to gain the final three marks without having gained the first four.

Figure 5 shows a sketch of the curve with parametric equations

$$x = 3\cos 2t, \quad y = 2\tan t \qquad 0 \leqslant t \leqslant \frac{\pi}{4}$$

The region R, shown shaded in Figure 4, is bounded by the curve, the x-axis and the y-axis.

Find the exact area of R.

(*Solutions relying entirely on calculator technology are not acceptable.*)

(7 marks)

11.

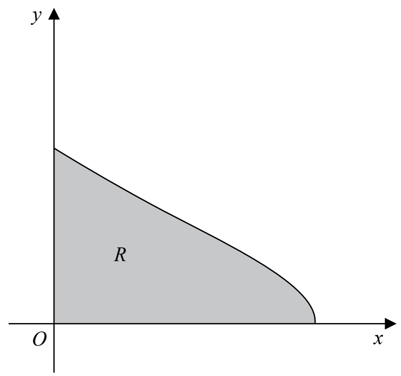


Figure 5

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$$x = 3\cos 2t, \quad y = 2\tan t \qquad 0 \leqslant t \leqslant \frac{\pi}{4}$$

The region R, shown shaded in Figure 5, is bounded by the curve, the x-axis and the y-axis.

(a) Show that the area of R is given by

$$\int_0^{\frac{\pi}{4}} 24\sin^2 t \, dt$$

(4)

(b) Hence, using algebraic integration, find the exact area of R.

(3)

Instead of one complete 9 mark question which asks students to find the exact area of R, adding the part (a) gives access to students who know how to differentiate but may not necessarily do so due to the complexity of the problem.

9.

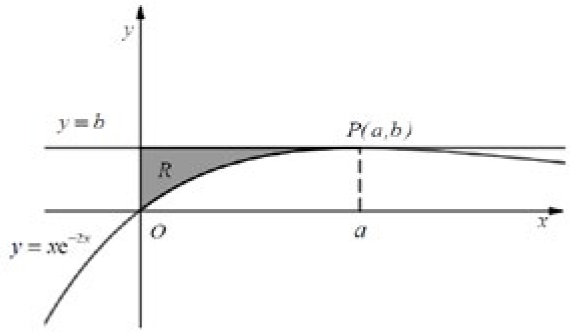

Figure 5

Figure 5 shows a sketch of part of the curve with equation

$$y = xe^{-2x}$$

The point $P(a,b)$ is the turning point of the curve.

The finite region R, shown shaded in Figure 5, is bounded by the curve, the line with equation $y = b$ and the y-axis.

Find the exact area of R.

(9)

(9 marks)

9.

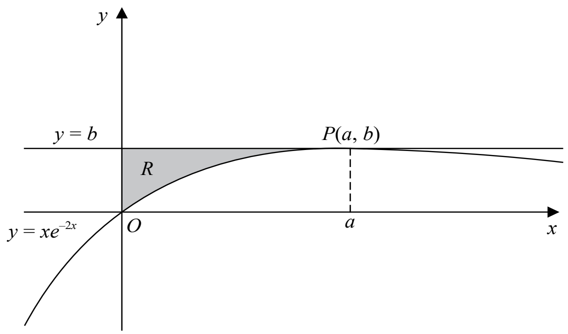

Figure 3

In this question you must show all stages of your working.

Solutions relying on calculator technology are not acceptable.

Figure 3 shows a sketch of part of the curve with equation

$$y = xe^{-2x}$$

The point $P(a, b)$ is the turning point of the curve.

(a) Find the value of a and the exact value of b

(4)

The finite region R, shown shaded in Figure 3, is bounded by the curve, the line with equation $y = b$ and the y-axis.

(b) Find the exact area of R.

(5)

Using clear, concise language and familiar contexts

We have refined the wording of our papers to better enable all students to access the questions and understand the type of response expected.

Relative to a fixed origin O, the points A, B and C have position vectors $-2\mathbf{i}+3\mathbf{j}$, $3\mathbf{i}+p\mathbf{j}$ and $q\mathbf{i}+7\mathbf{j}$ respectively.

Given that p is a constant and that $|\overrightarrow{AB}|=5\sqrt{2}$

(a) find the possible values of p.

(3)

Given that q is a constant and that the angle between $\overrightarrow{AC}$ and the unit vector $\mathbf{i}$ is $\frac{\pi}{3}$ radians,

(b) find the exact value of q.

(3)

(6 marks)

5. Relative to a fixed origin O,

- the point A has position vector $-2\mathbf{i} + 3\mathbf{j}$
- the point B has position vector $3\mathbf{i} + p\mathbf{j}$, where p is constant
- the point C has position vector $q\mathbf{i} + 7\mathbf{j}$, where q is constant

Given that $|\overrightarrow{AB}| = 5\sqrt{2}$

(a) find the possible values of p.

(3)

Given that the angle between $\overrightarrow{AC}$ and the unit vector $\mathbf{i}$ is $\frac{\pi}{3}$ radians,

(b) find the exact value of q.

(3)

Figure 4 shows a container in the shape of an inverted right circular cone which contains some water. The cone has an internal base radius of 2.5 m and a vertical height of 4 m.

At time t seconds, the height of the water is h m, the volume of the water is V m^3 and water is modelled as leaking from a hole at the bottom of the container at a rate of $\left(\frac{\pi}{512}\sqrt{h}\right)$ m^{3}s^{-1}

Figure 4 shows a container in the shape of an inverted right circular cone which contains some water.

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At time t seconds

- the height of the water is h m
- the volume of the water is V m^3
- the water is modelled as leaking from a hole at the bottom of the container at a rate of

$$\left(\frac{\pi}{512}\sqrt{h}\right) m^3 s^{-1}$$

In these questions, the use of bullet points increases readability and hence understanding of each question.

Figure 1 shows the plan view of a design for a stage at a concert. The stage is modelled as a sector *BCDF*, of a circle centre *F*, joined to two congruent triangles *ABF* and *EDF*.

The straight line *AFE* has $AF = FE = 10.7\,\text{m}$

Given that $BF = FD = 9.2\,\text{m}$ and angle $BFD = 1.82$ radians, find

Spacing aids readability and a context that is straightforward and simple to describe as well as being familiar to students will help them understand the question better.

3.

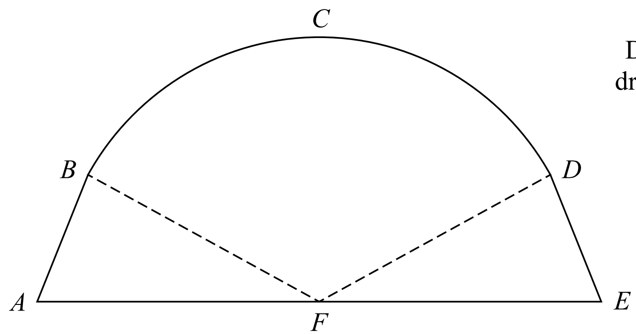


Diagram not drawn to scale

Figure 1

Figure 1 shows the plan view of a design for a stage at a concert.

The stage is modelled as a sector *BCDF*, of a circle centre *F*, joined to two congruent triangles *ABF* and *EDF*.

Given that

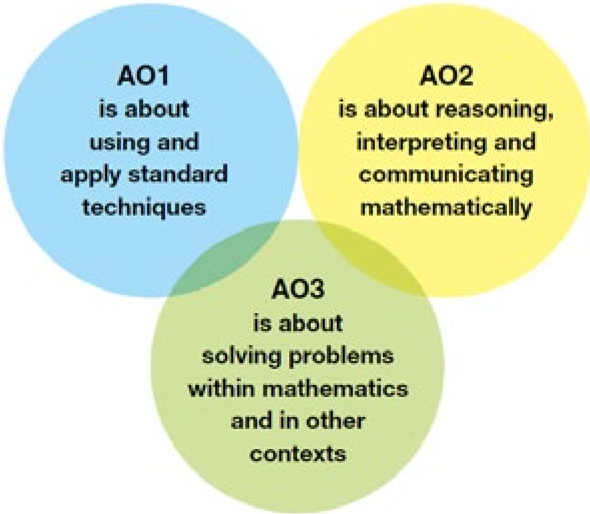
AFE is a straight line

$AF = FE = 10.7\,\text{m}$

$BF = FD = 9.2\,\text{m}$

angle $BFD = 1.82$ radians

Increasing the number of marks that students find most accessible



Analysis of the 2019 performance data has given us a detailed overview of how accessible individual marks were in each paper and how students grasped the skills demanded of each of the Assessment Objectives. We found that:

- **AO1 questions on their own are often shorter** than the more complex questions testing the other assessment objectives so students engage with them better
- **AO1 is a more straight-forward skill to apply in isolation**, marks allocated to it become less accessible when they are assessed in combination with AO2 and AO3.

We can create more questions that assess AO1 in isolation by releasing AO1 marks that are tied to AO2 and AO3. In this question, reducing the number of 'trapped' marks meant that we could divide it into two parts to make it more accessible.

10. (a) Use the substitution $x = u^2 + 1$ to show that

$$\int_5^{10} \frac{3\,\mathrm{d}x}{(x-1)\left(3+2\sqrt{x-1}\right)} = \int_p^q \frac{6\,\mathrm{d}u}{u(3+2u)}$$

where p and q are positive constants to be found.

(4)

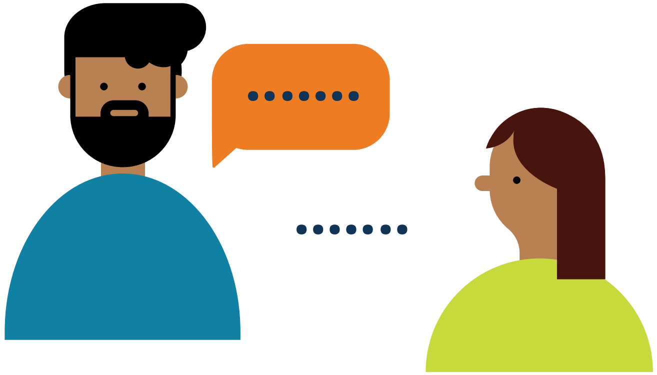
(b) Hence, using algebraic integration, show that

$$\int_5^{10} \frac{3\,\mathrm{d}x}{(x-1)\left(3+2\sqrt{x-1}\right)} = \ln a$$

where a is a rational constant to be found.

(6)

Question	Scheme	Marks	AOs
10 (a)	$x = u^2 + 1 \Rightarrow \mathrm{d}x = 2u\mathrm{d}u$ oe	B1	1.1b
	Full substitution $\int \frac{3\mathrm{d}x}{(x-1)\left(3+2\sqrt{x-1}\right)} = \int \frac{3\times 2u\,\mathrm{d}u}{\left(u^2+1-1\right)(3+2u)}$	M1	1.1b
	Finds correct limits e.g. $p = 2, q = 3$	B1	1.1b
	$= \int \frac{3\times 2\cancel{u}\,\mathrm{d}u}{u^{\cancel{2}}(3+2u)} = \int \frac{6\,\mathrm{d}u}{u(3+2u)}$ *	A1*	2.1
		(4)	
(b)	$\frac{6}{u(3+2u)} = \frac{A}{u} + \frac{B}{3+2u} \Rightarrow A = \ldots, B = \ldots$	M1	1.1b
	Correct PF. $\frac{6}{u(3+2u)} = \frac{2}{u} - \frac{4}{3+2u}$	A1	1.1b
	$\int \frac{6\,\mathrm{d}u}{u(3+2u)} = 2\ln u - 2\ln(3+2u) \quad (+c)$	dM1 A1ft	3.1a 1.1b
	Uses limits $u = "3", u = "2"$ with some correct ln work leading to $k\ln b$ E.g. $(2\ln 3 - 2\ln 9) - (2\ln 2 - 2\ln 7) = 2\ln\frac{7}{6}$	M1	1.1b
	$\ln\frac{49}{36}$	A1	2.1
		(6)	
			(10 marks)



We would like to take this opportunity to thank everyone who has offered feedback and been a vital part in helping us make these improvements.

Our work does not stop here – we will continue to look for ways to improve our assessments as the qualification evolves by listening to feedback and carefully monitoring the question paper performance data following each exam series.

If you have any further questions or feedback on these improvements, please **get in touch**

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