Pearson Edexcel

A level
Mathematics

A guide to our question paper improvements

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Refining our papers to improve the exam experience for all students

Following the summer 2019 exam series for A level Mathematics, we collected a large amount of feedback from teachers, parents and students. Since 2019 we have continued to conduct our own analysis of students' performance and have now embedded key principles to ensure our exams are more accessible and that all students have a positive exam experience. You can find more details around this process in the 2021 A level Mathematics efficacy report.

The improvements focus on:

- **Helping candidates get off to a good start** page 3
- **Providing more restart opportunities** pages 4-5
- **Unlocking trapped marks assessing standard techniques (AO1)** pages 6-7
- **Making language more accessible and reducing reading time** pages 8-10

To support you and your students, we've created this guide to show you what these improvements look like in practice and what you can expect in future exam series. We have used questions from our live exam series since 2019 to exemplify each of these improvements.

We'd like the take this opportunity to thank everyone who has offered feedback and been a vital part in helping us make these improvements. If you have any further questions or feedback on these improvements, please get in touch using assessmentfeedback@pearson.com.

1. Helping candidates get off to a good start

We have put more questions that students perform well on at the start of the paper to give them confidence as they start the assessment. We have been able to do this because we now have more knowledge about which questions students find more accessible and more clarity about our high, medium and low demand targets.

October 2021 Pure Mathematics Paper 1 Question 1

1. $$\mathrm{f}(x) = ax^3 + 10x^2 - 3ax - 4$$

Given that $(x - 1)$ is a factor of $\mathrm{f}(x)$, find the value of the constant a.

You must make your method clear.

(3)

To help more students achieve success at the beginning of each paper we've made sure early questions are short and snappy.

October 2021 Pure Mathematics Paper 2 Question 1

1. In an arithmetic series

- the first term is 16
- the 21st term is 24

(a) Find the common difference of the series.

(2)

(b) Hence find the sum of the first 500 terms of the series.

(2)

We also make sure that early questions assess familiar topics and that there are no surprises.

October 2021 Pure mathematics Paper 2 Question 3

3. Using the laws of logarithms, solve the equation

$$\log_3 (12y + 5) - \log_3 (1 - 3y) = 2$$

(3)

Problem-solving and modelling is kept at a low level in the opening questions of each exam.

Questions here are taken from the A level Mathematics Mock Papers (Pure Mathematics) published in January 2020. They exemplify some of the improvements we're making.

2. Providing more restart opportunities

One of our early improvements was to divide questions into parts. We have now gone further by restricting ourselves, where possible, to writing questions worth a maximum of five marks. We also give students opportunities to approach the solution in the way they are most comfortable with, rather than it being scaffolded down a particular path.

Some questions had previously been broken into steps in an attempt to guide a candidate through their answer. This had an unintended consequence: where a candidate made a mistake in an early step, it became more difficult to gain marks in later steps. Where the topic allows, this has been changed either to remove the reliance of later question parts on earlier ones, or to ask the question as a single large entity. The approach taken in each case is informed by the topic of the question and on past assessment performance.

October 2020 Pure Mathematics Paper 1 Question 10

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)

There will be a greater number of ‘show that’ questions so that potential barriers to candidates completing questions are reduced. In the example above, students who could not complete part (a) are able to use the given result to answer part (b).

2. Providing more restart opportunities

October 2021 Pure Mathematics Paper 2 Question 7

7.

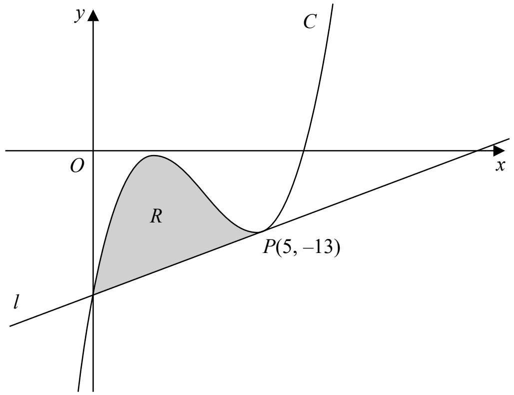

Figure 2

Figure 2 shows a sketch of part of the curve C with equation

$$y = x^3 - 10x^2 + 27x - 23$$

The point $P(5, -13)$ lies on C

The line l is the tangent to C at P

(a) Use differentiation to find the equation of l, giving your answer in the form $y = mx + c$ where m and c are integers to be found.

(4)

(b) Hence verify that l meets C again on the y-axis.

(1)

The finite region R, shown shaded in Figure 2, is bounded by the curve C and the line l.

(c) Use algebraic integration to find the exact area of R.

(4)

Longer questions are also broken up into manageable chunks.

October 2020 Pure Mathematics Paper 2 Question 6

6. (a) Given that

$$\frac{x^2 + 8x - 3}{x + 2} \equiv Ax + B + \frac{C}{x + 2} \qquad x \in \mathbb{R} \; x \neq -2$$

find the values of the constants A, B and C

(3)

(b) Hence, using algebraic integration, find the exact value of

$$\int_0^6 \frac{x^2 + 8x - 3}{x + 2} \, dx$$

giving your answer in the form $a + b\ln 2$ where a and b are integers to be found.

(4)

Attempts have been made to support candidates through questions, especially in the first half of the paper. In this example, the form of the answer to part (a) is given, thus reducing potential errors in the division and also providing support for the integration in part (b)

3. A new approach to assessing standard techniques (AO1 marks)

We have been able to increase the number of items that assess AO1 in isolation by releasing some of the AO1 marks that were tied into questions assessing other, more difficult assessment objectives. Releasing the ‘trapped’ marks in this way means that they are more accessible to all students.

June 2019 Pure Mathematics Paper 1 Question 11

11. A competitor is running a 20 kilometre race.

She runs each of the first 4 kilometres at a steady pace of 6 minutes per kilometre.
After the first 4 kilometres, she begins to slow down.

In order to estimate her finishing time, the time that she will take to complete each subsequent kilometre is modelled to be 5% greater than the time that she took to complete the previous kilometre.

Using the model,

(a) show that her time to run the first 6 kilometres is estimated to be 36 minutes 55 seconds, **(2)**

(b) show that her estimated time, in minutes, to run the rth kilometre, for $5 \leqslant r \leqslant 20$, is

$$6 \times 1.05^{r-4}$$

(1)

In this question from 2019, there is a total of 3 AO1 marks. All of these marks are “trapped” as none of them can be obtained unless a student is successful in achieving the modelling and problem-solving marks that precede them in each part of the question.

Final 2019 Pure Mathematics Paper 1 – Question 11 (Mark Scheme)

Question	Scheme	Marks	AOs
11 (a)	Total time for 6 km = 24 minutes + $6\times1.05+6\times1.05^2$ minutes	M1	3.4
	$= 36.915$ minutes = 36 minutes 55 seconds *	A1*	1.1b
		(2)	
(b)	**5** $^{\text{th}}$ km is $6\times1.05 = 6\times1.05^1$ **6**$^{\text{th}}$ km is $6\times1.05\times1.05 = 6\times1.05^2$ **7**$^{\text{th}}$ km is $6\times1.05\times1.05\times1.05 = 6\times1.05^3$ Hence the time for the r^{th} km is $6\times1.05^{r-4}$	B1	3.4
		(1)	
(c)	Attempts the total time for the race = Eg. 24 minutes + $\sum_{r=5}^{r=20} 6\times1.05^{r-4}$ minutes	M1	3.1a
	Uses the series formula to find an allowable sum Eg. Time for 5 $^{\text{th}}$ to 20$^{\text{th}}$ km $= \dfrac{6.3\left(1.05^{16}-1\right)}{1.05-1} = (149.04)$	M1	3.4
	Correct calculation that leads to the **total time** Eg. Total time = 24 + $\dfrac{6.3\left(1.05^{16}-1\right)}{1.05-1}$	A1	1.1b
	Total time = awrt 173 minutes and 3 seconds	A1	1.1b
		(4)	
			(7 marks)

3. A new approach to assessing standard techniques (AO1 marks)

October 2021 Pure Mathematics Paper 1 Question 5

5. **In this question you should show all stages of your working.**

Solutions relying entirely on calculator technology are not acceptable.

A company made a profit of £20 000 in its first year of trading, Year 1

A model for future trading predicts that the yearly profit will increase by 8% each year, so that the yearly profits will form a geometric sequence.

According to the model,

(a) show that the profit for Year 3 will be £23 328 **(1)**

(b) find the first year when the yearly profit will exceed £65 000 **(3)**

(c) find the total profit for the first 20 years of trading, giving your answer to the nearest £1000 **(2)**

In this question from 2021, there is also a total of 3 AO1 marks. However, two of these marks are independent of any other marks in the questions and only one mark is trapped.

Final 2021 Pure Mathematics Paper 1 – Question 5 (Mark Scheme)

Question	Scheme	Marks	AOs
5(a)	$u_3 = £20000 \times 1.08^2 = (£)23328$*	B1*	1.1b
		(1)	
(b)	$20\,000 \times 1.08^{n-1} > 65\,000$	M1	1.1b
	$1.08^{n-1} > \frac{13}{4} \Rightarrow n-1 > \frac{\ln(3.25)}{\ln(1.08)}$ or e.g. $1.08^{n-1} > \frac{13}{4} \Rightarrow n-1 > \log_{1.08}\left(\frac{13}{4}\right)$	M1	3.1b
	Year 17	A1	3.2a
		(3)	
(c)	$S_{20} = \frac{20\,000(1-1.08^{20})}{1-1.08}$	M1	3.4
	Awrt (£) 915 000	A1	1.1b
		(2)	
			(6 marks)
	Notes		

4. Making language more accessible and reducing reading time

A priority has been to ensure that all language used in A level Mathematics papers is accessible. Improvements from this work included the following:

- Employ concise, clear and straightforward language to describe simple, age-appropriate scenarios.
- Make more use of bullet points to reduce the number of words and to separate key pieces of information.
- Reduce the reading time required for each question, where appropriate.
- Remove questions where the reading time outweighed the available marks and replace them with questions containing simple sentence structures.

October 2020 Pure Mathematics Paper 1 Question 14

14. A large spherical balloon is deflating.

At time t seconds the balloon has radius r cm and volume $V\text{cm}^3$

The volume of the balloon is modelled as decreasing at a constant rate.

(a) Using this model, show that

$$\frac{\mathrm{d}r}{\mathrm{d}t} = -\frac{k}{r^2}$$

where k is a positive constant.

(3)

Given that

- the initial radius of the balloon is 40 cm
- after 5 seconds the radius of the balloon is 20 cm
- the volume of the balloon continues to decrease at a constant rate until the balloon is empty

(b) solve the differential equation to find a complete equation linking r and t.

(5)

(c) Find the limitation on the values of t for which the equation in part (b) is valid.

(2)

To help reduce reading time, we will use bullet points to present key information.

4. Making language more accessible and reducing reading time

October 2021 Pure Mathematics Paper 1 Question 8

8. A scientist is studying the growth of two different populations of bacteria.

The number of bacteria, N, in the **first** population is modelled by the equation

$$N = Ae^{kt} \qquad t \geqslant 0$$

where A and k are positive constants and t is the time in hours from the start of the study.

Given that

- there were 1000 bacteria in this population at the start of the study
- it took exactly 5 hours from the start of the study for this population to double

(a) find a complete equation for the model.

(4)

(b) Hence find the rate of increase in the number of bacteria in this population exactly 8 hours from the start of the study. Give your answer to 2 significant figures.

(2)

The number of bacteria, M, in the **second** population is modelled by the equation

$$M = 500e^{1.4kt} \qquad t \geqslant 0$$

where k has the value found in part (a) and t is the time in hours from the start of the study.

Given that T hours after the start of the study, the number of bacteria in the two different populations was the same,

(c) find the value of T.

(3)

Key equations/formulae needed to answer a question will be clearly displayed to reduce transcription errors.

October 2021 Pure Mathematics Paper 2 Question 14

14.

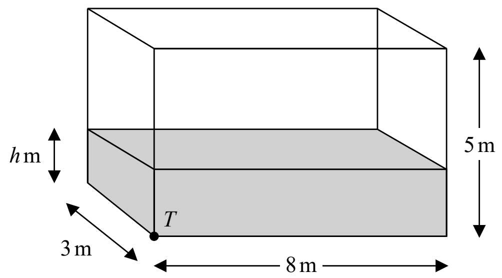

Figure 5

Water flows at a constant rate into a large tank.

The tank is a cuboid, with all sides of negligible thickness.

The base of the tank measures 8 m by 3 m and the height of the tank is 5 m.

There is a tap at a point T at the bottom of the tank, as shown in Figure 5.

At time t minutes after the tap has been opened

- the depth of water in the tank is h metres
- water is flowing into the tank at a constant rate of $0.48\,\text{m}^3$ per minute
- water is modelled as leaving the tank through the tap at a rate of $0.1h\,\text{m}^3$ per minute

(a) Show that, according to the model,

$$1200\frac{dh}{dt} = 24 - 5h$$

(4)

continued on p.10

4. Making language more accessible and reducing reading time

October 2021 Pure Mathematics Paper 2 Question 14

Given that when the tap was opened, the depth of water in the tank was 2 m,

(b) show that, according to the model,

$$h = A + B\mathrm{e}^{-kt}$$

where A, B and k are constants to be found.

(6)

Given that the tap remains open,

(c) determine, according to the model, whether the tank will ever become full, giving a reason for your answer.

(2)

Where appropriate, we will write each new sentence on a new line and use diagrams to aid an understanding of the question and further reduce transcription errors.

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