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Examiners' report

MATHEMATICS B (MEI)

H630
For first teaching in 2017

H630/01 Summer 2019 series

Version 1

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Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates. The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report. A full copy of the question paper can be downloaded from OCR.

Paper 1 series overview

The paper seemed to be a fair one and there was no evidence that candidates were short of time. Some candidates seemed unsure of how much they should use their calculators: some lost marks in questions requiring detailed reasoning and some used precious time performing routine things by hand when simply writing down the answer from the calculator would have been acceptable. Further guidance on this is given below.

Question 1

1 In this question you must show detailed reasoning.

Show that the equation $x = 7 + 2x^2$ has no real roots. **[3]**

The majority of candidates were able to answer this question well. A few did not attempt to rearrange the equation into the required form and this cost them all the marks here. A small number simply quoted the complex roots of the equation, but without comment this received credit only for the first method mark.

Question 2

2 In this question you must show detailed reasoning.

Fig. 2 shows the graphs of $y = 4\sin x°$ and $y = 3\cos x°$ for $0 \leqslant x \leqslant 360$.

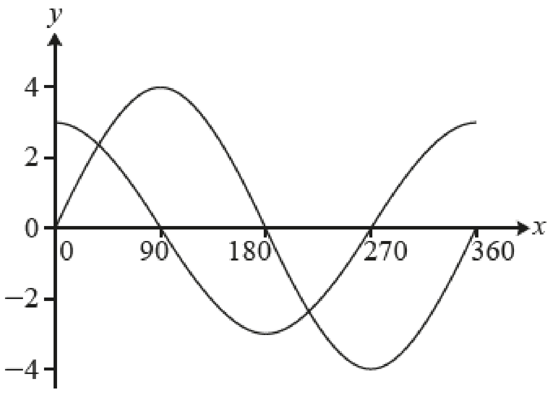


Fig. 2

Find the x-coordinates of the two points of intersection, giving your answers correct to 1 decimal place. **[3]**

Most candidates realised that this requires the two equations to be solved simultaneously and went on to achieve full marks. It was common to see mistakes in the rearranging leading to $\tan x = \frac{4}{3}$ which loses the accuracy mark. Some candidates lost the final mark as they did not check the rounding necessary in this question.

	AfL	Correct answer can be obtained using a calculator with no working and were awarded no marks. Because this question is labelled as a detailed reasoning question, candidates need to be aware that all the steps of working should be shown to achieve full marks.

Question 3

3 Given that k is an integer, express $\dfrac{3\sqrt{2}-k}{\sqrt{8}+1}$ in the form $a+b\sqrt{2}$ where a and b are rational expressions in terms of k. **[4]**

Most candidates made a good start to this question and most were awarded the mark for simplifying $\sqrt{8}$. To achieve the last mark, the answer had to be written in the correct form $a+b\sqrt{2}$ and most candidates did not see the need to factorise their expression.

Question 4 (a)

4 A triangle ABC has sides AB = 5 cm, AC = 9 cm and BC = 10 cm.

(a) Find the cosine of angle BAC, giving your answer as a fraction in its lowest terms. **[2]**

Most candidates knew the cosine formula but some struggled to rearrange it accurately. Many also went on to find the value of the angle *BAC,* the fact that they were not asked for it might have led them to realise what was required in part (b).

Question 4 (b)

(b) Find the exact area of the triangle. **[3]**

The formula for area was well understood, although a small number of candidates felt the need to evaluate the angle C rather than use $A=\frac{1}{2}bc\sin A$. Most gave a decimal answer using a value for *A* rather than use the exact link between $\sin A$ and $\cos A$.

	AfL	When the exam question uses the word exact, candidates should be expecting to use a fraction, a surd, a multiple of π or a term like ln2 etc. Exact answers are seldom found by using the decimal value from the calculator no matter how many decimal places are used.

Question 5 (a)

5 In this question, the unit vectors **i** and **j** are horizontal and vertically upwards respectively.

A particle has mass 2.5 kg.

(a) Write the weight of the particle as a vector. **[1]**

This had to be precise to obtain the mark and many candidates omitted at least one of the minus signs, the *g* or the **j**. As well as testing the accurate use of notation, the question here was structured to remind candidates to include the weight in their subsequent calculation.

Question 5 (b)

The particle moves under the action of its weight and two external forces $(3\mathbf{i}-2\mathbf{j})$ N and $(-\mathbf{i}+18\mathbf{j})$ N.

(b) Find the acceleration of the particle, giving your answer in vector form. **[2]**

The method mark here was awarded for an attempt to use Newton's second law either in vector form or two separate equations in the two directions. Many candidates had an equation with a mixture of vector and scalar terms which was not given any credit

Question 6 (a)

6 Fig. 6 shows a train consisting of an engine of mass 80 tonnes pulling two trucks each of mass 25 tonnes.

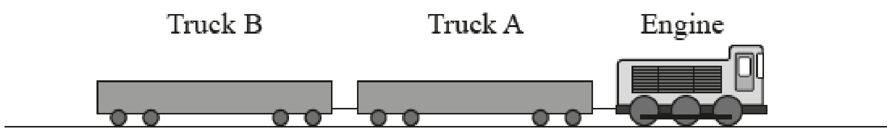


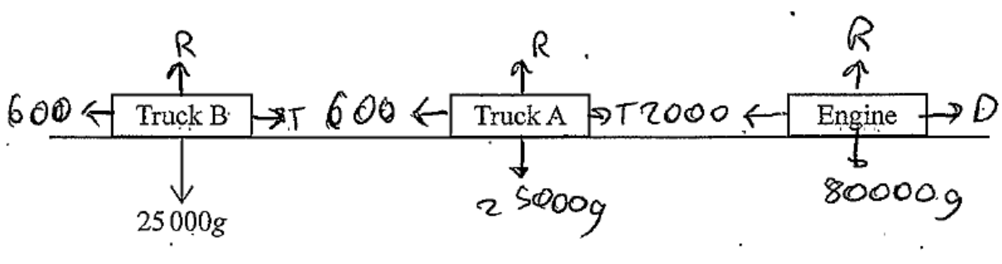
Fig. 6

The engine exerts a driving force of D N and experiences a resistance to motion of 2000 N. Each truck experiences a resistance of 600 N. The train travels in a straight line on a level track with an acceleration of $0.1\ \text{m s}^{-2}$.

(a) Complete the force diagram in the Printed Answer Booklet to show all the forces acting on the engine and each of the trucks. **[3]**

It was quite common to see both tensions labelled with T – the subsequent question even states that these are different. It was also common to omit the upwards vertical forces or to include them and label them all as R.

Exemplar 1



Force diagram

This diagram only has the tensions in the direction of motion and it was quite common to see both tensions labelled with T –the subsequent question even states that these are different. It was also common to label the upwards vertical forces all as R or omit them altogether.

Question 6 (b)

(b) Calculate the value of D. **[2]**

Candidates who used the whole train were the most successful in this part. The mass was used as an indicator of which part of the train was being considered when candidates did not explain their working. Where candidates used only one or two sections of the train, they had to include the relevant tension(s) to obtain the method mark.

Question 6 (c)

(c) The tension in the coupling between the engine and truck A is larger than that in the coupling between the trucks. Determine how much larger. **[2]**

Many candidates were able to achieve the method mark here for considering truck B even where their driving force had been incorrect. The expected method was to find the difference between the two tensions. Full credit was allowed for saying that one tension was twice the size of the other as the question asked candidates to "determine how much larger" rather than "find the difference".

Question 7 (a)

7 In this question you must show detailed reasoning.

(a) Nigel is asked to determine whether $(x+7)$ is a factor of $x^3-37x+84$. He substitutes $x=7$ and calculates $7^3-37\times7+84$. This comes to 168, so Nigel concludes that $(x+7)$ is not a factor.

Nigel's conclusion is wrong.

- Explain why Nigel's argument is not valid.
- Show that $(x+7)$ is a factor of $x^3-37x+84$. **[2]**

Many candidates understood the use of the factor theorem here but not all were able to explain sufficiently clearly to obtain full marks.

Exemplar 2

This exemplar is a case where the candidate did not have a very clear explanation of why Nigel's argument was wrong but was considered to be just enough. However, it is a very good example how the second mark can be lost if there is no conclusion given after finding the zero value.

Question 7 (b)

(b) Sketch the graph of $y = x^3 - 37x + 84$, indicating the coordinates of the points at which the curve crosses the coordinate axes. **[5]**

This is a question requiring detailed reasoning, so the method marks were awarded for finding a quadratic factor of the cubic and then obtaining the linear factors leading to the points where the graph crosses the *x*-axis. Examiners needed to be sure that the correct graph had not been obtained by simply typing the function into a graphical calculator and copying whatever they saw. The B marks for the *y* intercept and the general shape of the graph would have been still available but many candidates lost the final mark as they did not label their axes. (In order not to penalise the same mistake twice, this condition was not applied a second time in Q 10(a).)

Question 7 (c)

(c) The graph in part **(b)** is translated by $\begin{pmatrix} 1 \\ 0 \end{pmatrix}$. Find the equation of the translated graph, giving your answer in the form $y = x^3 + ax^2 + bx + c$ where a, b and c are integers. **[4]**

Many candidates understood the change to the algebra needed for a sideways translation but many candidates had their translation in the opposite direction by using $\mathrm{f}(x+1)$ instead. Most had efficient ways to expand the brackets to obtain the correct expansion but the omission of "*y* =" cost many candidates the final mark.

	AfL	Many candidates did not include *y* = in their answer despite it being included in the question and lost the final mark. In preparation for examinations, teachers need to stress the importance of accurate use of notation, and the value of checking how an answer needs to be given.

Question 8

8 In this question you must show detailed reasoning.

Show that the only stationary point on the graph of $y = x^2 - 4\sqrt{x}$ is a minimum point at $(1, -3)$. **[7]**

Most candidates looked for the points where $\frac{\mathrm{d}y}{\mathrm{d}x} = 0$ and many found it difficult to solve the resulting equation. Some introduced a spurious root at $x = 0$ and many others did not comment that the root they had found was the only root to be found. Verifying that the given point gives $\frac{\mathrm{d}y}{\mathrm{d}x} = 0$ was awarded one mark as a special case, as the method did not allow candidates to establish it as the only root. Some also argued (incorrectly) that this is a quadratic graph or a parabola so has only one stationary point.

Many also lost marks by not establishing that the stationary point was a minimum point. In this case where there is only one stationary point, full credit was given to candidates who checked the value of y either side of the stationary point even though the more usual method is to check the sign of the derivative.

	AfL	This mark was worth 7 marks and candidates could have used this to realise how much evidence would be needed to obtain full credit.

Question 9 (a)

9 In this question you must show detailed reasoning.

A car accelerates from rest along a straight level road. The velocity of the car after 8 s is $25.6\,\mathrm{m\,s^{-1}}$.

In one model for the motion, the velocity $v\,\mathrm{m\,s^{-1}}$ at time t seconds is given by $v = 1.2t^2 - kt^3$, where k is a constant and $0 \leqslant t \leqslant 8$.

(a) The model gives the correct velocity of $25.6\,\mathrm{m\,s^{-1}}$ at time 8 s. Show that $k = 0.1$. **[2]**

This was generally well answered by candidates who substituted the values of velocity and time and rearranged establish the correct value for *k.* Some candidates used the given value for k as well to obtain the value for v, but this was only awarded one mark unless a conclusion about k was also seen.

Question 9 (b)

A second model for the motion uses constant acceleration.

(b) Find the value of the acceleration which gives the correct velocity of $25.6\,\mathrm{m\,s^{-1}}$ at time 8 s. **[2]**

Many candidates did not pick up that the model had changed and so differentiated the first model instead of using the constant acceleration formulae. Those using $v = u + at$ were usually successful in obtaining both marks.

	AfL	Candidates should be aware that where there is a line of text that is not indented between part (a) and part (b), the situation will have changed.

Question 9 (c)

(c) Show that these two models give the same value for the displacement in the first 8 s. **[5]**

This question required candidates to find displacement for model 1 using integration and for model 2 using constant acceleration. A complete solution should also include a comment that the two answers were the same, but full credit was awarded for two correct answers obtained from the two models. To obtain full marks, a definite integral using the limits of 0 and 8 was required, or the candidate had to establish the value of the constant of integration to be zero. Many candidates only used one of the two models. Some used the constant acceleration formulae in two different ways.

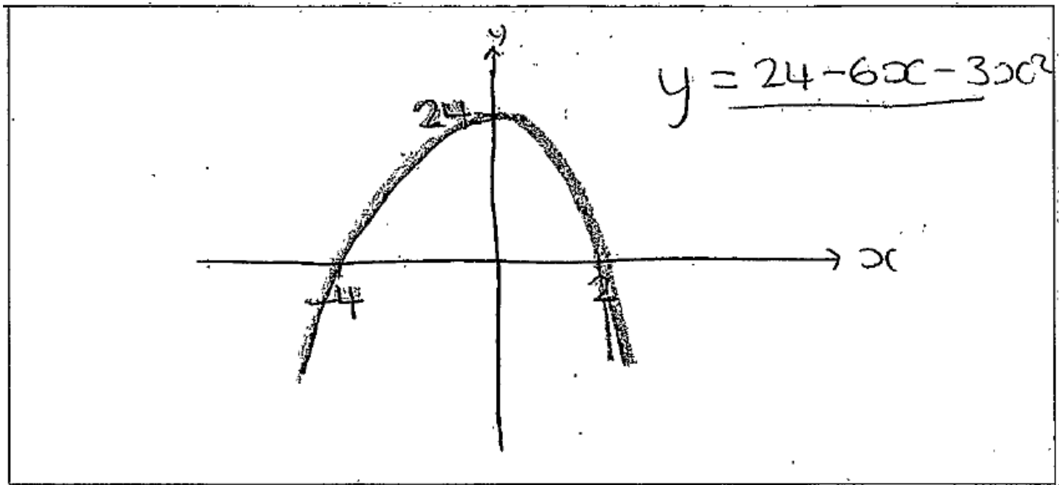
Question 10 (a)

10 In this question you must show detailed reasoning.

(a) Sketch the gradient function for the curve $y = 24x - 3x^2 - x^3$. **[5]**

A minority of candidates sketched the function and not the gradient function. The majority attempted to sketch the derived function but as in Question 7(b) did not show enough detailed reasoning. Often even when a full method was shown, the final mark was lost for careless positioning of the maximum point – the symmetry of the quadratic graph is an important part of its characteristic shape.

Exemplar 3



$y = 24x - 3x^2 - x^3$

$\frac{dy}{dx} = 24 - 6x - 3x^2$

y intercept = (0, 24)

x-axis intercept:

$(-x^2 - 2x + 8)$

$x = 2, \quad x = -4$

This exemplar indicates that where the question requires detailed reasoning, marks can easily be lost. Graphical calculators can be used rather than reasoning to establish the shape of the graph, so the solution must show sufficient detail to be awarded full marks. The derivative and the product of linear factors should have been equated to zero to fully establish the values $x = -4$ and $x = 2$. The final mark was also lost as the maximum point should have been clearly to the left of the *y*-axis – its exact position was not needed for full credit.

Question 10 (b)

(b) Determine the set of values of x for which $24x - 3x^2 - x^3$ is decreasing. **[2]**

Many candidates wrongly assumed that further differentiation was required. The phrase "set of values" in the question had been used to encourage candidates to use proper set notation. As an alternative, the use of the word "or" between two correct inequalities was accepted. "And" was not accepted as this implies the intersection rather than the union of the two sets. Some scientific calculators will solve a quadratic inequality, so it this question has been used to test clear understanding and good use of notation as well as an understanding of decreasing functions.

Question 11 (a)

11 David puts a block of ice into a cool-box. He wishes to model the mass m kg of the remaining block of ice at time t hours later. He finds that when $t = 5$, $m = 2.1$, and when $t = 50$, $m = 0.21$.

(a) David at first guesses that the mass may be inversely proportional to time. Show that this model fits his measurements. **[3]**

The clearest solutions established the value of the constant of proportionality (10.5). Many candidates argued that going from one data point to the other, the value of t is multiplied by 10 and the value for m is divided by ten. Where the argument was clear, this also obtained full marks.

Question 11 (b) (i)

(b) Explain why this model

(i) is not suitable for small values of t, **[1]**

Candidates often wrongly took the initial value of m to be its value when $t = 1$. Any comment which indicated that the candidate was aware of the vertical asymptote of the reciprocal graph was awarded the mark however it was expressed.

	AfL	These questions were left out by more candidates than any other. Centres should prepare candidates for the questions where they are required to explain or interpret a model.

Question 11 (b) (ii)

(ii) cannot be used to find the time for the block to melt completely. **[1]**

An understanding of the problem involved in finding a time for which $m = 0$ was needed for this. Many candidates instead talked about the physical situation, for example, difficulties in measuring the mass, which was not a problem with the model itself.

Question 11 (c)

David instead proposes a linear model $m = at + b$, where a and b are constants.

(c) Find the values of the constants for which the model fits the mass of the block when $t = 5$ and $t = 50$. **[3]**

Most candidates substituted both pairs of values and solved the simultaneous equations and were largely successful.

	AfL	This is exactly the sort of question where using the simultaneous equations facility of the calculator is appropriate and expected. There is no need for detailed reasoning, the coefficients are not easy to work with and the question is only worth 3 marks including the marks for forming the equations.

Question 11 (d)

(d) Interpret these values of a and b. **[2]**

For full credit the candidates needed to refer to the specific values and what they meant in the context of the physical situation.

Question 11 (e)

(e) Find the time according to this model for the block of ice to melt completely. **[1]**

Most candidates who had solved the simultaneous equations in part (c) were able to get this mark as follow through was allowed. Candidates who did not have a negative value for *a* were not awarded the mark for conveniently not noticing that their *t* should have been negative.

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