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Examiners' report

MATHEMATICS B (MEI)

H630

For first teaching in 2017

H630/01 Summer 2022 series

Contents

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. A selection of candidate answers are also provided. 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 and the mark scheme can be downloaded from OCR.

Advance Information for Summer 2022 assessments

To support student revision, advance information was published about the focus of exams for Summer 2022 assessments. Advance information was available for most GCSE, AS and A Level subjects, Core Maths, FSMQ, and Cambridge Nationals Information Technologies. You can find more information on our website.

Paper 1 series overview

The paper produced a very good spread of marks and it appeared that most candidates were able to complete the paper in the time allowed. For many this was their first public examination in Maths and many candidates produced good work. Some seemed unsure about how much working to include and some lost marks in questions requiring detailed reasoning.

Candidates who did well on this paper generally did the following:	Candidates who did less well on this paper generally did the following:
• used their calculator sensibly for routine things like solving quadratic equations • showed sufficient working to convince the examiner they were using valid methods • made good comments when asked to explain their reasoning.	• jotted down fragments of working rather than setting out a convincing argument for their answers • were not able to compare a mathematical model with the context it was modelling • did not use technical vocabulary precisely which is particularly a problem in Mechanics.

Question 1

1 Rationalise the denominator of the fraction $\frac{2+\sqrt{n}}{3+\sqrt{n}}$, where n is a positive integer. **[3]**

Although an algebraic version of this question, most candidates made a good start and were able to expand brackets accurately.

Exemplar 1

1

$$\frac{2+\sqrt{n}}{3+\sqrt{n}} \times \frac{3-\sqrt{n}}{3-\sqrt{n}} = \frac{6-2\sqrt{n}+3\sqrt{n}-n}{9+3\sqrt{n}-3\sqrt{n}-n}$$

$$\frac{6+\sqrt{n}-\cancel{n}}{9-\cancel{n}}$$

$$\frac{6+\sqrt{n}}{9}$$

This is a clear exemplar of where a candidate selects the correct method and obtains the right answer on the way to an incorrect answer. There is a misconception about how algebraic fractions simplify.

Question 2 (a)

2 **(a)** Determine the value of $\frac{100!}{98!}$. **[2]**

The values in the question were such that simply typing into a calculator could not give an answer as the values are too big. Some candidates tried inappropriate "shortcuts" such as $\frac{50!}{49!}$ which do not give the correct answer.

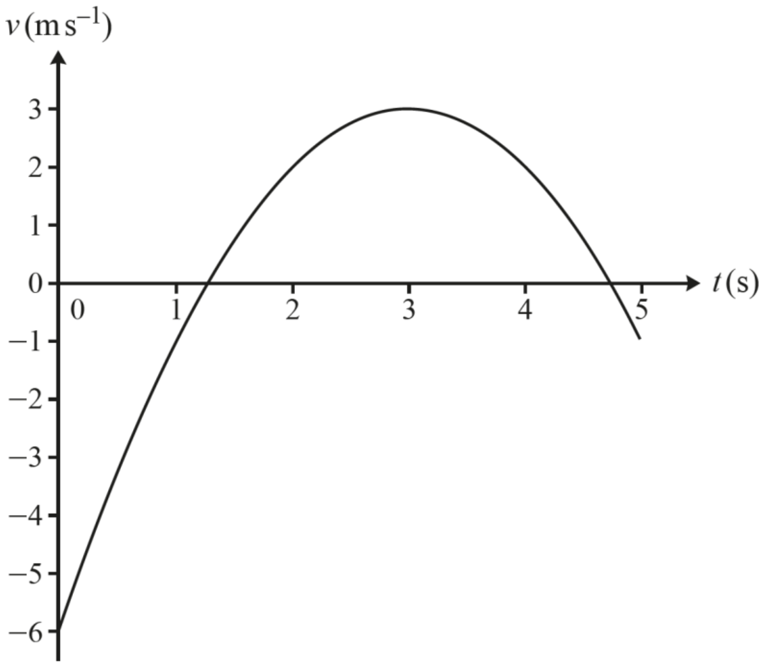
Question 2 (b)

(b) Find the coefficient of x^{98} in the expansion of $(1+x)^{100}$. **[1]**

Most candidates used their calculator to find the binomial coefficient which is a good use of technology.

Question 3 (a)

3 The velocity-time graph for the motion of a particle is shown below. The velocity $v\,\text{m s}^{-1}$ at time t s is given by $v = -t^2 + 6t - 6$ where $0 \leqslant t \leqslant 5$.



(a) Find the times at which the velocity is $2\,\text{m s}^{-1}$. **[2]**

This was generally well done but not all candidates showed the equation they were trying to solve. Where errors were made in the algebra, a check against the given graph should have helped candidates to notice and correct their mistakes.

Question 3 (b)

(b) Write down the greatest speed of the particle. **[1]**

Most candidates incorrectly found the maximum *velocity* of the particle writing $v = 3$ when $t = 3$.

Assessment for learning

The greatest *speed* here does not occur at the stationary point of the graph but rather at the beginning of the interval when $t = 0$. Finding the value of v at the maximum point would have been a lot of work for the 1 mark allocated and the amount of space in the Printed Answer Booklet. The command words "write down" should also have been a clue here.

Question 4 (a), (b), (c)

4 The quadratic function $\mathrm{f}(x)$ is given by $\mathrm{f}(x) = x^2 - 3x + 2$.

(a) Write $\mathrm{f}(x)$ in the form $(x+a)^2 + b$, where a and b are constants. **[2]**

(b) Write down the coordinates of the minimum point on the graph of $y = \mathrm{f}(x)$. **[2]**

(c) Describe fully the transformation that maps the graph of $y = \mathrm{f}(x)$ onto the graph of $y = (x+1)^2 - \frac{1}{4}$. **[2]**

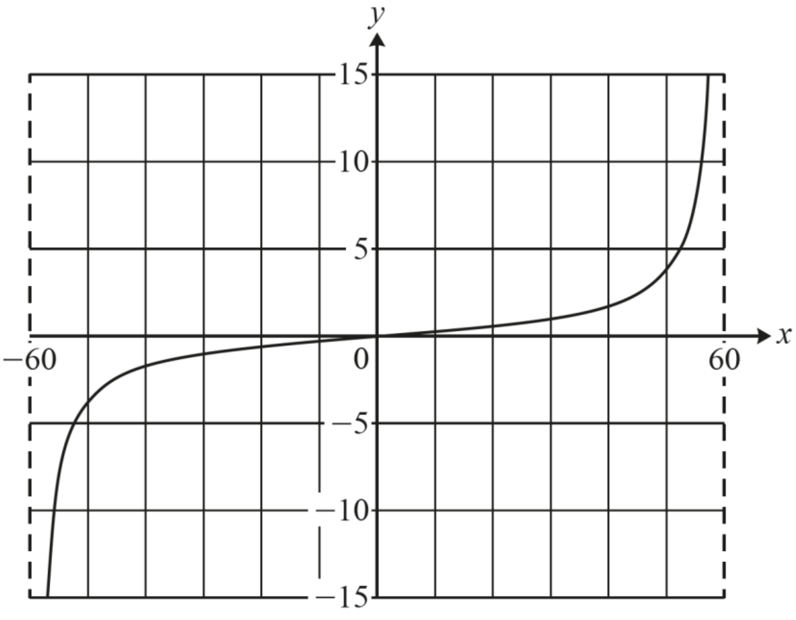
Most candidates were able to complete the square accurately and read off the coordinates of the minimum point. Most realised that the two graphs were translations of each other but many lost marks for not using the correct technical language being tested here.

Assessment for learning

"Slide" or "move" are not enough when describing a translation and a vector is the best way to indicate that the graph needs to be translated by 2.5 units to the left.

Question 5 (a)

5 Part of the graph of $y = \mathrm{f}(x)$ is shown below. The graph is the image of $y = \tan x°$ after a stretch in the x-direction.



(a) Find the equation of the graph. **[2]**

Many candidates did not realise that the description of the transformation given in the question meant they had to adjust the argument of the tan function. It was quite common to see $y = \frac{2}{3}\tan x$ here which gained no marks.

Question 5 (b)

(b) Write down the period of the function $\mathrm{f}(x)$. **[1]**

The word "period" was not well understood, so many candidates wrote about the domain of the function in the part of the given graph instead.

Question 5 (c)

(c) In this question you must show detailed reasoning.

Find all the roots of the equation $f(x) = 1$ for $0° \leqslant x° \leqslant 360°$. **[3]**

Candidates were given credit here for solving their function $f(x) = 1$ provided they had a transformation of the tan function. Many did not realise that the answer for part (b) could be used as a way of generating other roots. Notice, in a detailed reasoning question like this, it was not enough to read from the graph, or to solve their equation by calculator, although both these methods provide a useful check for algebraic working.

Question 6 (a)

6 The gradient of a curve is given by the equation $\frac{dy}{dx} = 6x^2 - 20x + 6$. The curve passes through the point (2, 6).

(a) Find the equation of the curve. **[3]**

This question was very well done. Some candidates lost marks when they omitted to include or to find the value of the constant.

Question 6 (b)

(b) Verify that the equation of the curve can be written as $y = 2(x+1)(x-3)^2$. **[2]**

For a "verify" question, candidates could either expand the brackets and compare with their answer to part (a) or factorise their expression from part (a). Either way, examiners were looking for a quadratic factor as evidence of their working. Some candidates used a calculator to solve the equation $y = 0$ and use the factor theorem to identify the factors of the expression. This was not easy to do well as candidates had to explain the factor of 2 and may not have known from the calculator that $x = 3$ was a repeated root.

Question 6 (c)

(c) Sketch the curve, indicating the points where the curve meets the axes. **[3]**

This was generally well done as the factorised form of the curve was given. Some candidates lost marks because they did not show the values of the intercepts with the axes.

Question 7 (a)

7 In this question the unit vectors $\mathbf{i}$ and $\mathbf{j}$ are directed east and north respectively.

A canal narrowboat of mass 9 tonnes is pulled by two ropes. The tensions in the ropes are $(450\mathbf{i}+20\mathbf{j})$ N and $(420\mathbf{i}-20\mathbf{j})$ N. The boat experiences a resistance to motion $\mathbf{R}$ of magnitude 300 N.

(a) Explain what it means to model the boat as a particle. **[1]**

When a particle is modelled as a particle it is considered as a point mass, so its size and shape are not relevant, and any rotation is not taken into account. Many candidates wrote about other modelling assumptions they might have come across in other contexts.

Question 7 (b)

The boat is travelling in a straight line due east.

(b) Find the equation of motion of the boat. **[2]**

The equation required here was a vector equation but use of two separate equations for the two directions instead was also allowed. Simply finding a total of the forces was not enough as Newton's second law was expected here.

Misconception

It is never a valid equation when vectors and scalars are added together in an equation. The resistance in this question should have been written as $-300\mathbf{i}$.

Question 7 (c)

(c) Find the acceleration of the boat giving your answer as a vector. **[1]**

Follow-through from an incorrect equation of motion was allowed here where the acceleration was given as a vector.

Question 8 (a)

8 A team of volunteers donates cakes for sale at a charity stall. The number of cakes that can be sold depends on the price. A model for this is $y = 190 - 70x$, where y cakes can be sold when the price of a cake is £x.

(a) Find how many cakes could be given away for free according to this model. **[1]**

Most candidates answered this well showing their use of $t = 0$.

Question 8 (b)

The number of volunteers who are willing to donate cakes goes up as the price goes up. If the cakes sell for £1.20 they will donate 50 cakes, but if they sell for £2.40 they will donate 140 cakes. They use the linear model $y = mx + c$ to relate the number of cakes donated, y, to the price of a cake, £x.

(b) Find the values of the constants m and c for which this linear model fits the two data points. **[2]**

Many candidates did a good job here either by calculating the gradient of the line or by setting up and using simultaneous equations. These could have been solved by calculator for full credit. Some candidates use pence instead of pounds but the unit for x is given in the question and should have been used.

Question 8 (c)

(c) Explain why the model is **not** suitable for very low prices. **[1]**

This question was not difficult for those who had a correct linear model for part (b). It is vital here to compare the model and the real-life situation.

Exemplar 2

8(c)	you will end up with a negative num or cakes sold. ~~ste~~

This candidate comments that for small values of x, the model predicts that the number of cakes would be negative. However, to be given the mark here, this must be related to the situation being modelled, so a comment such as "you can't have a negative number of cakes" was needed to get the mark.

Question 8 (d)

(d) The team would like to sell all the cakes that they donate.

Find the set of possible prices that the cakes could have to achieve this. **[3]**

Most candidates did not realise that there are two constraints here on the value of x, one from the positivity of y flagged in the previous part question, and the other from the need for the demand to be at least as great as the supply. One mark was given for attempting to find at least one of the boundary values, but inequalities were needed for the accuracy marks.

Question 9 (a)

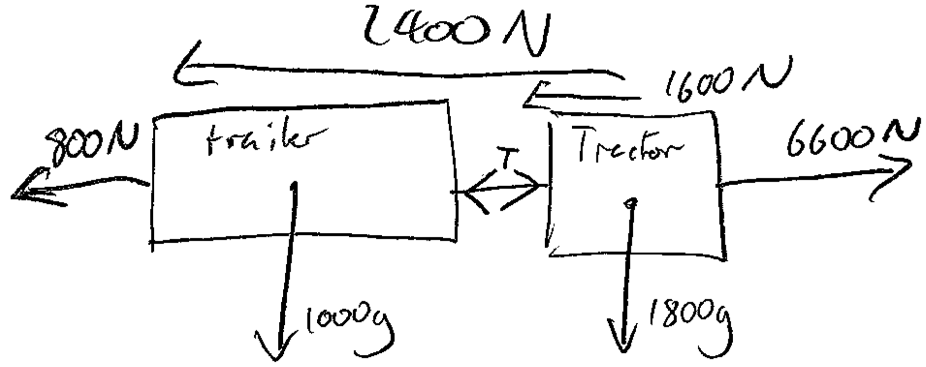
9 A tractor of mass 1800 kg uses a towbar to pull a trailer of mass 1000 kg on a level field. The tractor and trailer experience resistances to motion of 1600 N and 800 N respectively. The tractor provides a driving force of 6600 N.

(a) Draw a force diagram showing all the horizontal forces acting on the tractor and trailer. **[2]**

The ability to draw an accurate force diagram is a crucial skill in Mechanics but many candidates lacked the precision in placing the forces on the correct part of this system of connected particles. The direction of each force and where it is acting must be shown and each force must be properly labelled to gain full credit.

Exemplar 3

9(a)



This diagram has the driving force and the resistance on the trailer correct but the 1600N resistance should be attached to the tractor. There is also an unexplained additional force floating above the diagram so the first B1 was not given. The tension in the towbar is drawn as a thrust which makes no sense when the question states that the tractor is pulling the trailer – this could have been correct had a negative value been found and explained in part (b) of the question. The weights were correct but not needed as they have no horizontal component. As they are drawn, it would be better to also draw the distinct normal reactions on the tractor and trailer.

Question 9 (b)

(b) Find the tension in the towbar. **[4]**

Generally, candidates who scored well in part (a) did well here too. They either looked at the whole system or each of the separate parts. A few words of explanation of which part of the system was being considered would make the solutions much easier to understand.

Question 10 (a)

10 A triangle has vertices A $(1, 4)$, B $(7, 0)$ and C $(-4, -1)$.

(a) Show that the equation of the line AC is $y = x + 3$. **[2]**

This was very well done as most candidates showed their gradient calculation and how they evaluated the constant. A convincing argument was needed for both marks to be given.

Question 10 (b)

M is the midpoint of AB. The line AC intersects the x-axis at D.

(b) Determine the angle DMA. **[7]**

There were many good answers based on the cosine rule with a few candidates using an alternative method using the link between the gradient of lines and the angle they make with the axes. Many marks were lost due to errors with negative numbers or mis-remembering the midpoint formula or the cosine rule. There was follow-through given throughout this question.

Question 11 (a)

11 A sports car accelerates along a straight road from rest. After 5 s its velocity is $9\,\mathrm{m\,s^{-1}}$.

In model A, the acceleration is assumed to be constant.

(a) Calculate the distance travelled by the car in the first 5 seconds according to model A. **[2]**

Most candidates selected and used the correct *suvat* equation and applied it well. A few calculated a value for acceleration, but this was not necessary. Where candidates only calculated a, the method mark was not given as the method was incomplete.

Question 11 (b)

In model B, the velocity v in $\mathrm{m\,s^{-1}}$ is given by $v = 0.05t^3 + kt$, where t is the time in seconds after the start and k is a constant.

(b) Find the value of k which gives the correct value of v when $t = 5$. **[2]**

This was also done well although some candidates did not explain well what they were doing. The most common error was to equate the velocity to zero rather than 9.

Question 11 (c)

(c) Using this value of k in model B, calculate the acceleration of the car when $t = 5$. **[2]**

Many candidates used calculus well here, although some continued to use the *suvat* equations where they are not valid.

Question 11 (d)

The car travels 16 m in the first 5 seconds.

(d) Show that model B, with the value of k found in part **(b)**, better fits this information than model A does. **[3]**

Many candidates integrated accurately though many did not consider the arbitrary constant. In this question, the constant is zero, so their answers gave correct values. The use of a definite integral clearly seen and evaluated by calculator was sufficient here. To get the mark for the comparison of the models, the actual values needed to be quoted as evidence in their response.

Question 12 (a)

12 Below is a faulty argument that appears to show that the gradient of the curve $y = x^2$ at the point $(3, 9)$ is 1.

> Consider the chord joining $(3, 9)$ to the point $(3+h, (3+h)^2)$
>
> The gradient is $\dfrac{(3+h)^2-9}{h} = \dfrac{6h+h^2}{h}$
>
> When $h = 0$ the gradient is $\dfrac{0}{0}$ so the gradient of the curve is 1

(a) Identify a fault in the argument. **[1]**

> The fundamental flaw here is that the gradient formula relies on the two points being distinct, so it is not appropriate to equate h to zero. That would lead to an undefined quantity $\dfrac{0}{0}$ and statements such as "this is undefined" or "you can't divide by zero" were also allowed.

Question 12 (b)

(b) Write a valid first principles argument leading to the correct value for the gradient at $(3, 9)$. **[3]**

> This was not well answered, and some candidates assumed the issue was in the algebra, which did not contain a fault. To get full credit here, candidates had to demonstrate how they would simplify the fraction in the question to $6+h$ and show some understanding of the limit of this expression as h tends to zero – but putting $h = 0$ did not achieve this mark.

Question 12 (c)

(c) Find the equation of the normal to the curve at the point $(3, 9)$. **[2]**

> Some candidates did not attempt this question as they had not completed part (b). Full credit was given for candidates who found the gradient of the curve by any method and used it correctly to find the equation of the tangent.

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