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Examiners' report

MATHEMATICS B (MEI)

H630
For first teaching in 2017

H630/01 Summer 2018 series

Version 1

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. 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 H630/01 series overview

This paper produced a wide spread of marks, although few candidates achieved more than 60 out of 70 marks. In general, the Pure questions were better answered than the Mechanics, as many candidates did not demonstrate even a basic understanding of the principles involved in setting up equations of motion. The mean mark for this paper was considerable lower than that for paper 2.

The new specification has an emphasis on unstructured or longer questions which candidates found more challenging. Some abandoned questions where follow-through marks would have been available. Questions requiring candidates to explain their reasoning in words or to assess the validity of an argument were also not well answered.

Candidates seemed not to be sure when it was appropriate to use their calculators, for example to solve simultaneous equations, so guidance on this is given in the detail of this report.

Question 1

1 Write $\frac{8}{3-\sqrt{5}}$ in the form $a+b\sqrt{5}$, where a and b are integers to be found. **[2]**

This was well answered, although some arithmetic mistakes were seen in the simplifying.

Check numerical answers with a calculator.

Question 2

2 Find the binomial expansion of $(3-2x)^3$. **[4]**

This was well answered by the majority of candidates although a significant number did not correctly use brackets round the (-2x) and so lost a method mark and the accuracy marks. Some also made the mistake of writing $3^3 = 9$.

Check numerical answers with a calculator.

Question 3

3 A particle is in equilibrium under the action of three forces in newtons given by

$$\mathbf{F}_1 = \begin{pmatrix} 8 \\ 0 \end{pmatrix}, \quad \mathbf{F}_2 = \begin{pmatrix} 2a \\ -3a \end{pmatrix} \quad \text{and} \quad \mathbf{F}_3 = \begin{pmatrix} 0 \\ b \end{pmatrix}.$$

Find the values of the constants a and b. **[3]**

Many candidates did not form an equilibrium equation in vector form nor a pair of equilibrium equations for the two directions. Many made the mistake of writing $F_1 + F_2 = F_3$ or similar and received no marks. Others had correct equations to obtain the method mark but subsequent sign errors cost the accuracy marks.

In future teaching, emphasise to candidates the importance of setting up their equilibrium equation i.e. total force = 0

Question 4

4 Fig. 4 shows a block of mass $4m$ kg and a particle of mass m kg connected by a light inextensible string passing over a smooth pulley. The block is on a horizontal table, and the particle hangs freely. The part of the string between the pulley and the block is horizontal. The block slides towards the pulley and the particle descends. In this motion, the friction force between the table and the block is $\frac{1}{2}mg$ N.

Fig. 4

Find expressions for

- the acceleration of the system,
- the tension in the string. **[4]**

This question was a very standard question but many candidates did not correctly use Newton's 2nd law to form equations of motion. Those who attempted to write down a single equation for the whole system (the round-the-corner method) were rarely successful. Some wrongly included the weight of the object on the table in its equation of motion. Many candidates had fragments of working that were not clear - examiners used the mass to indicate which part(s) of the system was being considered and required the correct forces acting on that part. Some who had correct equations then lost a mark as they did not simplify their expressions for *a* and *T* fully.

Prepare candidates to consider each part of the system separately and to identify which forces are acting on that object in the direction of its motion.

There is evidence of candidates confusing mass and weight, essentially using $F = mga$ instead of Newton's 2nd law.

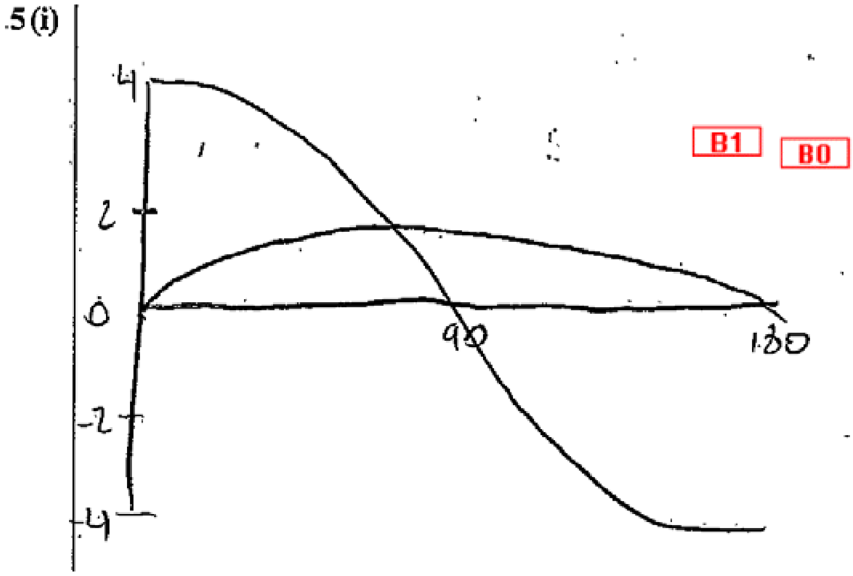
Question 5 (i)

5 **(i)** Sketch the graphs of $y = 4\cos x$ and $y = 2\sin x$ for $0° \leqslant x \leqslant 180°$ on the same axes. **[2]**

The graphs were generally well done although many candidates lost a mark as they did not indicate which graph was which. Some just drew the basic graphs of *y* = sin *x* and *y* = cos *x* with an amplitude of 1. Only rarely did candidates draw the graph of *y* = cos 4*x*. Some candidates who used their calculators to produce points to plot *y* = 4cos *x* gave too few points and drew a line from (0, 4) to (180, -4)

Make sure all graphs are fully labelled.

Exemplar 1



Question 5 (ii)

(ii) Find the exact coordinates of the point of intersection of these graphs, giving your answer in the form $(\arctan a, k\sqrt{b})$, where a and b are integers and k is rational. **[4]**

Key point call out

The question has specifically asked for the exact coordinates, it is not enough to use the calculator here to find decimal answers.

Many candidates divided by cos *x* to obtain an equation for tan *x*, but there were many who got mixed up and obtained $\tan x = \frac{1}{2}$ or even $\tan x = 0$. Most did not think to use Pythagoras' theorem to find the *y* coordinate of the point of intersection.

Where a value for tan *x* is known, draw a simple right angled triangle and using Pythagoras' theorem to give the values for sin *x* or cos *x*.

Question 5 (iii)

(iii) A student argues that without the condition $0° \leqslant x \leqslant 180°$ all the points of intersection of the graphs would occur at intervals of 360° because both $\sin x$ and $\cos x$ are periodic functions with this period. Comment on the validity of the student's argument. **[1]**

Few candidates used the periodicity of tan *x* to answer this question but many correct answers explained that there would be another point of intersection for $180° \leq x \leq 360°$.

Make sure that you clearly state whether the argument is valid or not and make sure this does not contradict your evidence.

Question 6 (i)

6 In this question you must show detailed reasoning.

You are given that $f(x) = 4x^3 - 3x + 1$.

(i) Use the factor theorem to show that $(x+1)$ is a factor of $f(x)$. **[2]**

This question specified a method that was to be tested, so no marks were obtained by candidates who used algebraic division here – marks for this skill were credited in part (ii). Most candidates were able to evaluate $f(-1) = 0$ but this did not obtain full marks without the detailed reasoning that this meant that $(x+1)$ was a factor of $f(x)$.

Question 6 (ii)

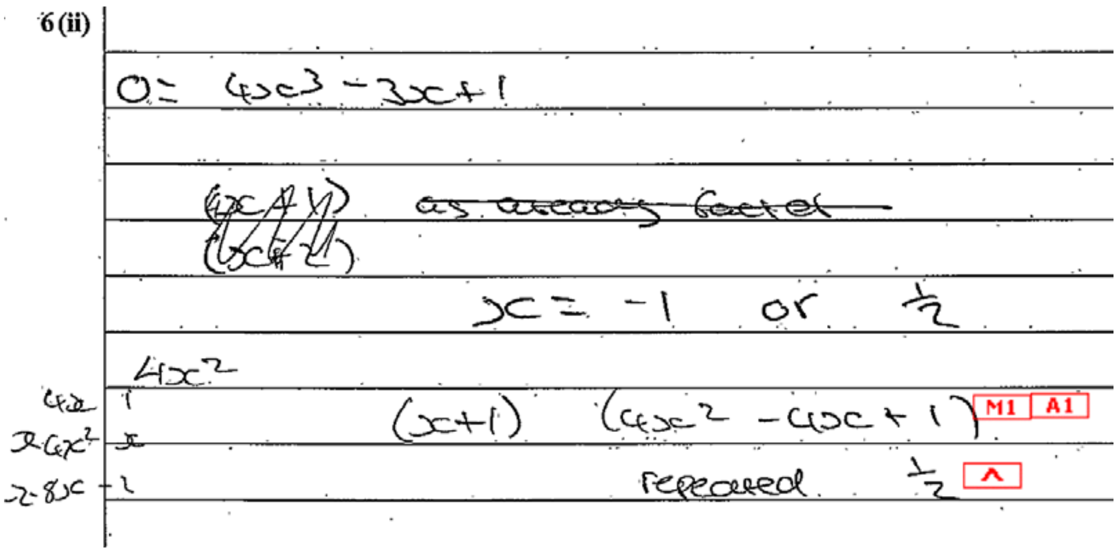
(ii) Solve the equation $f(x) = 0$. **[3]**

Key point call out

This question required detailed reasoning – all the lines of working must be clear to obtain full marks.

There were many good answers seen but some candidates who correctly divided then did not state what the roots of the equation were. Some candidates used their calculators to find the roots of the equation but were not able to give the correct linear factors of $f(x)$ that were needed for full marks as in this exemplar.

Exemplar 2



Question 7

7 A toy boat of mass 1.5 kg is pushed across a pond, starting from rest, for 2.5 seconds. During this time, the boat has an acceleration of $2\,\mathrm{m\,s^{-2}}$. Subsequently, when the only horizontal force acting on the boat is a constant resistance to motion, the boat travels 10 m before coming to rest. Calculate the magnitude of the resistance to motion. **[6]**

Many good clear solutions were seen, however some candidates did not realise that this question covered two phases of motion and used all the numbers in the question in a single set of *suvat* equations. Some simply extracted the values of mass and acceleration from the first phase of motion and multiplied them together. Some candidates who obtained a negative value for resistance did not notice that it was the magnitude of the resistance that was required, so a positive answer was needed.

Look out for two phases of motion and set up different equations for the two phases. Use the value of the velocity at the end of the first phase to link the two phases.

Key point call out

This question required an extended answer with three separate method marks. The mark allocation [6] indicates that several steps are required to solve the problem.

Question 8

8 In this question you must show detailed reasoning.

Fig. 8 shows the graph of a quadratic function. The graph crosses the axes at the points $(-1, 0)$, $(0, -4)$ and $(2, 0)$.

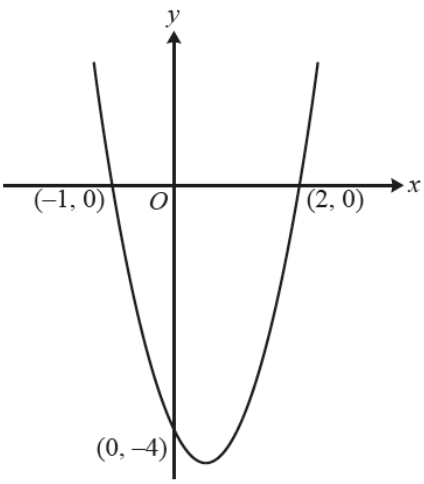


Fig. 8

Find the area of the finite region bounded by the curve and the x-axis. **[8]**

There were many very good answers to this question but many lost the final mark as they did not explain why their area is given as positive when the definitive integral gives a negative value. Only a few candidates used their calculators to evaluate their definite integral but lost marks as this was a detailed reasoning question that required all the lines of working to be clear. Examiners needed to see the indefinite integral and the substitution of limits. Some candidates made their answers unnecessarily complicated by splitting the required area into two or more regions.

Many candidates struggled to obtain the correct equation of the curve, either using $y=(x+1)(x-2)$ or $y=x^2-4$ but most of the rest of the marks in this question were obtained following through their equation if it was quadratic.

Make sure you do not write -9 = 9 without explaining the change of sign. Candidates needed to comment that the area is below the *x*-axis.

Do not abandon a long question if there is a problem with the first part. Use any vaguely sensible equation to demonstrate your ability to integrate and use limits – it is not enough to describe this process in words.

Question 9 (i)

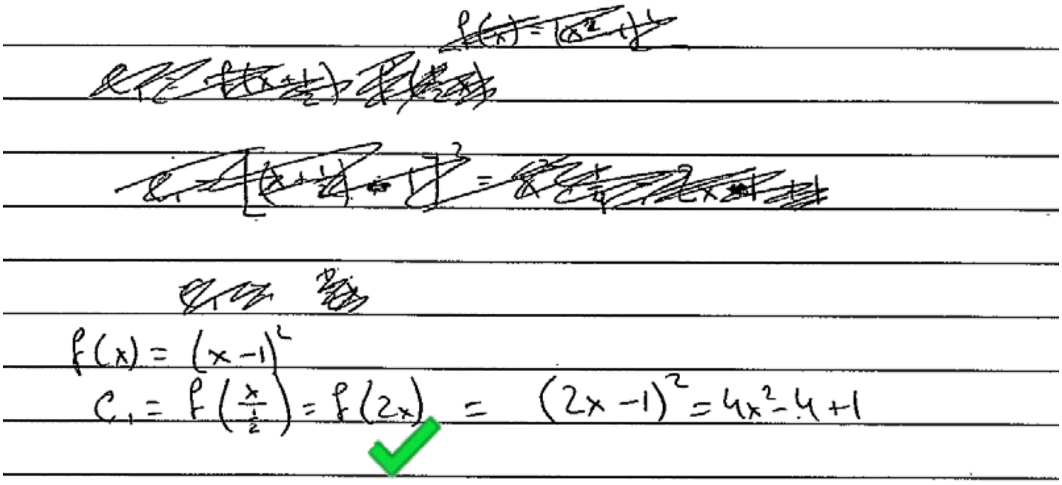
9 The curve $y = (x-1)^2$ maps onto the curve C_1 following a stretch scale factor $\frac{1}{2}$ in the x-direction.

(i) Show that the equation of C_1 can be written as $y = 4x^2 - 4x + 1$. **[2]**

Many candidates were credited one of two marks for this question as $(2x-1)^2$ was seen. The best answers used function notation to explain the effect of the stretch in the *x*-direction.

The following exemplar shows a candidate who is not sure what algebra is needed to achieve the given transformation. The given answer is used to identify the correct method and the notation makes it very clear that the full argument is given.

Exemplar 3



Question 9 (ii)

The curve C_2 is a translation of $y = 4.25x - x^2$ by $\begin{pmatrix} 0 \\ -3 \end{pmatrix}$.

(ii) Show that the normal to the curve C_1 at the point (0, 1) is a tangent to the curve C_2. **[7]**

There were many good solutions to this question. Some candidates correctly obtained the equation of the normal and the equation of C_2 but then did not know how to proceed. Some incorrectly assumed that the point (0, 1) was a point of intersection of the two curves. Some candidates found the point on C_2 which had the correct gradient but then did not go on to show that the tangent here was the same line as the normal to C_1 and not simply parallel to it.

Question 10 (i)

10 Rory runs a distance of 45 m in 12.5 s. He starts from rest and accelerates to a speed of $4\,\mathrm{m\,s^{-1}}$. He runs the remaining distance at $4\,\mathrm{m\,s^{-1}}$.

Rory proposes a model in which the acceleration is constant until time T seconds.

(i) Sketch the velocity-time graph for Rory's run using this model. **[2]**

Most candidates gave a graph with two straight line segments but marks were often lost for graphs that were not fully labelled.

Make sure you label the axes and show the values of *v* and *t* at the significant points.

Question 10 (ii)

(ii) Calculate T. **[2]**

Candidates who used the area under the graph were usually successful. Candidates using the *suvat* equations often incorrectly combined values from the two separate phases of motion into a single equation.

Question 10 (iii)

(iii) Find an expression for Rory's displacement at time t s for $0 \leqslant t \leqslant T$. **[2]**

This was not well answered, as many candidates did not realise that the value of the acceleration was the key to this question. Many incorrectly used $s = \frac{1}{2}(u+v)t$ with $u = 0$ and $v = 4$, and the resulting linear expression did not qualify for follow-through marks in part (iv).

Question 10 (iv)

(iv) Use this model to find the time taken for Rory to run the first 4 m. **[1]**

This was usually credited to candidates who had had a quadratic expression for *s* in part (iii) as follow-through was allowed.

Question 10 (v)

Rory proposes a refined model in which the velocity during the acceleration phase is a quadratic function of t. The graph of Rory's quadratic goes through $(0, 0)$ and has its maximum point at $(S, 4)$. In this model the acceleration phase lasts until time S seconds, after which the velocity is constant.

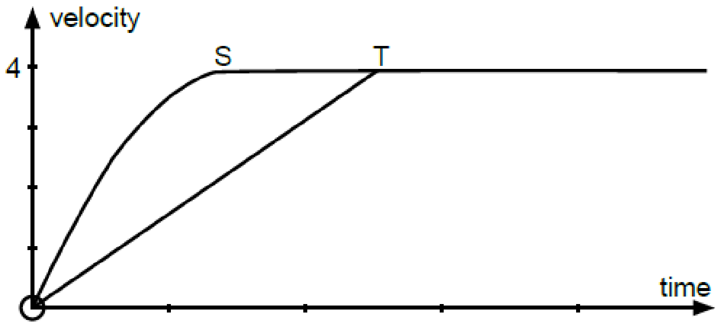
(v) Sketch a velocity-time graph that represents Rory's run using this refined model. **[1]**

Most candidates who attempted this question got it right. The mark was only credited where the curved part of the graph had a decreasing gradient.

Question 10 (vi)

(vi) State with a reason whether S is greater than T or less than T. (You are not required to calculate the value of S.) **[1]**

Very few candidates were credited this mark. Many argued that the decreasing gradient implied it would take longer to reach maximum speed – the incorrect underlying assumption here was that the gradient at the origin would be the same, so these arguments were not credited the mark. This model gives the same total distance in 12.5 s and only answers which compared distances or areas were eligible for the mark. The easiest way to decide was to sketch the graphs with $S < T$ and to realise that this meant the total distance would be larger and so to argue that $S > T$.



Question 11 (i)

11 The intensity of the sun's radiation, y watts per square metre, and the average distance from the sun, x astronomical units, are shown in Fig. 11 for the planets Mercury and Jupiter.

	x	y
Mercury	0.3075	14400
Jupiter	4.950	55.8

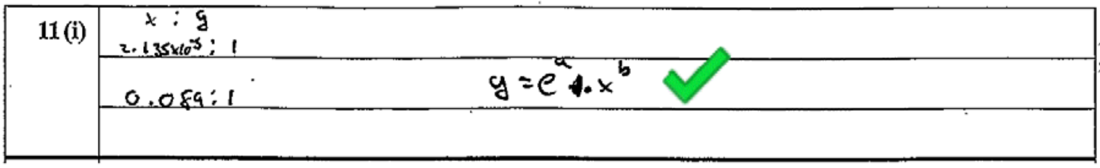
Fig. 11

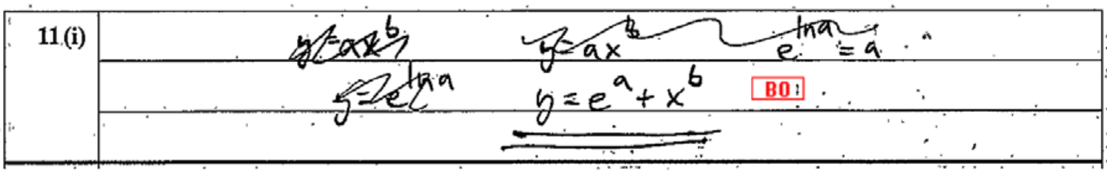
The intensity y is proportional to a power of the distance x.

(i) Write down an equation for y in terms of x and two constants. **[1]**

Many candidates seemed unprepared for this question which is covered by the specification point Ma14. Some tried to work backwards from the given answer in part (ii) but many made fundamental errors in the laws of logarithms and gave an expression which was the sum of two terms. There was some evidence that candidates who had had $y = ax^b$ returned to their answer and changed it when they obtained $y = \ln a + b \ln x$ in part (ii) which they did not recognise as being in the correct form. These two exemplars illustrate a successful and an unsuccessful attempt to use the given answer.

Exemplar 4





Question 11 (ii)

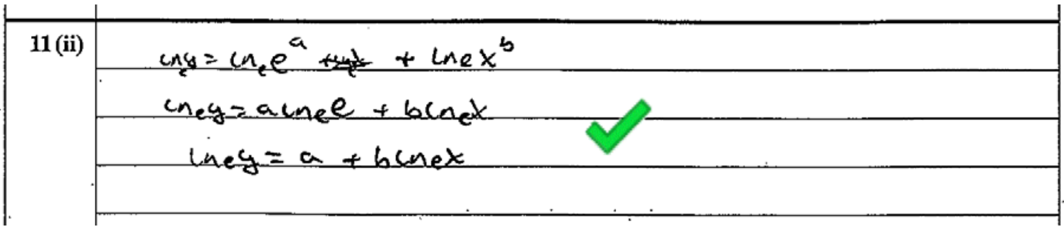
(ii) Show that the equation can be written in the form $\ln y = a + b \ln x$. **[2]**

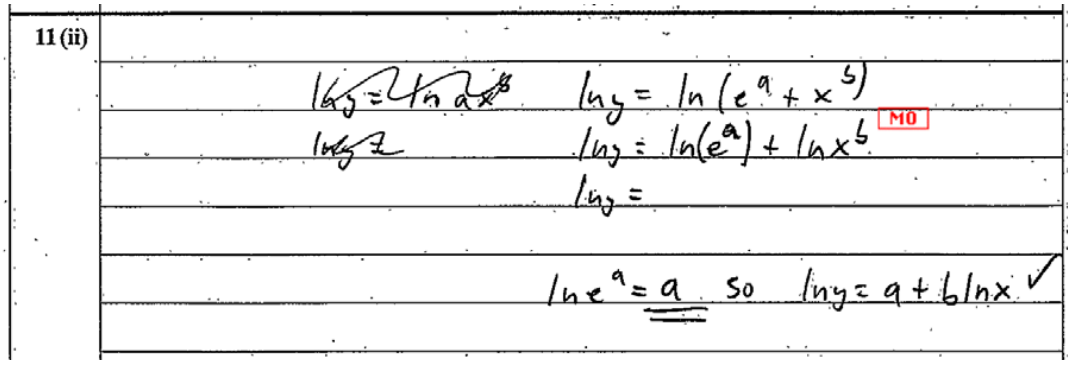
The method mark here was credited to candidates who took logarithms on both sides and demonstrated at least one correct use of the laws of logarithms, usually for correctly dealing with $\ln x^b$ or similar. Candidates who had the sum of terms in part (i) were not credited the mark for adding the logarithms of separate terms.

Candidates who did not know how to answer part (i) could access many of the subsequent marks by working from the equation given in here in part (ii). There was some evidence of candidates giving up on all of question 11 without realising that there were many marks accessible.

Prepare candidates to work through questions working from a given result even if they are unable to show where that result came from.

Exemplar 5





Question 11 (iii)

(iii) In the Printed Answer Booklet, complete the table for $\ln x$ and $\ln y$ correct to 4 significant figures. **[2]**

This was successfully done by the majority of candidates. It only required the use of the calculator and correct rounding to 4 significant figures – some candidates lost a mark for incorrect rounding. It was rare to see $\log_{10}$ used instead of natural logarithms.

Question 11 (iv)

(iv) Use the values from part **(iii)** to find a and b. **[3]**

Key point call out

It was expected that candidates used their calculator to answer this question – hence the relatively low mark allocation when the numbers were quite difficult to work with. Many calculators will give the equation of a regression line with this two-point data set. Calculators can also be used to solve the simultaneous equations that arise from the alternative method in the markscheme.

Candidates using the gradient method were often successful here. Many candidates using the alternative method were daunted by the complexity of the arithmetic here and made errors in the solution of their simultaneous equations.

Question 11 (v)

(v) Hence rewrite your equation from part **(i)** for y in terms of x, using suitable numerical values for the constants. **[2]**

Many candidates were hampered by incorrect work in parts (i) and (ii) and so did not realise that e^a was required. It was possible to obtain both marks here using their values in the given equation in part (ii) but this was rarely seen. Follow-through marks were given for using e^a and *b* in whatever equation had been seen in part (i).

Question 11 (vi)

(vi) Sketch a graph of the equation found in part **(v)**. **[2]**

When attempted, many candidates correctly drew a graph with the positive *x*-axis as an asymptote but many thought their curve would cross the vertical axis at their *a*. As two points on the curve were given in the question, no marks were given for an increasing function.

Question 11 (vii)

(vii) Earth is 1 astronomical unit from the sun. Find the intensity of the sun's radiation for Earth. **[1]**

This was an easy mark to obtain for candidates who substituted $x = 1$ into their equation even when the answer made little sense in the context.

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