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A LEVEL

Examiners' report

MATHEMATICS B (MEI)

H640
For first teaching in 2017

H640/01 Summer 2019 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 that 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/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

This is the second series of the reformed linear A Level Maths specification, and the first to be sat by candidates following the standard two year programme. This paper assesses Pure Mathematics and Mechanics and contributes 36.4% of the total A level.

The evidence indicates this paper was a fair one, where all the questions were accessible to the majority of candidates and there was no evidence of shortage of time. Most scripts were sufficiently legible to be marked, but too many candidates give fragmentary answers, particularly with question 6. Generally, candidates would benefit from giving a word or two of explanation of their thinking to help the examiner follow their method.

Some questions contain specific defined 'command words', in particular the instruction '**In this question you must show detailed working**'. In these questions, candidates are required to demonstrate their understanding of the relevant concepts by showing their working, rather than by presenting an answer gained simply by pressing a few buttons. Consequently, in these questions, marks will not be given unless correct working is seen. Remember that this does not preclude candidates from checking their working using the calculator.

i	**OCR support**	A poster detailing the different command words and what they mean is available here: https://teach.ocr.org.uk/italladdsup

The command words 'Show that' and 'Determine' also indicate that clear working must been seen. Conversely, some questions have slightly lower mark tariffs than seen in the legacy assessment, where candidates are expected to make efficient use of the full range of functions on their calculator. These are also signposted by the 'command words' used in the question: 'Find', 'Calculate', 'Write down'.

Some candidates did not always change the settings on their calculator from degrees to radians where necessary, losing accuracy marks as a result.

Section A overview

Section A is designed to give candidates the opportunity to answer questions needing minimal reading and interpretation. Generally candidates found these accessible, but less able candidates struggled with questions 4 and 6**.**

Question 1

1 **In this question you must show detailed reasoning.**

Show that $\int_4^9 (2x+\sqrt{x})\mathrm{d}x = \frac{233}{3}$. **[3]**

This was generally well answered with candidates showing at least the indefinite integral, the substitution of the limits and the final answer; it is however good practice to show some intermediate steps as well. Marks were sometimes lost where intermediate steps were given in decimals and a small number of candidates struggled to use fractional indices correctly.

Exemplar 1

$\int_4^9 (2x+\sqrt{x})\,dx = \int_4^9 (2x+x^{\frac{1}{2}})\,dx$

$\cancel{= \int_4^9 (2x)dx + \int^9}$

$= \left[x^2 + \frac{2}{3}x^{\frac{3}{2}}\right]_4^9$

$= (9^2 + \frac{2}{3} \times 9^{\frac{3}{2}}) - (4^2 + \frac{2}{3} \times 4^{\frac{3}{2}})$

$= 99 - \frac{64}{3}$

$= \frac{233}{3}$

This exemplar shows sufficient detail for a 'Show that' question. The candidate has thought about the surd; changing this into a fractional index, then finding the indefinite integral. They have then clearly shown the substitution and evaluation to get the given answer.

Question 2

2 Show that the line which passes through the points $(2, -4)$ and $(-1, 5)$ does not intersect the line $3x + y = 10$. **[3]**

Most candidates correctly found the equation of the line joining the points. When solving the two equations simultaneously, some would stop at $2 \neq 10$ with no further comment. Many candidates who found only gradients commented that the lines were parallel but did not consider the possibility that the given points were on the line $3x + y = 10$. Fortunately, relatively few thought that it was sufficient to show that either point lies on the given line (this received no marks).

Question 3(a)

3 The function $f(x)$ is given by $f(x) = (1 - ax)^{-3}$, where a is a non-zero constant. In the binomial expansion of $f(x)$, the coefficients of x and x^2 are equal.

(a) Find the value of a. **[3]**

A number of candidates could not apply the binomial expansion with a negative power, however the majority were able to expand sufficiently well to earn the method mark. Algebraic slips, lack of care with negative signs and failing to use brackets led to most of the mistakes seen. The second method mark was given for equating coefficients, so many candidates lost 2 marks here even where the value *a* = 2 was seen.

?	**Misconception**	The word coefficient was seemingly not understood by many candidates who equated terms rather than coefficients. Candidates who subsequently lost one or more *x* from their equation were not given full marks here.

Question 3(b)(i)

(b) Using this value for a,

(i) state the set of values of x for which the binomial expansion is valid, **[1]**

About half the candidates realised that $|x| < 2$ was required here, but many lost the mark for omitting the modulus or using $\leq$. $|x| < \frac{1}{2}$ was also often seen.

Question 3(b)(ii)

(ii) write down the quadratic function which approximates $f(x)$ when x is small. **[1]**

Even when the value of *a* was correct, many candidates did not realise what was required here. Those candidates who had values other than 2 for *a* did not seem to realise their error when the coefficients of x and x^2 in their expansion were not equal.

Question 4

4 Fig. 4 shows a uniform beam of mass 4 kg and length 2.4 m resting on two supports P and Q. P is at one end of the beam and Q is 0.3 m from the other end.
Determine whether a person of mass 50 kg can tip the beam by standing on it. **[3]**

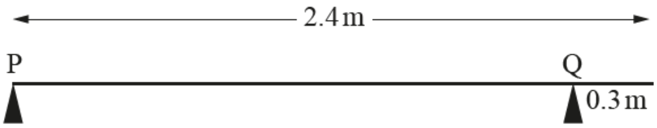


Fig. 4

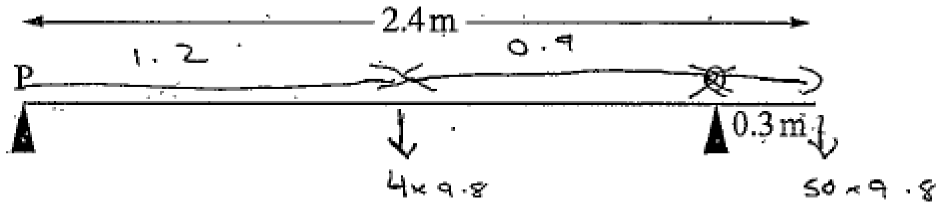
This more open-ended question was not well answered as many candidates did not write a convincing argument using the results of their calculations. Most realised moments were required and the first method mark was given for any use of moments. Some candidates omitted *g* in their calculations.

This question was most easily answered by taking moments about Q, the point about which the beam would turn if the person stood in a suitable place. A correct solution can also be constructed from moments about P, to give a value for the reaction at Q that was larger than the combined weights of the beam and the person, then arguing that the beam would need to be held down at P to maintain equilibrium.

Candidates often did not explain where their equations or terms came from or what they signified. Full marks were only given where sufficient explanation was also seen.

?	**Misconception**	Some candidates found the value of the reaction at either P or Q for the beam alone without realising that the reactions will be different when the person stands on the beam.

Exemplar 2



$4 \times 9.8 \times 0.9 = 35.28$ moments

$50 \times 9.8 \times 0.3 = 147$ moments

the person can tip the beam

This exemplar shows the importance of making explicit the link between the mathematical working and the conclusions to be drawn. Here they have written some correct arithmetic but not explicitly stated that their conclusion is based upon comparing these values (the anticlockwise and clockwise moments about Q) to show that the person's weight will tip the beam.

Question 5

5 A car of mass 1200 kg travels from rest along a straight horizontal road. The driving force is 4000 N and the total of all resistances to motion is 800 N.
Calculate the velocity of the car after 9 seconds. **[4]**

A few candidates were not clear about the distinction between mass and weight and used $F = mga$ for Newton's second law. The majority of candidates knew how to calculate the acceleration and use it to find the velocity. Some rounded or truncated their acceleration, but rarely so much that their final answer did not agree with the given answer to at least 2 significant figures.

Question 6(a)

6 **(a)** Prove that $\dfrac{\sin\theta}{1-\cos\theta}-\dfrac{1}{\sin\theta}=\cot\theta$. **[4]**

The majority of good answers were well structured, working from the left-hand side to the right. Many candidates began well, attempting to use a common denominator and replacing $\sin^2\theta$ with $1-\cos^2\theta$, but did not factorise to complete the proof. A significant number of candidates had fragments of working, presumably with restarts, but no wording or structure to help the examiner follow their argument. Candidates who began with the complete statement and rearranged to reach a known identity rarely argued it sufficiently well to get full marks.

Question 6(b)

(b) Hence find the exact roots of the equation $\dfrac{\sin\theta}{1-\cos\theta}-\dfrac{1}{\sin\theta}=3\tan\theta$ in the interval $0 \leqslant \theta \leqslant \pi$. **[3]**

Most candidates used the given result to obtain a quadratic in $\tan\theta$, a few candidates finding quadratics in $\sin\theta$ or $\cos\theta$. Many only used the positive square root and so only obtained one root. Others lost marks for giving their answer as decimals or in degrees.

	AfL	Check whether the question expects more than one root and if your working only gives one root, check for an error or omission.

Section B overview

Many candidates scored well in section B. Many did well with the modelling and problem solving, but Question 15 caused a lot of difficulty.

Question 7

7 The velocity $v\,\text{m}\,\text{s}^{-1}$ of a particle at time t s is given by

$v = 0.5t(7-t)$.

Determine whether the **speed** of the particle is increasing or decreasing when $t = 8$. **[4]**

Many candidates correctly evaluated acceleration to show that the velocity is decreasing and did not consider the value of velocity, or the concept of speed, at all. Others who had the negative values for v and a did not complete their argument. Candidates who used a good sketch graph of velocity were almost all successful here.

Some candidates wasted time here by using the product rule for differentiation rather than expanding the brackets.

?	**Misconception**	Candidates did not appear to understand the distinction between velocity and speed.

	AfL	The command word 'Determine' is not an instruction prohibiting the use of the numerical differentiation function on the calculator but it does indicate that an explicit line of reasoning must be seen to show that a is found by $a = \frac{\mathrm{d}v}{\mathrm{d}t}$.

Question 8(a)

8 An arithmetic series has first term 9300 and 10th term 3900.

(a) Show that the 20th term of the series is negative. **[3]**

Most candidates found the value for d and the correct value for the twentieth term, although many did not comment that their value was negative; this was not penalised, but we would recommend such comments in future. Some divided the difference in terms by 10 instead of 9, which lost accuracy marks in both parts of the question. A few candidates used the 'total' formula instead of the 'term' formula.

Question 8(b)

(b) The sum of the first n terms is denoted by S. Find the greatest value of S as n varies. **[4]**

Whilst part (a) was designed as a hint for this second part of the question, a significant number of candidates ignored the hint and proceeded with the first alternative method successfully. Some who were attempting to find the first negative term often tried to solve total = 0 rather than term = 0. Some good answers were seen from candidates who had used lists of values from their calculator.

	AfL	It is possible to create lists of values for terms or totals on a calculator that can be the basis of a good solution. Many candidates however did not show sufficient evidence to make a sound conclusion. The minimum required here was clearly labelled values for the total immediately either side of the maximum value seen; ideally an argument that the formula for total is quadratic so the maximum found is the maximum globally, or that the total will keep decreasing as the terms will remain negative should be given.

Question 9(a)

9 A cannonball is fired from a point on horizontal ground at $100\,\mathrm{m\,s^{-1}}$ at an angle of $25°$ above the horizontal. Ignoring air resistance, calculate

(a) the greatest height the cannonball reaches, **[3]**

This question is a very standard question and was well answered. Some candidates did not have their calculator set to degrees. A good number of candidates used a two-stage calculation, finding the time to reach the top as well as the height; this is an inefficient, but valid method. The method mark can only be awarded when both parts are attempted.

Question 9(b)

(b) the range of the cannonball. **[4]**

This was also well answered, with only a few candidates using only half the time interval; this lost both of the first 2 marks, but the last 2 marks were both still available. A few candidates had a weight term in the horizontal direction as well as the vertical. Few vector solutions were seen.

Question 10(a)

10 **(a)** Express $7\cos x - 2\sin x$ in the form $R\cos(x+\alpha)$ where $R > 0$ and $0 < \alpha < \frac{1}{2}\pi$, giving the exact value of R and the value of α correct to 3 significant figures. **[4]**

This is a very standard question that most candidates were at least able to begin. Some solutions were chaotic in how they were set out, however. There was some confusion with signs and which way up the equation for $\tan\alpha$ should be. Marks were lost for decimal values for R as well as values for α incorrectly rounded or given in degrees.

Question 10(b)

(b) Give details of a sequence of two transformations which maps the curve $y = \sec x$ onto the curve $y = \dfrac{1}{7\cos x - 2\sin x}$. **[3]**

Candidates who wrote out the equation of the curve in R, α form were generally the most successful here. The descriptions of the transformations were often attempted without technical language or vector notation. It was a predictable error to give the scale factor as $\sqrt{53}$. Follow-through was given for incorrect values of R and α.

	AfL	Candidates should expect that the two parts of a question like this are likely to be linked and that they should use their answer from part (a) here. They should also be prepared to use the technical language here, i.e. stretch and scale factor rather than enlargement as well as translation instead of shift/move along with proper vector notation used.

Question 11(a)

11 In this question, the unit vector $\mathbf{i}$ is horizontal and the unit vector $\mathbf{j}$ is vertically upwards.

A particle of mass 0.8 kg moves under the action of its weight and two forces given by $(k\mathbf{i}+5\mathbf{j})\,\mathrm{N}$ and $(4\mathbf{i}+3\mathbf{j})\,\mathrm{N}$. The acceleration of the particle is vertically upwards.

(a) Write down the value of k. **[1]**

Many candidates produced quite a bit of working for a 'Write down…' question, but many had the correct value. The mark was not given where *k* was given as a vector.

Question 11(b)

Initially the velocity of the particle is $(4\mathbf{i}+7\mathbf{j})\,\mathrm{m\,s^{-1}}$.

(b) Find the velocity of the particle 10 seconds later. **[4]**

There was considerable confusion about whether to use vectors or scalars and some candidates had equations with a mixture. More common was the omission of the weight in the N2L equation, resulting in an incorrect acceleration and eventually a very large vertical component of the velocity. Again, there was a lot of premature rounding of intermediate calculations, but there was some very efficient work from many candidates. Some realised that the fact there was a zero-horizontal component of force meant that they could work in a vertical direction until the end of the question, but the final answer had to be a vector.

Question 12

We are sorry for the error on this question. During marking, we looked at the performance of candidates taking the paper. As a result, we decided the fairest approach was to award all candidates full marks for question 12(a) and question 12 (b). However, we are pleased that there was little evidence that this question had an impact on candidate progress on the rest of the paper.

Question 12(a)

12 Fig. 12 shows a curve C with parametric equations $x = 4t^2$, $y = 4t$. The point P, with parameter t, is a general point on the curve. Q is the point on the line $x+4=0$ such that PQ is parallel to the x-axis. R is the point (4, 0).

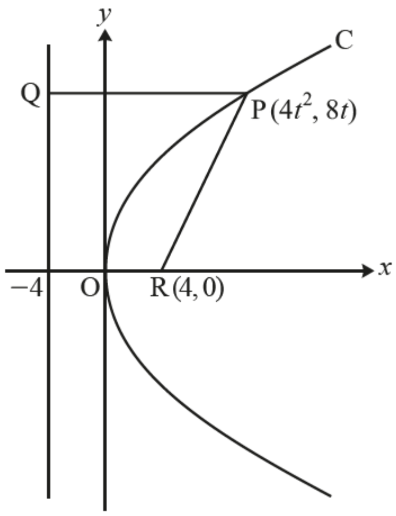


Fig. 12

(a) Show algebraically that P is equidistant from Q and R. **[4]**

The majority of candidates took the information for their calculations from the diagram and appeared not to notice that there was an error in the second equation in the stem of the question. Only a small minority made any comment about the error or used both given expressions for *y.*

The algebraic manipulation required in this question is quite tricky and many good solutions were seen, as were very poor or fragmented solutions.

A very small number of candidates who had used the value from the stem then repeated the work with the value from the diagram and were thus disadvantaged in the examination.

Question 12(b)

(b) Find a cartesian equation of C. **[2]**

This was generally well done, with most candidates using the parametric equations from the stem of the question without comment.

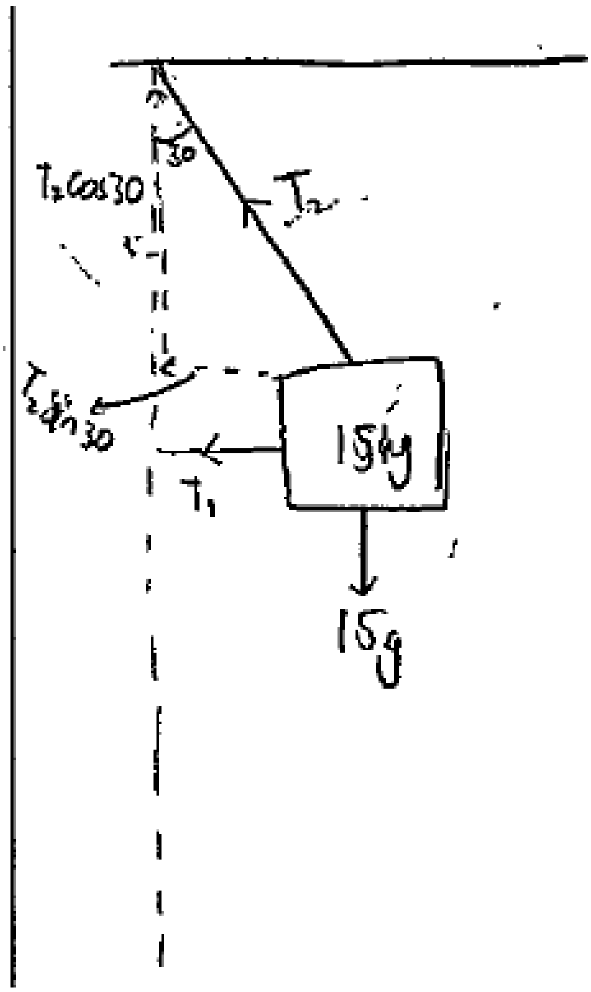
Question 13(a)

13 A 15 kg box is suspended in the air by a rope which makes an angle of 30° with the vertical. The box is held in place by a string which is horizontal.

(a) Draw a diagram showing the forces acting on the box. **[1]**

This question was mostly well done, but some diagrams omitted arrows. Some had two arrows on the strings, presumably because they believed that it was necessary to show the tension from both ends; if the arrow closest to the box was correct this was marked correct. A few had both forces on the same side of the box and occasionally other forces appeared (such as a normal reaction). The mark was also lost where *T* was used for both tensions, rather than inventing different names.

Exemplar 3



This exemplar shows good practice in that the forces and the components of the forces used in later parts are shown very differently. Unfortunately, the horizontal force is in the wrong direction and the mark could not be awarded (although the candidate was able to achieve full marks in part (c) with a negative value for the tension).

Question 13(b)

(b) Calculate the tension in the rope. **[2]**

This was mostly done correctly, but some candidates interchanged sine and cosine either in error or by marking the wrong angle 30°. Some candidates resolved the weight rather than the tension, creating an incorrect equilibrium equation.

Question 13(c)

(c) Calculate the tension in the string. **[2]**

This was also done well by those candidates who had a good diagram in part (a).

Question 14(a)

14 Fig. 14 shows a circle with centre O and radius r cm. The chord AB is such that angle AOB $= x$ radians. The area of the shaded segment formed by AB is 5% of the area of the circle.

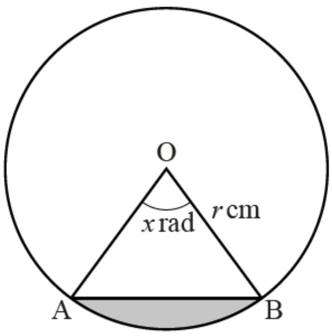


Fig. 14

(a) Show that $x - \sin x - \frac{1}{10}\pi = 0$. **[4]**

For candidates who clearly labelled the areas of the regions, this was quite a straightforward proof. Errors usually came from omitting the square for the radius or using incorrect formulae. Some candidates looked to the given answer and tried to get the 5% to give the fraction 1/10.

Question 14(b)

14 Fig. 14 shows a circle with centre O and radius r cm. The chord AB is such that angle AOB $= x$ radians. The area of the shaded segment formed by AB is 5% of the area of the circle.

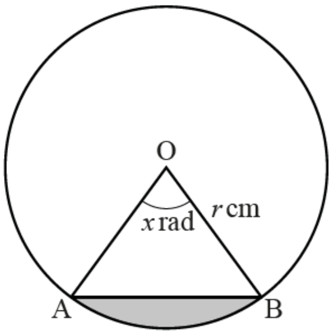


Fig. 14

The Newton-Raphson method is to be used to find x.

(b) Write down the iterative formula to be used for the equation in part **(a)**. **[1]**

The generic formula for Newton-Raphson iteration is given in the formula pages, so candidates should not have expected that all that was required was copying this and doing nothing more. Some lost the mark for the formula by giving only the expression from the right-hand side, missing the $x_{n+1} =$ to complete the formula. Where the formula only appeared in part (c), the mark for part (b) was not given retrospectively unless the candidate indicated where their answer was to be found.

Question 14(c)

(c) Use three iterations of the Newton-Raphson method with $x_0 = 1.2$ to find the value of x to a suitable degree of accuracy. **[3]**

A calculator set in degrees gave a sequence that did not converge, but many candidates did not realise how to fix the issue.

Some candidates who had a converging sequence did not use their answers to give a value for the root.

Exemplar 4

$x_0 = 1.2$

$x_{n+1} = \sin x_n + \frac{1}{16}\pi$

$x_1 = 1.246\cancel{1}2$
$x_2 = 1.2462$
$x_3 = 1.2668$
$x_4 = 1.2683$
$x_5 = 1.2688$
$x_6 = 1.2689$
$x_7 = 1.2689$
$x_8 = 1.2689$

$x = 1.269$

The question asks for the Newton-Raphson method to be used, yet in this example the $x = g(x)$ method is used. The method mark in part (c) was awarded for three terms of whichever sequence the candidate used but the first accuracy mark was not awarded since these are not the correct terms from the Newton-Raphson method. The second accuracy mark was given here as the sequence is seen converging to the correct root.

Question 15(a)

15 A model for the motion of a small object falling through a thick fluid can be expressed using the differential equation

$$\frac{dv}{dt} = 9.8 - kv,$$

where $v\,\mathrm{m\,s^{-1}}$ is the velocity after t s and k is a positive constant.

(a) Given that $v = 0$ when $t = 0$, solve the differential equation to find v in terms of t and k. **[7]**

Most candidates did attempt to separate the variables and the first mark was given even when the rearrangement was clearly the result of poor algebra and was not in the required form for integrating. Candidates who wrote $\frac{dt}{dv} = \frac{1}{9.8 - kv}$ were much more likely to integrate correctly. Many other candidates did not have the equation in the correct form so lost all the accuracy marks, however further method marks were available for using the boundary conditions and for rewriting into the form '$v =$'.

Some candidates with knowledge of Further Maths techniques were usually successful, when using for example an integrating factor.

Exemplar 5

$v = 9.8t - kvt$

$v + kvt = 9.8t$

$v(1 + kt) = 9.8t$

$v = \dfrac{9.8t}{1+kt}$

This candidate has not separated the variables here and treats *v* as a constant value. However, the solution is written in the form '*v* = ...' so the third method mark was given (it was not dependent on the first M mark). This is an example of an incorrect function that has a non-zero limiting value for large values of *t,* so all marks were available in parts (b) and (c).

Question 15(b)

(b) Sketch the graph of v against t. **[2]**

The shape of the graph was often drawn well by candidates who used the context rather than their solution, with the zero initial velocity and the terminal velocity using the zero value for acceleration directly from the differential equation. One follow-through mark was given for a graph through the origin with approximately the correct shape of their velocity.

Question 15(c) and (d)

Experiments show that for large values of t, the velocity tends to $7\,\mathrm{m\,s^{-1}}$.

(c) Find the value of k. **[2]**

(d) Find the value of t for which $v = 3.5$. **[1]**

Part (c) can be answered directly from the differential equation, with the understanding that the velocity tends to zero when the acceleration tends to zero also. Candidates who were successful in part (a) were able to access these marks.

Question 16(a)

16 A particle of mass 2 kg slides down a plane inclined at 20° to the horizontal. The particle has an initial velocity of $1.4\,\text{m}\,\text{s}^{-1}$ down the plane. Two models for the particle's motion are proposed.

In model A the plane is taken to be smooth.

(a) Calculate the time that model A predicts for the particle to slide the first 0.7 m. **[5]**

Most candidates realised the need to resolve in the direction of motion and there were plenty of fully correct answers. A few candidates tried to resolve horizontally and vertically, but usually had incomplete or incorrect equation so their working did not lead to a solution.

	AfL	In a question like this it is expected that candidates use their calculator to solve the quadratic equation they have set up.

Question 16(b)

(b) Explain why model A is likely to underestimate the time taken. **[1]**

Candidates need to give a proper explanation here; just stating that there is a friction force is not enough, the mark was for explaining that the resistance would result in a slowing of the particle.

	AfL	In a question starting 'Explain…' a response stating friction is present is not enough. The link between force information and time taken also needs to be explained, with a reference to acceleration or velocity in some way.

Question 16(c)

In model B the plane is taken to be rough, with a constant coefficient of friction between the particle and the plane.

(c) Calculate the acceleration of the particle predicted by model B given that it takes 0.8 s to slide the first 0.7 m. **[2]**

This was well answered, but some candidates were uncomfortable with the negative value they obtained and tried to change that.

Exemplar 6

$u = 1.4 \quad s = 0.7 \quad a = ? \quad t = 8$

$s = ut + \frac{1}{2}at^2$

$0.7 = (1.4)(8) + \frac{1}{2}a(8)^2$

$-10.5 = \frac{1}{2}a(64)$

$|a| = 0.328$

This exemplar shows the application of the misread rule. It is clearly stated that the value to be used is 8 rather than the 0.8 in the question. It also shows how the sign of the acceleration has been disregarded (some candidates just ignored the minus); this candidate did at least use modulus notation, before assuming that the acceleration must be positive because the particle is moving down a slope. Candidates who changed $a = -1.3125$ to 1.3125 were not given the A mark.

Question 16(d)

(d) Find the coefficient of friction predicted by model B, giving your answer correct to 3 significant figures. **[6]**

Many fully correct solutions were seen, with candidates able to resolve in two directions and manipulate the algebra to obtain a value for the coefficient of friction.

?	**Misconception**	Candidates need to be aware that the *F* in the equation $F = ma$ and the *F* in the equation $F \leq \mu R$ are not the same. It can be better to teach Newton's second law as 'resultant force = *ma*' rather than use the shorthand equation.

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