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Examiners' report

MATHEMATICS B (MEI)

H630

For first teaching in 2017

H630/01 Summer 2023 series

Version 1

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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 is 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.

Paper 1 series overview

This paper enabled many candidates to demonstrate what they knew and most questions were accessible to the majority of candidates. Candidates who worked algebraically often did well, while those attempting numerical methods often did not show enough evidence of their answer (if they reached one). Other candidates did not make full use of the calculators they had.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• worked algebraically rather than numerically to solve equations • found efficient ways of using their calculator • indicated to the examiner what they were attempting • were able to explain their reasoning when required.	• did not indicate their method, which would help the examiner award part-marks where the final answer was incorrect • worked numerically without explaining their method or giving sufficient evidence that their answer was correct • did not remember formulae correctly, or used them inappropriately.

Question 1

1 A particle moves along a straight line. Its velocity $v\,\mathrm{m\,s^{-1}}$ at time t s is given by $v = 2t + 0.6t^2$.

Find an expression for the acceleration of the particle at time t. **[2]**

Most candidates were able to answer this question correctly. A minority inappropriately used the *suvat* equations or divided by *t* to find the average acceleration instead.

Question 2 (a)

2 The height of the first part of a rollercoaster track is h m at a horizontal distance of x m from the start. A student models this using the equation $h = 17 + 15\cos 6x$, for $0 \leqslant x \leqslant 40$, using the values of h given when their calculator is set to work in degrees.

(a) Find the height that the student's model predicts when the horizontal distance from the start is 40 m. **[1]**

Most responses were correct, although some candidates tried to solve by equating the expression for height to 40 instead. Occasionally, candidates had their calculators set to radians and so this mark was lost.

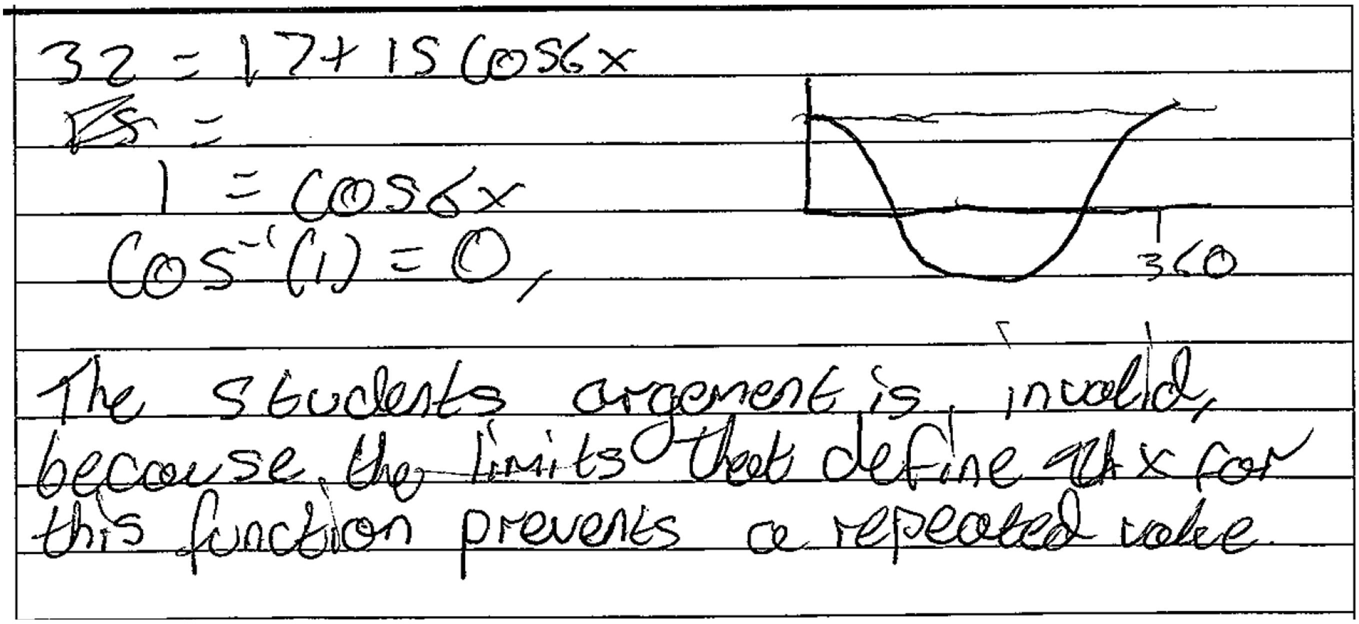
Question 2 (b)

(b) The student argues that the model predicts that the rollercoaster track will achieve a maximum height of 32 m more than once because the cosine function is periodic.

Comment on the validity of the student's argument. **[2]**

This question was not asking for a comparison between the real-life situation and the model, so responses referring to modelling assumptions did not score the mark. Many candidates realised that the key to this question is the periodicity of the cosine function without mentioning that the $\cos 6x$ function has a period of 60, not 360. A clear indication that the restricted domain for *x* did not include 60, or that the maximum value of 6*x* (i.e. 240) is too small for the function to return to its maximum, was required here.

Exemplar 1



$32 = 17 + 15\cos 6x$

$1 = \cos 6x$

$\cos^{-1}(1) = 0,$

The students argument is invalid, because the limits that define the x for this function prevents a repeated value.

The exemplar is an example of a response that was not detailed enough to be given the mark. The graph shows the basic cosine function that is periodic with a period of 360, not the cos 6*x* function that is periodic with a period of 60.

Question 3 (a)

3 The points A and B have position vectors $\begin{pmatrix} 2 \\ -1 \end{pmatrix}$ and $\begin{pmatrix} 5 \\ 4 \end{pmatrix}$ respectively. The vector $\overrightarrow{AC}$ is $\begin{pmatrix} -2 \\ 2 \end{pmatrix}$.

(a) Write down the position vector of C as a column vector. **[1]**

Correct values and correct notation were required for the mark here. Incorrect responses generally mixed up adding and subtracting vectors.

Question 3 (b)

(b) Show that B is equidistant from A and C. **[3]**

Most candidates found the two lengths as correct surds, although some candidates did not state their conclusion that B was equidistant from A and C. Others argued directly from the components that the vectors had the same magnitude, so the points were equidistant. Where incorrect vectors were found, some credit was given for finding both the lengths.

Question 4

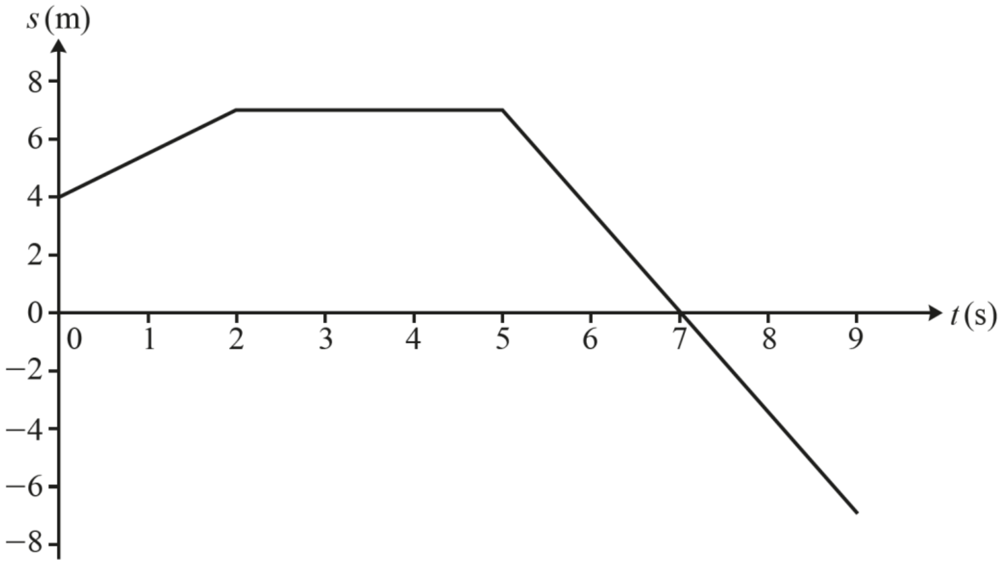
4 **In this question you must show detailed reasoning.**

Solve the equation $6\cos^2 x + \sin x = 5$, giving all the roots in the interval $-180° \leqslant x \leqslant 180°$. **[5]**

Candidates generally knew to use the trig identity to obtain a quadratic in $\sin x$. Full credit was given to candidates who used their calculator to solve their quadratic once it was written with a right-hand side of zero. Most candidates could then get at least one solution, but many struggled to find all the solutions in the range (generally with the negative values causing difficulties).

Question 5 (a)

5 The graph shows displacement s m against time t s for a model of the motion of a bead moving along a straight wire. The points (0, 4), (2, 7), (5, 7) and (9, –7) are the endpoints of the line segments.



(a) Find an expression for the displacement of the bead for $0 \leqslant t \leqslant 2$. **[2]**

The first mark was given for finding the gradient and full marks for the fully correct equation $s = 1.5t + 4$.

Assessment for learning

It was vital here to give s in terms of t, as x is most commonly used for horizontal displacement in Mechanics. It is good practice to be aware of correct variables throughout the course, especially as calculator equation solving software generally uses x.

Question 5 (b)

(b) Sketch the velocity-time graph for this model. **[2]**

Credit was given for graphs consisting of three horizontal lines. The graph only received full credit when the values of the velocities were seen on the graph. It was clear that some candidates did not appreciate that straight lines on a displacement-time graph mean the velocities are constant and a negative gradient indicates a negative velocity.

Question 5 (c)

(c) Explain why the model may not be suitable at $t = 2$ and $t = 5$. **[1]**

The graph describes a model where the velocities are constant with instantaneous changes in velocity at *t* = 2 and *t* = 5. Candidate were expected to point out that this was not achievable in the real world.

Misconception

A significant minority of candidates thought that at the times between *t* = 2 and *t* = 5 (where the velocity is zero) the bead had no velocity and that was the issue referred to in the question.

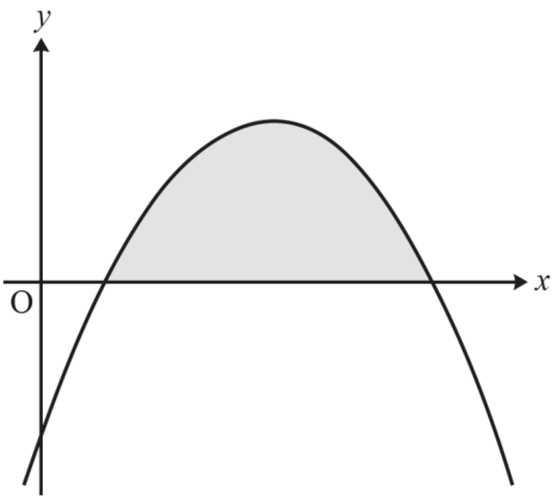
Question 6

6 Show that the expression $3x^3 + x^2 - 6x - 5$ can be written in the form $(x+2)(ax^2 + bx + c) + d$ where a, b, c and d are constants to be determined. **[5]**

There were many good responses to this question, both with long division and a grid method. The main difficulties arose because the division left a remainder (since (*x* + 2) is not a factor). For candidates who only knew the leading coefficient would be 3, the first B mark was given without any other working. Some candidates used the remainder theorem to find the remainder of -13. Where candidates worked by inspection, credit was given where at least one of *b* and *c* were correct.

Question 7

7 In this question you must show detailed reasoning.



Find the exact area of the shaded region shown in the diagram, enclosed by the x-axis and the curve $y = -3x^2 + 7x - 2$. **[6]**

In this detailed reasoning question, a correct answer from a graphical calculator with no supporting working received no marks. Most candidates showed clear working to find the limits and the indefinite integral as well as the final answer. Substitution of the limits was also expected to be seen. Some candidates really struggled to work with exact fractional values and gave a decimal approximation for their answer, but this was not enough for the final A mark, no matter how many decimal places were written.

Assessment for learning

Where the question asks for detailed reasoning, show all the steps required to reach the answer. This does not mean a non-calculator method must be used, however. Here, where the three-term quadratic was seen equal to zero and the correct roots of the equation, marks were not lost for using a calculator to solve the quadratic.

Question 8 (a)

8 In this question you must show detailed reasoning.

(a) Find the centre and radius of the circle with equation $x^2 + y^2 - 2x + 4y - 20 = 0$. **[4]**

There were many fully correct solutions here, however some were seen with sign errors in finding the coordinates of the centre. 2 marks were lost by candidates who wrote that $x^2 - 2x = (x - 1)^2 + 1$ or similar for the y terms as this was deemed to be a more serious error than a sign error for the centre. It was not uncommon to see a radius of $\sqrt{15}$, through similar sign errors.

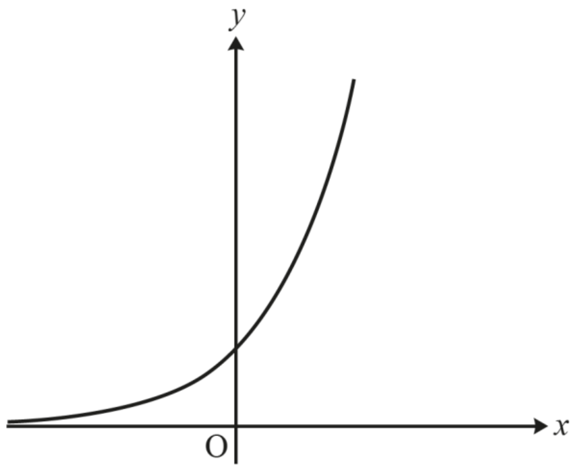
Question 8 (b)

(b) Find the points of intersection of the circle with the line $x+3y-10=0$. **[5]**

Many correct solutions were seen for this with clear substitution of $x = 10 – 3y$ giving the simplest method. Some candidates who used $y = \frac{1}{3}(10 – x)$ had problems with the fractions that arose. A follow through mark was given for the second coordinate of each of their points.

Question 9 (a)

9 The graph shows the function $y = e^{2x}$.



(a) Describe the transformation of the graph of $y = e^x$ that gives the graph of $y = e^{2x}$. **[2]**

Candidates were given no marks without the word 'stretch' and needed either 'scale factor $\frac{1}{2}$' or 'in the x-direction' for the first mark. Both were needed for full marks.

Misconception

Some candidates seem to think that a stretch by scale factor 2 in the y-direction is equivalent to a stretch in the x-direction with scale factor $\frac{1}{2}$. This is not the case.

Question 9 (b)

A second function is defined by $y = k + e^x$.

(b) A copy of the graph of $y = e^{2x}$ is given in the Printed Answer Booklet.

Add a sketch of the graph of $y = k + e^x$ in a case where k is a positive constant. **[2]**

The given graph has been stretched in the *x*-direction, so candidates needed to draw their response less steep than the given graph; many candidates lost a mark for not making that effect on the gradient clear. More candidates were aware that the graph of $y = e^x$ should be translated in the *y*-direction to give an asymptote parallel to and above the *x*-axis and an intersection with the *y*-axis above that for the given graph.

Question 9 (c)

(c) Show that the two graphs do not intersect for values of k less than $-\frac{1}{4}$. **[3]**

Many candidates were unsuccessful here. Some used an arbitrary value of *k* less than $-\frac{1}{4}$. Few seemed to realise that the points of intersection were to be found by solving a quadratic equation in e^x and the value of $-\frac{1}{4}$ was found from the discriminant.

Question 9 (d)

(d) In the case where $k = 2$, show that the only point of intersection occurs when $x = \ln 2$. **[2]**

Very few correct solutions were seen, as were responses verifying that $x = \ln 2$ was a correct solution.

Exemplar 2

$y = e^{2x}$ $\qquad y \neq k + e^{x}$

$$e^{2x} = k + e^{x}$$
$$\ln e^{2x} = \ln k + \ln e^{x}$$
$$2x = \ln k + x$$
$$x = \ln k$$

$k = 2$: $\qquad x = \ln 2$

This exemplar shows a very typical incorrect response, where a misconception about the laws of logs appears to give the required solution. This was given no marks.

Question 10 (a) (i)

10 Layla invests money in the bank and receives compound interest. The amount £L that she has after t years is given by the equation $L = 2800 \times 1.023^{t}$.

(a) **(i)** State the amount she invests. **[1]**

This was almost always answered correctly.

Question 10 (a) (ii)

(ii) State the annual rate of interest. **[1]**

A few candidates mixed up the percentage 2.3% with the scale factor of 1.023 and lost this mark.

Question 10 (b)

Amit invests £3000 and receives 2% compound interest per year. The amount £A that he has after t years is given by the equation $A = ab^t$.

(b) Determine the values of the constants a and b. **[2]**

This was an easy question on constructing a model. Candidates were expected to adapt the model for one investment for the other. Sometimes b = 2% or 0.02 were seen.

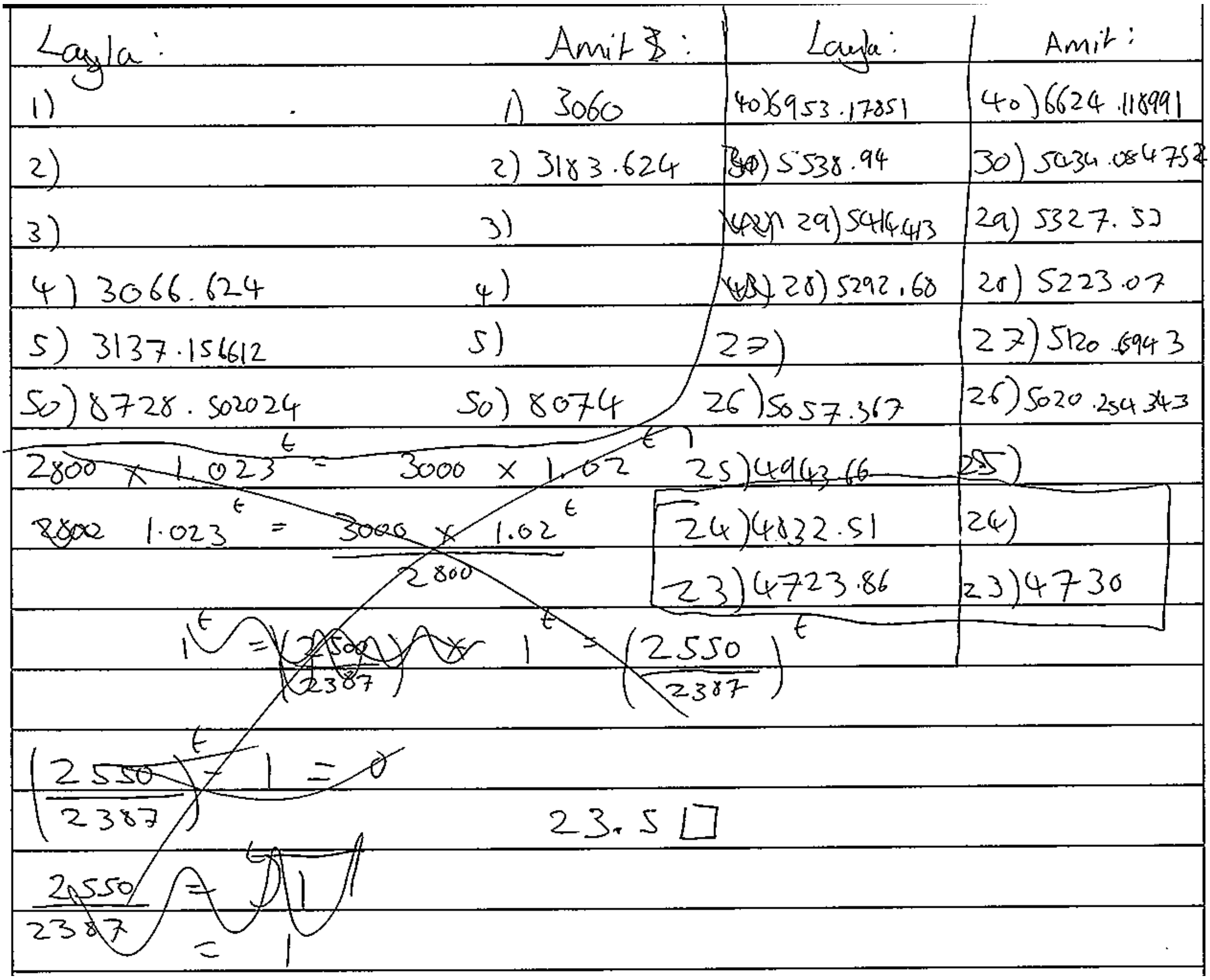
Question 10 (c)

(c) Layla and Amit invest their money in the bank at the same time.

Determine the value of t for which Layla and Amit have equal amounts in the bank. Give your answer correct to **1** decimal place. **[3]**

Candidates generally realised the equation they needed to solve, but few correct algebraic solutions were seen. Those who used the laws of logs correctly often went on to solve the resulting linear equation correctly. Those who took logs first often wrote products of logs such as $\log 2800 \times \log 1.023^t$ and thus made very little progress. Those who attempted to collect like terms usually made a better impression, but failed (as above) by incorrectly applying the addition rule for logs. Other errors involved combining the product before raising the power, e.g. $2800 \times 1.023^t = 2864.4^t$, etc.

Exemplar 3



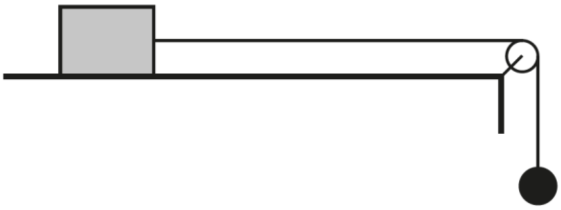
In this exemplar, there is a crossed-out attempt to collect t terms, but this is replaced with a numerical method. The candidate explains what they are attempting and states the correct answer (to 1 decimal place). They were only given 2/3 marks here as the matching value of £4778 was not given despite many other values being listed. As in this case, the method can be inefficient, but table mode can create side by side lists of values for two functions.

Assessment for learning

Numerical methods can be fully correct solutions, but they only get full marks where the answer is fully supported. Here, an attempt to calculate at least one value for the investment at matching times gets the first mark. Showing the value of the investment at $t = 23.5$ for both and a comment that this means 23.5 is the solution would have received full marks.

Question 11 (a)

11 A block of mass 3 kg is at rest on a smooth horizontal table. It is attached to a light inextensible string which passes over a smooth pulley. This part of the string is horizontal. A sphere of mass 1.2 kg is attached to the other end of the string. The sphere hangs with this part of the string vertical as shown in the diagram. A horizontal force of magnitude F N is applied to the block to prevent motion.



(a) Complete the copy of the diagram in the Printed Answer Booklet to show all the forces acting on the block and the sphere. **[2]**

Many fully correct diagrams were seen. Some candidates did not mark the tensions on the block and the sphere as being the same, while some did not make it clear that the weights were different.

Assessment for learning

A force diagram is not correct unless every force is shown as an arrow in the right direction. Where there are two weights, mark each one with *mg* N with the correct value for mass for each object. Where the tensions are the same, do not label them T_1 and T_2.

Question 11 (b)

(b) Find the value of F. **[2]**

Some candidates just wrote down F = 11.76 N and were given full marks. It is better to write down the equilibrium equation for the sphere, giving T = 11.76 N and the equilibrium equation for the block giving $F = T$.

Question 11 (c)

The force F N is removed, and the system begins to move.

(c) The equation of motion of the block is $T = 3a$, where T N is the tension in the string and $a\,\text{m}\,\text{s}^{-2}$ is the acceleration of the block.

Write down the equation of motion of the sphere. **[1]**

The equation of motion of the sphere needs to show the resultant force on the sphere equated to mass multiplied by acceleration. It is best to use T and only substitute $T = 3a$ in part (d) when finding the acceleration of the system and the tension by solving the two equations of motion simultaneously.

Assessment for learning

The tension in the string will not be the same in the moving system as it was when the additional force F held the system in equilibrium.

The second equation of motion should have the direction of motion as the positive direction to match the given equation.

Question 11 (d)

(d) Find the value of T. **[2]**

Many correct solutions were found here, most finding the value for acceleration first.

Question 12

12 Points A, B and C lie in a straight line in that order on horizontal ground. A box of mass 5 kg is pushed from A to C by a horizontal force of magnitude 8 N. The box is at rest at A and takes 3 seconds to reach B. The ground is smooth between A and B. Between B and C the ground is rough and the resistance to motion is 28 N. The box comes to rest at C.

Determine the distance AC. **[8]**

There were many fully correct solutions seen here, with candidates realising there were two phases of motion with different accelerations that need to be calculated from force information in the question. Some did not realise that the final velocity for the first phase was the initial velocity for the second phase. The question was marked allowing for follow through for the final 2 accuracy marks.

Assessment for learning

Most of the wrong working arose from a misunderstanding that the driving force of 8N only acts during the first phase of motion. The question does state that the driving force acts to push the object from A to C. Reinforce the importance of reading all the detail in a question, especially when it is worth 8 marks.

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