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Examiners' report

MATHEMATICS A

H240

For first teaching in 2017

H240/03 Summer 2024 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 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 3 series overview

This is the third examination component for the A Level examination for GCE Mathematics A. It is a two-hour paper consisting of 100 marks which tests content from Pure Mathematics (Section A, 51 marks) and Mechanics (Section B, 49 marks). Pure Mathematics content is tested on all three papers, and any topic could be tested on any of the three papers. Inevitably, the report that follows will concentrate on aspects of the candidates' performance where improvement is possible to assist centres in preparing candidates for future series'. However, this should not obscure the fact that a significant number of candidates who sat this paper in this produced solutions which were a pleasure for examiners to assess. Many candidates demonstrated an impressive level of mathematical ability and insight which enabled them to meet the various challenges posed by this paper on both the pure and mechanics content; precision, command of correct mathematical notation and excellent presentational skills were evident in many scripts.

The specification includes some guidance about the level of written evidence required in assessment questions; these were provided to reflect the increased functionality of the available calculators and the changes in assessment objectives, since there is a significant change from when the equivalent legacy qualifications were designed. There was one question and two part-questions on this paper which began with the demand 'In this question you must show detailed reasoning'; to quote the specification, 'when a question includes this instruction candidates must give a solution which leads to a conclusion showing a detailed and complete analytical method. Their solution should contain enough detail to allow the line of their argument to be followed. This is not a restriction on a candidate's use of a calculator when tackling a question, but it is a restriction on what will be accepted as evidence of a complete method.' The specification then considers several examples which centres should consider so that future candidates understand exactly what is required when this request appears in future series. This command phrase features in Questions 2, 4 (b) (i) and 12 (c).

The word 'determine' in a question does not simply imply that candidates should find the answer but, to quote the specification, 'this command word indicates that justification should be given for any results found, including working where appropriate.' This command word features in Questions 3 (c), 5 (b), 6 (b) (i), 7, 8 (b), 9 (a), 10 (a), 10 (b), 11 (b) and 13 (b). The phrase 'Show that' generally indicates that the answer has been given, and that candidates should provide an explanation that has enough detail to cover every step of their working. This command phrase features in Questions 4 (a), 4 (b) (ii), 5 (a) (i), 11 (a) and 13 (a). While there is no specific level of working needed to justify answers to questions which use the command word 'find …', method marks may still be available for valid attempts that do not result in a correct answer, and standard advice (included in the specification) that candidates should state explicitly any expressions, integrals, parameters and variables that they use a calculator to evaluate (using correct mathematical notation rather than model specific calculator notation).

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• made efficient use of calculators • understood the level of response required for command words used in the questions • read questions carefully and provided the answers that were requested • used formal mathematical notation and language correctly.	• made careless mistakes in algebraic manipulation • used imprecise notation or language • provided mathematical working that was correct but did not answer the specific question that was being asked • did not give sufficient evidence in 'Show that' and 'Determine' questions.

Section A overview

Content from the Pure section of the specification may be assessed on any of the three papers of H240. Most candidates appeared well prepared for the pure content, with method marks being given, but there were a number of places where more concise use of algebraic notation and language may have led to more of the corresponding accuracy marks.

Question 1 (a)

1 Simplify each of the following.

(a) $(2a^2)^3 \times \frac{3}{4}a^{-1}$ **[2]**

While most candidates answered this question correctly it was common to see $(2a^2)^3$ evaluated incorrectly as either $2a^6$ or with an incorrect power of 5.

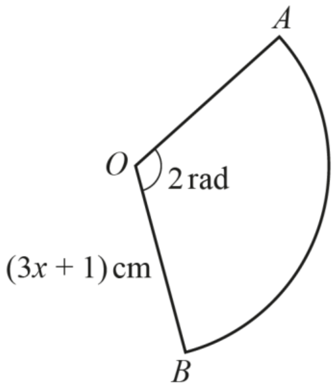
Question 1 (b)

(b) $\frac{4x^2-9}{(2x^2+5x-12)(2x+3)}$ **[2]**

Most candidates appreciated the need to factorise the quadratic expression in both the numerator and denominator and then simplify accordingly. Examiners noted that some candidates attempted to use partial fractions, but these attempts generally were not successful. It was pleasing to note that most candidates left their answer as $\frac{1}{x+4}$ and did not try to simplify this expression further.

Question 2

2 In this question you must show detailed reasoning.



The diagram shows a sector AOB of a circle with centre O and radius $(3x+1)$ cm. The angle AOB is 2 radians. The area of sector AOB is less than $(44x-7)\text{cm}^2$.

Find the set of possible values of x. Give your answer in set notation. **[5]**

Many candidates seemed unfamiliar with the formula $A=\frac{1}{2}r^2\theta$ for the area of a sector of a circle with θ measured in radians, with many either quoting incorrect formulae (so scoring no marks in this part) or having to convert from a corresponding formula with the angle given in degrees. Of those candidates who did know the correct formula most then simplified correctly to the inequality $9x^2-38x+8<0$. However, very few candidates showed a correct method for solving this quadratic inequality even though the question clearly said that 'detailed reasoning' must be shown. It was also the case that many candidates are still unfamiliar with set notation with many either leaving their answer as $\frac{2}{9}<x<4$, giving an answer using interval notation or using the symbol for 'union', rather than either correct answer of $\left\{x: \frac{2}{9}<x<4\right\}$ or $\left\{x: x>\frac{2}{9}\right\} \cap \{x: x<4\}$.

Assessment for learning

Candidates must be familiar with all the formulae given on pages 85–87 in [the H240 specification] (which will not be provided in the question paper).

Question 3 (a)

3 (a) Expand $(3-2x)^{-2}$ in ascending powers of x up to and including the term in x^2. **[4]**

This part was answered well with almost all candidates knowing the correct method for binomially expanding expressions of the form $(1+x)^n$ where $n \notin \mathbb{Z}^+$. The most common errors were not taking out the correct factor of $\frac{1}{9}$ or sign errors when evaluating either $(-2)\left(-\frac{2}{3}x\right)$ or $\frac{(-2)(-3)}{2!}\left(-\frac{2}{3}x\right)^2$.

Question 3 (b)

(b) State the set of values of x for which this expansion is valid. **[1]**

The most common incorrect answers seen in this part were either $|x| < 1$ or $|x| < \frac{2}{3}$.

Question 3 (c)

(c) When $\frac{a+x}{(3-2x)^2}$ is expanded in ascending powers of x, the coefficient of x is zero.

Determine the value of the constant a. **[2]**

This part was generally answered well with many candidates recognising the need to use the expansion from part (a), multiplying this by $(a + x)$ and then setting the coefficient of x equal to zero.

Question 4 (a)

4 **(a)** Show that the equation $2\cot^2 x - 9\operatorname{cosec} x - 3 = 0$ can be expressed in the form

$$5\sin^2 x + 9\sin x - 2 = 0.$$ **[3]**

Candidates were almost equally split between the two possible methods to derive the given result. The first method was to re-write the given equation (using $\cot x = \frac{\cos x}{\sin x}$ and $\operatorname{cosec} x = \frac{1}{\sin x}$) as $2\cos^2 x - 9\sin x - 3\sin^2 x = 0$ and then use the result that $\cos^2 x = 1 - \sin^2 x$ to obtain the required equation in sine. The second method was to use the identity $1 + \cot^2 x = \operatorname{cosec}^2 x$ to obtain $2\operatorname{cosec}^2 x - 9\operatorname{cosec} x - 5 = 0$ and then use $\operatorname{cosec} x = \frac{1}{\sin x}$ to obtain the given result. The only issue that examiners reported with the second method was that a number of candidates gave no indication of how they went directly from $2\operatorname{cosec}^2 x - 9\operatorname{cosec} x - 5 = 0$ to $2 - 9\sin x - 5\sin^2 x = 0$ which considering this was a 'show that' question meant that full credit could not be given. Furthermore, as this was a given answer all working needed to be correct as any errors seen meant that the final accuracy mark could not be given.

Question 4 (b) (i)

(b) (i) In this question you must show detailed reasoning.

Hence solve, for $0 < \theta < \pi$,

$2\cot^2 2\theta - 9\operatorname{cosec} 2\theta - 3 = 0$.

Give your answers correct to **3** decimal places. **[4]**

There were two main issues that candidates faced when answering this part. The first was that a good number did not appreciate that as this question required 'detailed reasoning'. They either showed no method for solving the quadratic in $\sin 2\theta$ or they gave no indication for why $\sin 2\theta$ could not equal -2. The other issue was that many candidates did not read the question carefully and instead solved the (simpler) equation of $2\cot^2\theta - 9\operatorname{cosec}\theta - 3 = 0$ and so scored only the first method mark. Of those that did solve the correct equation most gave the first root (0.101) correct to the required 3 decimal places but did not give the second to the same degree of accuracy (with many just stating the answer as 1.47).

Question 4 (b) (ii)

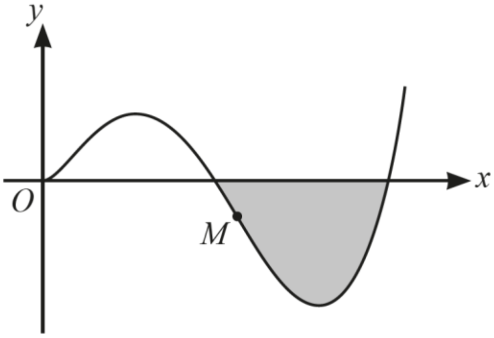
The small angle approximation for $\sin 2\theta$ is used to find an approximation for the smallest positive solution of the equation $2\cot^2 2\theta - 9\operatorname{cosec} 2\theta - 3 = 0$.

(ii) Show that this approximate solution is accurate to **2** decimal places. **[2]**

This part differentiated well with only the most successful recognising the need to apply the approximation $\sin 2\theta \approx 2\theta$, and then solve the resulting equation $5(2\theta)^2 + 9(2\theta) - 2 = 0$. Of those that did, not all realised the need to compare the smallest positive solution of this equation (which was 0.1000…) to the corresponding answer from the previous part (0.101) and conclude that both these values were the same to **2** decimal places.

Question 5 (a) (i)

5



The diagram shows the curve with equation $y = (x^3 - 2x^2)\ln x$. The curve has a point of inflection at the point M.

(a) **(i)** Show that the x-coordinate of M satisfies the equation

$$x = \frac{6 + (4 - 6x)\ln x}{5}.$$ **[5]**

While a small minority of candidates incorrectly believed that the point of inflection was when the first derivative was equal to zero, most candidates correctly set the second derivative equal to zero in their attempt to show that the x-coordinate of M satisfied the given equation.

Question 5 (a) (ii)

(ii) Use an iterative formula, based on the equation in part **(a)(i)**, to determine the x-coordinate of M correct to **2** decimal places. Use an initial value of 1.1 and show the result of each step of the iterative process. **[2]**

This part was answered well with most candidates using the iterative equation

$x_{n+1} = \frac{6+(4-6x_n)\ln x_n}{5}$ and showing sufficient iterations to obtain the correct value of 1.13 for the x-coordinate of M. Some candidates attempted to apply Newton-Raphson or did not give the answer to the required 2 decimal places.

Question 5 (b)

(b) Determine the exact area of the shaded region, giving your answer in the form $p\ln q - r$, where p and r are positive rational numbers and q is a positive integer. **[6]**

Most candidates correctly calculated the limits for the required area as 1 and 2 (although occasionally a lower limit of 0 was seen). Most candidates adopted the method of integration by parts when attempting to evaluate $\int_1^2 (x^3 - 2x^2)\ln x \, \mathrm{d}x$ and many were successful in obtaining the correct integrated expression. Those that attempted to use a substitution were generally unsuccessful. The most common errors in both the integration and when applying the limits were sign errors. Although many candidates correctly evaluated this integral as $-\frac{4}{3}\ln 2 + \frac{89}{144}$, many did not realise that this was negative (as the shaded area was below the x-axis) and did not take the required modulus (even though the question made it clear what form the constants p, q and r should take).

Question 6 (a)

6 The curve C is defined, for $0 \leqslant t < 2\pi$, by the parametric equations

$$x = 4k + k\sin t, \quad y = 2 + 4\cos t,$$

where k is a constant.

(a) Find a cartesian equation for C. You do **not** need to simplify your answer. **[2]**

Question 6 was the least well-answered question on the paper (most likely due to the unfamiliarity of applying parametric equations in such a context). It was rare to see candidates adopting the correct method of applying $\sin^2 t + \cos^2 t = 1$ to obtain the cartesian equation $\frac{(x-4k)^2}{k^2} + \frac{(y-2)^2}{16} = 1$. Most candidates, who did obtain a cartesian equation, usually included one of arcsin or arccos, e.g. $y = 2 + 4\cos\left(\arcsin\left(\frac{x-4k}{k}\right)\right)$ which gained some credit but could not score full marks as these forms did not fully define the curve C.

Question 6 (b) (i)

You are given that C is a circle.

(b) (i) Determine the radius of C. **[2]**

Most candidates left this part blank or made very little progress (especially if arcsin or arccos had been used in the previous part). Of those who had used $\sin^2 t + \cos^2 t = 1$ in part (a), many did not recognise the condition that for C to be a circle that $k^2 = 16$ and hence that the radius was 4.

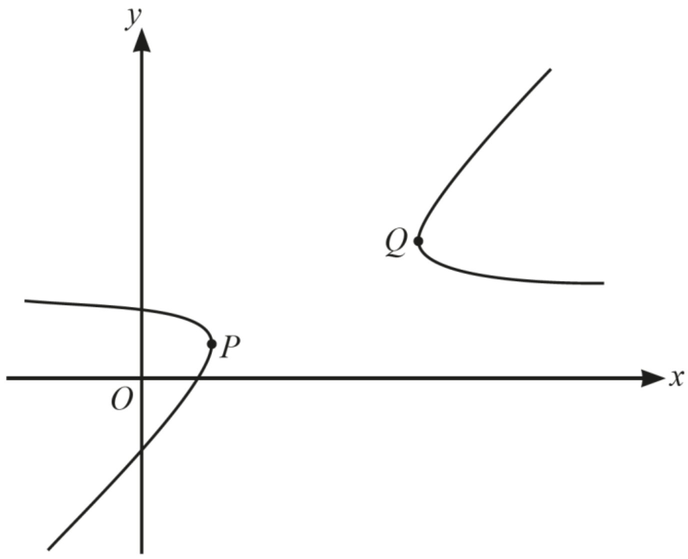
Question 6 (b) (ii)

(ii) Find the possible coordinates for the centre of C. **[2]**

This was similar to the previous part, in that very few candidates attempted this part and of those who did very few got the correct (two) answers. Of those that did make some progress, many gave a single answer in terms of k (most notably $(4k, 2)$).

Question 7

7



The diagram shows the curve $5x - 2xy + 2y^2 - k = 0$, where k is a positive integer.

At the points P and Q on the curve, the tangents to the curve are parallel to the y-axis.

Given that the difference in the y-coordinates of P and Q is 3, determine the x-coordinates of P and Q. **[7]**

The vast majority of candidates made a good start to this unstructured problem and used implicit differentiation to correctly differentiate the given expression with respect to either x or y. When errors occurred with this differentiation it was usually sign errors when differentiating $-2xy$ (using the product rule). Most candidates then found an expression for $\frac{\mathrm{d}y}{\mathrm{d}x}$ and were then almost equally split between either correctly setting the denominator equal to zero or incorrectly setting the numerator equal to zero. From there it was noted that while many candidates either obtained a correct quadratic equation in either y (e.g. $2y^2 - 10y + k = 0$) or x (e.g. $x^2 - 10x + 2k = 0$) very few could use the given condition that the difference in the y-coordinates was 3 (or equivalently the difference in x-coordinates was 6) to find the correct x-coordinates of P and Q.

Exemplar 1

7 Parallel to y axis → denominator = 0

$$5x - 2xy + 2y^2 - k = 0$$

↓

$$5 + -2y - 2x\frac{dy}{dx} + 4y\frac{dy}{dx} = 0$$

$u = -2x \quad du = -2$

$v = y \quad dv = \frac{dy}{dx}$

$$5 - 2y - 2x\frac{dy}{dx} + 4y\frac{dy}{dx} = 0$$

$$4y\frac{dy}{dx} - 2x\frac{dy}{dx} = 2y - 5$$

$P : (y+3, x_1)$

$Q : (y, x_2)$

$$\frac{dy}{dx}(4y - 2x) = 2y - 5$$

$$\frac{dy}{dx} = \frac{2y-5}{4y-2x}$$ ✓

$$4y - 2x = 0$$

$$4y = 2x$$

$$y = \frac{1}{2}x$$

$y(Q) = y$

$y(P) = y + 3$

$$5x - 2xy + 2y^2 - k = 0$$

$$5x - 2x\left(\frac{1}{2}x\right) + 2\left(\frac{1}{2}x\right)^2 - k = 0$$

$$5x - x^2 + \frac{1}{2}x^2 - k = 0$$

$$-\frac{1}{2}x^2 + 5x - k = 0$$

This candidate scored 4 out of the 7 marks available for correctly differentiating implicitly and obtaining the correct relationship that $4y - 2x = 0$. They then went on to obtain a correct quadratic equation in x but then did not make any further progress. This was relatively common as many candidates did not then realise how they could use the fact that the difference in the y values was 3 to find the required x coordinates.

Section B Overview

One general point with regard to the answering of certain mechanics questions should be made in this overview. This is that unless told otherwise the value that candidates should use for the acceleration due to gravity, *g*, is 9.8 and not 10 or 9.81 (and this value is stated explicitly on the front cover of the examination paper).

Question 8 (a)

8 A particle P is moving with constant acceleration $(-5\mathbf{i}+2\mathbf{j})\,\mathrm{m\,s^{-2}}$. At time $t=0$ seconds, P is at the origin and has velocity $(\mathbf{i}+3\mathbf{j})\,\mathrm{m\,s^{-1}}$.

(a) Find, in terms of $\mathbf{i}$ and $\mathbf{j}$, the displacement of P at time $t=2$ seconds. **[2]**

This part was answered extremely well with most candidates correctly applying $\mathbf{s}=\mathbf{u}t+\frac{1}{2}\mathbf{a}t^2$ to find the required displacement of P at time $t=2$. Those that used integration were less successful as they tended to make arithmetic (or algebraic) slips or did not substitute $t=2$ correctly.

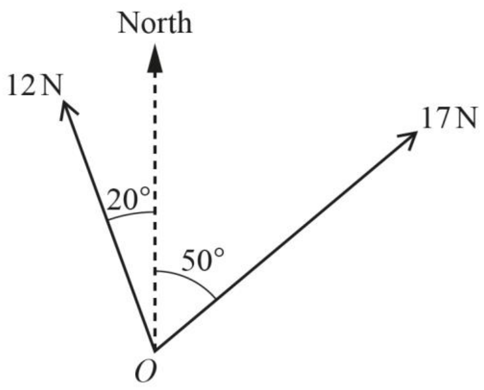
Question 8 (b)

(b) Determine the speed of P at time $t=2$ seconds. **[4]**

Most candidates correctly applied $\mathbf{v}=\mathbf{u}+\mathbf{a}t$ to obtain the velocity vector for P as $-9\mathbf{i}+7\mathbf{j}$. Many candidates left their answer as a vector and did not find the corresponding speed as directed. In this case the number of marks available should have been a strong indication of the amount of work required. Furthermore, a number of candidates attempted to use a vector form of $v^2=u^2+2as$ but most did not apply $|\mathbf{v}|^2=|\mathbf{u}|^2+2\mathbf{a}\cdot\mathbf{s}$ correctly (not realising that each term of this equation was a scalar).

Question 9 (a)

9



Two horizontal forces of magnitudes 17 N and 12 N act at a point O along bearings of 050° and 340° respectively (see diagram).

(a) Determine the magnitude and bearing of the resultant force. **[6]**

Most candidates resolved in a northerly and easterly direction in their attempts to find the magnitude and bearing of the resultant force (although attempts using a triangle of forces and the sine/cosine rules were just as successful). While many resolved correctly there were the usual sin/cos confusion and sign errors. It was surprising how many candidates, who found the magnitude correctly, did not find the correct bearing (and many who did not give the bearing in a correct three-figure form even though an example of a three-figure bearing was given in the question).

Assessment for learning

When resolving in two orthogonal directions candidates are reminded that if a component of a force appears in one term, then it must appear in the other term with the 'opposite' trig ratio. For example, in this question when resolving in a northerly direction, if done correctly then we would have expected to see $\pm(12\cos 20 + 17\cos 50)$. Therefore, when resolving in an easterly direction then we would expect to see the sine of these two angles appearing instead.

Question 9 (b)

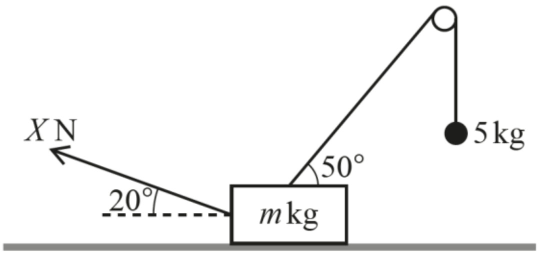
A third horizontal force **F** is now applied at O. The three forces are in equilibrium.

(b) State the magnitude of **F** and give the bearing along which it acts. **[2]**

Most candidates recognised in this part that the magnitude of **F** would be the same as the magnitude of their resultant force in part (a) and that the bearing would be a difference of 180 from their answer to part (a).

Question 10 (a)

10



A block of mass m kg is on smooth horizontal ground with one end of a light inextensible rope attached to its upper surface. The other end of the rope is attached to an object of mass 5 kg. The rope passes over a small smooth pulley, and the object hangs vertically below the pulley. The part of the rope between the block and the pulley makes an angle of 50° with the horizontal. A force of magnitude X N acts on the block at an angle of 20° above the horizontal in the vertical plane containing the rope (see diagram).

You are given that the block is in equilibrium.

(a) Determine the value of X. **[3]**

This part was answered very well with most candidates resolving vertically for the object (so obtaining the tension in the rope as $5g$), and then resolving horizontally for the block to obtain the correct value for X.

Question 10 (b)

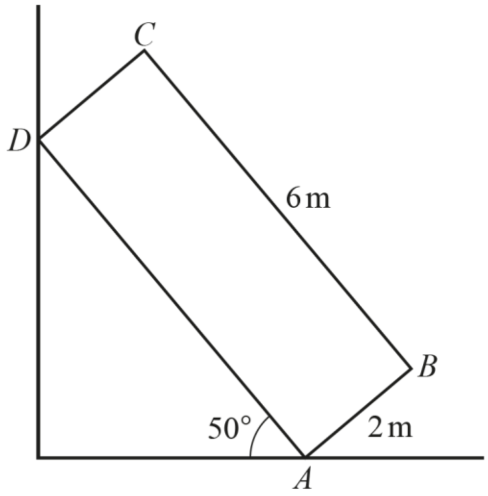
You are also given that the magnitude of the contact force exerted by the ground on the block is 147 N.

(b) Determine the value of m. **[3]**

The responses to this part were more mixed with many candidates either making sign errors or failing, when resolving vertically for the block, to include all four forces that were required to find the correct value of m. It was also common to see some candidates forgetting the g and therefore only having the mass (and not the weight) as one of the terms in their equation.

Question 11 (a)

11



A uniform rectangular lamina $ABCD$ has a mass of 0.5 kg. The length of AB is 2 m, and the length of BC is 6 m. The lamina is in limiting equilibrium with corner A in contact with rough horizontal ground and corner D in contact with a smooth vertical wall. The lamina rests in a vertical plane that is perpendicular to the wall, with AD inclined at 50° to the horizontal (see diagram).

(a) By taking moments, show that the magnitude of the normal contact force between the lamina and the wall is 1.24 N, correct to **3** significant figures. **[4]**

Although most candidates realised that the way to find the magnitude of the normal contact force acting on the lamina at B was to take moments about point A, many struggled with the corresponding geometry of the situation. Although most correctly realised that the expression for the moment of the normal contact force was given by $R_D \times (6\sin 50)$, almost all could not deal correctly with the corresponding moment for the weight. The most efficient way of considering this moment was to resolve the weight in directions parallel and perpendicular to the sides of the lamina (and hence obtain the moment as $3 \times (0.5g\cos 50) - 1 \times (0.5g \times \sin 50)$).

Assessment for learning

Candidates are strongly advised when taking moments to make it clear to the examiners which point (in this case on the lamina) they are taking moments about. A number of candidates attempted to take moments about another point other than A together with resolving forces vertically and/or horizontally; these attempts were always unsuccessful.

Question 11 (b)

(b) Determine the coefficient of friction between the lamina and the ground. **[3]**

Many candidates left this relatively straightforward part blank (most likely due to their inability in obtaining the given answer in part (a)). It is clear that many candidates did not realise the direction of the forces acting at A and/or D and included unnecessary trigonometric terms. Occasionally candidates gave an answer that was not correct to 3 significant figures.

Question 12 (a)

12 A particle P moves in a straight line. The velocity $v\,\mathrm{m\,s^{-1}}$ of P at time t seconds is given by

$v = \frac{1}{12}kt(t-3)$ for $0 \leqslant t \leqslant 6$,

$v = \frac{54k}{t^2}$ for $6 \leqslant t \leqslant 9$,

where k is a positive constant.

(a) Sketch, on the axes in the Printed Answer Booklet, the velocity-time graph for P for values of t from 0 to 9. **[3]**

Although this first part asked candidates to sketch a velocity-time graph for the motion of the particle, it was in essence testing parts of the pure specification (notably curve sketching (ref. 1.02n and 1.02o) which requires candidates to be able to sketch simple polynomials and curves defined by $y = \frac{a}{x^2}$). Many candidates incorrectly drew line segments for the entire graph. Examiners expected to see a quadratic curve for values of t from 0 to 6 passing through the origin with a minimum point in the fourth quadrant and then an inverse proportional to t^2 curve from 6 to 9. This was rare, and so was the labelling of any values on either axis.

Question 12 (b)

(b) State the value of t in the interval $0 \leqslant t \leqslant 9$ when the acceleration of P is zero. **[1]**

The most common incorrect answer in this part was 6 with the correct value of 1.5 rarely seen. Of those that did correctly attempt this part many used calculus techniques instead of considering their graph from part (a).

Question 12 (c)

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

You are given that the total distance travelled by P in the interval $0 \leqslant t \leqslant 9$ is 84 m.

Find the value of k. **[6]**

Many of the candidates who had drawn a correct velocity-time graph in part (a) did not realise the significance of the fact that part of this graph (between the times of 0 and 3) was below the t-axis and so therefore considered incorrect limits on their first integral i.e. $\int_0^6 \frac{1}{12}kt(t-3)\mathrm{d}t$. Some candidates seemed to use the trapezium rule (or other non-calculus method) in this part. It was rare for candidates to set up the correct equation for k as $-\int_0^3 \frac{1}{12}kt(t-3)\mathrm{d}t + \int_3^6 \frac{1}{12}kt(t-3)\mathrm{d}t + \int_6^9 \frac{54k}{t^2}\mathrm{d}t = 84$.

Exemplar 2

12(c)

$0 \le t \le 6 \rightarrow v = \frac{1}{12}kt(t-3)$

$\int_0^6 \frac{1}{12}kt(t-3)\,dt \rightarrow \int \frac{1}{12}kt^2 - \frac{1}{4}kt$

$= \left[\frac{1}{36}kt^3 - \frac{1}{8}kt^2\right]_0^6$

$\int_6^9 \frac{54k}{t^2}\,dt \rightarrow \int 54k(t)^{-2} = \left[-\frac{54k}{t}\right]_6^9$

$\left(\frac{1}{36}\times k\times 6^3 - \frac{1}{8}\times k\times 6^2\right) - 0 = 6k - \frac{9}{2}k$

$\left(-\frac{54k}{9}\right) - \left(-\frac{54k}{6}\right)$

$-\frac{54k}{9} + \frac{54k}{6}$

$6k - \frac{9}{2}k - \frac{54}{9}k + \frac{54}{6}k = 84$

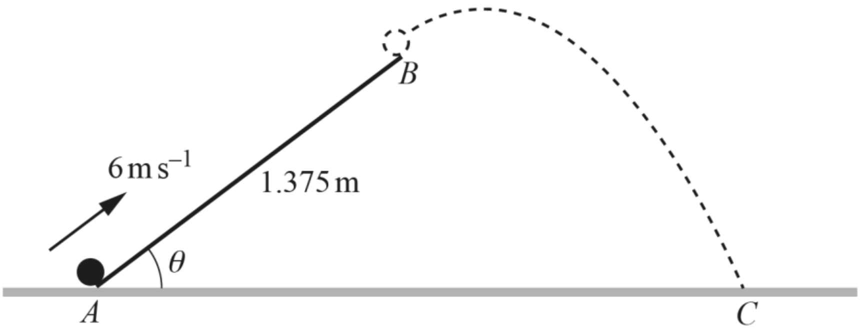
$\frac{9}{2}k = 84$

$k = \frac{56}{3}$

This candidate highlights the most common error seen by examiners in this part, which is considering the integral from 0 to 6 instead of considering the two integrals from 0 to 3 and from 3 to 6 separately. This response scored 3 of the 6 marks available.

Question 13 (a)

13



The points A and B are the lower and upper ends, respectively, of a line of greatest slope on a plane inclined at an angle θ to the horizontal, where $\sin\theta = 0.6$ and $AB = 1.375\,\mathrm{m}$ (see diagram).

A particle P is projected up the plane with speed $6\,\mathrm{m\,s^{-1}}$ from A towards B.

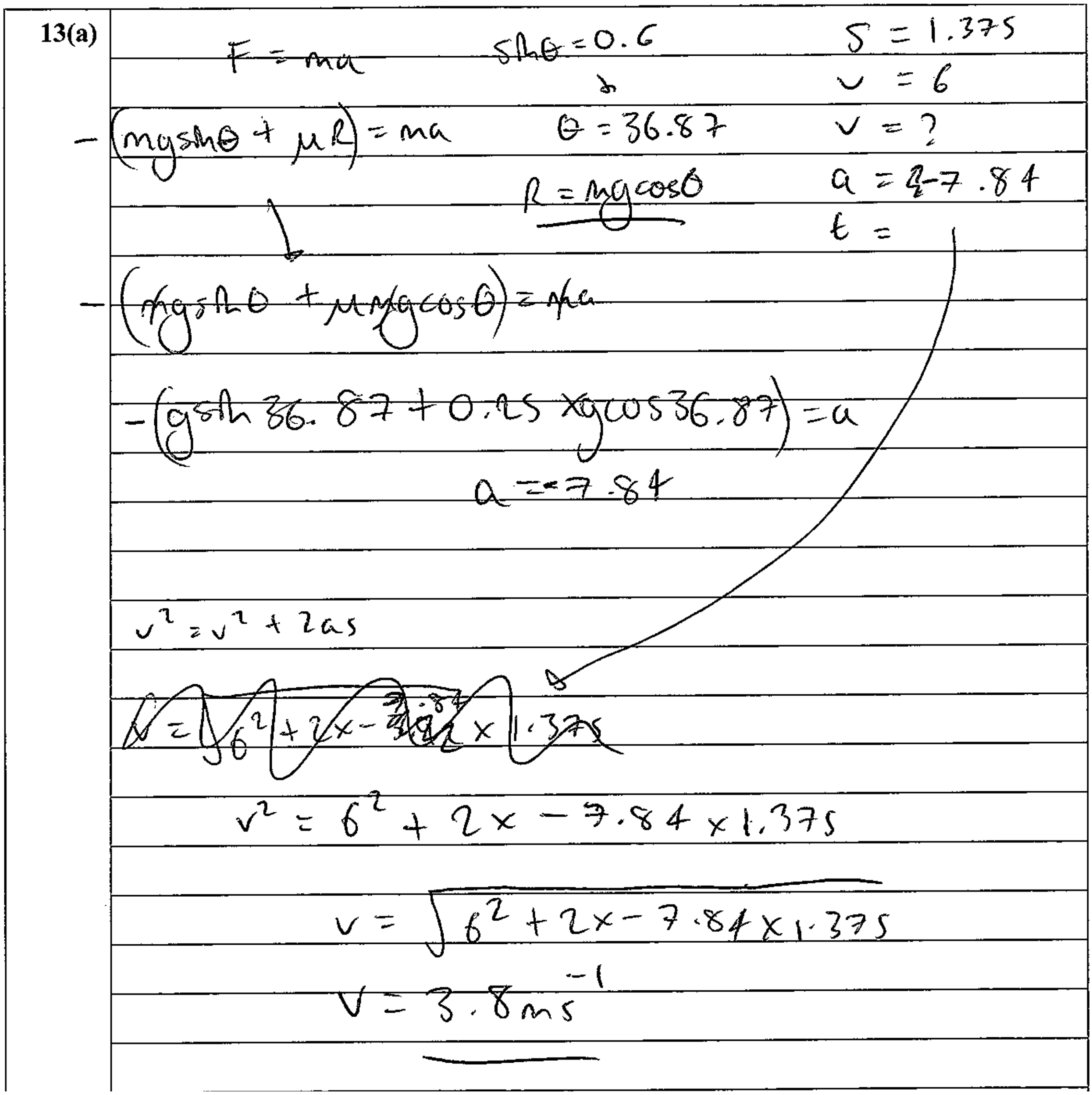
The plane at A is fixed to the ground which is horizontal.

The surface of the plane is rough and the coefficient of friction between P and the plane is 0.25.

(a) Show that the speed of P at B is $3.8\,\mathrm{m\,s^{-1}}$. **[6]**

The responses to this part were mixed. Many candidates did not make any significant progress towards the given answer as they seemed to believe that the entire question could be solved by only applying the equations of constant acceleration. Very few candidates applied Newton's second law parallel to the plane correctly (with the correct number of relevant terms) to find the acceleration of P as it moved up the plane from A to B. While some did correctly state that $a = -0.25g\cos\theta - g\sin\theta$ many gave no indication of where the value of -7.84 for the acceleration came from; as this is a 'show that' question candidates were expected to substitute the given values of $\sin\theta = 0.6$ and therefore $\cos\theta = 0.8$ into this equation to make it clear that they hadn't simply worked backwards to find the acceleration from the given final speed. Some candidates calculated θ as 36.8… and so therefore did not show that the speed of P at B was the exact (given) value of 3.8.

Exemplar 3



This candidate made very good progress in showing that the speed of P at B was 3.8. The only issue was one of accuracy in that the candidate used an approximate value for the angle (in this case using 36.87) which leads to an inaccurate value of -7.8400113 ... for the acceleration and therefore they could not score the final accuracy mark (and so instead scored 5 of the 6 marks available).

Question 13 (b)

The particle leaves the slope at B and moves freely under gravity.

The particle first lands at a point C on the horizontal ground. The time taken for P to travel from A to C is T seconds.

(b) Determine the value of T. **[6]**

It was pleasing to note that many candidates correctly worked out the time of flight from B to C using the given value of 3.8 and managed to correctly set up the equation $-0.825 = (3.8 \times 0.6)t + \frac{1}{2} \times -g \times t^2$ although occasionally sign errors appeared in this equation (as did the lack of a component with the 3.8 at the point where the particle became a projectile). It was clear that many candidates did not read the question carefully and gave the value of T as the time of flight only from B to C instead of the correct time of flight from A to C (and so therefore scored only 3 of the 6 marks available in this final part).

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