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Oxford Cambridge and RSA

AS LEVEL

Examiners' report

FURTHER MATHEMATICS B (MEI)

H635
For first teaching in 2017

Y411/01 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 Y411/01 series overview

This was the first session for this component, part of the new AS Level specification H635: Further Mathematics B (MEI).

Very few candidates took the trouble to include a description of what they intended to do in their solutions. For example, writing things like 'resolving horizontally for the equilibrium of the system' in Question 1, or 'by energy' in Question 2(iv) or 'taking moments about A for the whole system' in Question 6(iv) would make it clear what candidates are attempting to do. This sign posting of intention can help candidates focus on the techniques required to work through whilst answering each part of the questions.

Question 1

1 Forces of magnitude 4 N, 3 N, 5 N and R N act on a particle in the directions shown in Fig. 1.

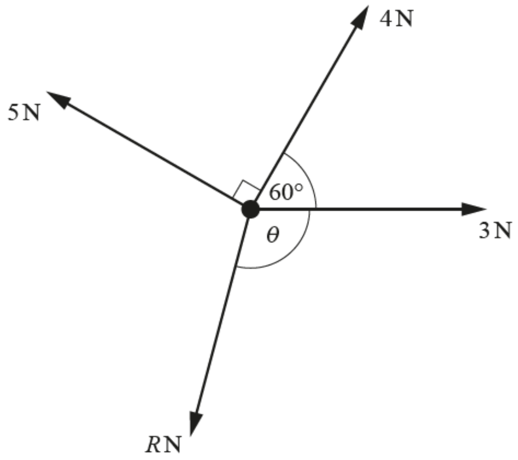

Fig. 1

The particle is in equilibrium.

Find each of the following.

- The value of R.
- The value of θ. **[6]**

The majority of candidates that attempted this question were able to find the horizontal and vertical components (parallel and perpendicular to the 3 N force) of the resultant. Hence, they successfully found the values of *R* and *θ.* Some of these candidates made arithmetical slips, and some had a little difficulty finding the value of *θ*, with 83.6° and 6.4° seen from time to time. A small proportion of candidates noted the right angle between the 4 N and 5 N forces and resolved parallel to each of these forces. Whilst this made the calculation simpler, they then needed to do a little more to find *θ*. However, candidates using this approach very often produced completely correct solutions.

A significant number of candidates made little or no attempt at this question. Many wrote down equations for the equilibrium but then struggled to deal with the angle *θ*. Common mistakes included mixing up sine and cosine in the components of the 4 N and 5 N forces, and/or failing to evaluate trigonometrical functions of 30°, 60° or 150°.

Question 2(i)

2 A car of mass 1350 kg travels along a straight horizontal road. Throughout this question the resistance force to the motion of the car is modelled as constant and equal to 920 N.

(i) Calculate the power, in kW, developed by the car when the car is travelling at a constant speed of $25\,\mathrm{m\,s^{-1}}$. **[2]**

This part was usually done correctly. A small number of candidates left the answer as 23 000 W, or made an arithmetic slip. Only a very small minority could make no attempt.

Question 2(ii)

The car is now used to tow a caravan of mass 1050 kg along the same road. When the car tows the caravan at a constant speed of $20\,\mathrm{m\,s^{-1}}$ the power developed by the car is 45 kW.

(ii) Find the additional resistance force due to the caravan. **[2]**

Candidates had little difficulty with this part. A few gave the answer as 2250 N, which is the total resistance due to the car and the caravan; they gained partial credit for this.

Question 2(iii)

In the remaining parts of this question the power developed by the car is constant and equal to 68 kW and the resistance force due to the caravan is modelled as constant and equal to the value found in part **(ii)**.

When the car and caravan pass a point A on the same straight horizontal road the speed of the car and caravan is $20\,\mathrm{m\,s^{-1}}$.

(iii) Find the acceleration of the car and caravan at point A. **[3]**

Some candidates omitted one or both of the resistance forces in this part. A small number of candidates used the mass of the car (or caravan) rather than the combined mass when working out the acceleration.

Question 2(iv)

The car and caravan later pass a point B on the same straight horizontal road with speed $28\,\mathrm{m\,s^{-1}}$. The distance AB is 1024 m.

(iv) Find the time taken for the car and caravan to travel from point A to point B. **[4]**

Most candidates did not appreciate that the acceleration of the car and caravan varies, and wrongly used equations of motion for constant acceleration. Candidates using a valid method did not always get signs right in their energy equation, and sometimes omitted essential terms.

Question 2(v)

(v) Suggest one way in which any of the modelling assumptions used in this question could have been improved. **[1]**

Many candidates correctly stated that either resistance or power could have been modelled as variable. A small number correctly suggested the road might not be completely straight or horizontal. Some candidates, who had assumed constant acceleration in (part (**iv**)), suggested that acceleration might not be constant; this gained no credit.

Question 3(i)

3 Jodie is doing an experiment involving a simple pendulum. The pendulum consists of a small object tied to one end of a piece of string. The other end of the string is attached to a fixed point O and the object is allowed to swing between two fixed points A and B and back again, as shown in Fig. 3.

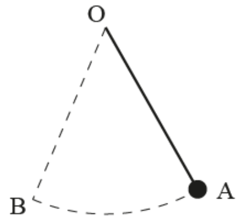

Fig. 3

Jodie thinks that P, the time the pendulum takes to swing from A to B and back again, depends on the mass, m, of the small object, the length, l, of the piece of string, and the acceleration due to gravity g. She proposes the formula $P = km^{\alpha}l^{\beta}g^{\gamma}$.

(i) What is the significance of k in Jodie's formula? **[1]**

Almost all candidates pointed out that k is a constant, though a few stated only that k is dimensionless.

Question 3(ii)

(ii) Use dimensional analysis to determine the values of α, β and γ. **[3]**

There were very many correct answers to this part. The most common error was to state the dimensions of g as M L T^{-2}. A small number of candidates did not seem to know how to set about getting the equations needed, while a few made slips solving them.

Question 3(iii)(*A*)

Jodie finds that when the mass of the object is 1.5 kg and the length of the string is 80 cm the time taken for the pendulum to swing from A to B and back again is 1.8 seconds.

(iii) Use Jodie's formula and your answers to part **(ii)** to find each of the following.

(A) The value of k **[2]**

This question was usually done correctly. Those with incorrect values in part (**ii**) were able to gain partial credit, as were those who used 80 (cm) in their formula, rather than 0.8 (m).

Question 3(iii)(*B*)

(B) The time taken for the pendulum to swing from A to B and back again when the mass of the object is 0.9 kg and the length of the string is 1.4 m **[2]**

Most candidates with part (A) correct were also correct in part (B). Candidates who used 140 (cm) in this part after using 80 (cm) in part (A) were given full credit for this part.

Question 3(iv)

(iv) Comment on the assumption made by Jodie that the formula for the time taken for the pendulum to swing from A to B and back again is dependent on m, l and g. **[1]**

Most candidates who had shown that $\alpha = 0$ in part (**i**) correctly stated that the time taken did not, in fact, depend on *m*, or that it depended only on *l* and *g*. Other candidates correctly explained that the time could possibly depend on other quantities.

Question 4(i)

4 A uniform lamina ABDE is in the shape of an equilateral triangle ABC of side 12 cm from which an equilateral triangle of side 6 cm has been removed from corner C. The lamina is situated on coordinate axes as shown in Fig. 4.

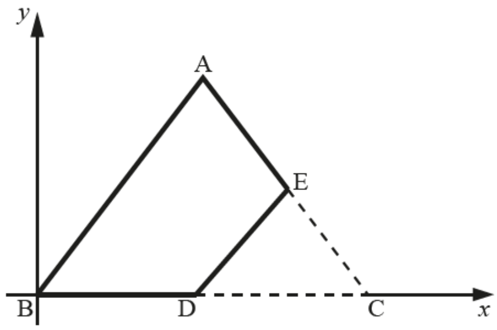

Fig. 4

(i) Explain why angle BDA = 90°. **[1]**

While many candidates gave perfectly acceptable explanations, there were quite a number of answers along the lines of 'AD is perpendicular to BD so angle BDA = 90°'. To be successful, candidates really had to include the fact that triangle ABC is equilateral, either directly or indirectly.

Question 4(ii)

(ii) Find the coordinates of the centre of mass of the lamina ABDE. **[5]**

Most candidates tackled this part by considering the lamina ABDE as being made up of the triangle ABC with the triangle CDE removed. There were two common errors made by candidates using this method. Some candidates correctly found the mass of ABC (for example 4 units) and the mass of CDE (1 unit) and then added, rather than subtracted, these values to find the mass of ABDE (wrongly getting 5 units). Other candidates thought the *y*-coordinate of the centre of mass of a triangle was half the height, or sometimes two thirds of the height. Other successful approaches seen were to regard ABDE as three equilateral triangles or to split ABDE into a right angle tringle ABD and an isosceles triangle ADE; these candidates avoided the 'mass' error, but were still likely to make the '*y*-coordinate' error. Attempts were also seen to split ABDE into tringles ABE and DBE.

A significant minority of candidates seemed unfamiliar with this type of question. Some gave answers that only used the coordinates of the centres of mass of different triangles, ignoring the masses of those triangles. Others read the question as one involving masses situated at the points A, B, C, D (and E); attempts involving rods AB, AE, BD and DE were also seen. Some other candidates attempted to do the question with no reference to the masses of the different parts of the shape.

Question 4(iii)

The lamina ABDE is now freely suspended from D and hangs in equilibrium.

(iii) Calculate the angle DE makes with the downward vertical. **[3]**

Whilst this part proved challenging, a number of different approaches were used to obtain correct solutions. The fact that DE is at an angle to start with proved problematic for a number of candidates. Candidates that started by considering the horizontal and vertical displacement of the centre of mass (G) from D, followed by an attempt to find the angle between DG and the vertical, were usually successfully. Other valid methods were also seen, for example using the cosine rule in triangle DEG.

Question 5(i)

5 A small ball is held at a height of 160 cm above a horizontal surface. The ball is released from rest and rebounds from the surface. After its first bounce on the surface the ball reaches a height of 122.5 cm.

(i) Find the height reached by the ball after its second bounce on the surface. **[8]**

Most candidates did this question well, usually by a method that involved first finding the speed of the ball before and after its first impact with the surface, then finding the coefficient of restitution between the ball and the surface, then finding the speed of the ball after its second impact and finally finding the height the ball reached. A small number of candidates made errors by using heights in centimetres without converting to metres; this does not work when g is used as $9.8\,\mathrm{m\,s^{-2}}$.

Some candidates found efficient and valid methods to find the correct answer much more quickly.

Question 5(ii)

After n bounces the height reached by the ball is less than 10 cm.

(ii) Find the minimum possible value of n. **[3]**

Candidates could tackle this question either by considering heights of 0.1 m and 1.6 m (or 1.225 m), or speeds of $1.4\,\mathrm{m\,s^{-1}}$ and $5.6\,\mathrm{m\,s^{-1}}$ (or $4.9\,\mathrm{m\,s^{-1}}$). Candidates then had to solve an equation involving e^n or e^{2n}, where e is the coefficient of restitution found in part (**i**). This could be done either by using logs or by a step-by-step approach. Errors were seen in rounding 10.38 down to 10 rather than up to 11, in forgetting to divide by 2 when using the distance method rather than the speed method, and in counting when using a step-by-step method.

Question 5(iii)(*A*)

(iii) State what would happen if the same ball is released from rest from a height of 160 cm above a different horizontal surface and

(A) the coefficient of restitution between the ball and the new surface is 0, **[1]**

This was generally correct, though some candidates gave the answer that it bounced back to 160 cm.

Question 5(iii)(*B*)

(*B*) the coefficient of restitution between the ball and the new surface is 1. **[1]**

This was usually correct, with most candidates saying the ball would bounce (repeatedly) to a height of 160 cm, but some saying that the speed of the ball after bouncing would be the same as before bouncing. Candidates who gave the wrong answer to part (*B*) usually gave an opposite wrong answer to this part.

Question 6(i)

6 A uniform rod AB has length $2a$ and weight W. The rod is in equilibrium in a horizontal position. The end A rests on a smooth plane which is inclined at an angle of 30° to the horizontal. The force exerted on AB by the plane is R. The end B is attached to a light inextensible string inclined at an angle of θ to AB as shown in Fig. 6. The rod and string are in the same vertical plane, which also contains the line of greatest slope of the plane on which A lies. The tension in the string is T.

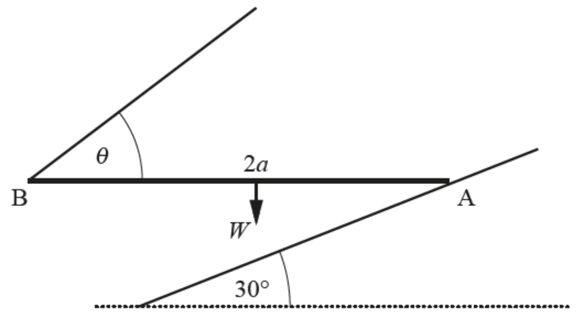

Fig. 6

(i) Add the forces R and T to the copy of Fig. 6 in the Printed Answer Booklet. **[1]**

While most candidates marked *T* and *R* correctly, with correct arrows, there were quite a lot of incorrect answers. Some candidates had *R* acting vertically at A, others horizontally. A small number had *R* acting at the midpoint of the rod AB. Candidates with *R* vertically through A were allowed one mark in part (**ii**); apart from this candidates with an incorrect diagram only rarely gained any credit on the rest of Question 6.

Question 6(ii)

(ii) By taking moments about B, find an expression for R in terms of W. **[2]**

Many candidates did this correctly, though some left the answer as $R = \frac{W}{2R\sin 60}$. A small number gave the answer as $W = \sqrt{3}R$, while others confused sine and cosine. A considerable number of candidates made no attempt at this part.

Question 6(iii)

(iii) By resolving horizontally, show that $6T\cos\theta = W\sqrt{3}$. **[3]**

Some good starts to this part were often followed by poor manipulation, meaning that the given result was not validly shown. A considerable number of candidates made no attempt at this part.

Question 6(iv)

(iv) By finding a second equation connecting T and θ, determine

- the value of θ,
- an expression for T in terms of W. **[5]**

A variety of approaches were successfully taken to solve this part. Some candidates dropped marks due to errors in algebraic manipulation. Other candidates gained initial marks by either resolving vertically to find an equation in *T*, *R*, *W* and *θ* or taking moments about A to find an equation in *W*, *T* and *θ*. This part was omitted by a considerable number of candidates.

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