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AS/A LEVEL GCE

Examiners' report

MATHEMATICS

3890-3892, 7890-7892

4730/01 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 4730/01 series overview

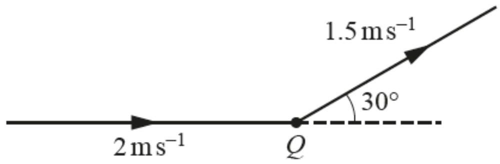
This paper proved a challenging test of the specification. Although many good answers were seen to each part of every question, only a few candidates managed to gain close to full marks. Weaker candidates found that there were several part questions on which they could be partially or completely successful, though these lower ability candidates did often omit some questions or part questions. The most commonly omitted parts were Question 2(iii), Question 4(iii), Question 5(ii) and Question 7(iii). Candidates gaining high marks also sometimes omitted Question 7(iii), so it may be that some omitting this part did so because they had run out of time.

Many candidates presented their work well, with clear and understandable working. There were a considerable number of scripts where writing was difficult to read; an examiner can only give credit where work can be read and understood. Candidates who made errors and had to make a second attempt at a part question usually made appropriate use of additional paper. Quite a number of candidates ignored blank pages 15 and 16, intended to be used for extra working, and used a four page additional answer booklet instead.

A large number of candidates worked the whole of some quite complicated questions in surds or exact fractions, rather than using approximate decimals. This was particularly noticeable on Question 4(iii), but also on Question 5 and Question 7 parts (ii) and (iii).

Question 1

1



A particle Q of mass 0.3 kg is moving in a straight line on a smooth horizontal surface with speed 2 m s^{-1} when it is struck by a horizontal impulse of magnitude I N s. After the impulse acts Q moves with speed 1.5 m s^{-1} in a direction making an angle of 30° with its original direction of motion (see diagram).

Find I and the angle the line of action of the impulse makes with the original direction of motion of Q. Draw a sketch to show this angle. **[4]**

The majority of candidates answered this question, usually correctly, by first using the cosine rule to find *I* and then the sine rule to find the angle. A minority of candidates found components of *I* and then usually went on to give the correct answers. Although 133° was the expected answer for the angle, 46.9° and 43.1° were each given full credit if shown correctly on a diagram.

Question 2(i)

2 One end of a light elastic string of natural length 0.6 m and modulus of elasticity $3mg$ N is attached to a fixed point O. A particle P of mass m kg is attached to the other end of the string, and moves in a vertical line below O. At an instant when P is 0.6 m below O it is moving downwards with speed 3.5 m s^{-1}. The greatest distance below O reached by P is h m.

(i) By considering energy, show that $h^2 + ah + b = 0$, where a and b are constants to be determined. **[5]**

The most common errors in setting up the model were to omit the initial potential energy term (0.6*mg*), to have a sign error in the energy equation and not to use the variable *h* as it is defined in the question. After correct energy equations some candidates made arithmetic slips and others left the equation in a form where the coefficient of h^2 was not 1. These candidates did not gain full marks.

Question 2(ii)

(ii) Hence find the greatest distance below O reached by P. **[1]**

The mark for this question depended on a correct equation in part (i); it was allowed when the coefficients of the equation in part (i) were a multiple of the correct values. Candidates whose answers rounded to 1.34 (m) from a slightly wrong equation in part (i) were not given any credit, nor were those who got 1.34 by chance. Candidates who lost marks in part (i) by using a different *h* from the one defined in the question were given credit in part (ii) if they obtained 1.34 legitimately.

Question 2(iii)

(iii) State with a reason whether the quadratic equation in part **(i)** can be used to find the least distance of P below O. **[1]**

Most candidates correctly explained why the quadratic equation could not be used, though very few who used the word could spell 'taut' correctly. A significant number of candidates thought the second root of the equation would give the least distance, while others gave incorrect or incomplete reasons.

Question 3(i)

3 A particle P of mass 0.2 kg is projected with velocity $5\,\mathrm{m\,s^{-1}}$ from a fixed point O on a smooth horizontal plane. After t seconds P is x m from O and has velocity $v\,\mathrm{m\,s^{-1}}$ away from O. The only force acting on P has magnitude Ae^{-t} N in the direction of motion of P, where A is a constant.

(i) Find an expression in terms of A and t for the velocity of P at time t. **[5]**

This question was answered very well. Some candidates made slips finding the constant of integration, and some left the answer including terms like $\frac{A}{0.2}$ so did not gain full marks. There were a few algebraic slips where the mass term (0.2) was misplaced, and not quite all candidates could integrate e^{-t} correctly.

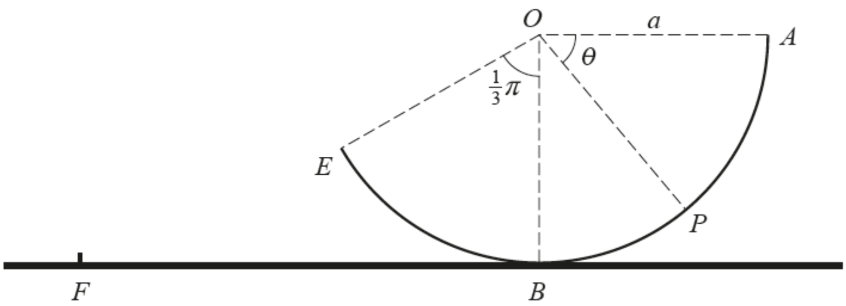
Question 3(ii)

(ii) Given that the velocity of P tends to $12\,\mathrm{m\,s^{-1}}$ as t increases, find the distance of P from O when its velocity is $6\,\mathrm{m\,s^{-1}}$. **[7]**

Candidates with part (i) wrong were able to gain partial credit here. Many candidates gave a completely correct answer. The most common error was to assume the constant of integration when finding the distance was 0. This led to a wrong answer of 7.85 (m).

Question 4(i)

4



The diagram shows a smooth track $APBE$ in the form of an arc of a circle with centre O and radius a. The track is fixed in a vertical plane with its lowest point B in contact with horizontal ground. A particle Q, of mass m, is released from rest at A, which is at the same horizontal level as O. The particle Q passes through P, where angle $AOP = \theta$. The track finishes at E, where angle $BOE = \frac{1}{3}\pi$. Q leaves the track at E and moves freely under gravity, landing on the ground at a point F.

(i) On the diagram in the Printed Answer Book, show the radial and transverse components of the acceleration of Q when it is at P. State the magnitude of each component and make the direction of each component clear. **[2]**

Candidates were expected to indicate the radial and transverse component with arrows (of any style) and give the magnitudes $a\dot{\theta}^2$ and $a\ddot{\theta}$ respectively. This form of answer was uncommon, but any equivalent form for the magnitudes was accepted – even when candidates used r as the radius rather than a. Despite this, only a minority of candidates gained both marks, with many making errors like writing the transverse component of acceleration as $mg\cos\theta$, the radial component as $g\sin\theta$ or having an arrow in the wrong direction.

Question 4(ii)

(ii) Find, in terms of m, g and θ, an expression for the force exerted on Q by the track when Q is at P. **[4]**

Some candidates seemed to find this part difficult because the angle θ given in the question was between the radius at P and the horizontal, rather than the vertical. Some candidates ignored the component of the weight of Q when using Newton's second law in the direction PO. However, there were also many concise correct answers.

Question 4(iii)

(iii) Find, in terms of a, an expression for the distance BF. **[7]**

There were some elegant and efficient solutions to this part; there were also rather more lengthy attempts – a few successful in the end, but more often making a slip in the calculation or the logic at some point. There were also a number of candidates who found this part too complicated and made little or no attempt at it.

Most reasonable attempts found the speed of Q at E and used the vertical component of this speed in $s = ut + \frac{1}{2}at^2$ to find a quadratic equation in t. The larger root gave the time taken before Q landed at F. However, some candidates had the direction of the distance wrong, or the vertical component of the velocity of Q wrong. Using this approach candidates then found the horizontal distance from E to F, but not all realised that they then needed to add on the horizontal distance from B to E. A variation of this method was that some candidates replaced t by $\left(d \div \frac{1}{2}\sqrt{ag}\right)$, where d represents the horizontal distance from E to F; they then had to solve an equivalent quadratic equation in d rather than t.

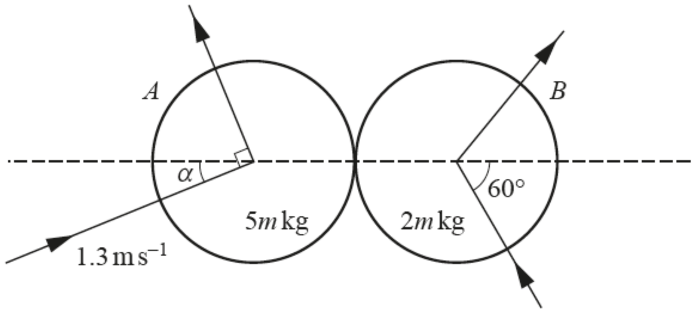
Other candidates used the equation of the trajectory of a particle to find the horizontal distance from E to F; this method was often successful.

On a small number of scripts a simpler calculation was seen. This involved finding the vertical component of the speed of Q when it landed at F, and using this and the vertical component of the speed of Q at E to find the time taken from E to F. This method was only successful when candidates took care with the directions of the velocities.

The vast majority of candidates making good attempts at this question worked throughout in surds; approximate answers in decimals were accepted, but rarely seen.

Question 5(i)

5



Two small uniform smooth spheres A and B, of equal radius, have masses $5m$ kg and $2m$ kg respectively. The spheres are moving on a smooth horizontal surface when they collide. Before the collision A is moving with speed $1.3\,\text{m s}^{-1}$ in a direction making an angle α with the line of centres, where $\tan\alpha = \frac{5}{12}$, and B is moving towards A in a direction making an angle of 60° with the line of centres. After the collision A moves in a direction at right angles to its original direction of motion (see diagram). The coefficient of restitution between A and B is $\frac{5}{6}$.

(i) Find the speed of A after the collision. **[3]**

The way to do this part is to use the fact that the component of the velocity of *A* perpendicular to the line of centres is conserved. Quite a lot of candidates started by writing down the 'usual' equations for this type of question – from the law of conservation of momentum parallel to the line of centres and from Newton's experimental law – before realising that this was not needed and either answering the question asked or else abandoning it. However, most candidates ended up with the correct value for the speed of *A* after the collision, some of them completing the working in a couple of lines.

Question 5(ii)

(ii) Find the component of the velocity of B parallel to the line of centres after the collision. **[7]**

This part did require the 'usual' two equations, though a few candidates also included irrelevant work considering motion perpendicular to the line of centres. The main errors seen were to omit one or more mass term in the conservation of momentum equation, to include mass in the NEL equation, to use the speed of *A* rather than the component parallel to the line of centres and sign errors. Candidates could solve the question by using either the speeds of B before and after the collision as their variables, or the components parallel to the line of centres (or a mixture); some candidates were not consistent with the variables they used, or with the directions of components of velocity. Quite a number of candidates arrived at correct, compatible simultaneous equations, but then made slips in solving them. A good number of candidates, however, did provide the correct answer.

Question 6(i)

6 One end of a light elastic string of natural length 1.0 m and modulus of elasticity $5mg$ N is attached to a fixed point O. A particle P of mass m kg is attached to the other end of the string. P is held at a point 1.5 m vertically below O and then released.

(i) Show that P initially moves with simple harmonic motion and find the distance of the centre of this simple harmonic motion from O. **[5]**

A common approach was to start by using $F = ma$ to find an equation for the acceleration of P. Some candidates used the distance of P from O as their variable, others the extension of the string and a few used the distance from the point from which P was released. Most of these attempts led to a valid proof that the motion was simple harmonic, though there were some sign errors, and some candidates omitted the necessary step of stating that their final equation was in a form that represented SHM. These candidates were then usually able to find the distance of the centre of the motion of P from O.

Other candidates first found that the equilibrium position is when the extension of the string is 0.2 m, and then usually gave the correct distance from O. They then usually used $F = ma$, with the extension of the string from its equilibrium position as their variable, to demonstrate SHM. A minority of candidates were able to find the correct distance from O of 1.2 m, but were not able to show that P initially moves with simple harmonic motion.

Question 6(ii)

The highest point P reaches in its subsequent motion is H.

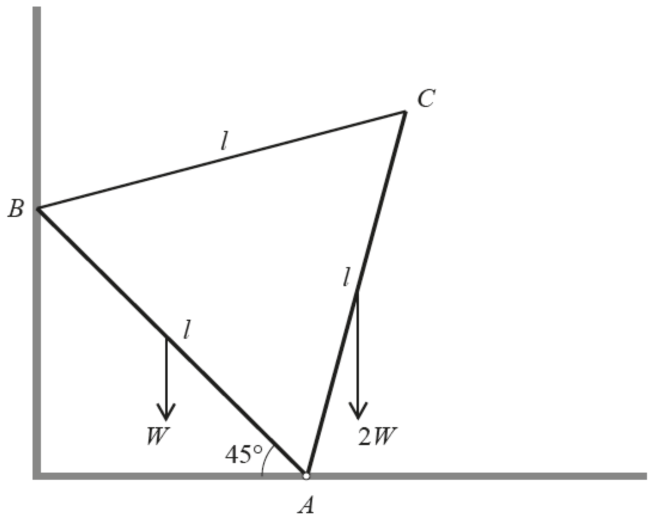
(ii) Find the distance OH and the time taken for P to travel from its point of release to H. **[8]**

Candidates needed to realise that P is moving under SHM while the string is extended, and then under gravity until it reaches H. There were some very concise solutions showing that the time P moves under SHM is 0.329 seconds and that it is then moving upwards with speed 1.57 m s^{-1}; these solutions went on to find the time taken and distance moved under gravity to complete the solution. Other candidates split the time under SHM into a quarter period plus the time taken for the extension to go from 0 to 0.2 m; some of these solutions became confused.

Other candidates used energy considerations to find OH first; however some of these gave the answer as 0.625 m (the distance from the point of release to H). Some other candidates unnecessarily found the speed at the point where the string is in equilibrium; these candidates rarely managed to arrive at a completely correct solution after this.

Question 7(i)

7



The uniform rods AB, of length l and weight W, and AC, of length l and weight $2W$, are freely pivoted to a fixed point A. The rods are at rest in equilibrium in a vertical plane which is perpendicular to a smooth vertical wall. B rests against the wall and A is on a horizontal floor. AB is inclined at an angle of 45° to the horizontal. The ends B and C of the rods are joined by a light inextensible string of length l so that triangle ABC is equilateral (see diagram).

(i) Show that the tension in the string BC is $W\dfrac{\cos 75°}{\cos 30°}$. **[2]**

This part was usually done well, with almost all candidates taking moments about *A* for the equilibrium of *AC*. However, some candidates did not take due account of the lengths used being different, or that the weight of *AC* is 2*W*.

Question 7(ii)

(ii) The normal reaction between the rod AB and the wall at B is αW. Find the value of α correct to 3 significant figures. **[4]**

Some candidates approached this by taking moments about *A* for the equilibrium of both rods, which gave an equation involving *R* and *W*, with *l* cancelling out. These candidates were usually successful, though there were some sign errors and some arithmetic slips. Other candidates took moments about *A* for the equilibrium of rod *AB*. This method involved *T*, and candidates then had to use the result from part (i) to eliminate *T*. Candidates using this method made a wide variety of errors but were sometimes successful. As well as sign errors and arithmetic slips, some candidates tried to use one or more component of *T*; this often led to errors.

Question 7(iii)

The string of length l is now replaced by a light inextensible string which has length y. The system now rests in equilibrium with AC making an angle θ with the floor, where $0° < \theta < 90°$.

(iii) Find, in terms of l, the range of possible values of y. **[7]**

This part was often omitted; it was not always clear if this was because candidates had run out of time or were not able to start the problem. Quite a number of candidates realised that the minimum value of *y* would occur when rod *AC* was (almost) vertical, and that this part was a simple exercise in geometry. Some candidates made the wrong assumption that the greatest value of *y* occurs when rod *AC* is horizontal; this is excluded by the statement in the question that $\theta < 90°$. Only a minority of candidates realised that the greatest value of *y* occurs when the system is balanced in equilibrium with the normal reaction at *B* being zero. Candidates realising this would often correctly calculate the smallest possible value of θ, but were not always able to find the value of *y* corresponding to this. Some candidates gained partial credit for taking moments about *A* for the equilibrium of the whole system even though their equation still included a normal reaction force at *B*.

For either the greatest or the least value of *y* some candidates took moments about *A* for rod *AC*. This meant they had a tension term in the equation. This gained no credit if candidates removed the tension term using the expression for *T* from part (i) since that value does not now apply; however, some candidates did manage to use an equation found by taking moments about *A* for *AB* to eliminate the tension term and go on to a correct answer.

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