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AS/A LEVEL GCE

Examiners' report

MATHEMATICS (MEI)

3895-3898, 7895-7898

4762/01 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 4762/01 series overview

The standard of work presented by candidates was usually very good, demonstrating an understanding of the specification content and an ability to apply it. Q1 was an unfamiliar context and this did seem to confuse some candidates, although in this question, as in others, a clearly labelled diagram would have been of great help.

Question 1 (i)

1 A and B are two points on smooth horizontal ground. Two particles, P of mass 5.5 kg and Q of mass 0.5 kg, are projected from these points with the velocity components shown in Fig. 1. Initially, the particles have the same horizontal speed of $15\,\mathrm{m\,s^{-1}}$ and the same vertical speed of $U\,\mathrm{m\,s^{-1}}$.

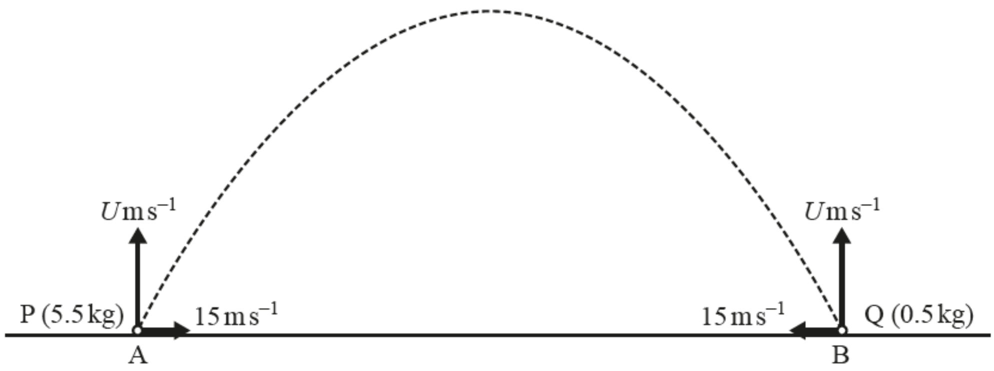

Fig. 1

Air resistance should be neglected.

The particles are projected at the same time and collide 2.5 s after projection when each is at the top of its trajectory.

(i) Find the value of U. **[2]**

The context of this question on collisions involved two projectiles. Some candidates struggled to apply their knowledge in this unfamiliar scenario. This first part was a simple application of the use of a *suvat* equation for the vertical motion of one of the particles to its greatest height.

Question 1 (ii)

(ii) Show that, immediately after the particles collide, they separate at $30e\,\mathrm{m\,s^{-1}}$, where e is the coefficient of restitution in the collision. **[2]**

In a 'show that' request, candidates need to show sufficient working to convince the examiner of their understanding. Here, it was essential to include 15 + 15 in the use of Newton's experimental law, to justify the 30 in the given result.

Question 1 (iii)

When the particles hit the ground they are 45 m apart.

(iii) Deduce that $e = 0.6$.

Find the velocities of P and of Q immediately after they collide. **[7]**

The majority of candidates omitted the request to deduce the value of *e* and instead assumed it. They were then on familiar territory with the application of conservation of momentum and Newton's experimental law. Finding *e* required use of the fact that the particles took 2.5 s to return to ground level, giving $30e = \frac{45}{2.5}$.

Inaccuracies in finding the velocities of P and Q were prevalent. There were many sign errors and inconsistencies between the momentum and restitution equations. Most of these could have been avoided if the candidate had drawn a diagram with the directions of the velocities clearly shown. There continues to be a reluctance by candidates to draw diagrams and it should be stressed that a clear diagram almost always helps in solving a mechanics problem accurately.

Question 1 (iv)

(iv) Calculate the impulse that acts on Q in the collision. **[2]**

All candidates knew the definition of impulse as the change in momentum, but again, there were many sign errors resulting from unclear directions of the velocities. A minority of candidates found the impulse of P and then related it to the impulse on Q.

Question 1 (v)

(v) What is the displacement of Q from B when Q reaches the ground? **[2]**

Few candidates scored full marks in this part. The common error was to find the distance of Q from B, and not the displacement.

Question 1 (vi)

When particle P reaches the ground it bounces with a coefficient of restitution of $\frac{2}{7}$.

(vi) At what angle to the horizontal does P leave the ground? **[4]**

Many candidates were able to make an attempt at this part, although by this stage many of their numbers were inaccurate. They knew that the horizontal component of the velocity was unchanged and that the vertical component was reduced by a factor $\frac{2}{7}$. Some candidates quoted the formula $\tan\alpha = e\tan b$, but they rarely made any credit-worthy progress.

Question 2 (i)

2 A particle is pulled along a smooth horizontal floor by a force of magnitude 35 N inclined at a constant angle α to the horizontal, as shown in Fig. 2.1. The force acts in a fixed vertical plane.

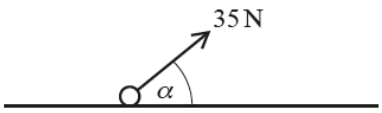

Fig. 2.1

144 J of work is done by the force on the particle as it slides through 5 m from A to B.

(i) Calculate the value of α. **[3]**

Question 2 (ii)

The mass of the particle is 6 kg and it has a speed of $4\,\mathrm{m\,s^{-1}}$ at A.

(ii) Using an energy method, calculate the speed of the particle at B. Calculate the power of the pulling force at this point. **[5]**

Most candidates equated the change in the kinetic energy of the particle to the work done by the force and successfully obtained the speed at B. A minority of candidates did not follow the instruction to 'use an energy method' and were not credited marks. A common error in finding the power of the pulling force was to use 35 N rather than the resolved part of 35 N along the direction of motion.

Question 2 (iii)

In a new situation, shown in Fig. 2.2, the particle of mass 6 kg can move on a rough plane surface inclined at 50° to the horizontal.

At all times in parts **(iii)** and **(iv)**, a force of magnitude 35 N acts on the particle; this force is inclined at 30° to a line of greatest slope of the surface.

The coefficient of friction between the particle and the surface is μ.

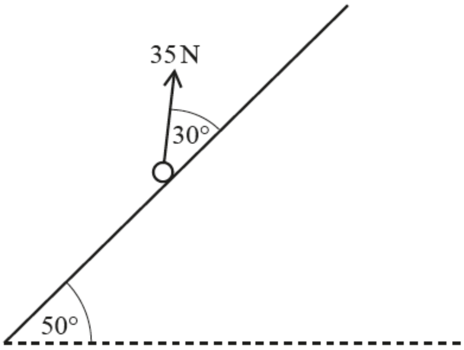

Fig. 2.2

(iii) The particle is placed on the surface and does not slide downwards.

Find the possible values of μ. **[6]**

The majority of candidates knew what they needed to do to answer this part, but there were several common errors. Many candidates omitted the component of the pulling force from the normal reaction. Others had friction acting in the wrong direction and then conveniently lost minus signs so that their value of the coefficient of friction μ was positive. There were also the usual resolution errors, with sine and cosine confusion. Unusually, there was a lot of premature rounding in this part, and the critical value of 0.726 (0.73) was incorrect.

Almost all candidates realised that they needed to give an inequality as their final answer, but all possible variations were seen. Only a few candidates worked through the question with the inequality $F \leq \mu R$. Most opted to work with equality and then seemingly hope for the best as they inserted an inequality.

Some candidates colluded with the misconception that the coefficient of friction has to be less than one, and added this to their solution.

Question 2 (iv)

The surface is now treated so that μ becomes 0.6 and the particle is placed on it.

(iv) Using an energy method, determine how far down the surface the particle has slid when it reaches a speed of $1.5\,\mathrm{m\,s^{-1}}$. **[4]**

Most candidates made a good attempt at this part, but a significant number did not achieve the correct final answer. As in part (iii), there were sign errors, resolution errors and omission of the effect of one of the forces in the work-energy equation.

Question 3 (a) (i)

3 (a)

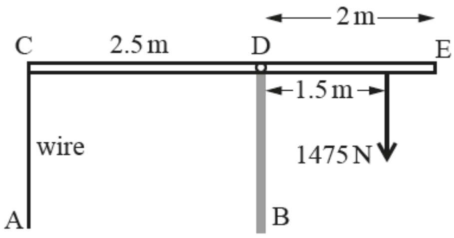

Fig. 3.1

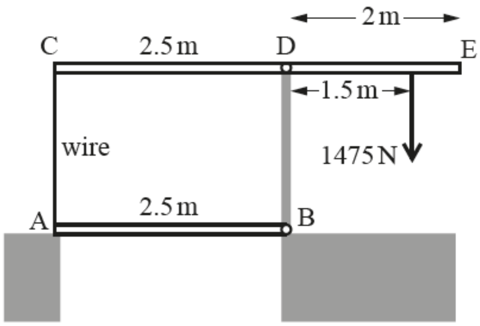

Fig. 3.2

Fig. 3.1 shows a uniform horizontal beam, CE, with weight 4000 N and length 4.5 m. BD is a rigid vertical support and the beam is freely pivoted at D, where CD is 2.5 m. The beam has a vertical load of 1475 N acting at a point that is 1.5 m from D. A vertical, light, inextensible wire is attached to the beam at C and held at A.

The beam is in equilibrium.

(i) Calculate the tension in the wire AC. **[3]**

Question 3 (a) (ii)

This beam is part of a simple lift bridge which is shown in its 'down' position in Fig. 3.2. The uniform lower beam, AB, has a weight of 1000 N and length 2.5 m. AB is freely pivoted at B, attached to the wire CA and also rests on a support at A. ABDC is a rectangle.

The bridge is in equilibrium.

(ii) Calculate the normal reaction on the beam AB of its support at A. **[4]**

The normal reaction on the beam AB of its support at A is most easily found by taking moments about B for the rod AB. The only other forces involved are then the weight of AB and the tension in AC found in part (i). A significant number of candidates opted to take moments about B (and sometimes D) for the whole system. Almost invariably, the tension in the wire AC was included, even though when the whole system is considered, the effects of the tension at A and C cancel each other out.

Question 3 (b) (i)

(b) In this part of the question you may leave your answers in surd form.

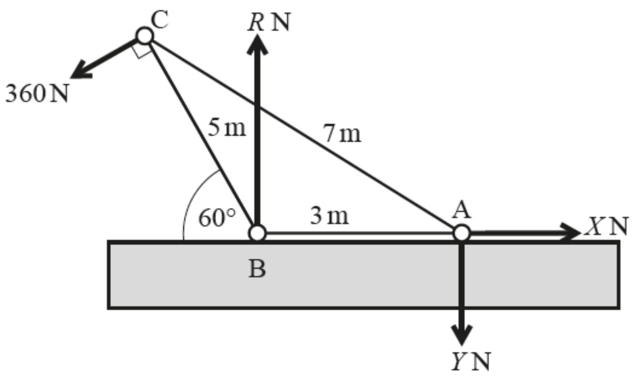

Fig. 3.3

Fig. 3.3 shows a framework in equilibrium in a vertical plane. The framework is made from three light rigid rods AB, AC and BC, of lengths 3 m, 7 m and 5 m respectively. AB is horizontal and BC is at 60° to the horizontal.

The rods are freely pin-jointed to each other at A, B and C. The pin-joint at A is fixed to a smooth horizontal floor and the pin-joint at B rests on this floor.

The figure also shows the external forces acting on the framework: there is a force of 360 N at C acting perpendicular to BC; the normal reaction of the floor on the pin-joint at B is R N; horizontal and vertical forces X N and Y N act on the framework from the pin-joint at A.

(i) Calculate the values of X and Y. Show that $R = 780$. **[4]**

This part is most easily solved by taking moments about B to find Y and then resolving horizontally to find X and vertically to find R. A significant number of candidates decided to take moments about A and then struggled to find the moment of the 360 N force.

Question 3 (b) (ii)

(ii) Calculate the forces internal to the three rods, stating whether each rod is in tension or in compression (thrust). [You may use without proof that $\sin\alpha = \frac{5\sqrt{3}}{14}$, where α = angle BAC] **[8]**

Many candidates gave clear and concise solutions to this part.

Question 4 (i)

4 The object shown in Fig. 4.1 is cut from a flat sheet of thin uniform rigid metal. OCFJ, OABC, CDEF, FHIJ and JKLO are rectangles with dimensions, in centimetres, shown in the figure.

(i) Calculate the coordinates of the centre of mass of the object referred to the axes shown in Fig. 4.1. **[4]**

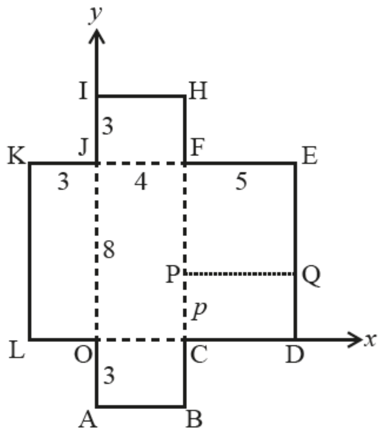

Fig. 4.1

Candidates are well-drilled in finding centres of mass of composite bodies and they work methodically through the procedure. In this question, they could have invoked the use of symmetry and reduced the number of calculations: $\bar{y} = 4$.

Question 4 (ii)

Fig. 4.2 shows the object folded as follows: rectangle FHIJ is folded along FJ and rectangle JKLO along JO so that the edges JI and JK come together; rectangle OABC is folded along OC so that it is perpendicular to OCFJ and on the other side of OCFJ to FHIJ and JKLO.

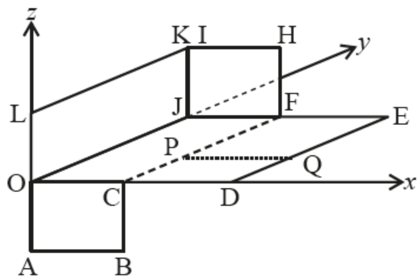

Fig. 4.2

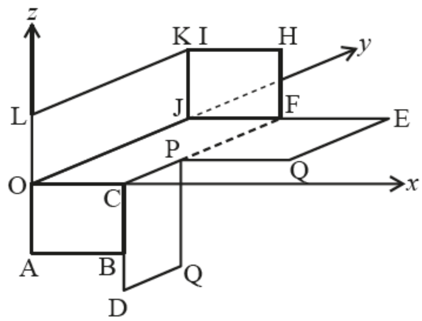

Fig. 4.3

(ii) Show that, referred to the axes shown in Fig. 4.2, the x-coordinate of the centre of mass of the folded object is 3.1. **[3]**

Again, candidates applied their tried-and-tested routine method and most worked accurately to gain full marks.

Question 4 (iii)

Rectangle CDEF is now cut along the line PQ which is perpendicular to CF. The distance CP is p cm. Rectangle CDQP is folded along CP so that part of CD is in contact with CB, as shown in Fig. 4.3. Referred to the axes shown in Fig. 4.3, the centre of mass of the folded object is at the point G with coordinates $(\bar{x}, \bar{y}, \bar{z})$.

(iii) Given that $\bar{z} = 0$, show that $p = 2.88$ and calculate $\bar{x}$ and $\bar{y}$. **[5]**

There were few problems beyond arithmetical errors in this part.

Question 4 (iv)

The folded object in Fig. 4.3 is now freely suspended from the point L and hangs in equilibrium.

(iv) Calculate the angle between OG and the vertical. **[4]**

This part required a little thought to determine which triangle to use. A significant number of candidates used their 'formula' $\tan\theta = \frac{\bar{x}}{\bar{y}}$ without stopping to consider the geometry and trigonometry of the situation.

Those candidates who drew a diagram usually identified the correct angle as $\angle$OGL and then proceeded to calculate it successfully.

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