OCR
Oxford Cambridge and RSA

Wednesday 16 May 2018 – Morning

A2 GCE MATHEMATICS (MEI)

4762/01 Mechanics 2

QUESTION PAPER

Candidates answer on the Printed Answer Book.

OCR supplied materials:
- Printed Answer Book 4762/01
- MEI Examination Formulae and Tables (MF2)

Other materials required:
- Scientific or graphical calculator

Duration: 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

These instructions are the same on the Printed Answer Book and the Question Paper.
- The Question Paper will be found inside the Printed Answer Book.
- Write your name, centre number and candidate number in the spaces provided on the Printed Answer Book. Please write clearly and in capital letters.
- **Write your answer to each question in the space provided in the Printed Answer Book**. Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the barcodes.
- You are permitted to use a scientific or graphical calculator in this paper.
- Final answers should be given to a degree of accuracy appropriate to the context.
- The acceleration due to gravity is denoted by $g\,\mathrm{m\,s^{-2}}$. Unless otherwise instructed, when a numerical value is needed, use $g = 9.8$.

INFORMATION FOR CANDIDATES

This information is the same on the Printed Answer Book and the Question Paper.
- The number of marks is given in brackets **[ ]** at the end of each question or part question on the Question Paper.
- You are advised that an answer may receive **no marks** unless you show sufficient detail of the working to indicate that a correct method is being used.
- The total number of marks for this paper is **72**.
- The Printed Answer Book consists of **12** pages. The Question Paper consists of **8** pages. Any blank pages are indicated.

INSTRUCTION TO EXAMS OFFICER/INVIGILATOR

- Do not send this Question Paper for marking; it should be retained in the centre or recycled. Please contact OCR Copyright should you wish to re-use this document.

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 $U\,\mathrm{m\,s^{-1}}$.

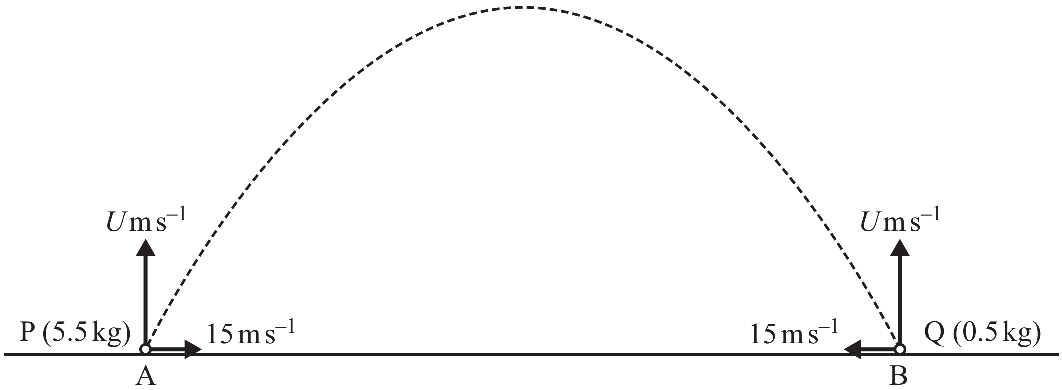

Fig. 1

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]**

(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]**

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]**

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

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

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]**

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.

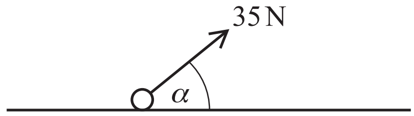

Fig. 2.1

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]**

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]**

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.

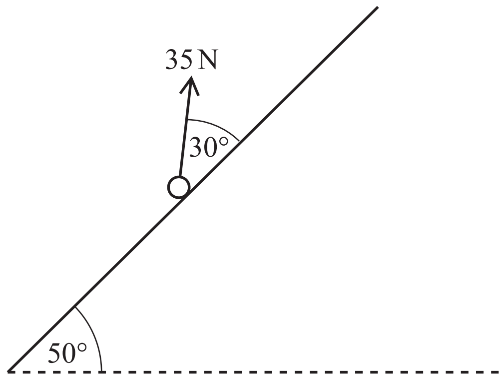

Fig. 2.2

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

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

The 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]**

3 **(a)**

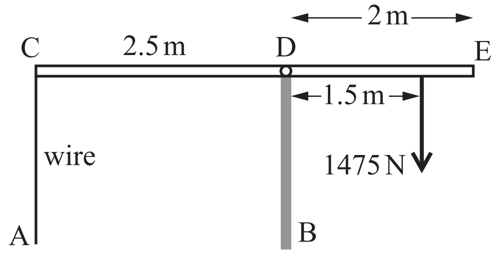

Fig. 3.1

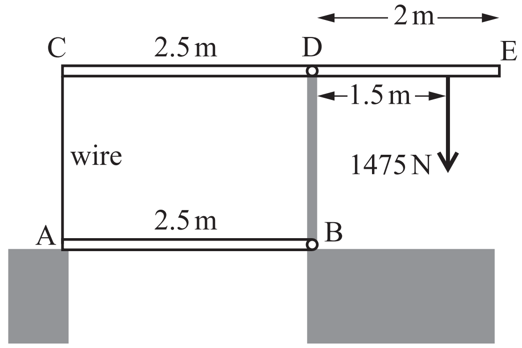

Fig. 3.2

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]**

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]**

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

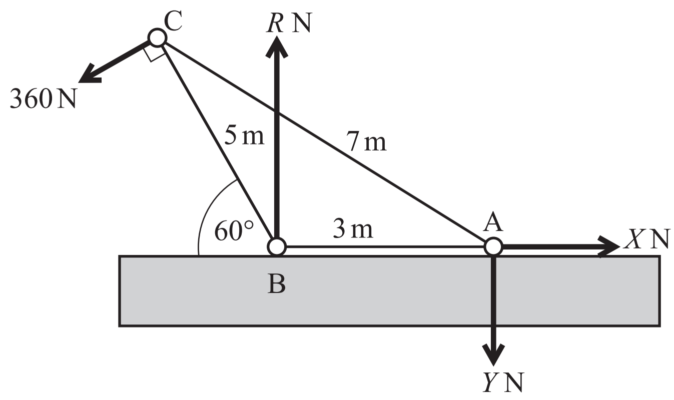

Fig. 3.3

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]**

(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]**

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]**

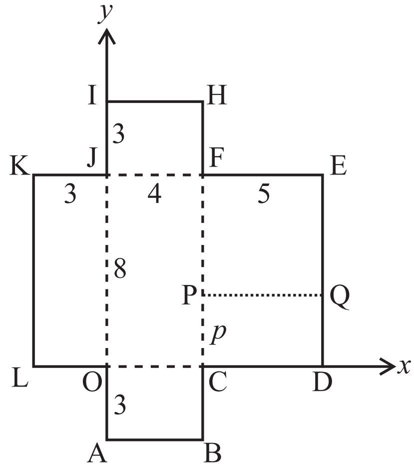

Fig. 4.1

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.

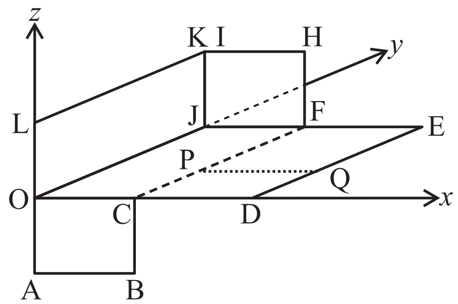

Fig. 4.2

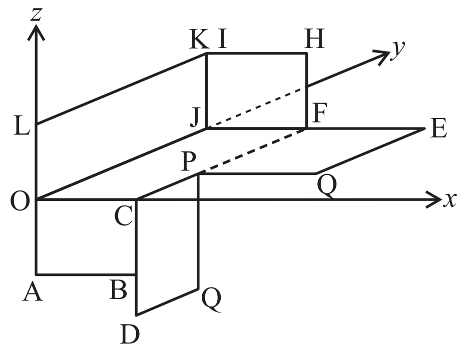

Fig. 4.3

(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]**

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]**

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]**

END OF QUESTION PAPER

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