OCR

Monday 19 May 2014 – Morning

A2 GCE MATHEMATICS (MEI)

4762/01 Mechanics 2

QUESTION PAPER

3 1 4 4 5 2 2 8 3 3

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 bar codes.
- 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 **16** 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)** A particle, P, of mass 5 kg moving with speed u m s^{-1} collides with another particle, Q, of mass 30 kg travelling with a speed of $\frac{u}{3}$ m s^{-1} towards P. The particles P and Q are moving in the same horizontal straight line with negligible resistance to their motion. As a result of the collision, the speed of P is halved and its direction of travel reversed; the speed of Q is now V m s^{-1}.

(i) Draw a diagram showing this information.

Find the velocity of Q immediately after the collision in terms of u. Find also the coefficient of restitution between P and Q. **[6]**

(ii) Find, in terms of u, the impulse of P on Q in the collision. **[2]**

(b) Fig. 1 shows a small object R of mass 5 kg travelling on a smooth horizontal plane at 6 m s^{-1}. It explodes into two parts of masses 2 kg and 3 kg. The velocities of these parts are in the plane in which R was travelling with the speeds and directions indicated. The angles α and β are given by $\cos\alpha = \frac{4}{5}$ and $\cos\beta = \frac{3}{5}$.

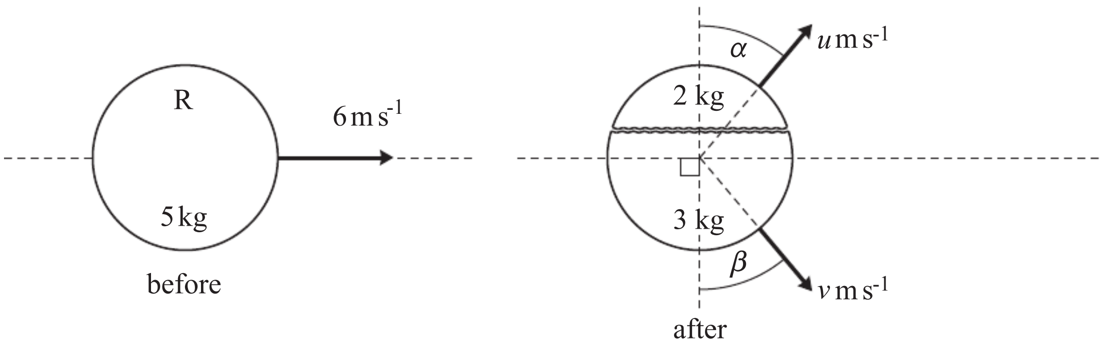

Fig. 1

(i) Calculate u and v. **[7]**

(ii) Calculate the increase in kinetic energy resulting from the explosion. **[2]**

2 Fig. 2.1 shows the positions of the points P, Q, R, S, T, U, V and W which are at the vertices of a cube of side a; Fig. 2.1 also shows coordinate axes, where O is the mid-point of PQ.

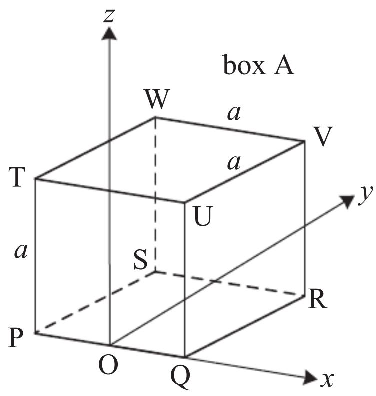

Fig. 2.1

An **open** box, A, is made from thin uniform material in the form of the faces of the cube with just the face TUVW missing.

(i) Find the z-coordinate of the centre of mass of A. **[3]**

Strips made of a thin heavy material are now fixed to the edges TW, WV and VU of box A, as shown in Fig. 2.2. Each of these three strips has the same mass as one face of the box. This new object is B.

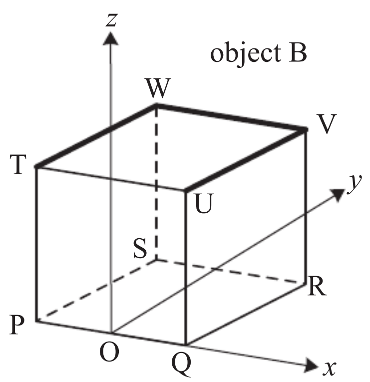

Fig. 2.2

(ii) Find the x- and z- coordinates of the centre of mass of B and show that the y-coordinate is $\frac{9a}{16}$. **[6]**

Object B is now placed on a plane which is inclined at θ to the horizontal. B is positioned so that face PQRS is on the plane with SR at right angles to a line of greatest slope of the plane and with PQ higher than SR, as shown in Fig. 2.3.

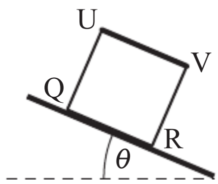

Fig. 2.3

(iii) Assuming that B does not slip, find θ if B is on the point of tipping. **[5]**

B is now placed on a different plane which is inclined at 30° to the horizontal. When B is released it accelerates down the plane at $2\,\text{m}\,\text{s}^{-2}$.

(iv) Calculate the coefficient of friction between B and the inclined plane. **[5]**

3 (a) Fig. 3.1 shows a framework in equilibrium in a vertical plane. The framework is made from 3 light rigid rods AB, BC and CA which are freely pin-jointed to each other at A, B and C. The pin-joint at A is attached to a fixed horizontal beam; the pin-joint at C rests on a smooth horizontal floor. BC is 2 m and angle BAC is 30º; BC is at right angles to AC. AB is horizontal.

Fig. 3.1 also shows the external forces acting on the framework; there is a vertical load of 60 N at B, horizontal and vertical forces X N and Y N act at A; the reaction of the floor at C is R N.

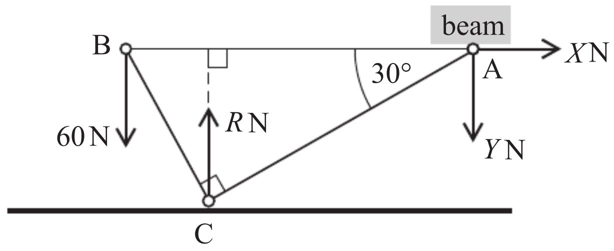

Fig. 3.1

(i) Show that $R = 80$ and find the values of X and Y. **[4]**

(ii) Using the diagram in your printed answer book, show all the forces acting on the pin-joints, including those internal to the rods. **[1]**

(iii) Calculate the forces internal to the rods AB, BC and CA, stating whether each rod is in tension or thrust (compression). [You may leave your answers in surd form. Your working in this part should correspond to your diagram in part **(ii)**.] **[6]**

(b) Fig 3.2 shows a non-uniform rod of length 6 m and weight 68 N with its centre of mass at G. This rod is free to rotate in a vertical plane about a horizontal axis through B, which is 2 m from A. G is 2 m from B. The rod is held in equilibrium at an angle θ to the horizontal by a horizontal force of 102 N acting at C and another force acting at A (not shown in Fig. 3.2). Both of these forces and the force exerted on the rod by the hinge (also not shown in Fig 3.2) act in a vertical plane containing the rod. You are given that $\sin\theta = \frac{15}{17}$.

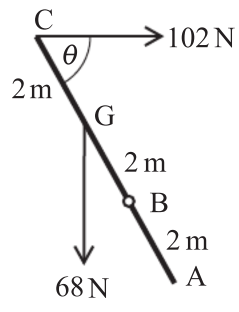

Fig. 3.2

(i) First suppose that the force at A is at right angles to ABC and has magnitude P N.

Calculate P. **[4]**

(ii) Now instead suppose that the force at A is horizontal and has magnitude Q N.

Calculate Q.

Calculate also the magnitude of the force exerted on the rod by the hinge. **[5]**

4 **(a)** A small heavy object of mass 10 kg travels the path ABCD which is shown in Fig. 4. ABCD is in a vertical plane; CD and AEF are horizontal. The sections of the path AB and CD are smooth but section BC is rough.

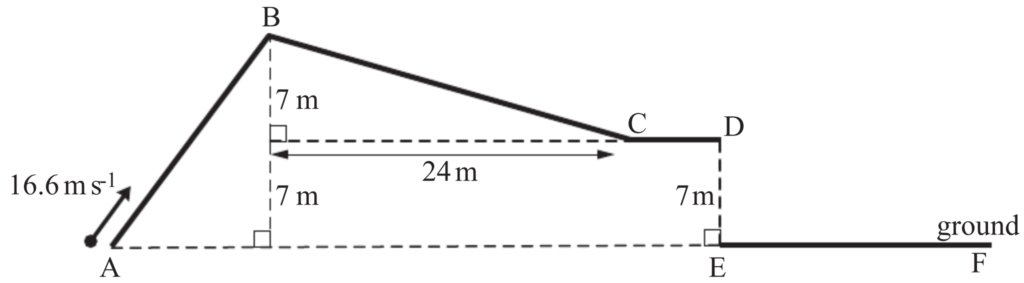

Fig. 4

You should assume that

- the object does not leave the path when travelling along ABCD and does not lose energy when changing direction
- there is no air resistance.

Initially, the object is projected from A at a speed of $16.6\,\mathrm{m\,s^{-1}}$ up the slope.

(i) Show that the object gets beyond B. **[2]**

The section of the path BC produces a constant resistance of 14 N to the motion of the object.

(ii) Using an energy method, find the velocity of the object at D. **[5]**

At D, the object leaves the path and bounces on the smooth horizontal ground between E and F, shown in Fig. 4. The coefficient of restitution in the collision of the object with the ground is $\frac{1}{2}$.

(iii) Calculate the greatest height above the ground reached by the object after its first bounce. **[3]**

(b) A car of mass 1500 kg travelling along a straight, horizontal road has a steady speed of $50\,\mathrm{m\,s^{-1}}$ when its driving force has power P W.

When at this speed, the power is suddenly reduced by 20%. The resistance to the car's motion, F N, does not change and the car begins to decelerate at $0.08\,\mathrm{m\,s^{-2}}$.

Calculate the values of P and F. **[6]**

END OF QUESTION PAPER

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