ADVANCED GCE

MATHEMATICS (MEI) 4762

Mechanics 2

Candidates answer on the Answer Booklet

OCR Supplied Materials:
- 8 page Answer Booklet
- Graph paper
- MEI Examination Formulae and Tables (MF2)

Other Materials Required:
None

Friday 9 January 2009
Morning

Duration: 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the spaces provided on the Answer Booklet.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that 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 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

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- 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**.
- This document consists of **8** pages. Any blank pages are indicated.

1 **(i)** What constant force is required to accelerate a particle of mass m kg from rest to $2u\,\mathrm{m\,s^{-1}}$ in 5 seconds? **[3]**

Two discs P and Q are moving in the same straight line over a smooth, horizontal surface. Fig. 1 shows the masses (in kg) and the velocities (in $\mathrm{m\,s^{-1}}$) of the discs before and after they collide directly. The collision is perfectly elastic.

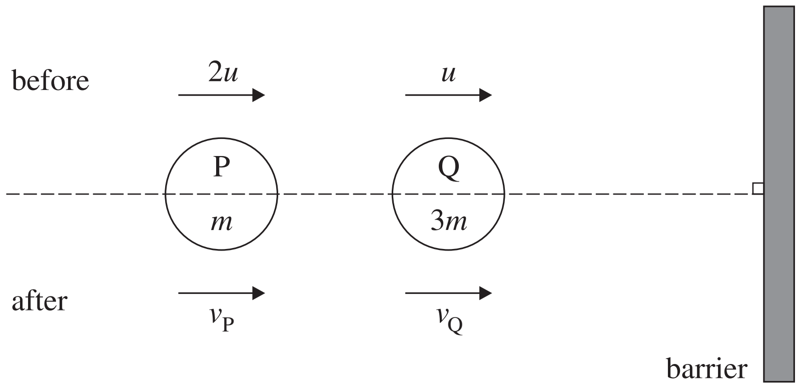

Fig. 1

(ii) Show that $v_Q = \frac{3}{2}u$ and find the value of v_P. **[6]**

After the collision, Q hits the barrier shown in Fig. 1 which is perpendicular to its path and bounces back directly. The coefficient of restitution in this collision is e. Q collides again with P and on this occasion they stick together (coalesce) to form a single object, R, that has a speed of $\frac{1}{4}u\,\mathrm{m\,s^{-1}}$ away from the barrier.

(iii) Write down an expression in terms of e and u for the velocity of Q after collision with the barrier. Find, in either order, the value of e and the impulse on the barrier. **[9]**

2 One way to load a box into a van is to push the box so that it slides up a ramp. Some removal men are experimenting with the use of different ramps to load a box of mass 80 kg.

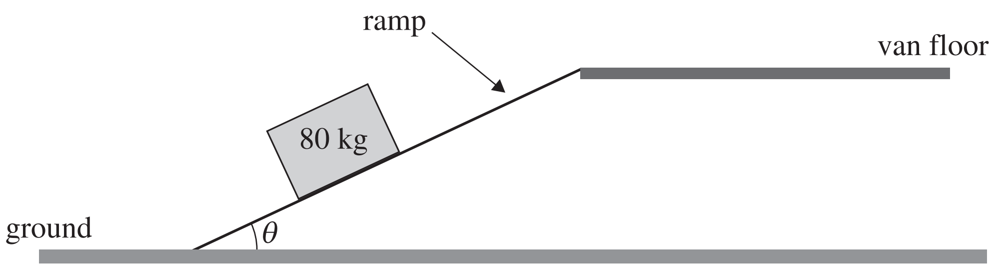

Fig. 2

Fig. 2 shows the general situation. The ramps are all uniformly rough with coefficient of friction 0.4 between the ramp and the box. The men push parallel to the ramp. As the box moves from one end of the ramp to the other it travels a vertical distance of 1.25 m.

(i) Find the limiting frictional force between the ramp and the box in terms of θ. **[3]**

(ii) From rest at the bottom, the box is pushed up the ramp and left at rest at the top. Show that the work done against friction is $\frac{392}{\tan\theta}$ J. **[3]**

(iii) Calculate the gain in the gravitational potential energy of the box when it is raised from the ground to the floor of the van. **[2]**

For the rest of the question take $\theta = 35°$.

(iv) Calculate the power required to slide the box up the ramp at a steady speed of 1.5 m s^{-1}. **[4]**

(v) The box is given an initial speed of 0.5 m s^{-1} at the top of the ramp and then slides down without anyone pushing it. Determine whether it reaches a speed of 3 m s^{-1} while it is on the ramp. **[5]**

3 A fish slice consists of a blade and a handle as shown in Fig. 3.1. The rectangular blade ABCD is of mass 250 g and modelled as a lamina; this is 24 cm by 8 cm and is shown in the Oxy plane. The handle EF is of mass 125 g and is modelled as a thin rod; this is 30 cm long and E is attached to the mid-point of CD. EF is at right angles to CD and inclined at α to the plane containing ABCD, where $\sin\alpha = 0.6$ (and $\cos\alpha = 0.8$). Coordinates refer to the axes shown in Fig. 3.1. Lengths are in centimetres. The y- and z-coordinates of the centre of mass of the fish slice are $\bar{y}$ and $\bar{z}$ respectively.

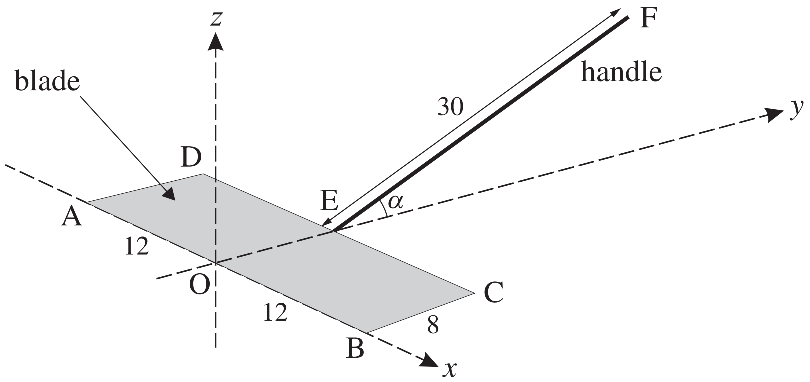

Fig. 3.1

(i) Show that $\bar{y} = 9\frac{1}{3}$ and $\bar{z} = 3$. **[8]**

(ii) Suppose that the plane Oxy in Fig. 3.1 is horizontal and represents a table top and that the fish slice is placed on it as shown. Determine whether the fish slice topples. **[2]**

The 'superior' version of the fish slice has an extra mass of 125 g uniformly distributed over the existing handle for 10 cm from F towards E, as shown in Fig. 3.2. This section of the handle may still be modelled as a thin rod.

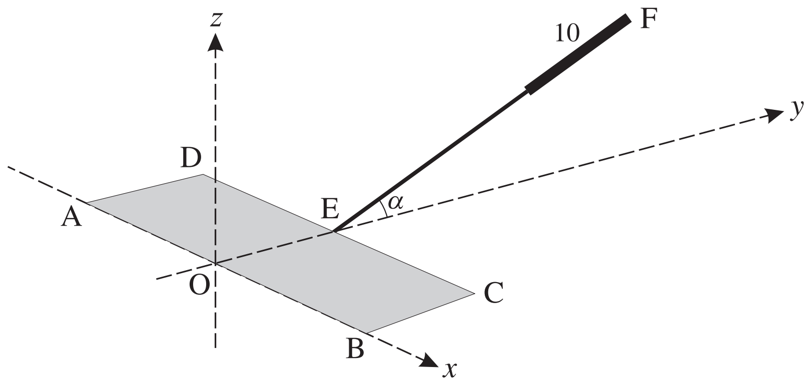

Fig. 3.2

(iii) In this new situation show that $\bar{y} = 14$ and $\bar{z} = 6$. **[4]**

A sales feature of the 'superior' version is the ability to suspend it using a very small hole in the blade. This situation is modelled as the fish slice hanging in equilibrium when suspended freely about an axis through O.

(iv) Indicate the position of the centre of mass on a diagram and calculate the angle of the line OE with the vertical. **[4]**

4 **(a)** A uniform, rigid beam, AB, has a weight of 600 N. It is horizontal and in equilibrium resting on two small smooth pegs at P and Q. Fig. 4.1 shows the positions of the pegs; lengths are in metres.

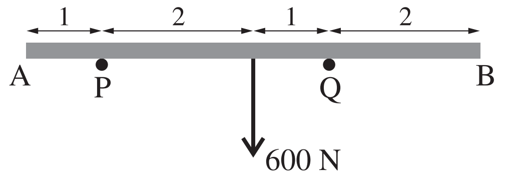

Fig. 4.1

(i) Calculate the forces exerted by the pegs on the beam. **[4]**

A force of L N is applied vertically downwards at B. The beam is in equilibrium but is now on the point of tipping.

(ii) Calculate the value of L. **[3]**

(b) Fig. 4.2 shows a framework in a vertical plane constructed of light, rigid rods AB, BC and CA. The rods are freely pin-jointed to each other at A, B and C and to a fixed point at A. The pin-joint at C rests on a smooth, horizontal support. The dimensions of the framework are shown in metres. There is a force of 340 N acting at B in the plane of the framework. This force and the rod BC are both inclined to the vertical at an angle α, which is defined in triangle BCX. The force on the framework exerted by the support at C is R N.

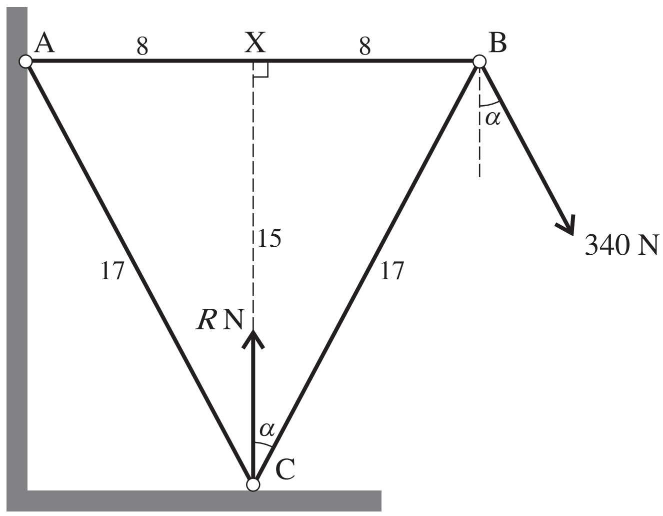

Fig. 4.2

(i) Show that $R = 600$. **[4]**

(ii) Draw a diagram showing all the forces acting on the framework and also the internal forces in the rods. **[2]**

(iii) Calculate the internal forces in the three rods, indicating whether each rod is in tension or in compression (thrust). [Your working in this part should correspond to your diagram in part **(ii)**.] **[6]**

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