OCR RECOGNISING ACHIEVEMENT

ADVANCED GCE
MATHEMATICS (MEI) 4762
Mechanics 2

QUESTION PAPER

Candidates answer on the printed answer book.

OCR supplied materials:
- Printed answer book 4762
- MEI Examination Formulae and Tables (MF2)

Other materials required:
- Scientific or graphical calculator

Monday 10 January 2011
Morning

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 in the centre of 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. 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 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 destroyed.

1 Fig. 1.1 shows block A of mass 2.5 kg which has been placed on a long, uniformly rough slope inclined at an angle α to the horizontal, where $\cos \alpha = 0.8$. The coefficient of friction between A and the slope is 0.85.

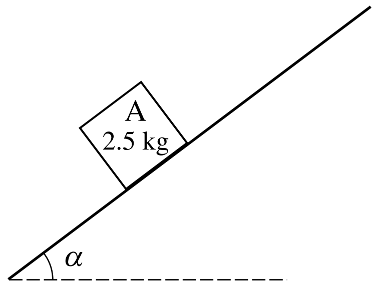

Fig. 1.1

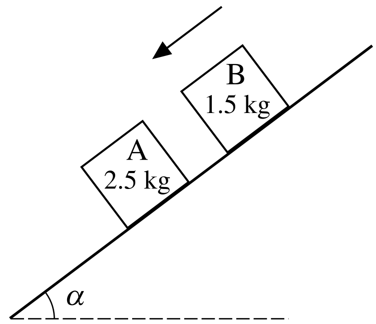

Fig. 1.2

(i) Calculate the maximum possible frictional force between A and the slope.

Show that A will remain at rest. **[6]**

With A still at rest, block B of mass 1.5 kg is projected down the slope, as shown in Fig. 1.2. B has a speed of $16\,\text{m}\,\text{s}^{-1}$ when it collides with A. In this collision the coefficient of restitution is 0.4, the impulses are parallel to the slope and linear momentum parallel to the slope is conserved.

(ii) Show that the velocity of A immediately after the collision is $8.4\,\text{m}\,\text{s}^{-1}$ down the slope.

Find the velocity of B immediately after the collision. **[6]**

(iii) Calculate the impulse on B in the collision. **[3]**

The blocks do not collide again.

(iv) For what length of time after the collision does A slide before it comes to rest? **[4]**

2 **(a)** A firework is instantaneously at rest in the air when it explodes into two parts. One part is the body B of mass 0.06 kg and the other a cap C of mass 0.004 kg. The total kinetic energy given to B and C is 0.8 J. B moves off horizontally in the **i** direction.

By considering both kinetic energy and linear momentum, calculate the velocities of B and C immediately after the explosion. **[8]**

(b) A car of mass 800 kg is travelling up some hills.

In one situation the car climbs a vertical height of 20 m while its speed decreases from 30 m s^{-1} to 12 m s^{-1}. The car is subject to a resistance to its motion but there is no driving force and the brakes are not being applied.

(i) Using an energy method, calculate the work done by the car against the resistance to its motion. **[4]**

In another situation the car is travelling at a constant speed of 18 m s^{-1} and climbs a vertical height of 20 m in 25 s up a uniform slope. The resistance to its motion is now 750 N.

(ii) Calculate the power of the driving force required. **[5]**

3

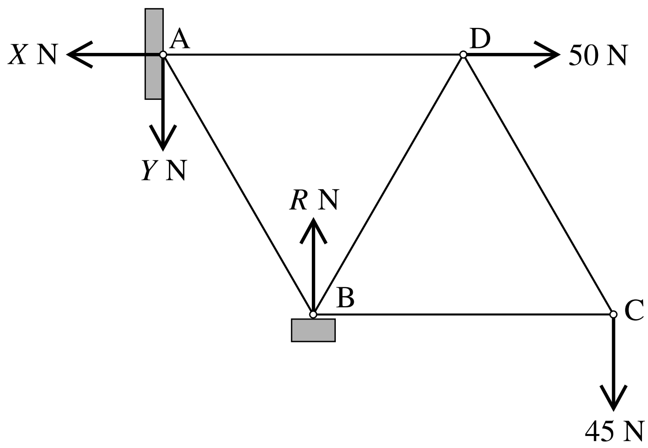

Fig. 3

Fig. 3 shows a framework in equilibrium in a vertical plane. The framework is made from the equal, light, rigid rods AB, AD, BC, BD and CD so that ABD and BCD are equilateral triangles of side 2 m. AD and BC are horizontal.

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

Fig. 3 also shows the external forces acting on the framework: there is a vertical load of 45 N at C and a horizontal force of 50 N applied at D; the normal reaction of the support on the framework at B is R N; horizontal and vertical forces X N and Y N act at A.

(i) Write down equations for the horizontal and vertical equilibrium of the framework. **[2]**

(ii) Show that $R = 135$ and $Y = 90$. **[3]**

(iii) On the diagram in your printed answer book, show the forces internal to the rods acting on the pin-joints. **[2]**

(iv) Calculate the forces internal to the five rods, stating whether each rod is in tension or compression (thrust). [You may leave your answers in surd form. Your working in this part should correspond to your diagram in part **(iii)**.] **[10]**

(v) Suppose that the force of magnitude 50 N applied at D is no longer horizontal, and the system remains in equilibrium in the same position.

By considering the equilibrium at C, show that the forces in rods CD and BC are not changed. **[2]**

4 You are given that the centre of mass, G, of a uniform lamina in the shape of an isosceles triangle lies on its axis of symmetry in the position shown in Fig. 4.1.

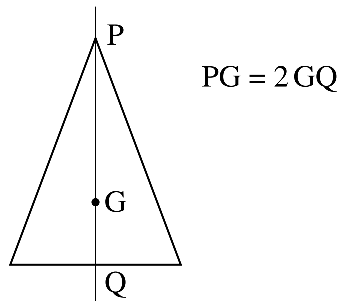

Fig. 4.1

Fig. 4.2 shows the cross-section OABCD of a prism made from uniform material. OAB is an isosceles triangle, where OA = AB, and OBCD is a rectangle. The distance OD is h cm, where h can take various positive values. All coordinates refer to the axes Ox and Oy shown. The units of the axes are centimetres.

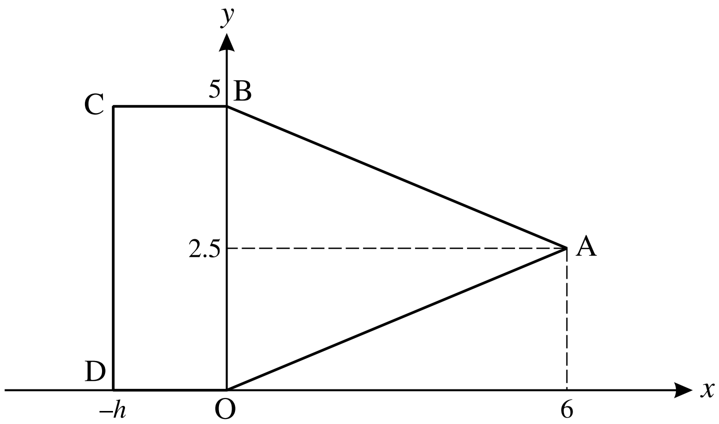

Fig. 4.2

(i) Write down the coordinates of the centre of mass of the triangle OAB. **[1]**

(ii) Show that the centre of mass of the region OABCD is $\left(\dfrac{12 - h^2}{2(h + 3)}, 2.5\right)$. **[6]**

The x-axis is horizontal.

The prism is placed on a horizontal plane in the position shown in Fig. 4.2.

(iii) Find the values of h for which the prism would topple. **[3]**

The following questions refer to the case where $h = 3$ with the prism held in the position shown in Fig. 4.2. The cross-section OABCD contains the centre of mass of the prism. The weight of the prism is 15 N. You should assume that the prism does not slide.

(iv) Suppose that the prism is held in this position by a vertical force applied at A. Given that the prism is on the point of tipping clockwise, calculate the magnitude of this force. **[3]**

(v) Suppose instead that the prism is held in this position by a force in the plane of the cross-section OABCD, applied at 30° below the horizontal at C, as shown in Fig. 4.3. Given that the prism is on the point of tipping anti-clockwise, calculate the magnitude of this force. **[4]**

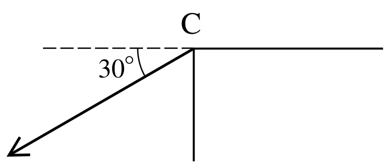

Fig. 4.3

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