



**ADVANCED GCE
MATHEMATICS (MEI)**

Mechanics 2

4762

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 $g \text{ m s}^{-2}$. 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.

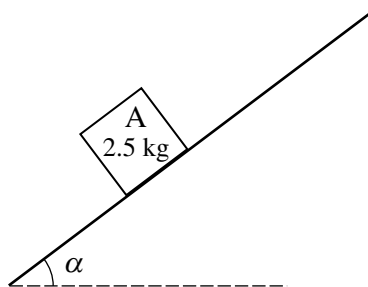


Fig. 1.1

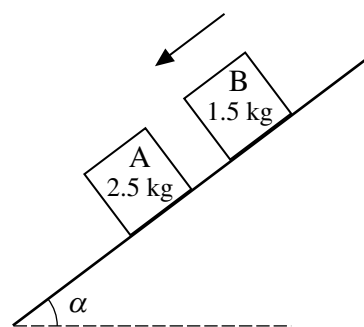


Fig. 1.2

- (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 m 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 m 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]

3

- 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 \mathbf{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]

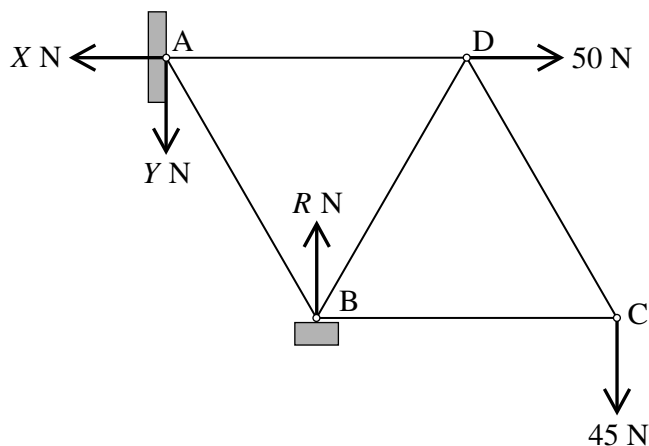


Fig. 3

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.

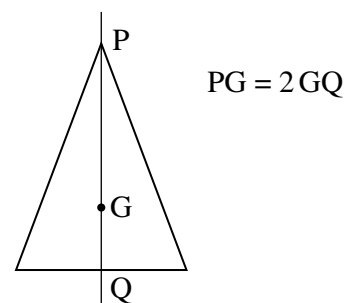


Fig. 4.1

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.

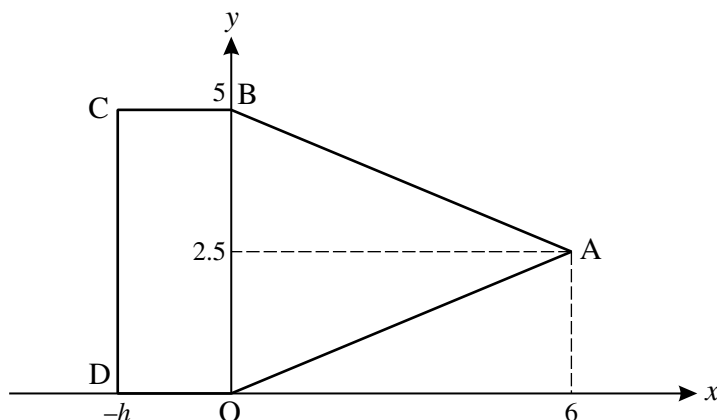


Fig. 4.2

- (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 $\left(\frac{12-h^2}{2(h+3)}, 2.5\right)$. [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]

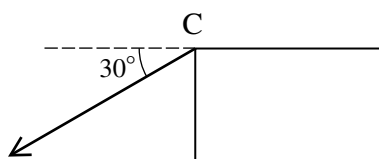


Fig. 4.3

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