OCR
RECOGNISING ACHIEVEMENT

Friday 1 June 2012 – Morning

A2 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

Duration: 1 hour 30 minutes

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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. 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 $g\,\text{m}\,\text{s}^{-2}$. 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)** A stone of mass 0.6 kg falls vertically 1.5 m from A to B against resistance. Its downward speeds at A and B are $5.5\,\text{m}\,\text{s}^{-1}$ and $7.5\,\text{m}\,\text{s}^{-1}$ respectively.

(i) Calculate the change in kinetic energy and the change in gravitational potential energy of the stone as it falls from A to B. **[3]**

(ii) Calculate the work done against resistance to the motion of the stone as it falls from A to B. **[2]**

(iii) Assuming the resistive force is constant, calculate the power with which the resistive force is retarding the stone when it is at A. **[4]**

(b) A uniform plank is inclined at 40° to the horizontal. A box of mass 0.8 kg is on the point of sliding down it. The coefficient of friction between the box and the plank is μ.

(i) Show that $\mu = \tan 40°$. **[4]**

The plank is now inclined at 20° to the horizontal.

(ii) Calculate the work done when the box is pushed 3 m up the plank, starting and finishing at rest. **[5]**

2 The rigid object shown in Fig. 2.1 is made of thin non-uniform rods. ABC is a straight line; BC, BE and ED form three sides of a rectangle. The centre of mass of the object is at G. The lengths are in centimetres. The weight of the object is 15 N.

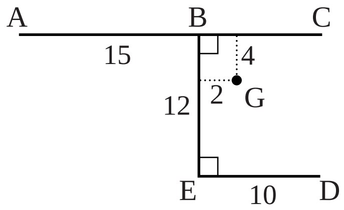

Fig. 2.1

Initially, the object is suspended by light vertical strings attached to B and to C and hangs in equilibrium with AC horizontal.

(i) Calculate the tensions in each of the strings. **[4]**

In a new situation the strings are removed. The object can rotate freely in a vertical plane about a fixed horizontal axis through A and perpendicular to ABCDE. The object is held in equilibrium with AC horizontal by a force of magnitude T N in the plane ABCDE acting at C at an angle of 30° to CA. This situation is shown in Fig. 2.2.

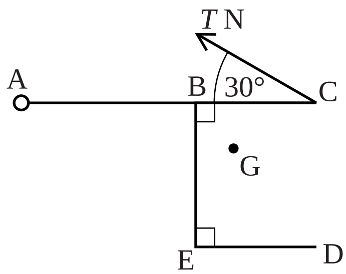

Fig. 2.2

(ii) Calculate T.

Calculate also the magnitude of the force exerted on the object by the axis at A. **[6]**

The object is now placed on a rough horizontal table and is in equilibrium with ABCDE in a vertical plane and DE in contact with the table. The coefficient of friction between the edge DE and the table is 0.65. A force of slowly increasing magnitude (starting at 0 N) is applied at A in the direction AB. Assume that the object remains in a vertical plane.

(iii) Determine whether the object slips before it tips. **[6]**

3 **(a)** You are given that the position of the centre of mass, G, of a right-angled triangle cut from thin uniform material in the position shown in Fig. 3.1 is at the point $(\frac{1}{3}a, \frac{1}{3}b)$.

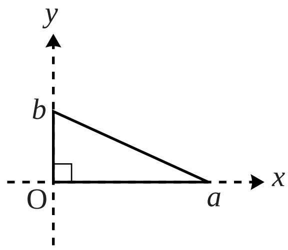

Fig. 3.1

A plane thin uniform sheet of metal is in the shape OABCDEFHIJO shown in Fig. 3.2. BDEA and CDIJ are rectangles and FEH is a right angle. The lengths of the sides are shown with each unit representing 1 cm.

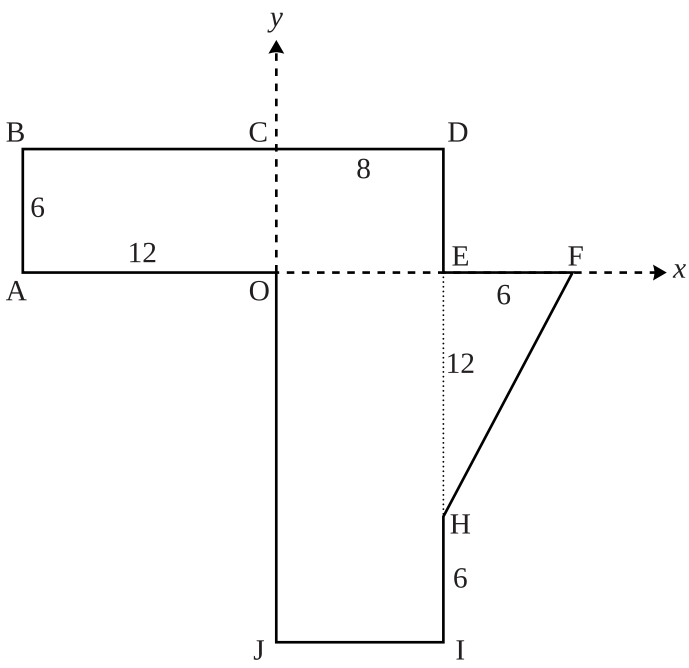

Fig. 3.2

(i) Calculate the coordinates of the centre of mass of the metal sheet, referred to the axes shown in Fig. 3.2. **[5]**

The metal sheet is freely suspended from corner B and hangs in equilibrium.

(ii) Calculate the angle between BD and the vertical. **[4]**

(b) Part of a framework of light rigid rods freely pin-jointed at their ends is shown in Fig. 3.3. The framework is in equilibrium.

All the rods meeting at the pin-joints at A, B and C are shown. The rods connected to A, B and C are connected to the rest of the framework at P, Q, R, S and T.

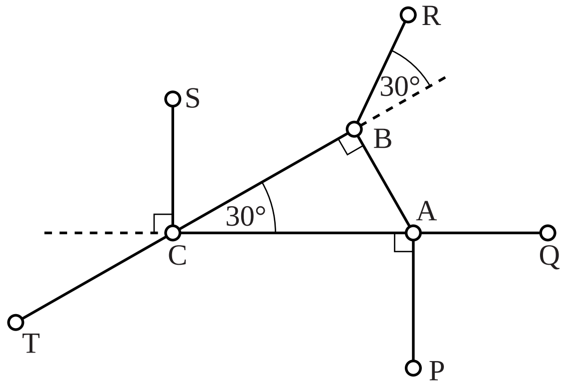

Fig. 3.3

There is a tension of 18 N in rod AP and a thrust (compression) of 5 N in rod AQ.

(i) Show the forces internal to the rods acting on the pin-joints at A, B and C. **[2]**

(ii) Calculate the forces internal to the rods AB, BC and CA, stating whether each rod is in tension or compression. [You may leave your answers in surd form. Your working in this part should be consistent with your diagram in part **(i)**.] **[7]**

Turn over

4 P and Q are circular discs of mass 3 kg and 10 kg respectively which slide on a smooth horizontal surface. The discs have the same diameter and move in the line joining their centres with no resistive forces acting on them. The surface has vertical walls which are perpendicular to the line of centres of the discs. This information is shown in Fig. 4 together with the direction you should take as being positive.

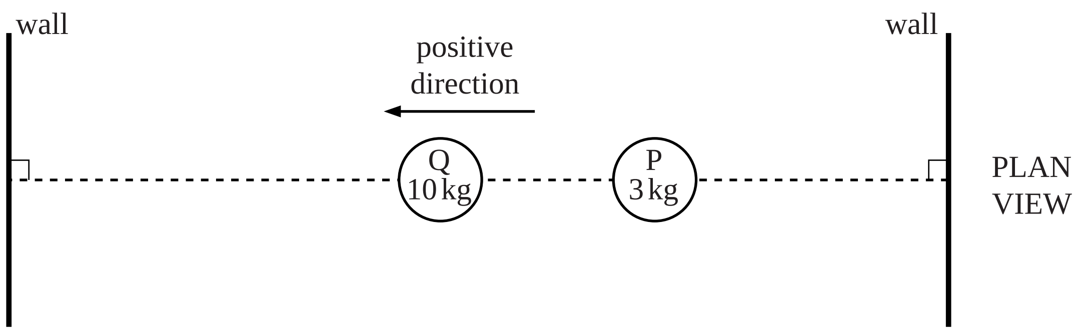

Fig. 4

(i) For what time must a force of 26 N act on P to accelerate it from rest to 13 m s^{-1}? **[2]**

P is travelling at 13 m s^{-1} when it collides with Q, which is at rest. The coefficient of restitution in this collision is e.

(ii) Show that, after the collision, the velocity of P is $(3 - 10e)$ m s^{-1} and find an expression in terms of e for the velocity of Q. **[7]**

(iii) For what set of values of e does the collision cause P to reverse its direction of motion? **[2]**

(iv) Determine the set of values of e for which P has a greater speed than Q immediately after the collision. **[4]**

You are now given that $e = \frac{1}{2}$. After P and Q collide with one another, each has a perfectly elastic collision with a wall. P and Q then collide with one another again and in this second collision they stick together (coalesce).

(v) Determine the common velocity of P and Q. **[4]**

(vi) Determine the impulse of Q on P in this collision. **[1]**

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