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

Thursday 16 June 2011
Afternoon

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 **(a)** Sphere P, of mass 10 kg, and sphere Q, of mass 15 kg, move with their centres on a horizontal straight line and have no resistances to their motion. P, Q and the positive direction are shown in Fig. 1.1.

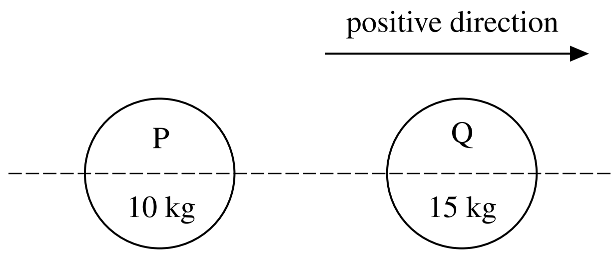

Fig. 1.1

Initially, P has a velocity of $-1.75\,\text{m s}^{-1}$ and is acted on by a force of magnitude 13 N acting in the direction PQ.

After T seconds, P has a velocity of $4.75\,\text{m s}^{-1}$ and has not reached Q.

(i) Calculate T. **[3]**

The force of magnitude 13 N is removed. P is still travelling at $4.75\,\text{m s}^{-1}$ when it collides directly with Q, which has a velocity of $-0.5\,\text{m s}^{-1}$.

Suppose that P and Q coalesce in the collision to form a single object.

(ii) Calculate their common velocity after the collision. **[2]**

Suppose instead that P and Q separate after the collision and that P has a velocity of $1\,\text{m s}^{-1}$ afterwards.

(iii) Calculate the velocity of Q after the collision and also the coefficient of restitution in the collision. **[6]**

(b) Fig. 1.2 shows a small ball projected at a speed of $14\,\text{m s}^{-1}$ at an angle of 30° below the horizontal over smooth horizontal ground.

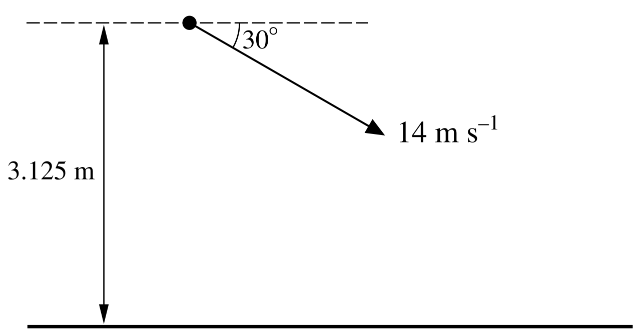

Fig. 1.2

The ball is initially 3.125 m above the ground. The coefficient of restitution between the ball and the ground is 0.6.

Calculate the angle with the horizontal of the ball's trajectory immediately after the **second** bounce on the ground. **[8]**

2 Any non-exact answers to this question should be given correct to four significant figures.

A thin, straight beam AB is 2 m long. It has a weight of 600 N and its centre of mass G is 0.8 m from end A. The beam is freely pivoted about a horizontal axis through A.

The beam is held horizontally in equilibrium.

Initially this is done by means of a support at B, as shown in Fig. 2.1.

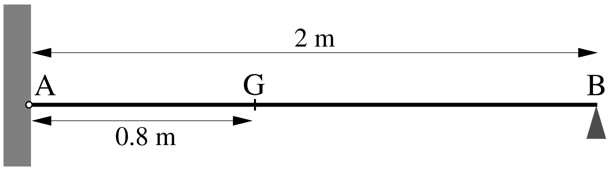

Fig. 2.1

(i) Calculate the force on the beam due to the support at B. **[3]**

The support at B is now removed and replaced by a wire attached to the beam 0.3 m from A and inclined at 50° to the beam, as shown in Fig. 2.2. The beam is still horizontal and in equilibrium.

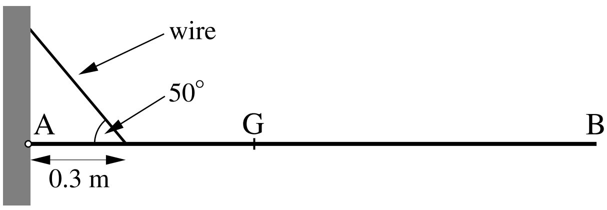

Fig. 2.2

(ii) Calculate the tension in the wire. **[5]**

The forces acting on the beam at A due to the hinge are a horizontal force X N in the direction AB, and a downward vertical force Y N, which have a resultant of magnitude R at α to the horizontal.

(iii) Calculate X, Y, R and α. **[7]**

The dotted lines in Fig. 2.3 are the lines of action of the tension in the wire and the weight of the beam. These lines of action intersect at P.

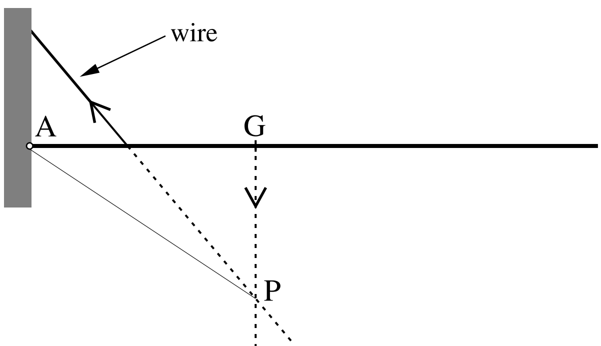

Fig. 2.3

(iv) State with a reason the size of the angle GAP. **[2]**

3 A bracket is being made from a sheet of uniform thin metal. Firstly, a plate is cut from a square of the sheet metal in the shape OABCDEFHJK, shown shaded in Fig. 3.1. The dimensions shown in the figure are in centimetres; axes Ox and Oy are also shown.

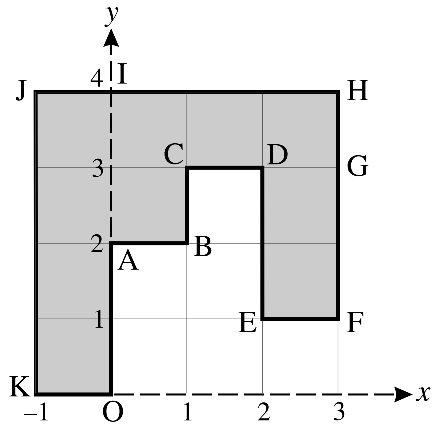

Fig. 3.1

(i) Show that, referred to the axes given in Fig. 3.1, the centre of mass of the plate OABCDEFHJK has coordinates (0.8, 2.5). **[4]**

The plate is hung using light vertical strings attached to J and H. The edge JH is horizontal and the plate is in equilibrium. The weight of the plate is 3.2 N.

(ii) Calculate the tensions in each of the strings. **[5]**

The plate is now bent to form the bracket. This is shown in Fig. 3.2: the rectangle IJKO is folded along the line IA so that it is perpendicular to the plane ABCGHI; the rectangle DEFG is folded along the line DG so it is also perpendicular to the plane ABCGHI but on the other side of it. Fig. 3.2 also shows the axes Ox, Oy and Oz.

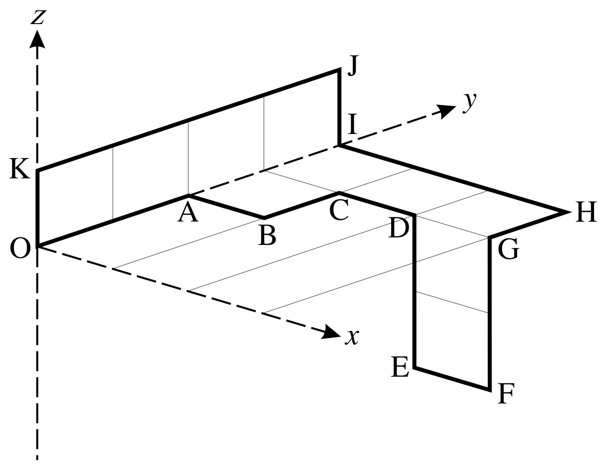

Fig. 3.2

(iii) Show that, referred to the axes given in Fig. 3.2, the centre of mass of the bracket has coordinates (1, 2.7, 0). **[5]**

The bracket is now hung freely in equilibrium from a string attached to O.

(iv) Calculate the angle between the edge OI and the vertical. **[4]**

4 **(a)** A parachutist and her equipment have a combined mass of 80 kg. During a descent where the parachutist loses 1600 m in height, her speed reduces from $V\,\text{m s}^{-1}$ to $6\,\text{m s}^{-1}$ and she does 1.3×10^6 J of work against resistances.

Use an energy method to calculate the value of V. **[5]**

(b) A vehicle of mass 800 kg is climbing a hill inclined at θ to the horizontal, where $\sin\theta = 0.1$. At one time the vehicle has a speed of $8\,\text{m s}^{-1}$ and is accelerating up the hill at $0.25\,\text{m s}^{-2}$ against a resistance of 1150 N.

(i) Show that the driving force on the vehicle is 2134 N and calculate its power at this time. **[7]**

The vehicle is pulling a sledge, of mass 300 kg, which is sliding up the hill. The sledge is attached to the vehicle by a light, rigid coupling parallel to the slope. The force in the coupling is 900 N.

(ii) Assuming that the only resistance to the motion of the sledge is due to friction, calculate the coefficient of friction between the sledge and the ground. **[6]**

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