OXFORD CAMBRIDGE AND RSA EXAMINATIONS

A2 GCE

4762/01

MATHEMATICS (MEI)

Mechanics 2

QUESTION PAPER

MONDAY 10 JUNE 2013: Morning

DURATION: 1 hour 30 minutes
plus your additional time allowance

MODIFIED ENLARGED

Candidates answer on the Printed Answer Book or any other suitable paper provided by the centre. The Printed Answer Book may be enlarged by the centre.

OCR SUPPLIED MATERIALS:

Printed Answer Book 4762/01
MEI Examination Formulae and Tables (MF2)

OTHER MATERIALS REQUIRED:

Scientific or graphical calculator

READ INSTRUCTIONS OVERLEAF

DC (RW/SW) 1649592997 79952/1

INSTRUCTIONS TO CANDIDATES

- **Write your name, centre number and candidate number in the spaces provided on the Printed Answer Book or on the paper provided by the centre. Please write clearly and in capital letters.**
- **IF YOU USE THE PRINTED ANSWER BOOK WRITE YOUR ANSWER TO EACH QUESTION IN THE SPACE PROVIDED. 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.**
- **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 $g\,\mathrm{m\,s^{-2}}$. 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 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.**
- **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) In this part-question, all the objects move along the same straight line on a smooth horizontal plane. All their collisions are direct.

The masses of the objects P, Q and R and the initial velocities of P and Q (but not R) are shown below in Fig. 1.1.

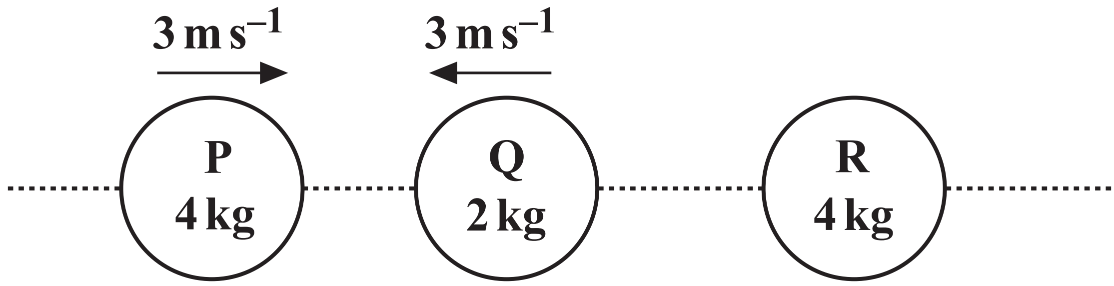

FIG. 1.1

A force of 21 N acts on P for 2 seconds in the direction PQ. P does not reach Q in this time.

(i) Calculate the speed of P after the 2 seconds. [2]

The force of 21 N is removed after the 2 seconds. When P collides with Q they stick together (coalesce) to form an object S of mass 6 kg.

(ii) Show that immediately after the collision S has a velocity of 8 m s^{-1} towards R. [2]

The collision between S and R is elastic with coefficient of restitution $\frac{1}{4}$. After the collision, S has a velocity of 5 m s^{-1} in the direction of its motion before the collision.

(iii) Find the velocities of R before and after the collision. [6]

(b) IN THIS PART-QUESTION TAKE $g = 10$.

A particle of mass 0.2 kg is projected vertically downwards with initial speed $5\,\text{m}\,\text{s}^{-1}$ and it travels 10 m before colliding with a fixed smooth plane. The plane is inclined at α to the vertical where $\tan\alpha = \frac{3}{4}$. Immediately after its collision with the plane, the particle has a speed of $13\,\text{m}\,\text{s}^{-1}$. This information is shown below in Fig. 1.2. Air resistance is negligible.

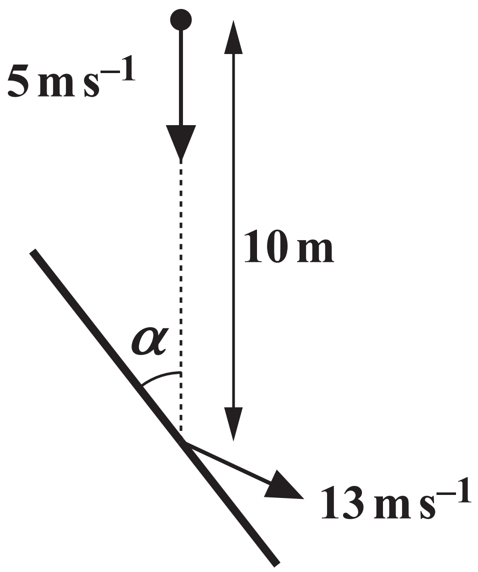

FIG. 1.2

(i) Calculate the angle between the direction of motion of the particle and the plane immediately after the collision.

Calculate also the coefficient of restitution in the collision. [8]

(ii) Calculate the magnitude of the impulse of the plane on the particle. [2]

2 **A fairground ride consists of raising vertically a bench with people sitting on it, allowing the bench to drop and then bringing it to rest using brakes. Fig. 2 below shows the bench and its supporting tower. The tower provides lifting and braking mechanisms. The resistances to motion are modelled as having a constant value of 400 N whenever the bench is moving up or down; the only other resistance to motion comes from the action of the brakes.**

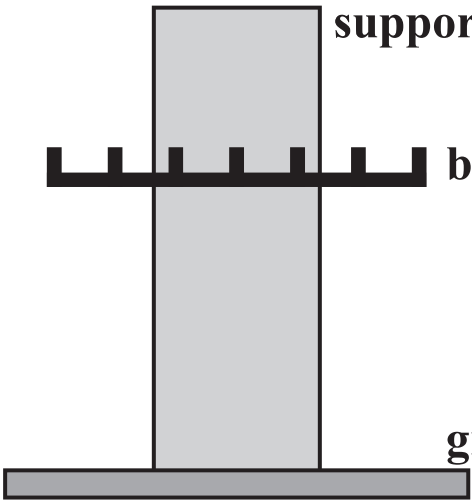

FIG. 2

On one occasion, the mass of the bench (with its riders) is 800 kg.

With the brakes not applied, the bench is lifted a distance of 6 m in 12 seconds. It starts from rest and ends at rest.

(i) Show that the work done in lifting the bench in this way is 49 440 J and calculate the average power required. [4]

For a short period while the bench is being lifted it has a constant speed of 0.55 m s^{-1}.

(ii) Calculate the power required during this period. [3]

With neither the lifting mechanism nor the brakes applied, the bench is now released from rest and drops 3 m.

(iii) Using an energy method, calculate the speed of the bench when it has dropped 3 m. [4]

The brakes are now applied and they halve the speed of the bench while it falls a further 0.8 m.

(iv) Using an energy method, calculate the work done by the brakes. [5]

3 **Fig. 3.1 below shows a rigid, thin, NON-UNIFORM 20 cm by 80 cm rectangular panel ABCD of weight 60 N that is in a vertical plane. Its dimensions and the position of its centre of mass, G, are shown in centimetres. The panel is free to rotate about a fixed horizontal axis through A perpendicular to its plane; the panel rests on a small smooth fixed peg at B positioned so that AB is at 40° to the horizontal. A horizontal force in the plane of ABCD of magnitude *P* N acts at D away from the panel.**

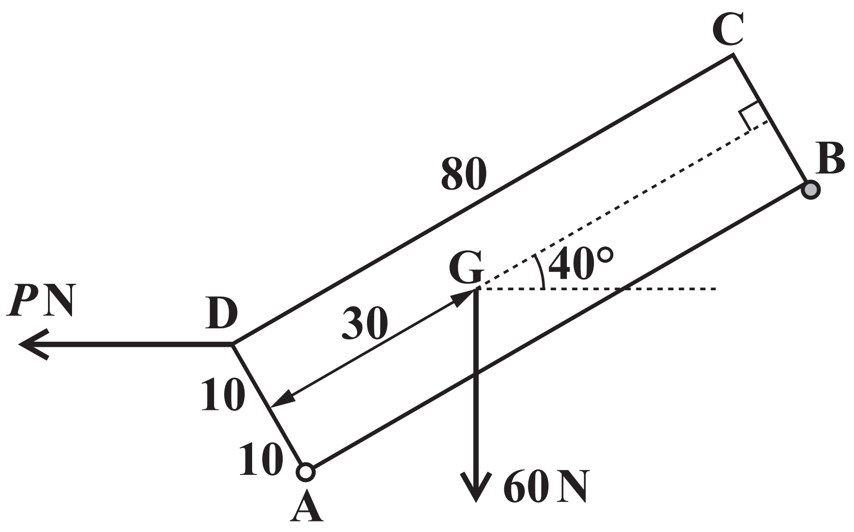

FIG. 3.1

(i) Show that the clockwise moment of the weight about A is 9.93 N m, correct to 3 significant figures. [3]

(ii) Calculate the value of *P* for which the panel is on the point of turning about the axis through A. [2]

(iii) In the situation where *P* = 0, calculate the vertical component of the force exerted on the panel by the axis through A. [4]

The panel is now placed on a line of greatest slope of a rough plane inclined at 40° to the horizontal. The panel is at all times in a vertical plane. A horizontal force in the plane ABCD of magnitude 200 N acts at D towards the panel. This situation is shown below in Fig. 3.2.

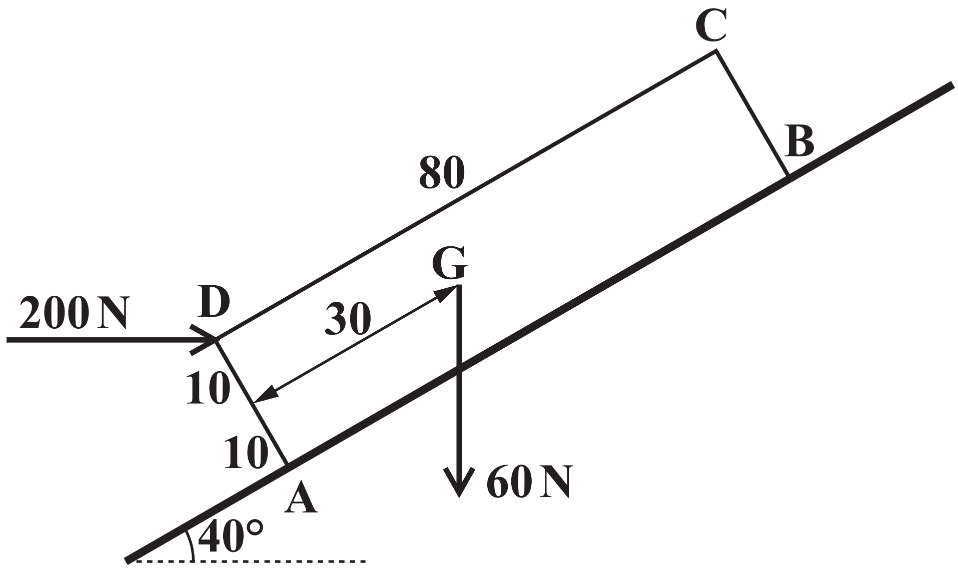

FIG. 3.2

(iv) Given that the panel is moving up the plane with acceleration up the plane of $1.75\,\text{m}\,\text{s}^{-2}$, calculate the coefficient of friction between the panel and the plane. [8]

4 (a) Fig. 4.1 below shows a framework constructed from 4 uniform heavy rigid rods OP, OQ, PR and RS, rigidly joined at O, P, Q, R and S and with OQ perpendicular to PR. Fig. 4.1 also shows the dimensions of the rods and axes Ox and Oy: the units are metres.

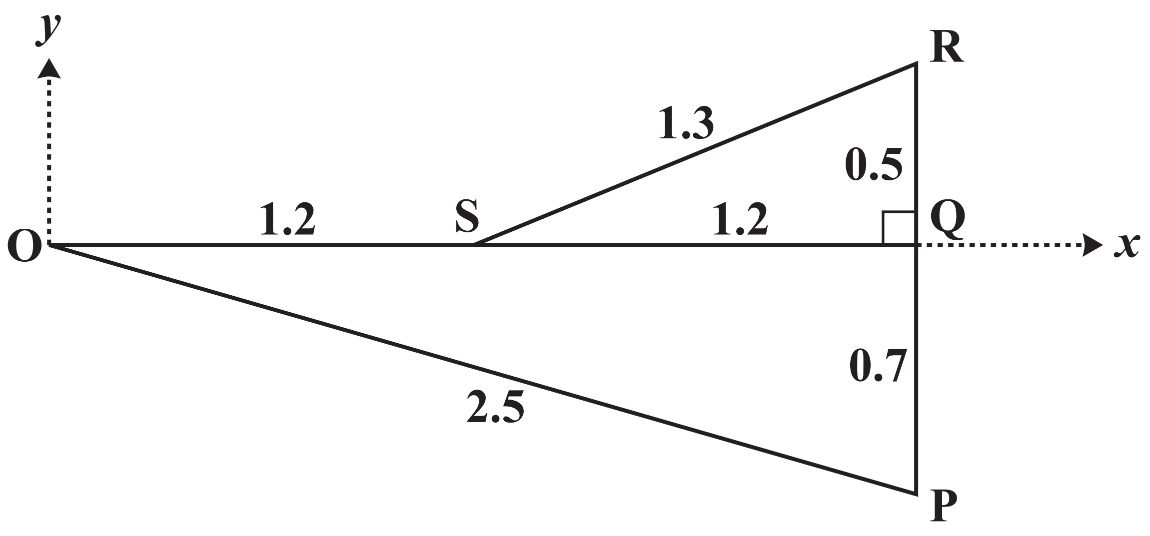

FIG. 4.1

Each rod has a mass of 0.8 kg per metre.

(i) Show that, referred to the axes in Fig. 4.1, the x-coordinate of the centre of mass of the framework is 1.5 and calculate the y-coordinate. [5]

The framework is freely suspended from S and a small object of mass m kg is attached to it at O. The framework is in equilibrium with OQ horizontal.

(ii) Calculate m. [3]

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[QUESTION 4 IS CONTINUED OVERLEAF.]

(b) Fig. 4.2 below shows a framework in equilibrium in a vertical plane. The framework is made from 5 light, rigid rods OP, OQ, OR, PQ and QR. Its dimensions are indicated. PQ is horizontal and OR vertical.

The rods are freely pin-jointed to each other at O, P, Q and R. The pin-joint at O is fixed to a wall.

Fig. 4.2 also shows the external forces acting on the framework: there are vertical loads of 120 N and 60 N at Q and P respectively; a horizontal string attached to Q has tension T N; horizontal and vertical forces X N and Y N act on the framework from the pin-joint at O.

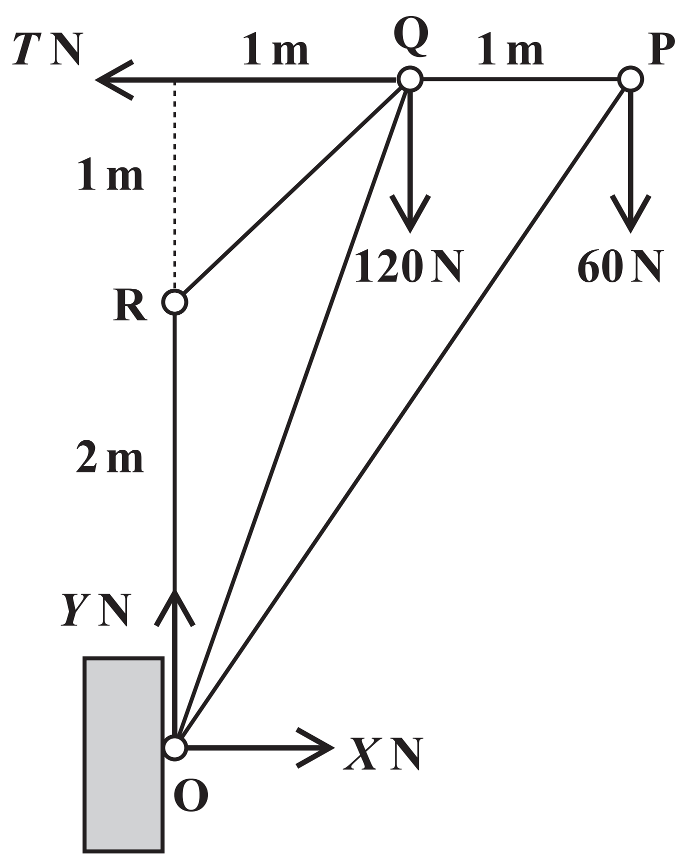

FIG. 4.2

(i) By considering only the pin-joint at R, explain why the rods OR and RQ must have zero internal force. [2]

(ii) Find the values of *T*, *X* and *Y*. [3]

(iii) Using the diagram in your printed answer book, show all the forces acting on the pin-joints, including those internal to the rods. [1]

(iv) Calculate the forces internal to the rods OP and PQ, stating whether each rod is in tension or compression (thrust). [You may leave answers in surd form. Your working in this part should correspond to your diagram in part (iii).] [5]

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