

Monday 10 June 2013 – Morning

A2 GCE MATHEMATICS (MEI)

4762/01 Mechanics 2

QUESTION PAPER

Candidates answer on the Printed Answer Book.

OCR supplied materials:

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

Other materials required:

- Scientific or graphical calculator

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. 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 $g \text{ m s}^{-2}$. 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 **16** 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) 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 in Fig. 1.1.

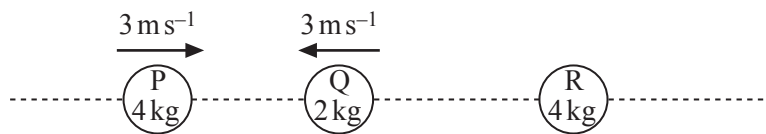


Fig. 1.1

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 m 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 m s^{-1} . This information is shown in Fig. 1.2. Air resistance is negligible.

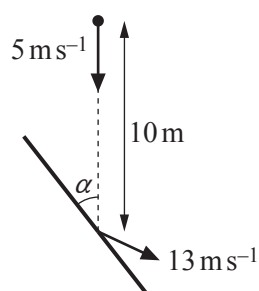


Fig. 1.2

- (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 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.

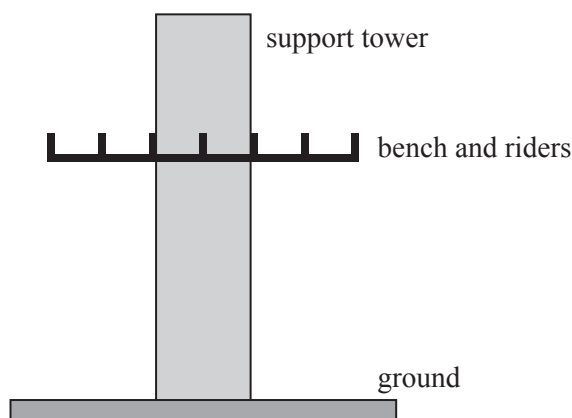


Fig. 2

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 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.

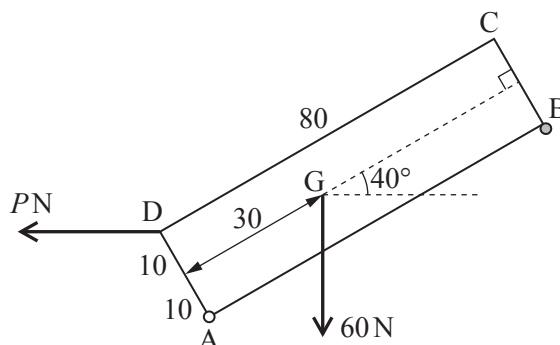


Fig. 3.1

- (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 in Fig. 3.2.

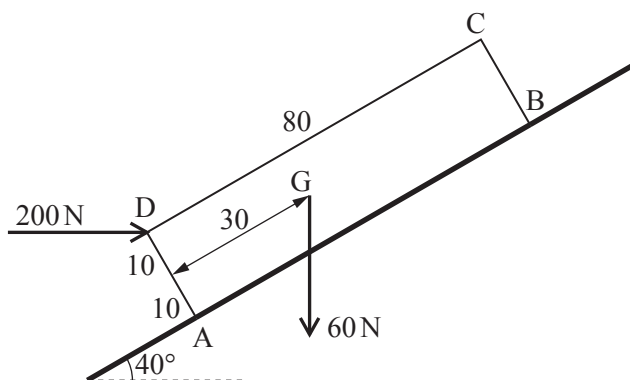


Fig. 3.2

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

- 4 (a) Fig. 4.1 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.

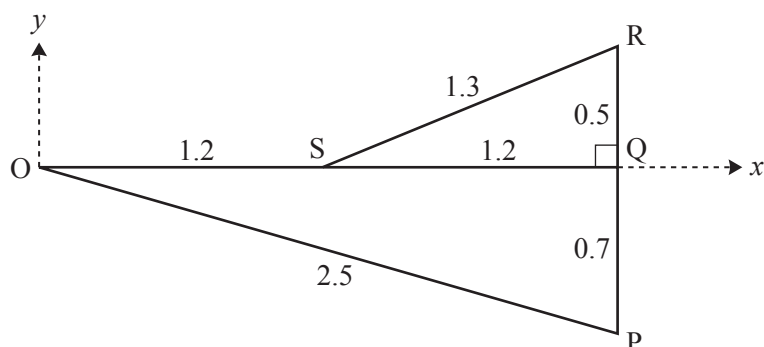


Fig. 4.1

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]

[Question 4 is continued overleaf.]

- (b) Fig. 4.2 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.

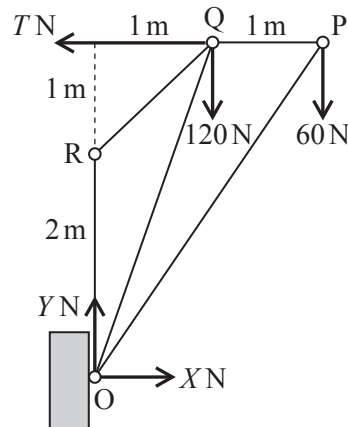


Fig. 4.2

- (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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