OCR
RECOGNISING ACHIEVEMENT

# 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 $g\,\mathrm{m\,s^{-2}}$. 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.

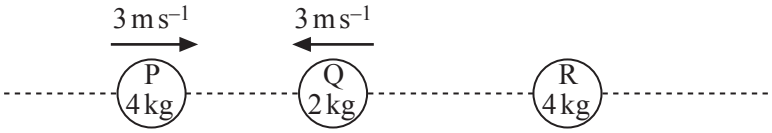


**Fig. 1.1**

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 $8\,\mathrm{m\,s^{-1}}$ 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 $5\,\mathrm{m\,s^{-1}}$ 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 $5\,\mathrm{m\,s^{-1}}$ and it travels 10 m before colliding with a fixed smooth plane. The plane is inclined at $\alpha$ to the vertical where $\tan\alpha = \frac{3}{4}$. Immediately after its collision with the plane, the particle has a speed of $13\,\mathrm{m\,s^{-1}}$. This information is shown in Fig. 1.2. Air resistance is negligible.

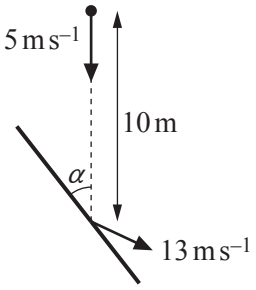


**Fig. 1.2**

**(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.

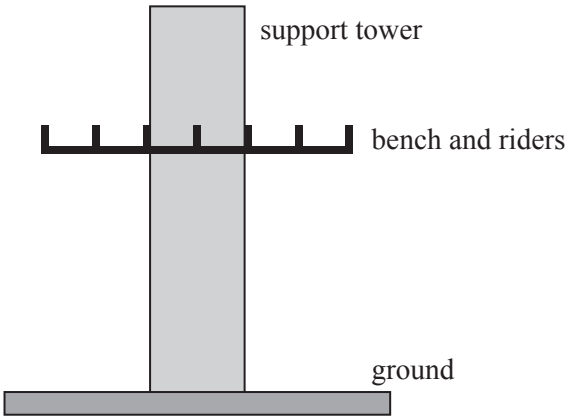


**Fig. 2**

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 $0.55\,\text{m}\,\text{s}^{-1}$.

**(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.

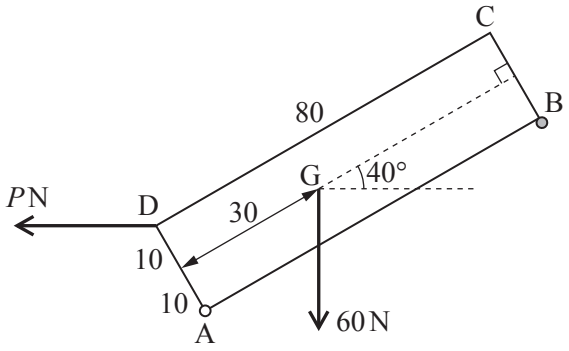


**Fig. 3.1**

**(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.

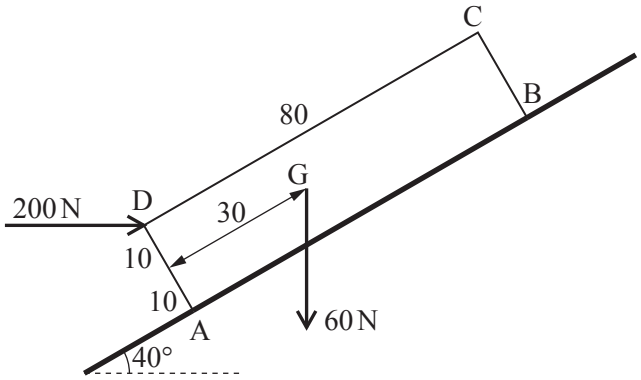


**Fig. 3.2**

**(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 O*x* and O*y*: the units are metres.

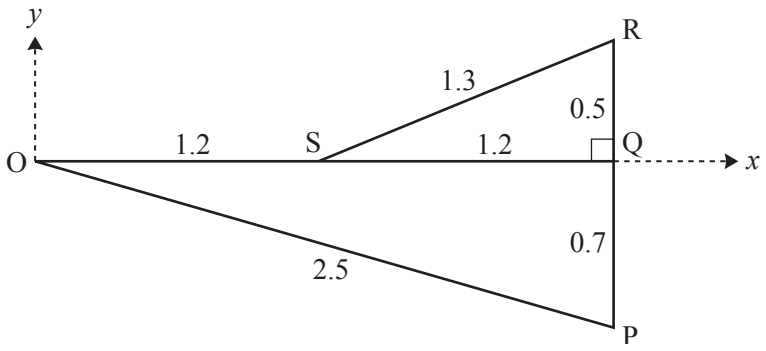


**Fig. 4.1**

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.

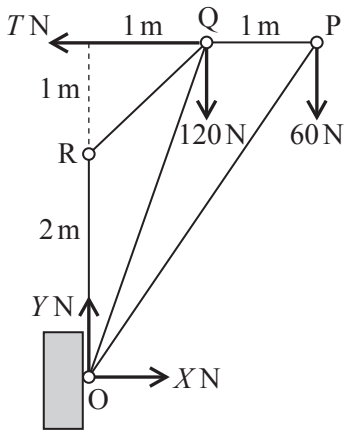


**Fig. 4.2**

**(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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