

Monday 14 January 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

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- 1 (a) Fig. 1.1 shows the velocities of a tanker of mass 120 000 tonnes before and after it changed speed and direction.

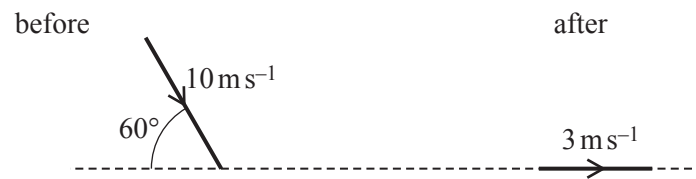


Fig. 1.1

Calculate the magnitude of the impulse that acted on the tanker.

[4]

- (b) An object of negligible size is at rest on a horizontal surface. It explodes into two parts, P and Q, which then slide along the surface.

Part P has mass 0.4 kg and speed 6 m s^{-1} . Part Q has mass 0.5 kg .

- (i) Calculate the speed of Q immediately after the explosion. State how the directions of motion of P and Q are related.

[2]

The explosion takes place at a distance of 0.75 m from a raised vertical edge, as shown in Fig. 1.2. P travels along a line perpendicular to this edge.

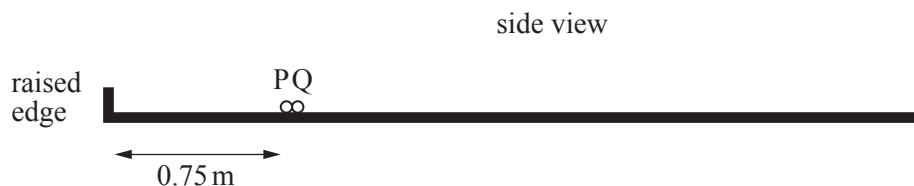


Fig. 1.2

After the explosion, P has a perfectly elastic direct collision with the raised edge and then collides again directly with Q. The collision between P and Q occurs $\frac{2}{3} \text{ s}$ after the explosion. Both collisions are instantaneous.

The contact between P and the surface is smooth but there is a constant frictional force between Q and the surface.

- (ii) Show that Q has speed 2.7 m s^{-1} just before P collides with it. [4]
- (iii) Calculate the coefficient of friction between Q and the surface. [4]
- (iv) Given that the coefficient of restitution between P and Q is $\frac{1}{8}$, calculate the speed of Q immediately after its collision with P. [5]

- 2 This question is about 'kart gravity racing' in which, after an initial push, unpowered home-made karts race down a sloping track.

The moving karts have only the following resistive forces and these both act in the direction opposite to the motion.

- A force R , called rolling friction, with magnitude $0.01Mg \cos \theta$ N where M kg is the mass of the kart and driver and θ is the angle of the track with the horizontal
- A force F of varying magnitude, due to air resistance

A kart with its driver has a mass of 80 kg.

One stretch of track slopes uniformly downwards at 4° to the horizontal. The kart travels 12 m down this stretch of track. The total work done by the kart against both rolling friction and air resistance is 455 J.

(i) Calculate the work done against air resistance. [4]

(ii) During this motion, the kart's speed increases from 2 ms^{-1} to $v \text{ ms}^{-1}$. Use an energy method to calculate v . [5]

To reach the starting line, the kart (with the driver seated) is pushed *up* a slope against rolling friction and air resistance.

At one point the slope is at 5° to the horizontal, the air resistance is 15 N, the acceleration of the kart is 1.5 ms^{-2} up the slope and the power of the pushing force is 405 W.

(iii) Calculate the speed of the kart at this point. [7]

- 3 The object shown shaded in Fig. 3.1 is cut from a flat sheet of thin rigid uniform material; LMJK, OAIJ, AEFH and CDEB are rectangles. The grid-lines in Fig. 3.1 are 1 cm apart.

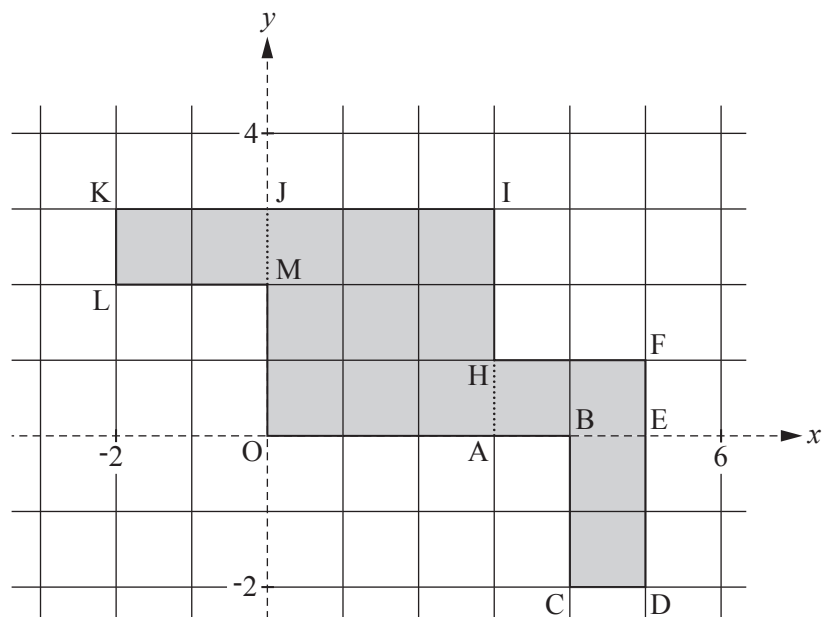


Fig. 3.1

- (i) Calculate the coordinates of the centre of mass of the object referred to the axes shown in Fig. 3.1. [5]

The object is freely suspended from the point K and hangs in equilibrium.

- (ii) Calculate the angle that KI makes with the vertical. [4]

The mass of the object is 0.3 kg.

A particle of mass m kg is attached to the object at a point on the line OJ so that the new centre of mass is at the centre of the square OAIJ.

- (iii) Calculate the value of m and the position of the particle referred to the axes shown in Fig. 3.1. [6]

The extra particle is now removed and the object shown in Fig. 3.1 is folded: LMJK is folded along JM so that it is perpendicular to OAIJ; ABCDEFH is folded along AH so that it is perpendicular to OAIJ and on the same side of OAIJ as LMJK. The folded object is placed on a horizontal table with the edges KL and FED in contact with the table. A plan view and a 3D representation are shown in Fig. 3.2.

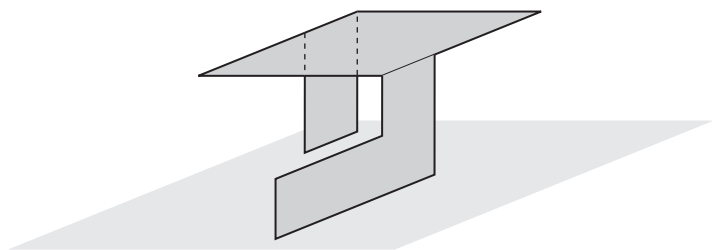
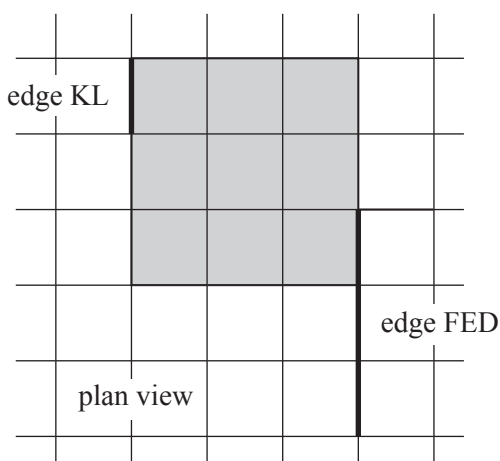


Fig. 3.2

- (iv) On the plan, indicate the region corresponding to positions of the centre of mass for which the folded object is stable.

You are given that the x -coordinate of the centre of mass of the folded object is 1.7. Determine whether the object is stable. [4]

4 A rigid thin uniform rod AB with length 2.4 m and weight 30 N is used in different situations.

- (i) In the first situation, the rod rests on a small support 0.6 m from B and is held horizontally in equilibrium by a vertical string attached to A, as shown in Fig. 4.1.



Fig. 4.1

Calculate the tension in the string and the force of the support on the rod.

[4]

- (ii) In the second situation, the rod rests in equilibrium on the point of slipping with end A on a horizontal floor and the rod resting at P on a fixed block of height 0.9 m, as shown in Fig. 4.2. The rod is perpendicular to the edge of the block on which it rests and is inclined at θ to the horizontal.

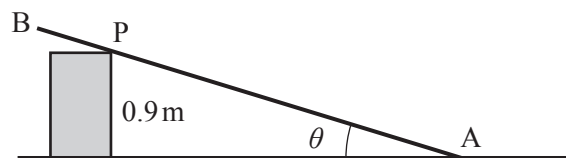


Fig. 4.2

- (A) Suppose that the contact between the block and the rod is rough with coefficient of friction 0.6 and contact between the end A and the floor is smooth.

Show that $\tan \theta = 0.6$.

[5]

- (B) Suppose instead that the contact between the block and the rod is smooth and the contact between the end A and the floor is rough. The rod is now in limiting equilibrium at a different angle θ such that the distance AP is 1.5 m.

Calculate the normal reaction of the block on the rod.

Calculate the coefficient of friction between the rod and the floor.

[9]

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