OCR
RECOGNISING ACHIEVEMENT

# 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

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## 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 $g\,\text{m}\,\text{s}^{-2}$. 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)** Fig. 1.1 shows the velocities of a tanker of mass 120 000 tonnes before and after it changed speed and direction.

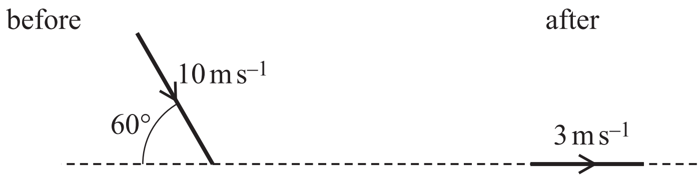


**Fig. 1.1**

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 $6\,\text{m s}^{-1}$. 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.

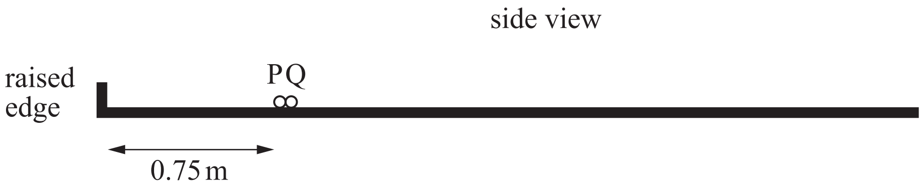


**Fig. 1.2**

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 $\frac{2}{3}$ 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 $2.7\,\text{m s}^{-1}$ 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 $\theta$ 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 $2\,\mathrm{m\,s^{-1}}$ to $v\,\mathrm{m\,s^{-1}}$. 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 $1.5\,\mathrm{m\,s^{-2}}$ 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.

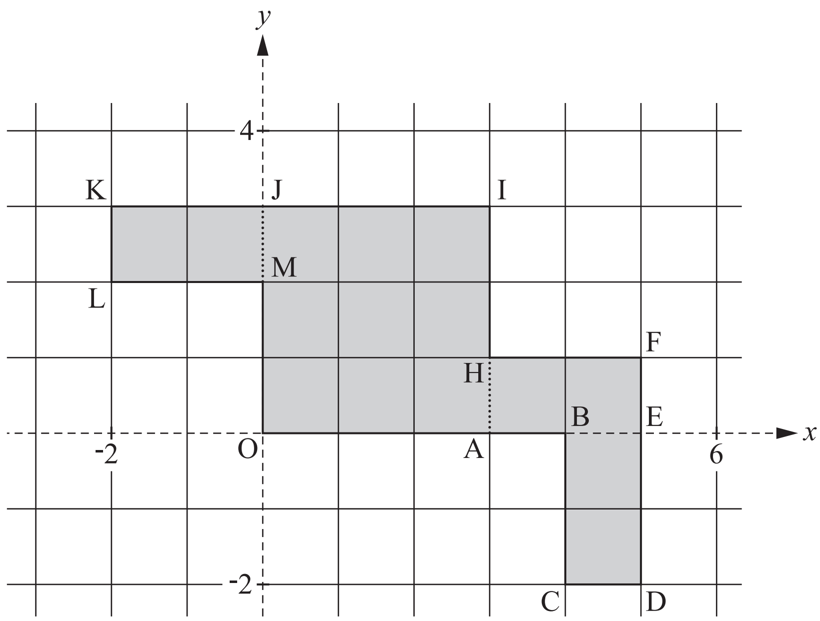


**Fig. 3.1**

**(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.

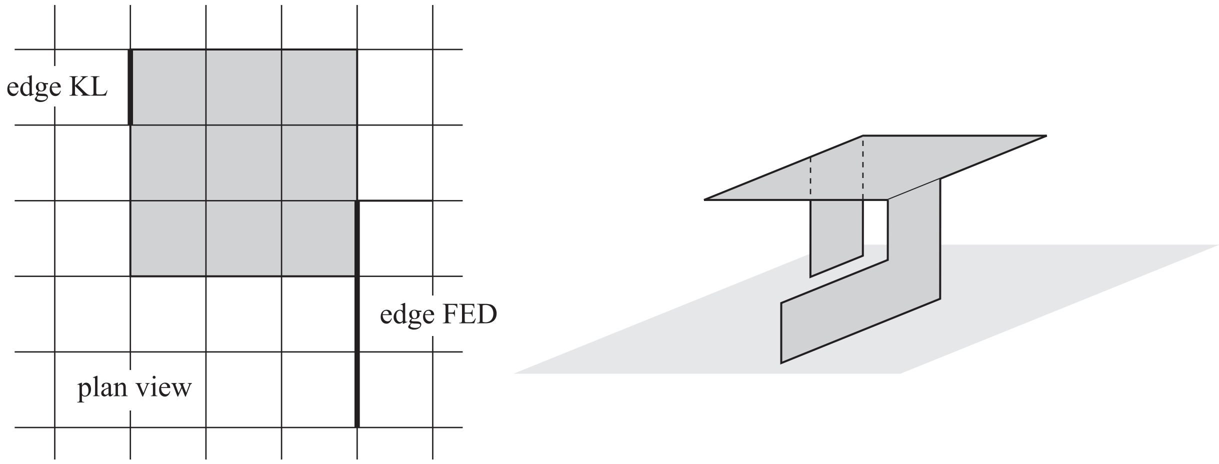


**Fig. 3.2**

**(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 $\theta$ to the horizontal.

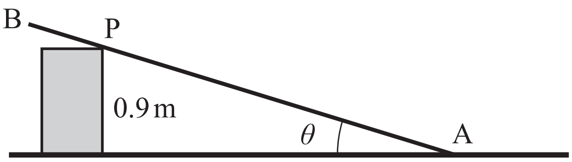


**Fig. 4.2**

(*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 $\theta$ 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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