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

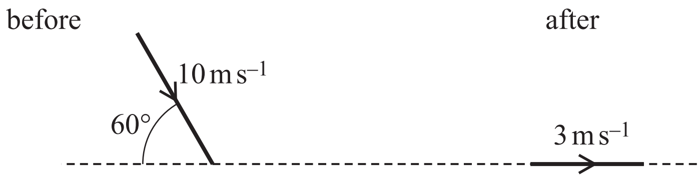

Fig. 1.1

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.

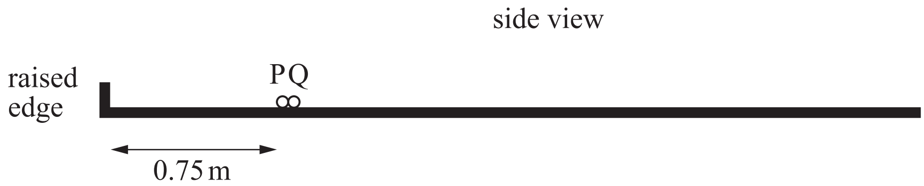

Fig. 1.2

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

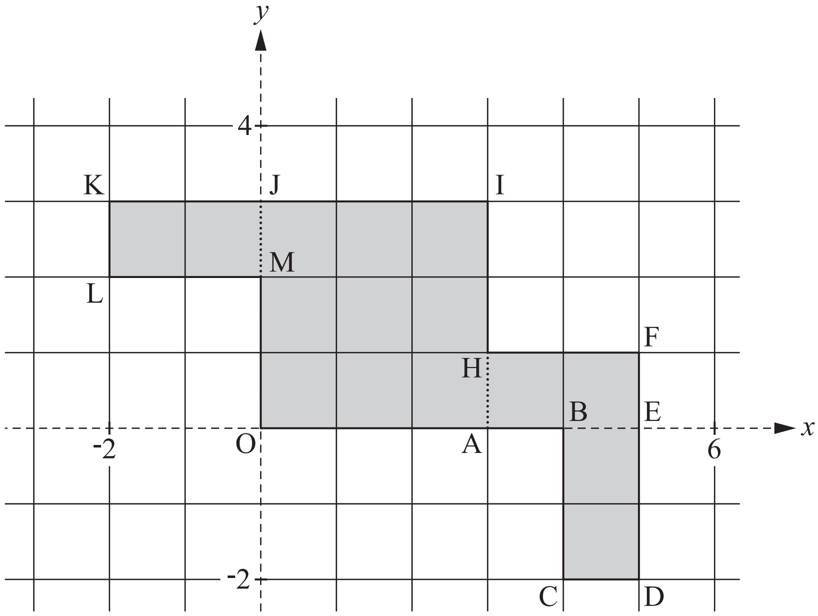

Fig. 3.1

(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.

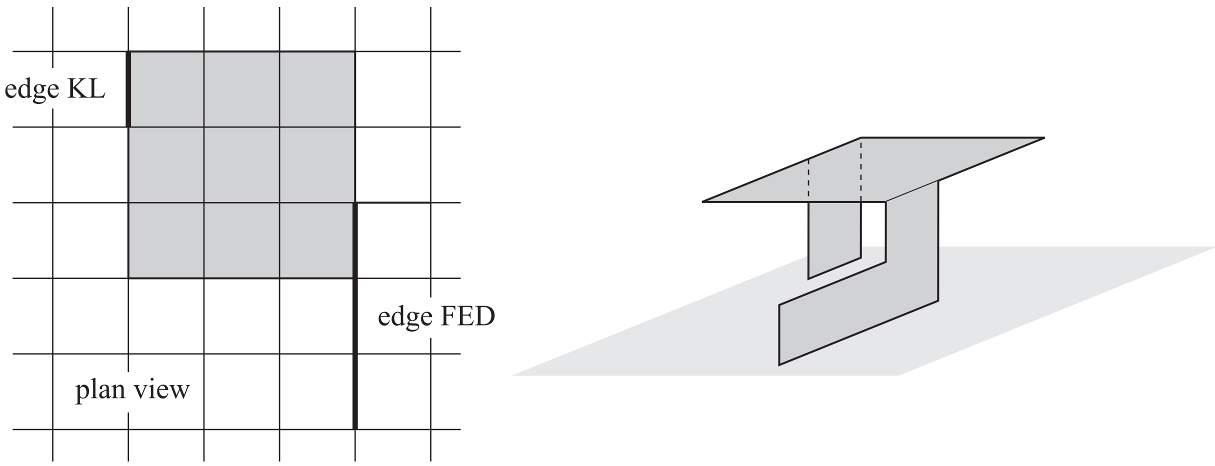

Fig. 3.2

(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 θ to the horizontal.

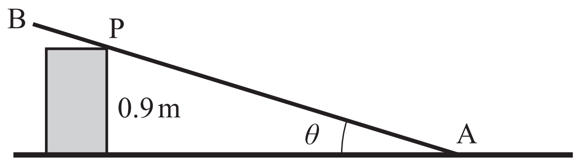

Fig. 4.2

(*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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