OCR
Oxford Cambridge and RSA

Tuesday 9 June 2015 – Morning

AS GCE MATHEMATICS (MEI)

4761/01 Mechanics 1

QUESTION PAPER

Candidates answer on the Printed Answer Book.

OCR supplied materials:
- Printed Answer Book 4761/01
- 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 inside 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.

Section A (36 marks)

1 Fig. 1 shows four forces acting at a point. The forces are in equilibrium.

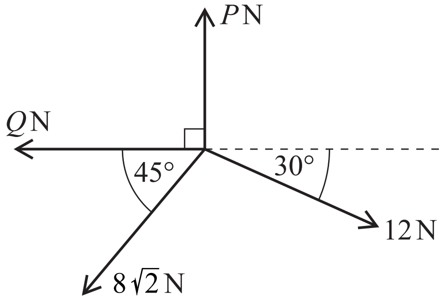

Fig. 1

Show that $P = 14$.

Find Q, giving your answer correct to 3 significant figures. **[5]**

2 Fig. 2 shows a 6 kg block on a smooth horizontal table. It is connected to blocks of mass 2 kg and 9 kg by two light strings which pass over smooth pulleys at the edges of the table. The parts of the strings attached to the 6 kg block are horizontal.

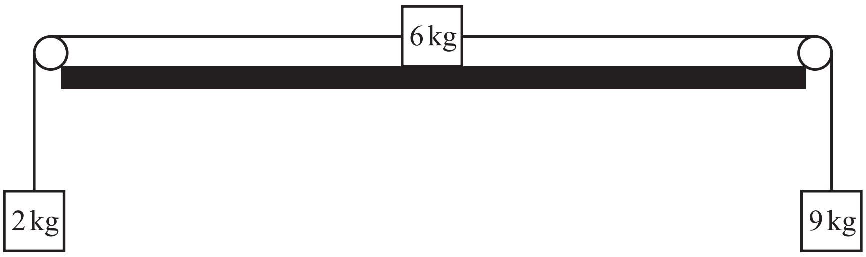

Fig. 2

(i) Draw three separate diagrams showing all the forces acting on each of the blocks. **[3]**

(ii) Calculate the acceleration of the system and the tension in each string. **[5]**

3 The map of a large area of open land is marked in 1 km squares and a point near the middle of the area is defined to be the origin. The vectors $\begin{pmatrix}1\\0\end{pmatrix}$ and $\begin{pmatrix}0\\1\end{pmatrix}$ are in the directions east and north.

At time t hours the position vectors of two hikers, Ashok and Kumar, are given by:

Ashok $\quad \mathbf{r}_\mathrm{A} = \begin{pmatrix}-2\\0\end{pmatrix} + \begin{pmatrix}8\\1\end{pmatrix}t,$

Kumar $\quad \mathbf{r}_\mathrm{K} = \begin{pmatrix}7t\\10-4t\end{pmatrix}.$

(i) Prove that the two hikers meet and give the coordinates of the point where this happens. **[4]**

(ii) Compare the speeds of the two hikers. **[3]**

4 Fig. 4 illustrates a straight horizontal road. A and B are points on the road which are 215 metres apart and M is the mid-point of AB.

When a car passes A its speed is $12\,\mathrm{m\,s^{-1}}$ in the direction AB. It then accelerates uniformly and when it reaches B its speed is $31\,\mathrm{m\,s^{-1}}$.

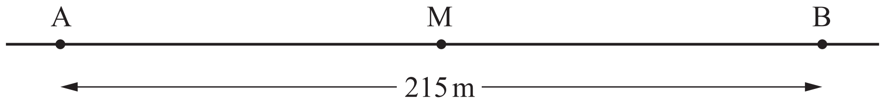

Fig. 4

(i) Find the car's acceleration. **[2]**

(ii) Find how long it takes the car to travel from A to B. **[2]**

(iii) Find how long it takes the car to travel from A to M. **[3]**

(iv) Explain briefly, in terms of the speed of the car, why the time taken to travel from A to M is more than half the time taken to travel from A to B. **[1]**

5 A golf ball is hit at an angle of 60° to the horizontal from a point, O, on level horizontal ground. Its initial speed is $20\,\mathrm{m\,s^{-1}}$. The standard projectile model, in which air resistance is neglected, is used to describe the subsequent motion of the golf ball. At time t s the horizontal and vertical components of its displacement from O are denoted by x m and y m.

(i) Write down equations for x and y in terms of t. **[2]**

(ii) Hence show that the equation of the trajectory is

$$y = \sqrt{3}x - 0.049x^2.$$ **[2]**

(iii) Find the range of the golf ball. **[2]**

(iv) A bird is hovering at position $(20, 16)$.

Find whether the golf ball passes above it, passes below it or hits it. **[2]**

Section B (36 marks)

6 The battery on Carol and Martin's car is flat so the car will not start. They hope to be able to "bump start" the car by letting it run down a hill and engaging the engine when the car is going fast enough. Fig. 6.1 shows the road leading away from their house, which is at A. The road is straight, and at all times the car is steered directly along it.

- From A to B the road is horizontal.
- Between B and C, it goes up a hill with a uniform slope of 1.5° to the horizontal.
- Between C and D the road goes down a hill with a uniform slope of 3° to the horizontal. CD is 100 m. (This is the part of the road where they hope to get the car started.)
- From D to E the road is again horizontal.

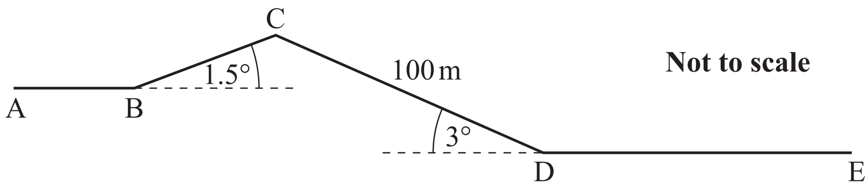

Fig. 6.1

The mass of the car is 750 kg, Carol's mass is 50 kg and Martin's mass is 80 kg.

Throughout the rest of this question, whenever Martin pushes the car, he exerts a force of 300 N along the line of the car.

(i) Between A and B, Martin pushes the car and Carol sits inside to steer it. The car has an acceleration of $0.25\,\mathrm{m\,s^{-2}}$.

Show that the resistance to the car's motion is 100 N. **[3]**

Throughout the rest of this question you should assume that the resistance to motion is constant at 100 N.

(ii) They stop at B and then Martin tries to push the car up the hill BC.

Show that Martin cannot push the car up the hill with Carol inside it but can if she gets out.

Find the acceleration of the car when Martin is pushing it and Carol is standing outside. **[6]**

(iii) While between B and C, Carol opens the window of the car and pushes it from outside while steering with one hand. Carol is able to exert a force of 150 N parallel to the surface of the road but at an angle of 30° to the line of the car. This is illustrated in Fig. 6.2.

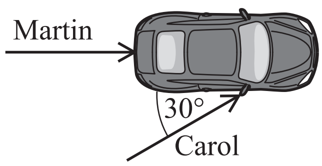

Fig. 6.2

Find the acceleration of the car. **[4]**

(iv) At C, both Martin and Carol get in the car and, starting from rest, let it run down the hill under gravity. If the car reaches a speed of $8\,\mathrm{m\,s^{-1}}$ they can get the engine to start.

Does the car reach this speed before it reaches D? **[5]**

7 A box of emergency supplies is dropped to victims of a natural disaster from a stationary helicopter at a height of 1000 metres. The initial velocity of the box is zero.

At time t s after being dropped, the acceleration, $a\,\mathrm{m\,s^{-2}}$, of the box in the vertically downwards direction is modelled by

$$a = 10 - t \quad \text{for} \quad 0 \leqslant t \leqslant 10,$$

$$a = 0 \qquad \text{for} \qquad t > 10.$$

(i) Find an expression for the velocity, $v\,\mathrm{m\,s^{-1}}$, of the box in the vertically downwards direction in terms of t for $0 \leqslant t \leqslant 10$.

Show that for $t > 10$, $v = 50$. **[4]**

(ii) Draw a sketch graph of v against t for $0 \leqslant t \leqslant 20$. **[3]**

(iii) Show that the height, h m, of the box above the ground at time t s is given, for $0 \leqslant t \leqslant 10$, by

$$h = 1000 - 5t^2 + \frac{1}{6}t^3.$$

Find the height of the box when $t = 10$. **[4]**

(iv) Find the value of t when the box hits the ground. **[2]**

(v) Some of the supplies in the box are damaged when the box hits the ground. So measures are considered to reduce the speed with which the box hits the ground the next time one is dropped. Two different proposals are made. Carry out suitable calculations and then comment on each of them.

(A) The box should be dropped from a height of 500 m instead of 1000 m. **[2]**

(B) The box should be fitted with a parachute so that its acceleration is given by

$$a = 10 - 2t \quad \text{for} \quad 0 \leqslant t \leqslant 5,$$

$$a = 0 \qquad \text{for} \qquad t > 5.$$

[3]

END OF QUESTION PAPER

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