OCR
Oxford Cambridge and RSA

Friday 17 June 2016 – Afternoon

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

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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 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 a block of mass M kg being pushed over level ground by means of a light rod. The force, T N, this exerts on the block is along the line of the rod.

The ground is rough.

The rod makes an angle α with the horizontal.

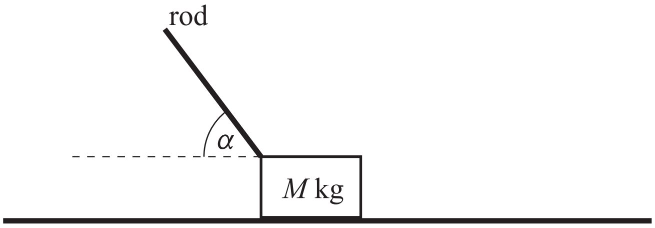

Fig. 1

(i) Draw a diagram showing all the forces acting on the block. **[3]**

(ii) You are given that $M = 5$, $\alpha = 60°$, $T = 40$ and the acceleration of the block is $1.5\,\text{m s}^{-2}$.

Find the frictional force. **[3]**

2

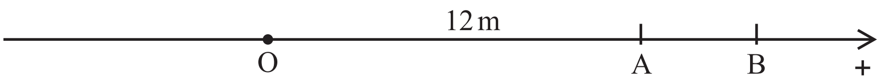

Fig. 2

A particle moves on the straight line shown in Fig. 2. The positive direction is indicated on the diagram.

The time, t, is measured in seconds. The particle has constant acceleration, $a\,\text{m s}^{-2}$.

Initially it is at the point O and has velocity $u\,\text{m s}^{-1}$.

When $t = 2$, the particle is at A where OA is 12 m. The particle is also at A when $t = 6$.

(i) Write down two equations in u and a and solve them. **[4]**

(ii) The particle changes direction when it is at B.

Find the distance AB. **[3]**

3 Fig. 3.1 shows a block of mass 8 kg on a smooth horizontal table.

This block is connected by a light string passing over a smooth pulley to a block of mass 4 kg which hangs freely. The part of the string between the 8 kg block and the pulley is parallel to the table.

The system has acceleration $a\,\text{m}\,\text{s}^{-2}$.

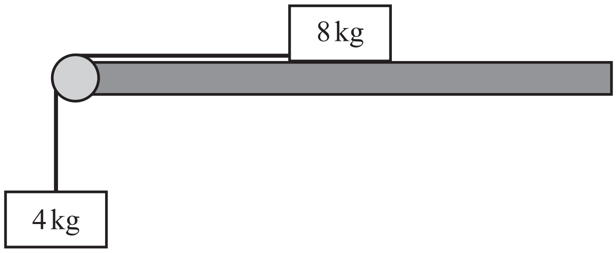

Fig. 3.1

(i) Write down two equations of motion, one for each block. **[2]**

(ii) Find the value of a. **[2]**

The table is now tilted at an angle of θ to the horizontal as shown in Fig. 3.2. The system is set up as before; the 4 kg block still hangs freely.

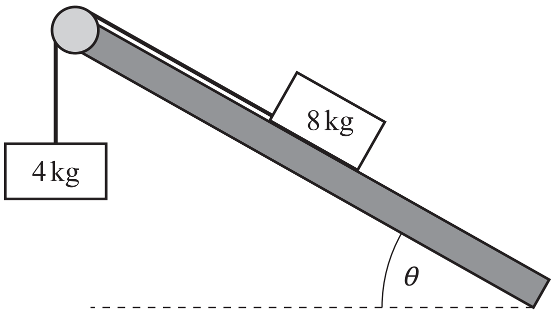

Fig. 3.2

(iii) The system is now in equilibrium. Find the value of θ. **[4]**

4 A particle is initially at the origin, moving with velocity **u**. Its acceleration **a** is constant.

At time t its displacement from the origin is $\mathbf{r} = \begin{pmatrix} x \\ y \end{pmatrix}$, where $\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 2 \\ 6 \end{pmatrix} t - \begin{pmatrix} 0 \\ 4 \end{pmatrix} t^2$.

(i) Write down **u** and **a** as column vectors. **[2]**

(ii) Find the speed of the particle when $t = 2$. **[3]**

(iii) Show that the equation of the path of the particle is $y = 3x - x^2$. **[3]**

5 Mr McGregor is a keen vegetable gardener. A pigeon that eats his vegetables is his great enemy.

One day he sees the pigeon sitting on a small branch of a tree. He takes a stone from the ground and throws it. The trajectory of the stone is in a vertical plane that contains the pigeon. The same vertical plane intersects the window of his house. The situation is illustrated in Fig. 5.

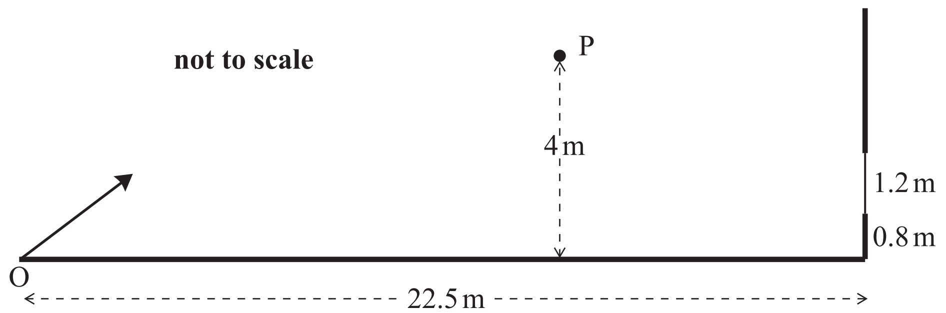

Fig. 5

- The stone is thrown from point O on level ground. Its initial velocity is $15\,\mathrm{m\,s^{-1}}$ in the horizontal direction and $8\,\mathrm{m\,s^{-1}}$ in the vertical direction.
- The pigeon is at point P which is 4 m above the ground.
- The house is 22.5 m from O.
- The bottom of the window is 0.8 m above the ground and the window is 1.2 m high.

Show that the stone does not reach the height of the pigeon.

Determine whether the stone hits the window. **[7]**

Section B (36 marks)

6 In this question you should take g to be $10\,\text{m}\,\text{s}^{-2}$.

Piran finds a disused mineshaft on his land and wants to know its depth, d metres.

Local records state that the mineshaft is between 150 and 200 metres deep.

He drops a small stone down the mineshaft and records the time, T seconds, until he hears it hit the bottom. It takes 8.0 seconds.

Piran tries three models, A, B and C.

In model A, Piran uses the formula $d = 5T^2$ to estimate the depth.

(i) Find the depth that model A gives and comment on whether it is consistent with the local records.

Explain how the formula in model A is obtained. **[4]**

In model B, Piran uses the speed-time graph in Fig. 6.

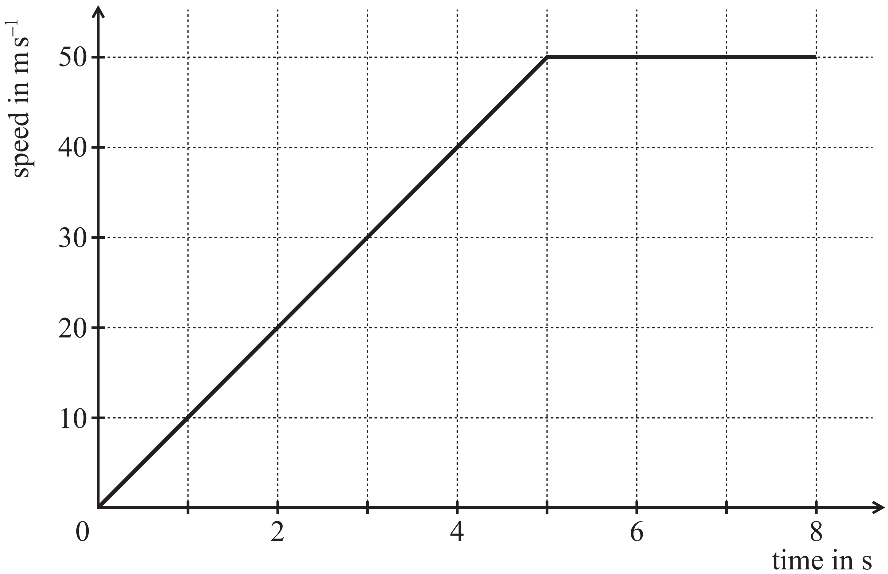

Fig. 6

(ii) Calculate the depth of the mineshaft according to model B.

Comment on whether this depth is consistent with the local records. **[4]**

(iii) Describe briefly one respect in which model B is the same as model A and one respect in which it is different. **[2]**

Piran then tries model C in which the speed, $v\,\text{m}\,\text{s}^{-1}$, is given by

$v = 10t - t^2$ for $0 \leqslant t \leqslant 5$,

$v = 25$ for $5 < t \leqslant 8$.

(iv) Calculate the depth of the mineshaft according to model C.

Comment on whether this depth is consistent with the local records. **[6]**

(v) Describe briefly one respect in which model C is similar to model B and one respect in which it is different. **[2]**

7 Fig. 7 illustrates a situation on a building site. An unexploded bomb is being lifted by light ropes that pass over smooth pulleys. The ropes are attached to winches V and W.

- The weight of the bomb is 7500 N.
- The winches are on horizontal ground and are at the same level.
- The sloping parts of the ropes from V and W are at angles α and β to the horizontal.
- The point P is level with the horizontal sections of the ropes and is 16 m and 9 m from the two pulleys, as shown.
- The winches are controlled so that the bomb moves in a vertical line through P. The tension in the rope attached to winch W is kept constant at 8000 N. The tension, T N, in the rope attached to winch V is varied.
- The distance between the top of the bomb, B, and the point P is d metres.

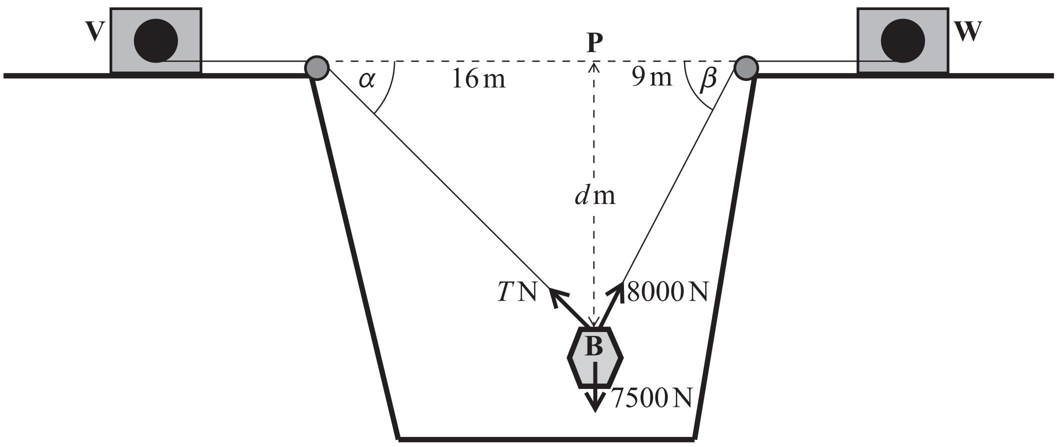

Fig. 7

At a particular stage in the lift, $d = 12$ and $T = 6000$.

(i) Find the values of $\cos\alpha$ and $\cos\beta$ at this stage. **[1]**

(ii) Verify that, at this stage, the horizontal component of the bomb's acceleration is zero. Find the vertical component of its acceleration. **[7]**

At a later stage, the bomb is higher up and so the values of d, T, α and β have all changed.

(iii) Show that $T = \dfrac{8000\cos\beta}{\cos\alpha}$.

Hence show that $T = \dfrac{4500\sqrt{d^2+256}}{\sqrt{d^2+81}}$.

[4]

(iv) Find the acceleration of the bomb when $d = 6.75$. **[4]**

(v) Explain briefly why it is not possible for the bomb to be in equilibrium with B at P.

What could you say about the acceleration of the bomb if B were at P and the tensions in the two ropes were equal? **[2]**

END OF QUESTION PAPER

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