OCR
RECOGNISING ACHIEVEMENT

Monday 10 June 2013 – 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 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.

Turn over

Section A (36 marks)

1   Fig. 1 shows a pile of four uniform blocks in equilibrium on a horizontal table. Their masses, as shown, are 4 kg, 5 kg, 7 kg and 10 kg.
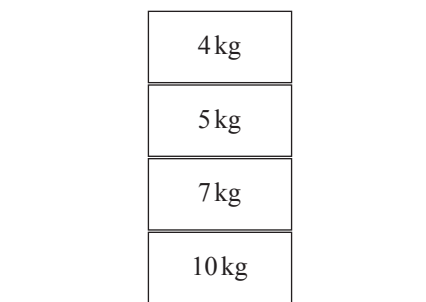

Fig. 1

Mark on the diagram the magnitude and direction of each of the forces acting on the 7 kg block.   **[3]**

2   In this question, air resistance should be neglected.

Fig. 2 illustrates the flight of a golf ball. The golf ball is initially on the ground, which is horizontal.
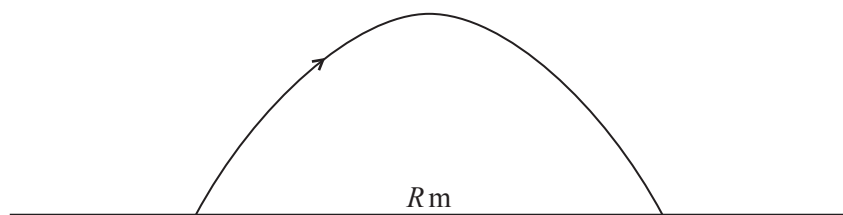

Fig. 2

It is hit and given an initial velocity with components of $15\,\mathrm{m\,s^{-1}}$ in the horizontal direction and $20\,\mathrm{m\,s^{-1}}$ in the vertical direction.

   (i) Find its initial speed.   **[1]**

   (ii) Find the ball's flight time and range, R m.   **[4]**

   (iii) (*A*) Show that the range is the same if the components of the initial velocity of the ball are $20\,\mathrm{m\,s^{-1}}$ in the horizontal direction and $15\,\mathrm{m\,s^{-1}}$ in the vertical direction.   **[1]**

   (*B*) State, justifying your answer, whether the range is the same whenever the ball is hit with the same initial speed.   **[2]**

3 **In this question take $g = 10$.**

The directions of the unit vectors $\begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix}$, $\begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix}$ and $\begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix}$ are east, north and vertically upwards.

Forces **p**, **q** and **r** are given by $\mathbf{p} = \begin{pmatrix} -1 \\ -1 \\ 5 \end{pmatrix}$ N, $\mathbf{q} = \begin{pmatrix} -1 \\ -4 \\ 2 \end{pmatrix}$ N and $\mathbf{r} = \begin{pmatrix} 2 \\ 5 \\ 0 \end{pmatrix}$ N.

 (i) Find which of **p**, **q** and **r** has the greatest magnitude. **[2]**

 (ii) A particle has mass 0.4 kg. The forces acting on it are **p**, **q**, **r** and its weight.

 Find the magnitude of the particle's acceleration and describe the direction of this acceleration. **[4]**

**4** The directions of the unit vectors **i** and **j** are east and north.

The velocity of a particle, $\mathbf{v}\,\text{m s}^{-1}$, at time t s is given by

$$\mathbf{v} = \left(16 - t^2\right)\mathbf{i} + \left(31 - 8t\right)\mathbf{j}.$$

Find the time at which the particle is travelling on a bearing of 045° and the speed of the particle at this time. **[6]**

5 Fig. 5 shows blocks of mass 4 kg and 6 kg on a smooth horizontal table. They are connected by a light, inextensible string. As shown, a horizontal force F N acts on the 4 kg block and a horizontal force of 30 N acts on the 6 kg block.

The magnitude of the acceleration of the system is $2\,\text{m s}^{-2}$.
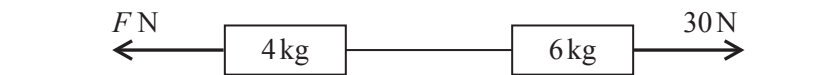
Fig. 5

 (i) Find the two possible values of F. **[4]**

 (ii) Find the tension in the string in each case. **[3]**

6 A particle moves along a straight line through an origin O. Initially the particle is at O.

At time t s, its displacement from O is x m and its velocity, $v\,\text{m s}^{-1}$, is given by

$$v = 24 - 18t + 3t^2.$$

 (i) Find the times, T_1 s and T_2 s (where $T_2 > T_1$), at which the particle is stationary. **[2]**

 (ii) Find an expression for x at time t s.

 Show that when $t = T_1$, $x = 20$ and find the value of x when $t = T_2$. **[4]**

Section B (36 marks)

7   Abi and Bob are standing on the ground and are trying to raise a small object of weight 250 N to the top of a building. They are using long light ropes. Fig. 7.1 shows the initial situation.
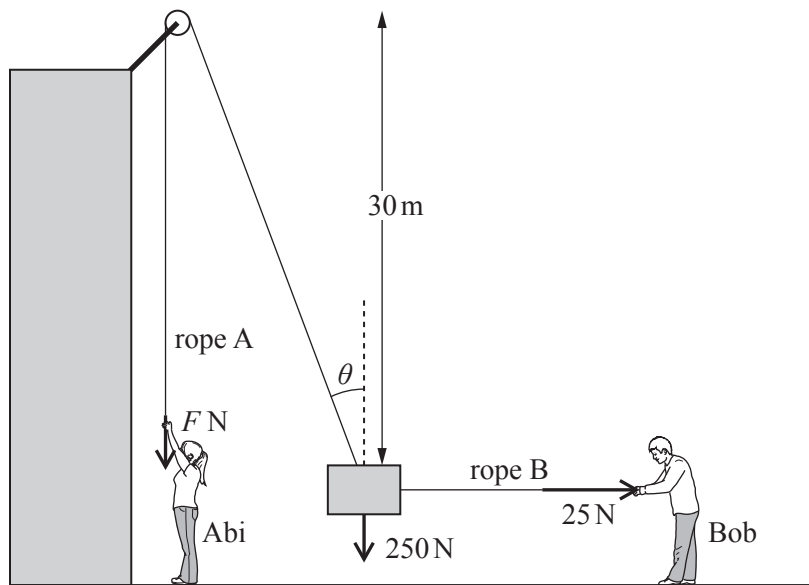

Fig. 7.1

Abi pulls vertically downwards on the rope A with a force F N. This rope passes over a small smooth pulley and is then connected to the object. Bob pulls on another rope, B, in order to keep the object away from the side of the building.

In this situation, the object is stationary and in equilibrium. The tension in rope B, which is horizontal, is 25 N. The pulley is 30 m above the object. The part of rope A between the pulley and the object makes an angle θ with the vertical.

(i) Represent the forces acting on the object as a fully labelled triangle of forces. **[3]**

(ii) Find F and θ.

   Show that the distance between the object and the vertical section of rope A is 3 m. **[5]**

[Question 7 is continued on the next page.]

Abi then pulls harder and the object moves upwards. Bob adjusts the tension in rope B so that the object moves along a vertical line.

Fig. 7.2 shows the situation when the object is part of the way up. The tension in rope A is S N and the tension in rope B is T N. The ropes make angles α and β with the vertical as shown in the diagram. Abi and Bob are taking a rest and holding the object stationary and in equilibrium.
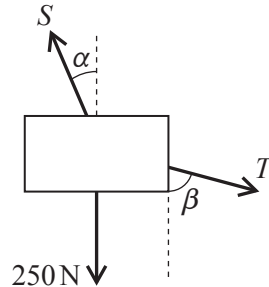
Fig. 7.2

(iii) Give the equations, involving S, T, α and β, for equilibrium in the vertical and horizontal directions.

[3]

(iv) Find the values of S and T when $\alpha = 8.5°$ and $\beta = 35°$. **[4]**

 (v) Abi's mass is 40 kg.

Explain why it is not possible for her to raise the object to a position in which $\alpha = 60°$. **[3]**

[Question 8 is printed overleaf.]

8   Fig. 8.1 shows a sledge of mass 40 kg. It is being pulled across a horizontal surface of deep snow by a light horizontal rope. There is a constant resistance to its motion.

The tension in the rope is 120 N.

Fig. 8.1

The sledge is initially at rest. After 10 seconds its speed is $5\,\mathrm{m\,s^{-1}}$.

  (i) Show that the resistance to motion is 100 N.   **[4]**

When the speed of the sledge is $5\,\mathrm{m\,s^{-1}}$, the rope breaks.

The resistance to motion remains 100 N.

 (ii) Find the speed of the sledge

   (*A*)   1.6 seconds after the rope breaks,   **[3]**

   (*B*)   6 seconds after the rope breaks.   **[1]**

The sledge is then pushed to the bottom of a ski slope. This is a plane at an angle of 15° to the horizontal.
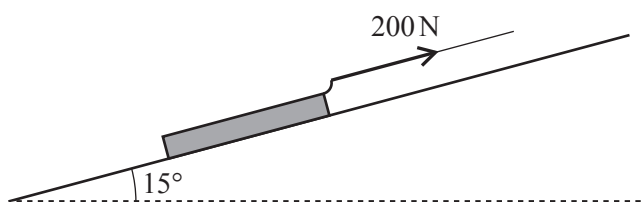

Fig. 8.2

The sledge is attached by a light rope to a winch at the top of the slope. The rope is parallel to the slope and has a constant tension of 200 N. Fig. 8.2 shows the situation when the sledge is part of the way up the slope.

The ski slope is smooth.

 (iii) Show that when the sledge has moved from being at rest at the bottom of the slope to the point when its speed is $8\,\mathrm{m\,s^{-1}}$, it has travelled a distance of 13.0 m (to 3 significant figures).   **[4]**

When the speed of the sledge is $8\,\mathrm{m\,s^{-1}}$, this rope also breaks.

 (iv) Find the time between the rope breaking and the sledge reaching the bottom of the slope.   **[6]**

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