RECOGNISING ACHIEVEMENT

Oxford Cambridge and RSA Examinations

Advanced Subsidiary General Certificate of Education
Advanced General Certificate of Education

MEI STRUCTURED MATHEMATICS

MECHANICS 1, M1

4761

Specimen Paper

Additional materials: Answer booklet
Graph paper
MEI Examination Formulae and Tables (MF 2)

TIME 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

- Write your name, Centre number and candidate number in the spaces provided on the answer booklet.
- Answer **all** the questions.
- You **may** use a graphical or scientific calculator in this paper.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [ ] at the end of each question or part question.
- 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.
- Final answers should be given to a degree of accuracy appropriate to the context.
- The total number of marks for this paper is **72**.
- Unless otherwise specified, the value of g should be taken to be exactly 9.8ms^{-2}.

Section A (36 marks)

1

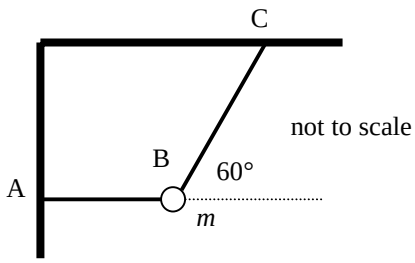

Fig.1

As shown in Fig.1, an object of mass *m* kg at B is held in equilibrium by two light strings AB and BC.
String AB is horizontal and fixed at A, string BC is at 60° to the horizontal and is fixed at C.
The tension in string BC is 10 N.

(i) **(*A*)** Draw a diagram showing all the forces acting on the object at B. **[1]**

(*B*) Calculate the tension in the string section AB. **[2]**

(ii) Calculate the value of *m*. **[3]**

2 In this question the unit of length is the metre and the time is in seconds.
An object has initial position $\begin{pmatrix} 2 \\ -1 \end{pmatrix}$ and initial velocity $\begin{pmatrix} -1 \\ 4 \end{pmatrix}$.
It has a constant acceleration of $\begin{pmatrix} 2 \\ 5 \end{pmatrix}$.

(i) Calculate the initial speed of the object. **[2]**

(ii) Calculate the object's velocity and position after four seconds. **[4]**

3 A model truck of mass 5 kg is being pulled by a light string along a straight path.

The resistance to its motion is 8 N.

In one situation, the string and the path are horizontal, as shown in Fig.3.1.

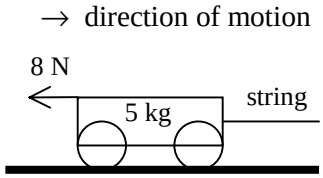

Fig.3.1

(i) Given that the acceleration of the truck is 4 ms^{-2}, calculate the tension in the string. **[3]**

In another situation, the path is horizontal and the string is inclined at 30° to the horizontal, as shown in Fig.3.2.

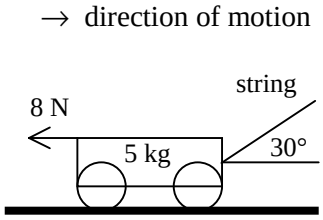

Fig.3.2

(ii) Given that the tension in the string is 40 N, calculate the acceleration of the truck. **[3]**

4

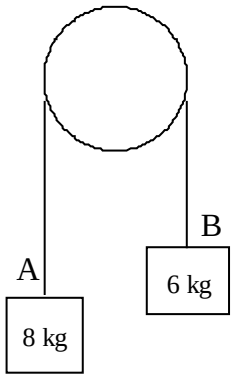

Fig. 4

A light inextensible string AB passes over a smooth peg.
Particles of mass 8 kg and 6 kg are attached to the ends A and B of the string and hang vertically, as shown in Fig.4.
The system is released from rest.

(i) Draw separate diagrams showing the forces acting on the particles at A and at B. **[1]**

(ii) **(*A*)** Write down the equation of motion for the particle at A and the equation of motion for the particle at B. **[3]**

(*B*) Show that the acceleration of the system is 1.4 ms^{-2}. **[2]**

5 A particle has a velocity, **v** ms^{-1}, given by $\mathbf{v} = (t^2 - t)\,\mathbf{i} + (t - 1)\,\mathbf{j}$ where **i** and **j** are the standard unit vectors due east and north respectively, t is the time in seconds and the unit of length is the metre.

(i) Find the acceleration when $t = 2$. **[2]**

(ii) Determine the time(s), if any, when the particle is:

(*A*) at rest,

(*B*) moving due south. **[4]**

6

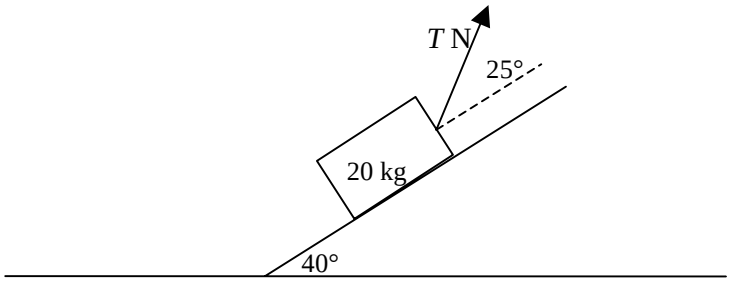

Fig. 6

A rough plane is at 40° to the horizontal. A force of T N at 25° to the greatest slope of the plane acts on a block of mass 20 kg on a plane, as shown in Fig. 6.

(i) Draw a diagram showing all the forces acting on the block. **[1]**

(ii) Given that the block is in equilibrium, calculate the frictional force between the block and the plane when $T = 172$. **[3]**

(iii) For what values of T will the frictional force on the block act up the plane? **[2]**

Section B (36 marks)

7 A car starts from rest and travels along a straight road.
Its speed, v ms^{-1}, at time t seconds is modelled by

$v = 4t - 0.2t^2$ $\quad 0 \le t \le 10$,
$v = \text{constant}$ $\quad 10 \le t \le 15$,
$v = 8 + 0.8t$ $\quad t \ge 15$.

(i) Calculate the speed of the car at $t = 0$, $t = 10$, $t = 15$ and $t = 20$. **[3]**

(ii) **F**ind the values of the acceleration at:

(*A*) $t = 7$,

(*B*) $t = 12$,

(*C*) $t = 16$. **[4]**

(iii) Calculate the distance the car travels in the interval $10 \le t \le 20$. **[6]**

(iv) Calculate the distance the car travels in the interval $0 \le t \le 10$. **[5]**

8 In this question, air resistance should be neglected.

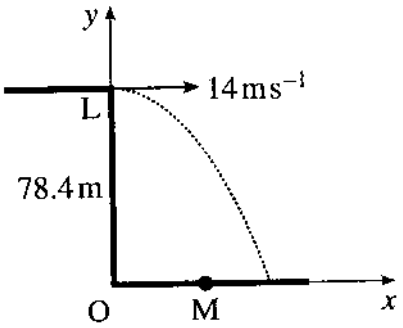

Fig. 7

Fig.7 shows a small stone being projected horizontally at a speed of 14 ms^{-1} from the point L at the top of a vertical cliff.
The cliff is 78.4 m above horizontal ground.
Coordinate axes are drawn through the origin O on the horizontal ground vertically below the point of projection.

(i) **(*A*)** Show that, t seconds after projection, the height, y m, of the stone is given by $y = 78.4 - 4.9t^2$. **[3]**

(*B*) Write down an expression in terms of t for the horizontal distance, x m, of the stone from O. **[2]**

(ii) **(*A*)** Calculate the time it takes the stone to hit the ground. **[2]**

(*B*) Calculate also the horizontal distance travelled by the stone. **[1]**

(iii) Show that the equation of the trajectory of the stone is $40y = 3136 - x^2$. **[2]**

On another occasion the stone is projected from L as before.
At the same time, a second small stone is projected vertically upwards at speed u ms^{-1} from a point M on the horizontal ground 35 m from O. The stones collide.

(iv) Show that the collision takes place just less than 48 m above the ground, 2.5 seconds after projection. **[4]**

(v) Calculate the value of u. **[4]**