8 In this question, positions are given relative to a fixed origin, O. The x-direction is east and the y-direction north; distances are measured in kilometres.

Two boats, the *Rosemary* and the *Sage*, are having a race between two points A and B.

The position vector of the *Rosemary* at time t hours after the start is given by

$$\mathbf{r} = \begin{pmatrix} 3 \\ 2 \end{pmatrix} + \begin{pmatrix} 6 \\ 8 \end{pmatrix} t, \text{ where } 0 \leqslant t \leqslant 2 .$$

The *Rosemary* is at point A when $t = 0$, and at point B when $t = 2$.

(i) Find the distance AB. **[3]**

(ii) Show that the *Rosemary* travels at constant velocity. **[1]**

The position vector of the *Sage* is given by

$$\mathbf{r} = \begin{pmatrix} 3(2t+1) \\ 2(2t^2+1) \end{pmatrix} .$$

(iii) Plot the points A and B.

Draw the paths of the two boats for $0 \leqslant t \leqslant 2$. **[3]**

(iv) What can you say about the result of the race? **[1]**

(v) Find the speed of the *Sage* when $t = 2$. Find also the direction in which it is travelling, giving your answer as a compass bearing, to the nearest degree. **[6]**

(vi) Find the displacement of the *Rosemary* from the *Sage* at time t and hence calculate the greatest distance between the boats during the race. **[4]**

Monday 28 January 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

4734120113

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.

This paper has been pre modified for carrier language

Turn over

Section A (36 marks)

1 Fig. 1 shows a block of mass 3 kg on a plane which is inclined at an angle of 30° to the horizontal.

A force P N is applied to the block parallel to the plane in the upwards direction.

The plane is rough so that a frictional force of 10 N opposes the motion.

The block is moving at constant speed up the plane.

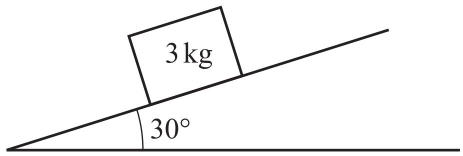

Fig. 1

(i) Mark and label all the forces acting on the block. **[3]**

(ii) Calculate the magnitude of the normal reaction of the plane on the block. **[1]**

(iii) Calculate the magnitude of the force P. **[2]**

2 In this question, the unit vectors $\begin{pmatrix}1\\0\end{pmatrix}$ and $\begin{pmatrix}0\\1\end{pmatrix}$ are in the directions east and north.

Distance is measured in metres and time, t, in seconds.

A radio-controlled toy car moves on a flat horizontal surface. A child is standing at the origin and controlling the car.

When $t = 0$, the displacement of the car from the origin is $\begin{pmatrix}0\\-2\end{pmatrix}$ m, and the car has velocity $\begin{pmatrix}2\\0\end{pmatrix}$ m s^{-1}.

The acceleration of the car is constant and is $\begin{pmatrix}-1\\1\end{pmatrix}$ m s^{-2}.

(i) Find the velocity of the car at time t and its speed when $t = 8$. **[4]**

(ii) Find the distance of the car from the child when $t = 8$. **[4]**

3 Fig. 3 shows two people, Sam and Tom, pushing a car of mass 1000 kg along a straight line l on level ground.

Sam pushes with a constant horizontal force of 300 N at an angle of 30° to the line l.

Tom pushes with a constant horizontal force of 175 N at an angle of 15° to the line l.

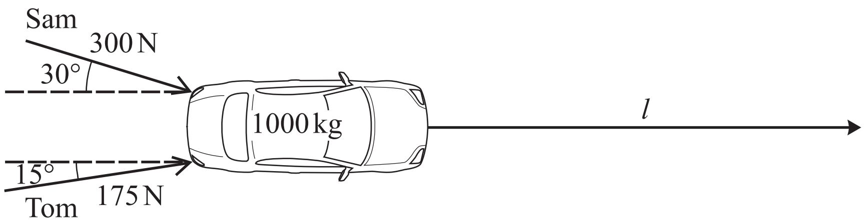

Fig. 3

(i) The car starts at rest and moves with constant acceleration. After 6 seconds it has travelled 7.2 m.

Find its acceleration. **[3]**

(ii) Find the resistance force acting on the car along the line l. **[4]**

(iii) The resultant of the forces exerted by Sam and Tom is not in the direction of the car's acceleration. Explain briefly why. **[1]**

4 A particle is travelling along a straight line with constant acceleration. P, O and Q are points on the line, as illustrated in Fig. 4. The distance from P to O is 5 m and the distance from O to Q is 30 m.

Fig. 4

Initially the particle is at O. After 10 s, it is at Q and its velocity is $9\,\text{m s}^{-1}$ in the direction $\overrightarrow{OQ}$.

(i) Find the initial velocity and the acceleration of the particle. **[4]**

(ii) Prove that the particle is never at P. **[3]**

5 Ali is throwing flat stones onto water, hoping that they will bounce, as illustrated in Fig. 5.

Ali throws one stone from a height of 1.225 m above the water with initial speed $20\,\mathrm{m\,s^{-1}}$ in a horizontal direction. Air resistance should be neglected.

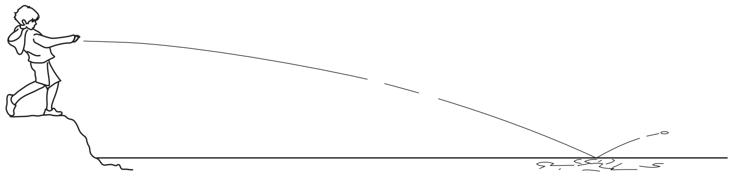

Fig. 5

(i) Find the time it takes for the stone to reach the water. **[2]**

(ii) Find the speed of the stone when it reaches the water and the angle its trajectory makes with the horizontal at this time. **[5]**

Section B (36 marks)

6 The speed of a 100 metre runner in $\mathrm{m\,s^{-1}}$ is measured electronically every 4 seconds.

The measurements are plotted as points on the speed-time graph in Fig. 6. The vertical dotted line is drawn through the runner's finishing time.

Fig. 6 also illustrates Model P in which the points are joined by straight lines.

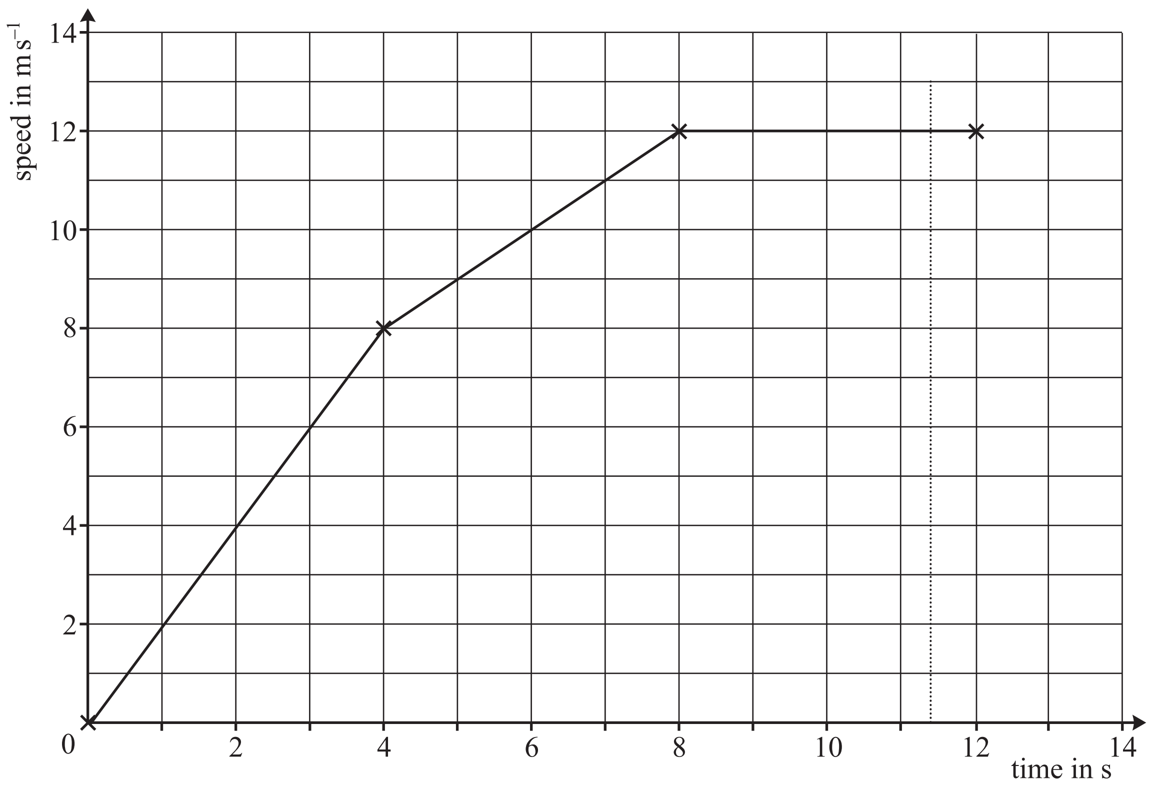

Fig. 6

(i) Use Model P to estimate

(A) the distance the runner has gone at the end of 12 seconds,

(B) how long the runner took to complete 100 m. **[6]**

A mathematician proposes Model Q in which the runner's speed, $v\ \mathrm{m\,s^{-1}}$ at time t s, is given by

$$v = \frac{5}{2}t - \frac{1}{8}t^2.$$

(ii) Verify that Model Q gives the correct speed for $t = 8$. **[1]**

(iii) Use Model Q to estimate the distance the runner has gone at the end of 12 seconds. **[4]**

(iv) The runner was timed at 11.35 seconds for the 100 m.

Which model places the runner closer to the finishing line at this time? **[3]**

(v) Find the greatest acceleration of the runner according to each model. **[4]**

7 A block of weight 50 N is in equilibrium, suspended from fixed points A and B which are 2 m apart on a horizontal ceiling.

Fig. 7.1 illustrates one way of doing this. A light, inextensible string of length 2.8 m is passed round a small smooth light pulley attached to a point C on the block. The parts of the string from C to A and from C to B should be treated as straight lines making angles θ and ϕ with the vertical.

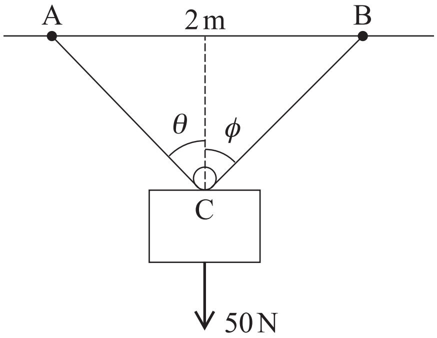

Fig. 7.1

(i) (*A*) State which piece of the information that you have been given tells you that the tension in the string is the same on each side of the pulley. **[1]**

(*B*) Hence show that $\theta = \phi$. **[2]**

(ii) Show that $\cos\theta = \frac{\sqrt{24}}{7}$. **[2]**

(iii) Find the tension in the string. **[3]**

Fig. 7.2 illustrates another way of suspending the block from the same two points, A and B, with the string now cut into two parts, AC and BC. The length of AC is 1.2 m and BC is 1.6 m. The angles the strings make with the horizontal are α and β. The tension in the string AC is T_1 N and the tension in the string BC is T_2 N.

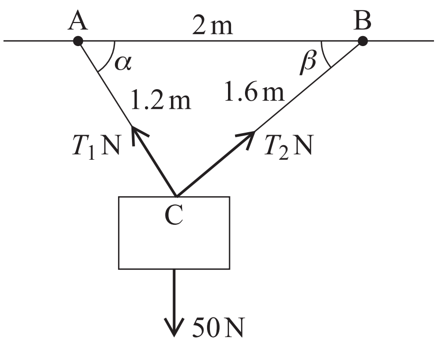

Fig. 7.2

(iv) Show that $\angle ACB = 90°$.

Write down the values of $\cos\alpha$ and $\cos\beta$. **[2]**

(v) Find T_1 and T_2. **[5]**

In a different arrangement, the string is cut so that the lengths of the two parts are 0.5 m and 2.3 m.

(vi) Describe how the block hangs in equilibrium in this case and state the tensions in the two strings. **[3]**

THERE ARE NO QUESTIONS PRINTED ON THIS PAGE.