

**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



**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  $g \text{ ms}^{-2}$ . 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

## Section A (36 marks)

- 1 Fig. 1 shows a block of mass 3 kg on a plane which is inclined at an angle of  $30^\circ$  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.

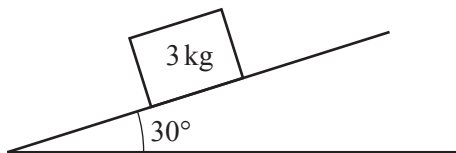


Fig. 1

- (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  $\begin{pmatrix} 2 \\ 0 \end{pmatrix}$   $\text{m s}^{-1}$ .

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

- (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  $30^\circ$  to the line  $l$ .

Tom pushes with a constant horizontal force of 175 N at an angle of  $15^\circ$  to the line  $l$ .

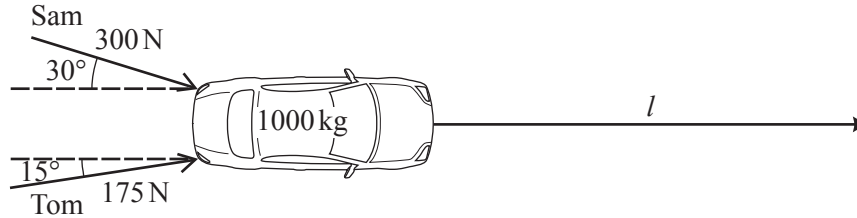


Fig. 3

- (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.

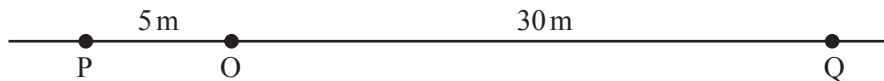


Fig. 4

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.

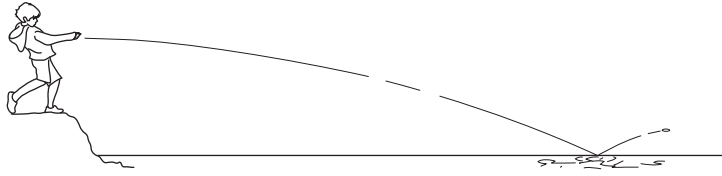
[4]

- (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  $20 \text{ ms}^{-1}$  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  $\text{m s}^{-1}$  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.

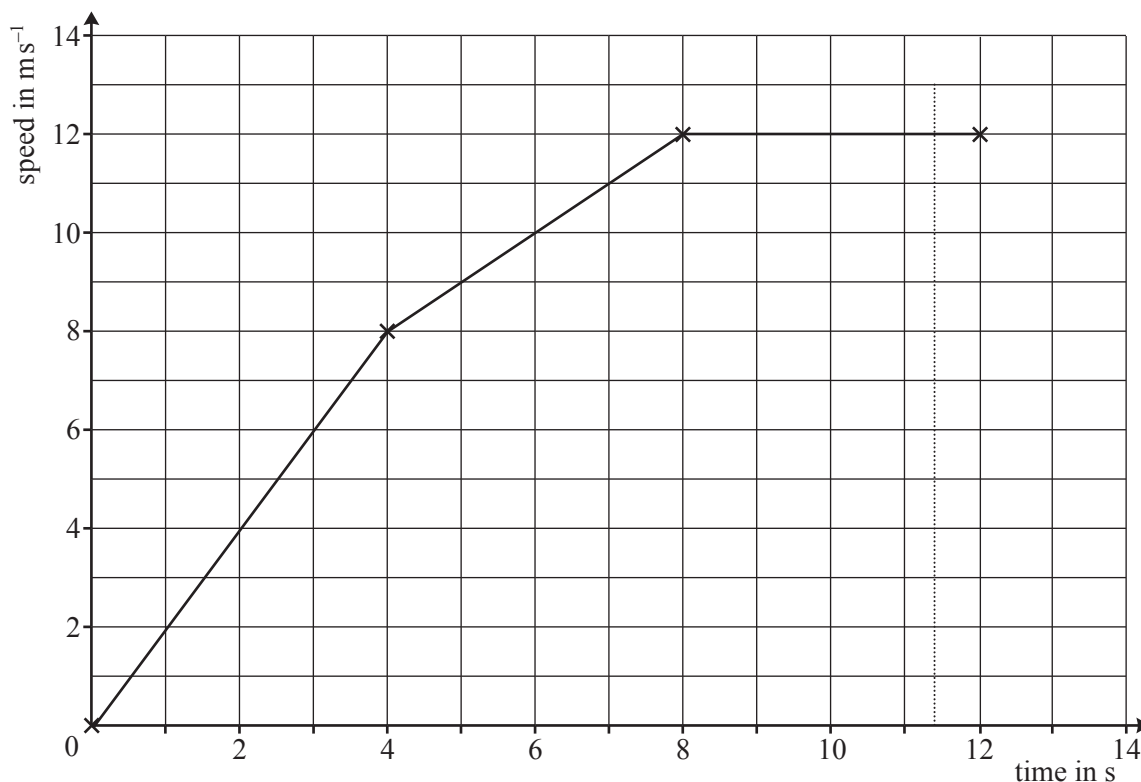


Fig. 6

- (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,  $v \text{ m s}^{-1}$  at time  $t \text{ s}$ , 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?

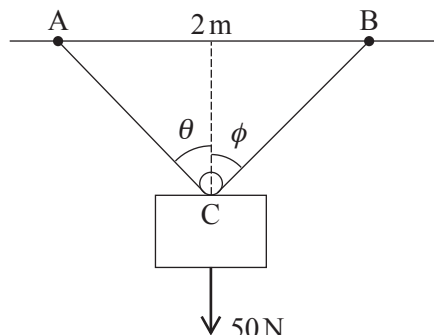
[3]

- (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.

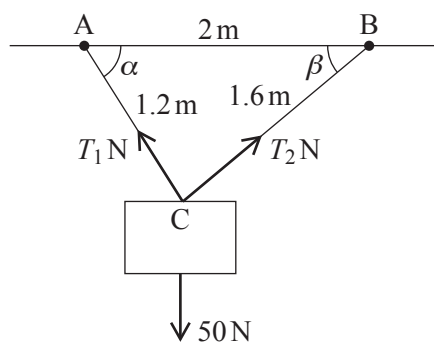
Fig. 7.1 illustrates one way of doing this. A light, inextensible string of length 2.8 m is passed round a small smooth light pulley attached to a point C on the block. The parts of the string from C to A and from C to B should be treated as straight lines making angles  $\theta$  and  $\phi$  with the 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  $\alpha$  and  $\beta$ . 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  $\angle ACB = 90^\circ$ .

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.**



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