

ADVANCED SUBSIDIARY GCE
MATHEMATICS (MEI)
Mechanics 1

4761

Candidates answer on the Answer Booklet

OCR Supplied Materials:

- 8 page Answer Booklet
- Graph paper
- MEI Examination Formulae and Tables (MF2)

Other Materials Required:

None

Thursday 11 June 2009
Morning

Duration: 1 hour 30 minutes



INSTRUCTIONS TO CANDIDATES

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the spaces provided on the Answer Booklet.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that 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 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 $g \text{ m s}^{-2}$. Unless otherwise instructed, when a numerical value is needed, use $g = 9.8$.

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.
- The total number of marks for this paper is **72**.
- This document consists of **8** pages. Any blank pages are indicated.

Section A (36 marks)

- 1 The velocity-time graph shown in Fig. 1 represents the straight line motion of a toy car. All the lines on the graph are straight.

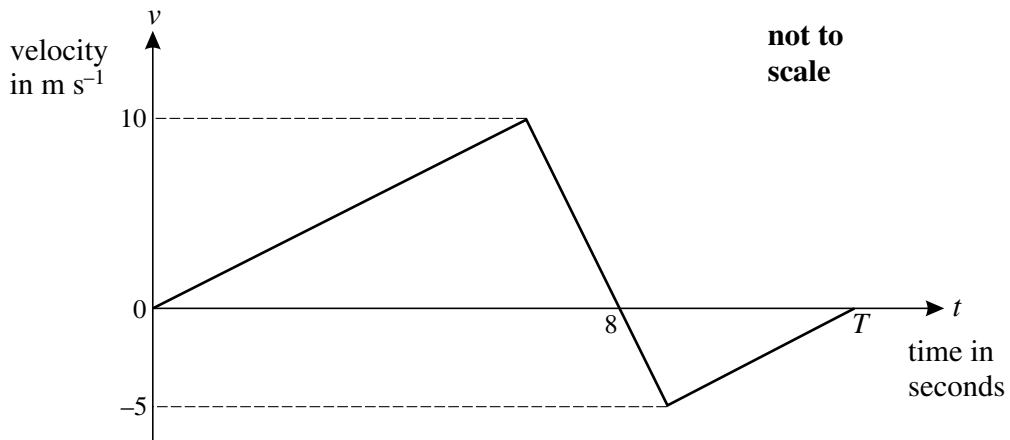


Fig. 1

The car starts at the point A at $t = 0$ and in the next 8 seconds moves to a point B.

- (i) Find the distance from A to B. [2]

T seconds after leaving A, the car is at a point C which is a distance of 10 m from B.

- (ii) Find the value of T . [3]

- (iii) Find the displacement from A to C. [1]

- 2 A small box has weight W N and is held in equilibrium by two strings with tensions T_1 N and T_2 N. This situation is shown in Fig. 2 which also shows the standard unit vectors \mathbf{i} and \mathbf{j} that are horizontal and vertically upwards, respectively.

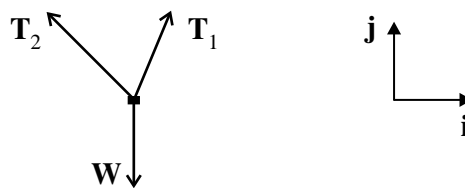


Fig. 2

The tension T_1 is $10\mathbf{i} + 24\mathbf{j}$.

- (i) Calculate the magnitude of T_1 and the angle between T_1 and the vertical. [3]

The magnitude of the weight is w N.

- (ii) Write down the vector \mathbf{W} in terms of w and \mathbf{j} . [1]

The tension T_2 is $k\mathbf{i} + 10\mathbf{j}$, where k is a scalar.

- (iii) Find the values of k and of w . [3]

- 3 Fig. 3 is a sketch of the velocity-time graph modelling the velocity of a sprinter at the start of a race.

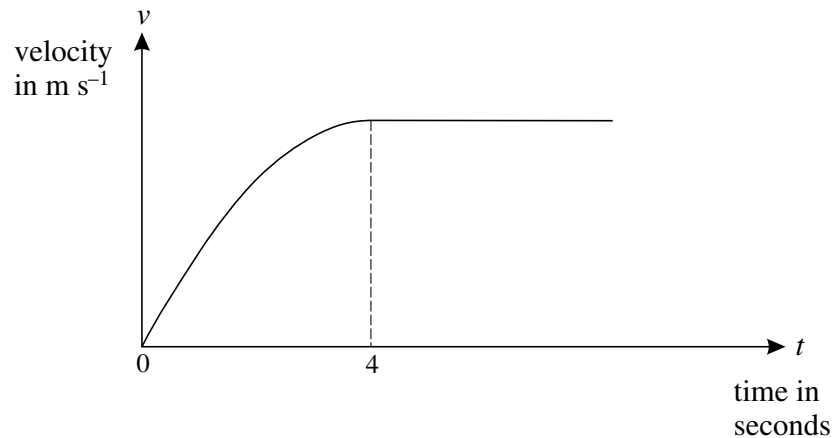


Fig. 3

- (i) How can you tell from the sketch that the acceleration is not modelled as being constant for $0 \leq t \leq 4$? [1]

The velocity of the sprinter, $v \text{ m s}^{-1}$, for the time interval $0 \leq t \leq 4$ is modelled by the expression

$$v = 3t - \frac{3}{8}t^2.$$

- (ii) Find the acceleration that the model predicts for $t = 4$ and comment on what this suggests about the running of the sprinter. [3]
- (iii) Calculate the distance run by the sprinter from $t = 1$ to $t = 4$. [4]

- 4 Fig. 4 shows a particle projected over horizontal ground from a point O at ground level. The particle initially has a speed of 32 m s^{-1} at an angle α to the horizontal. The particle is a horizontal distance of 44.8 m from O after 5 seconds. Air resistance should be neglected.

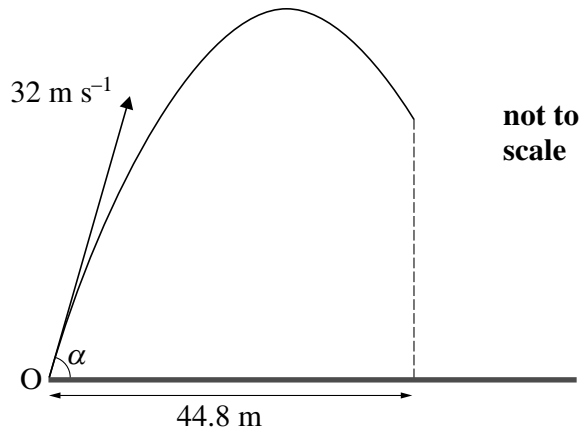


Fig. 4

- (i) Write down an expression, in terms of α and t , for the horizontal distance of the particle from O at time t seconds after it is projected. [1]
- (ii) Show that $\cos \alpha = 0.28$. [2]
- (iii) Calculate the greatest height reached by the particle. [4]
- 5 The position vector of a toy boat of mass 1.5 kg is modelled as $\mathbf{r} = (2 + t)\mathbf{i} + (3t - t^2)\mathbf{j}$ where lengths are in metres, t is the time in seconds, \mathbf{i} and \mathbf{j} are horizontal, perpendicular unit vectors and the origin is O.
- (i) Find the velocity of the boat when $t = 4$. [3]
- (ii) Find the acceleration of the boat and the horizontal force acting on the boat. [3]
- (iii) Find the cartesian equation of the path of the boat referred to x - and y -axes in the directions of \mathbf{i} and \mathbf{j} , respectively, with origin O. You are not required to simplify your answer. [2]

Section B (36 marks)

6 An empty open box of mass 4 kg is on a plane that is inclined at 25° to the horizontal.

In one model the plane is taken to be smooth.

The box is held in equilibrium by a string with tension T N parallel to the plane, as shown in Fig. 6.1.

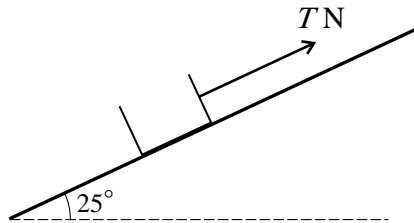


Fig. 6.1

(i) Calculate T . [2]

A rock of mass m kg is now put in the box. The system is in equilibrium when the tension in the string, still parallel to the plane, is 50 N.

(ii) Find m . [3]

In a refined model the plane is rough.

The empty box, of mass 4 kg, is in equilibrium when a frictional force of 20 N acts down the plane and the string has a tension of P N inclined at 15° to the plane, as shown in Fig. 6.2.

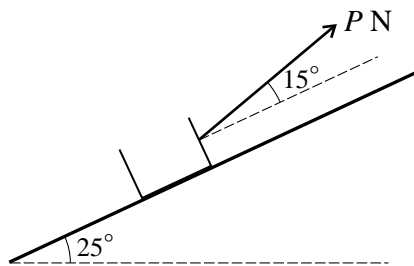


Fig. 6.2

(iii) Draw a diagram showing all the forces acting on the box. [2]

(iv) Calculate P . [5]

(v) Calculate the normal reaction of the plane on the box. [4]

7 A box of mass 8 kg slides on a horizontal table against a constant resistance of 11.2 N.

- (i) What horizontal force is applied to the box if it is sliding with acceleration of magnitude 2 m s^{-2} ? [3]

Fig. 7 shows the box of mass 8 kg on a long, rough, horizontal table. A sphere of mass 6 kg is attached to the box by means of a light inextensible string that passes over a smooth pulley. The section of the string between the pulley and the box is parallel to the table. The constant frictional force of 11.2 N opposes the motion of the box. A force of 105 N parallel to the table acts on the box in the direction shown, and the acceleration of the system is in that direction.

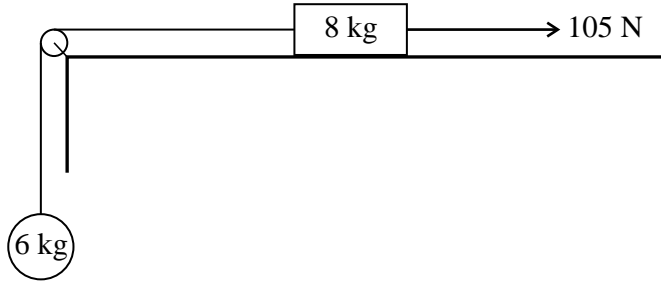


Fig. 7

- (ii) What information in the question indicates that while the string is taut the box and sphere have the same acceleration? [1]
- (iii) Draw two separate diagrams, one showing all the horizontal forces acting on the box and the other showing all the forces acting on the sphere. [2]
- (iv) Show that the magnitude of the acceleration of the system is 2.5 m s^{-2} and find the tension in the string. [7]

The system is stationary when the sphere is at point P. When the sphere is 1.8 m above P the string breaks, leaving the sphere moving upwards at a speed of 3 m s^{-1} .

- (v) (A) Write down the value of the acceleration of the sphere after the string breaks. [1]
- (B) The sphere passes through P again at time T seconds after the string breaks. Show that T is the positive root of the equation $4.9T^2 - 3T - 1.8 = 0$. [2]
- (C) Using part (B), or otherwise, calculate the total time that elapses after the sphere moves from P before the sphere again passes through P. [4]