

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary General Certificate of Education
Advanced General Certificate of Education

MEI STRUCTURED MATHEMATICS

4761

Mechanics 1

Tuesday 7 JUNE 2005 Afternoon 1 hour 30 minutes

- Additional materials:
- Answer booklet
 - Graph paper
 - MEI Examination Formulae and Tables (MF2)

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 are permitted to use a graphical 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 acceleration due to gravity is denoted by $g \text{ m s}^{-2}$. Unless otherwise instructed, when a numerical value is needed, use $g = 9.8$.
- The total number of marks for this paper is 72.

This question paper consists of 5 printed pages and 3 blank pages.

Section A (36 marks)

- 1 A particle travels along a straight line. Its *acceleration* during the time interval $0 \leq t \leq 8$ is given by the acceleration–time graph in Fig. 1.

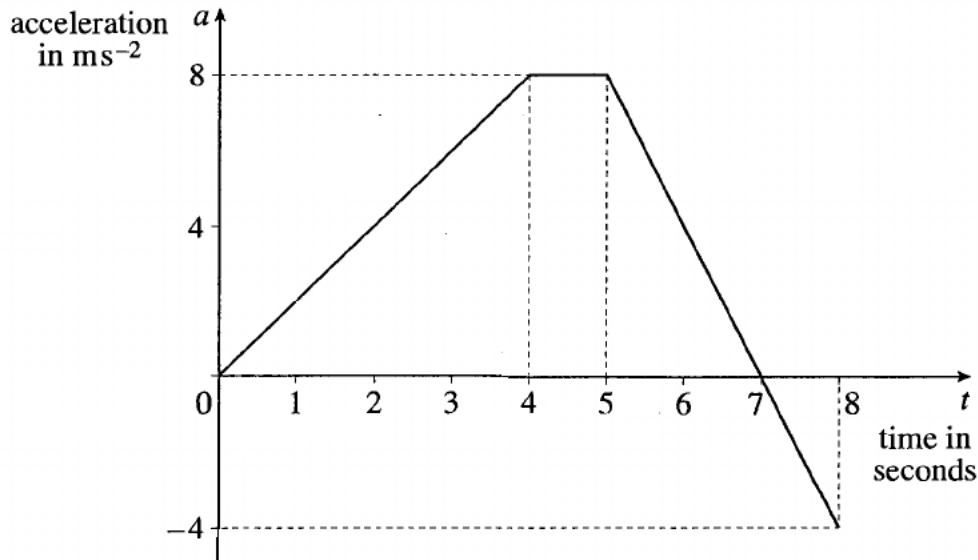


Fig. 1

- (i) Write down the acceleration of the particle when $t = 4$. Given that the particle starts from rest, find its speed when $t = 4$. [2]
- (ii) Write down an expression in terms of t for the acceleration, $a \text{ ms}^{-2}$, of the particle in the time interval $0 \leq t \leq 4$. [1]
- (iii) Without calculation, state the time at which the *speed* of the particle is greatest. Give a reason for your answer. [2]
- (iv) Calculate the change in speed of the particle from $t = 5$ to $t = 8$, indicating whether this is an increase or a decrease. [3]

- 2 A particle moves along the x -axis with velocity, $v \text{ m s}^{-1}$, at time t given by

$$v = 24t - 6t^2.$$

The positive direction is in the sense of x increasing.

- (i) Find an expression for the acceleration of the particle at time t . [2]
- (ii) Find the times, t_1 and t_2 , at which the particle has zero speed. [2]
- (iii) Find the distance travelled between the times t_1 and t_2 . [4]

- 3 A particle rests on a smooth, horizontal plane. Horizontal unit vectors \mathbf{i} and \mathbf{j} lie in this plane. The particle is in equilibrium under the action of the three forces $(-3\mathbf{i} + 4\mathbf{j})\text{N}$ and $(21\mathbf{i} - 7\mathbf{j})\text{N}$ and $\mathbf{R}\text{N}$.
- (i) Write down an expression for \mathbf{R} in terms of \mathbf{i} and \mathbf{j} . [2]
- (ii) Find the magnitude of \mathbf{R} and the angle between \mathbf{R} and the \mathbf{i} direction. [4]
- 4 A block of mass 4 kg is in equilibrium on a rough plane inclined at 60° to the horizontal, as shown in Fig. 4. A frictional force of 10 N acts up the plane and a vertical string AB attached to the block is in tension.

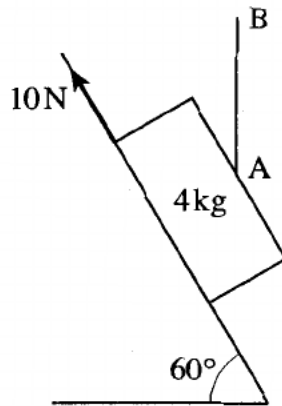


Fig. 4

- (i) Draw a diagram showing the four forces acting on the block. [1]
- (ii) By considering the components of the forces parallel to the slope, calculate the tension in the string. [3]
- (iii) Calculate the normal reaction of the plane on the block. [3]
- 5 The position vector of a particle at time t is given by

$$\mathbf{r} = \frac{1}{2}t\mathbf{i} + (t^2 - 1)\mathbf{j},$$

referred to an origin O where \mathbf{i} and \mathbf{j} are the standard unit vectors in the directions of the cartesian axes Ox and Oy respectively.

- (i) Write down the value of t for which the x -coordinate of the position of the particle is 2. Find the y -coordinate at this time. [2]
- (ii) Show that the cartesian equation of the path of the particle is $y = 4x^2 - 1$. [2]
- (iii) Find the coordinates of the point where the particle is moving at 45° to both Ox and Oy . [3]

Section B (36 marks)

- 6 A car of mass 1000 kg is travelling along a straight, level road.

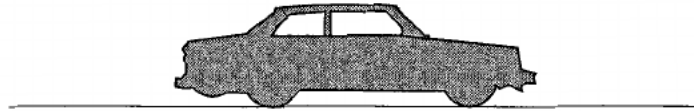


Fig. 6.1

- (i) Calculate the acceleration of the car when a resultant force of 2000 N acts on it in the direction of its motion.

How long does it take the car to increase its speed from 5 ms^{-1} to 12.5 ms^{-1} ? [3]

The car has an acceleration of 1.4 ms^{-2} when there is a driving force of 2000 N.

- (ii) Show that the resistance to motion of the car is 600 N. [2]

A trailer is now attached to the car, as shown in Fig. 6.2. The car still has a driving force of 2000 N and resistance to motion of 600 N. The trailer has a mass of 800 kg. The tow-bar connecting the car and the trailer is light and horizontal. The car and trailer are accelerating at 0.7 ms^{-2} .

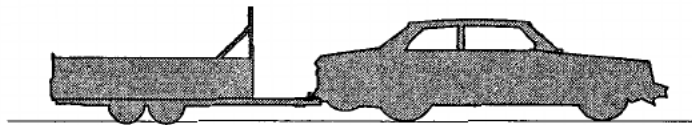


Fig. 6.2

- (iii) Show that the resistance to the motion of the trailer is 140 N. [3]

- (iv) Calculate the force in the tow-bar. [3]

The driving force is now removed and a braking force of 610 N is applied to the car. All the resistances to motion remain as before. The trailer has no brakes.

- (v) Calculate the new acceleration. Calculate also the force in the tow-bar, stating whether it is a tension or a thrust (compression). [6]

7 In this question take the value of g to be 10 m s^{-2} .

A particle A is projected over horizontal ground from a point P which is 9 m above a point O on the ground. The initial velocity has horizontal and vertical components of 10 m s^{-1} and 12 m s^{-1} respectively, as shown in Fig. 7. The trajectory of the particle meets the ground at X. Air resistance may be neglected.

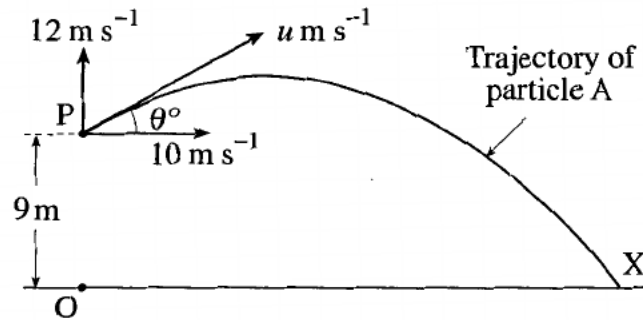


Fig. 7

- (i) Calculate the speed of projection $u \text{ m s}^{-1}$ and the angle of projection θ° . [3]
- (ii) Show that, t seconds after projection, the height of particle A above the ground is $9 + 12t - 5t^2$. Write down an expression in terms of t for the horizontal distance of the particle from O at this time. [4]
- (iii) Calculate the maximum height of particle A above the point of projection. [2]
- (iv) Calculate the distance OX. [4]

A second particle, B, is projected from O with speed 20 m s^{-1} at 60° to the horizontal. The trajectories of A and B are in the same vertical plane. Particles A and B are projected at the same time.

- (v) Show that the horizontal displacements of A and B are always equal. [2]
- (vi) Show that, t seconds after projection, the height of particle B above the ground is $10\sqrt{3}t - 5t^2$. [1]
- (vii) Show that the particles collide 1.7 seconds after projection (correct to two significant figures). [3]