OCR
RECOGNISING ACHIEVEMENT

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 $g\ \mathrm{m\,s^{-2}}$. 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 $0 \leqslant t \leqslant 8$ is given by the acceleration–time graph in Fig. 1.

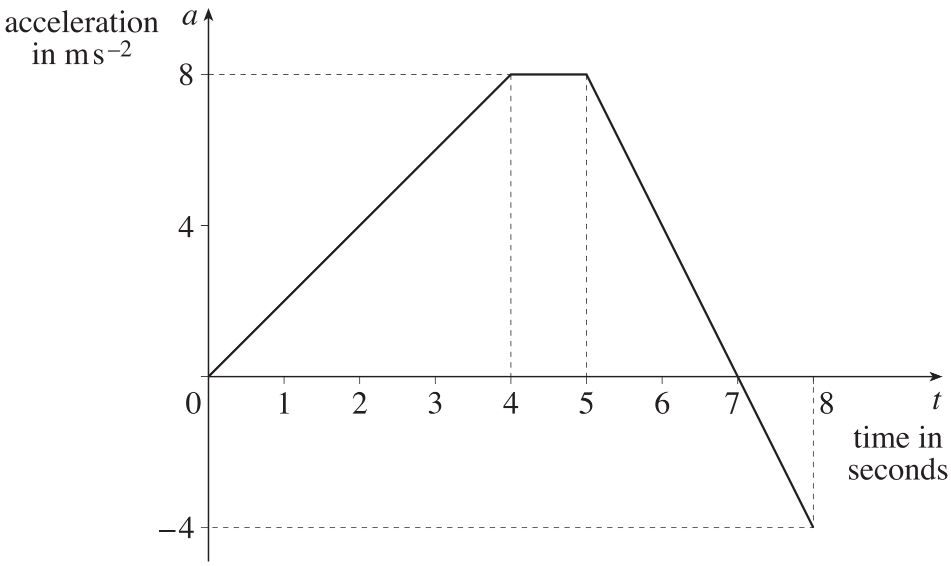

Fig. 1

(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, $a\,\mathrm{m\,s^{-2}}$, of the particle in the time interval $0 \leqslant t \leqslant 4$. [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, $v\,\mathrm{m\,s^{-1}}$, 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 **i** and **j** lie in this plane. The particle is in equilibrium under the action of the three forces $(-3\mathbf{i} + 4\mathbf{j})$ N and $(21\mathbf{i} - 7\mathbf{j})$ N and **R** N.

(i) Write down an expression for **R** in terms of **i** and **j**. [2]

(ii) Find the magnitude of **R** and the angle between **R** and the **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.

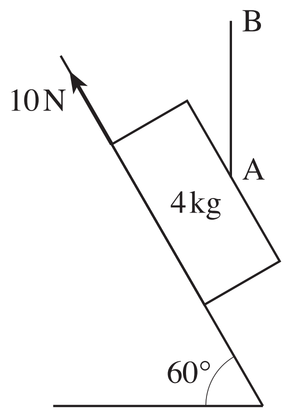

Fig. 4

(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

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

referred to an origin O where **i** and **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]

[Turn over

Section B (36 marks)

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

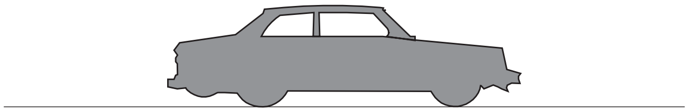

Fig. 6.1

(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 $5\,\mathrm{m\,s^{-1}}$ to $12.5\,\mathrm{m\,s^{-1}}$? [3]

The car has an acceleration of $1.4\,\mathrm{m\,s^{-2}}$ 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 atached 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 $0.7\,\mathrm{m\,s^{-2}}$.

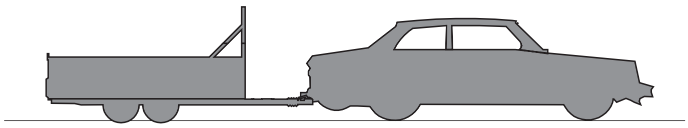

Fig. 6.2

(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 $10\,\mathrm{m\,s^{-2}}$.

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 $10\,\mathrm{m\,s^{-1}}$ and $12\,\mathrm{m\,s^{-1}}$ respectively, as shown in Fig. 7. The trajectory of the particle meets the ground at X. Air resistance may be neglected.

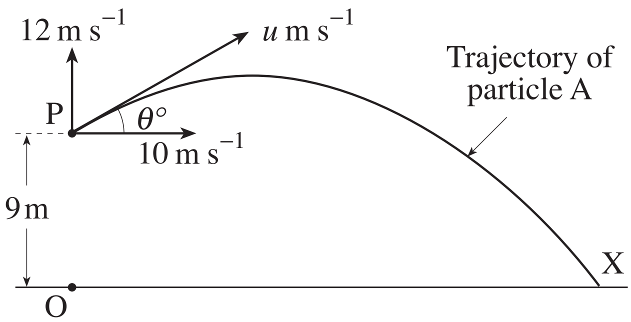

Fig. 7

(i) Calculate the speed of projection $u\,\mathrm{m\,s^{-1}}$ and the angle of projection $\theta°$. [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 $20\,\mathrm{m\,s^{-1}}$ 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]

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