OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary General Certificate of Education
Advanced General Certificate of Education

MEI STRUCTURED MATHEMATICS 2607

Mechanics 1

Friday **14 JANUARY 2005** Morning 1 hour 20 minutes

Additional materials:
Answer booklet
Graph paper
MEI Examination Formulae and Tables (MF12)

TIME 1 hour 20 minutes

INSTRUCTIONS TO CANDIDATES

- Write your Name, Centre Number and Candidate Number in the spaces provided on the answer booklet.
- Answer **all** questions.
- You are permitted to use a graphical calculator in this paper.

INFORMATION FOR CANDIDATES

- The allocation 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.
- Take g = 9.8 m s^{-2} unless otherwise instructed.
- The total number of marks for this paper is 60.

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

Registered Charity 1066969
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1 (a) In this part-question take g as $10\,\mathrm{m\,s^{-2}}$.

A small ball is released from rest. It falls for 2 seconds and is then brought to rest over the next 5 seconds. This motion is modelled in the speed-time graph Fig. 1.

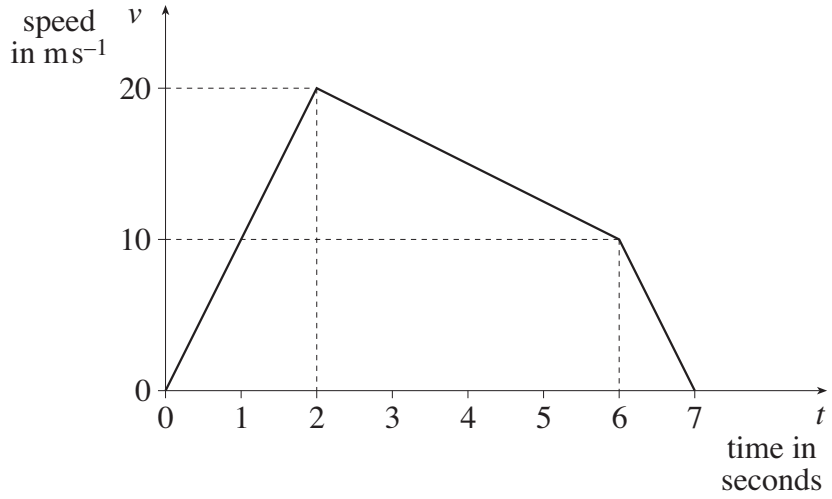

Fig. 1

(i) Calculate the distance fallen from $t = 0$ to $t = 7$. [3]

(ii) Find the acceleration of the ball from $t = 2$ to $t = 6$, specifying the direction. [3]

(iii) Obtain an expression in terms of t for the downward speed of the ball from $t = 2$ to $t = 6$. [3]

(iv) State the assumption that has been made about the resistance to motion from $t = 0$ to $t = 2$. [1]

(b) The position vector, $\mathbf{r}$, of a particle at time t is given by

$$\mathbf{r} = t^2\mathbf{i} + (5t - 2t^2)\mathbf{j},$$

where $\mathbf{i}$ and $\mathbf{j}$ are the standard unit vectors, lengths are in metres and time is in seconds.

(i) Find an expression for the acceleration of the particle. [4]

(ii) Is the particle ever at rest? [2]

[Total 16]

2 A small box B of weight 400 N is held in equilibrium by two light strings AB and BC. The string BC is fixed at C. The end A of string AB is fixed so that AB is at an angle α to the vertical where $\alpha < 60°$. String BC is at 60° to the vertical. This information is shown in Fig. 2.

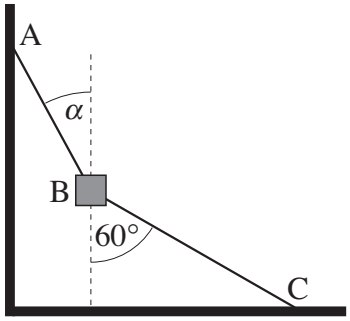

Fig. 2

(i) Draw a labelled diagram showing all the forces acting on the box. [1]

(ii) In one situation, the tension in the string BC is 200 N.

By resolving horizontally and vertically, or otherwise, calculate α and the tension in string AB. [7]

(iii) In a new situation, string AB is fixed so that $\alpha = 30°$ and BC remains at 60° to the vertical.

By drawing a triangle of forces, or otherwise, calculate the tension in the string BC and the tension in the string AB. [4]

(iv) Show carefully, but briefly, that the box cannot be in equilibrium if $\alpha = 60°$ and BC remains at 60° to the vertical. [2]

[Total 14]

[Turn over

3 **(a)** A particle of mass 4 kg is subject to a force **F** and a force $12\mathbf{j}$ N. It has an acceleration of $(2\mathbf{i} - 4\mathbf{j})\,\mathrm{m\,s^{-2}}$. Find **F**. [3]

(b) Two blocks are connected by a light inextensible string AC that passes over a small, smooth pulley at B, as shown in Fig. 3. The blocks slide on the horizontal plane and on the inclined plane. The masses of the blocks, the resistances to motion of 4 N and 3 N, and the angle of the inclined plane are also given in the figure. The string sections AB and BC are parallel to the horizontal and inclined planes respectively.

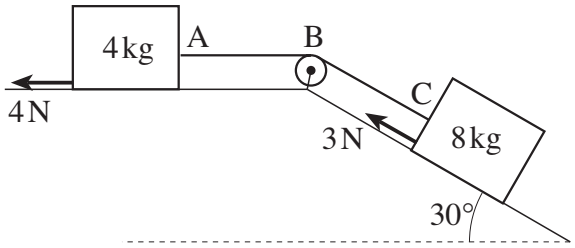

Fig. 3

(i) State what information in the question tells you that

(*A*) the magnitudes of the accelerations of the blocks are the same,

(*B*) the tension in string section AB is the same as that in BC. [2]

The tension in the string is *T*N and the magnitude of the acceleration of the two blocks is $a\,\mathrm{m\,s^{-2}}$.

(ii) By considering the motion of the 4 kg block, write down an equation connecting *T* and *a*. [2]

(iii) Draw a diagram showing the forces acting on the 8 kg block. By considering the motion of this block find another equation connecting *T* and *a*. [5]

(iv) Find the value of *a*. [3]

[Total 15]

4 The trajectory ABCD of a small stone moving with negligible air resistance is shown in Fig. 4. AD is horizontal and BC is parallel to AD.

The stone is projected from A with speed $40\,\mathrm{m\,s^{-1}}$ at 50° to the horizontal.

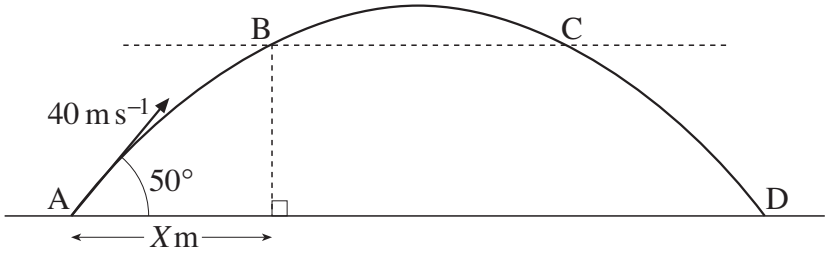

Fig. 4

(i) Write down an expression for the horizontal displacement from A of the stone t seconds after projection. Write down also an expression for the vertical displacement at time t. [3]

(ii) Show that the stone takes 6.253 seconds (to three decimal places) to travel from A to D. [3]

You are given that $X = 30$.

(iii) Calculate the time it takes the stone to reach B. Hence determine the time for it to travel from A to C. [4]

(iv) Calculate the direction of the motion of the stone at C. [5]

[Total 15]

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