RECOGNISING ACHIEVEMENT

Oxford Cambridge and RSA Examinations

Advanced Subsidiary General Certificate of Education
Advanced General Certificate of Education

MEI STRUCTURED MATHEMATICS

MECHANICS 2, M2

4762

Specimen Paper

Additional materials: Answer booklet
Graph paper
MEI Examination Formulae and Tables (MF 2)

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 **may** use a graphical or scientific 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 total number of marks for this paper is **72**.
- Unless otherwise specified, the value of g should be taken to be exactly 9.8 ms^{-2}.

1 Two young skaters, Percy of mass 55 kg and Queenie of mass 45 kg, are moving on a smooth horizontal plane of ice. You may assume that there are no external forces acting on the skaters in this plane.

Percy and Queenie are moving with speeds of 2 ms^{-1} and $\frac{4}{3}$ ms^{-1} respectively **towards** one another in the same line of motion. When they meet they embrace.

(i) Calculate the common velocity of the two skaters after they meet and the magnitude and direction of the impulse on Percy in the collision. **[6]**

Percy and Queenie, still together, collide directly with a moving skater, Roger, of mass 60 kg.
The coefficient of restitution in the collision is 0.2.
After the collision, Percy and Queenie have a speed of 0.1 ms^{-1} in the same direction as before the collision.

(ii) Calculate Roger's velocity before the collision and his velocity after it. **[7]**

While moving at 0.1 ms^{-1} horizontally, Percy drops a small ball. The ball has zero vertical speed initially and drops 0.4 m onto the ice. The coefficient of restitution in the collision between the ball and the ice is 0.5.

(iii) At what angle to the horizontal does the ball leave the ice as it bounces? **[5]**

2 A parcel of mass 20 kg is pushed **up** a slope at 30° to the horizontal against a constant sliding resistance of 50 N at a steady speed of 4 ms^{-1}.

(i) Calculate the power developed by the pushing force. **[3]**

The parcel now slides **down** a slope at 35° to the horizontal that produces a different resistance to its motion. Its speed increases from 4 ms^{-1} to 6 ms^{-1} while sliding a distance of 5 m down the slope.

(ii) Calculate the work done against the resistance to motion. **[4]**

(iii) Assuming that a constant frictional force between the parcel and the slope is the only resistance to motion, show that the coefficient of friction between the parcel and the slope is 0.45, correct to two significant figures. **[4]**

(iv) For what value of the coefficient of friction would the parcel slide down the slope at a constant speed? **[2]**

The parcel is sliding down the slope and the coefficient of friction is 0.45.
A force, applied parallel to the slope, does 520 J of work and brings the parcel to rest from 6 ms^{-1} in x m.

(v) Calculate the value of x. **[5]**

3

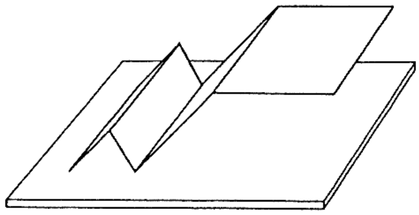

Fig. 3.1

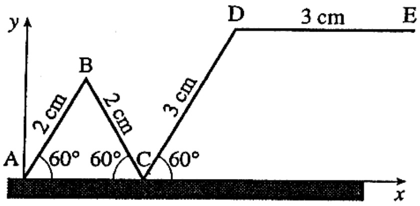

Fig. 3.2

A uniform, rectangular lamina of mass 25 kg is folded and placed on a horizontal floor, as shown in Fig. 3.1.
Fig 3.2 shows the cross-section ABCDE of the folded lamina.
The dimensions and angles of the cross-section are given in Fig. 3.2 and DE is horizontal.

(i) Show that the *x*-coordinate of the centre of mass of the lamina is 2.725, referred to the axes shown in Fig 3.2.
Calculate also the *y*-coordinate, referred to the same axes, giving your answer correctly to three decimal places. **[6]**

(ii) Explain briefly why the lamina cannot be in equilibrium in the position shown without the application of an additional force. **[2]**

(iii) What is the least vertical force that must be applied to the lamina at A so that it will stay in equilibrium in the position shown? **[4]**

Instead of applying the vertical force at A, a horizontal force is applied to the lamina at E.
The lamina does not slide on the floor.

(iv) Calculate the least value of the horizontal force at E for the lamina to be in equilibrium. **[3]**

(v) Calculate the greatest value the horizontal force at E can take without the lamina turning *anti*-clockwise. **[3]**

4

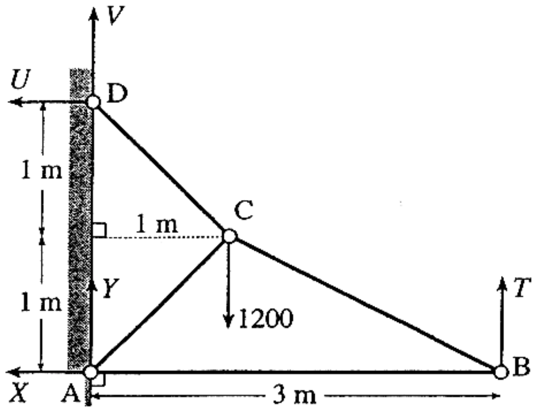

Fig. 4

Fig. 4 shows a light framework ABCD freely pin-jointed together at A, B and C and freely attached to a vertical wall at A and D.
There is a load of 1200N at C and a vertical force of *T*N acts at B.
The other external forces *U, V, X* and *Y* N and essential geometrical information are marked in the diagram.
The framework is in equilibrium.

(i) Show that $X = -U$ and that $U = \frac{1}{2}(1200 - 3T)$. **[3]**

(ii) By considering the equlibirium at D, show that $U = V$. **[2]**

(iii) Show that $Y = \frac{1}{2}(1200 + T)$ and find expressions in terms of *T* for the internal forces in each of the rods AB, BC, AC and CD. **[9]**

(iv) As *T* increases from zero through positive values, show that one of the rods changes from being in tension to being in thrust.
For what value of *T* is there no internal force in this rod?
Describe what happens to the forces in the rods as *T* decreases from zero through negative values. **[4]**