General Certificate of Education
June 2004
Advanced Subsidiary Examination

MATHEMATICS AND STATISTICS (SPECIFICATION B) Unit Mechanics 1

MBM1

Friday 28 May 2004 Afternoon Session

In addition to this paper you will require:
- a 12-page answer book;
- the AQA booklet of formulae and statistical tables.

You may use a graphics calculator.

Time allowed: 1 hour 45 minutes

Instructions
- Use blue or black ink or ball-point pen. Pencil should only be used for drawing.
- Write the information required on the front of your answer book. The *Examining Body* for this paper is AQA. The *Paper Reference* is MBM1.
- Answer **all** questions.
- Take $g = 9.8\,\text{m}\,\text{s}^{-2}$ unless stated otherwise.
- All necessary working should be shown; otherwise marks for method may be lost.
- The **final** answer to questions requiring the use of tables or calculators should normally be given to three significant figures.

Information
- The maximum mark for this paper is 80.
- Mark allocations are shown in brackets.

Advice
- Unless stated otherwise, formulae may be quoted, without proof, from the booklet.

Answer **all** questions.

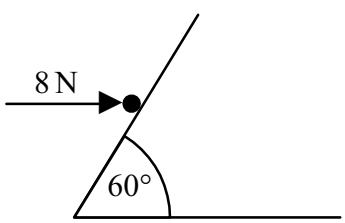
1 A small stone falls vertically from rest. When the stone hits the ground it is travelling at a speed of $24.5\,\text{m s}^{-1}$. Model the stone as a particle and assume that no resistance forces act on the stone as it falls.

(a) Find the time that it takes for the stone to fall to the ground. *(2 marks)*

(b) Show that the stone falls a distance of 30.625 metres. *(3 marks)*

(c) Find the time for which the stone has been falling when it is 5 metres above ground level. *(4 marks)*

2 A particle is held at rest on a smooth slope by a horizontal force of magnitude 8 newtons, as shown in the diagram below. The slope is at an angle of 60° to the horizontal.



(a) Draw a diagram to show the forces acting on the particle. *(1 mark)*

(b) By resolving horizontally show that the magnitude of the normal reaction force acting on the particle is approximately 9.24 newtons. *(3 marks)*

(c) Find the mass of the particle, giving your answer to two significant figures. *(3 marks)*

3 A box, of mass 20 kg, is initially at rest on a rough horizontal surface. A horizontal force of magnitude P newtons is applied to the box. The coefficient of friction between the box and the surface is 0.3.

(a) State the magnitude of the normal reaction force acting on the box. *(1 mark)*

(b) Find the magnitude of the friction force that acts on the box if:

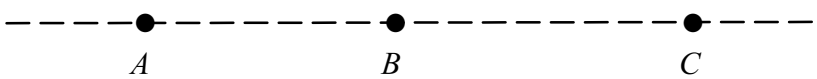
(i) $P = 80$;

(ii) $P = 40$. *(3 marks)*

(c) Find the value of P when the box is accelerating at $0.8\,\text{m s}^{-2}$. *(3 marks)*

(d) When the box reaches a speed of $6\,\text{m s}^{-1}$, the horizontal force P is removed. Find the distance that the box travels after the force P is removed. *(5 marks)*

4 Three particles, A, B and C, are initially at rest in a straight line on a smooth horizontal surface. The masses of the particles are 2 kg, 4 kg and m kg respectively.

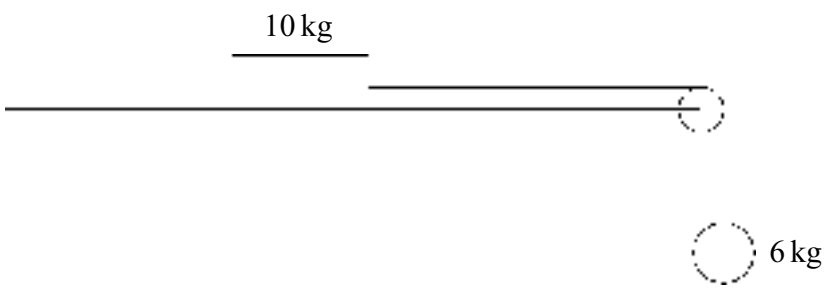


(a) Particle A is set in motion with speed $4\,\text{m s}^{-1}$ directly towards particle B. After colliding with B, particle A continues to move in the same direction but with speed $1\,\text{m s}^{-1}$. Find the speed of B after this collision. *(3 marks)*

(b) Particle B then collides with particle C. After this collision, C moves with a speed of $2\,\text{m s}^{-1}$. Find the speed of B after this collision, giving your answer in terms of m. *(3 marks)*

(c) If A collides with B again, show that $m > 1$. *(4 marks)*

5 A block, of mass 10 kg, rests on a rough horizontal surface. It is connected by a light, inextensible string to a particle of mass 6 kg. The string passes over a light, smooth pulley, so that the string hangs vertically, as shown in the diagram.



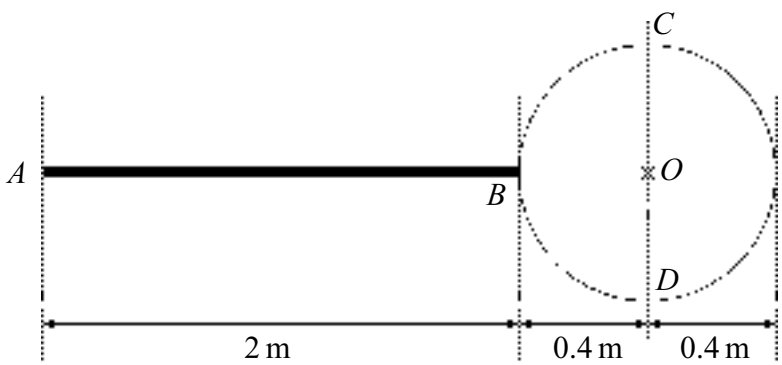
Model the block as a particle.

(a) The system is released from rest and the block travels 0.5 metres in 2 seconds. Find the acceleration of the system. *(2 marks)*

(b) Show that the tension in the string is 57.3 N. *(3 marks)*

(c) Find the coefficient of friction between the block and the plane. *(6 marks)*

6 A uniform circular disc is attached to one end of a uniform pole to form the body shown in the diagram below.



The pole AB has length 2 metres and mass 6 kg.
The disc, centre O, has radius 0.4 metres and mass 2 kg.
The points A, B and O lie on a straight line.

(a) Show that the centre of mass of the body is 1.35 metres from A. *(3 marks)*

(b) The diameter, CD, of the disc is perpendicular to OA. The body is suspended from the point C. Find the angle between the pole and the vertical when the body hangs at rest in equilibrium. *(4 marks)*

7 A particle of mass 4 kg moves on a smooth horizontal plane. It is initially at rest at the origin. A force $\mathbf{F} = (8\mathbf{i} - 12\mathbf{j})$ N acts on the particle for 20 seconds. The unit vectors $\mathbf{i}$ and $\mathbf{j}$ are perpendicular and lie in the horizontal plane.

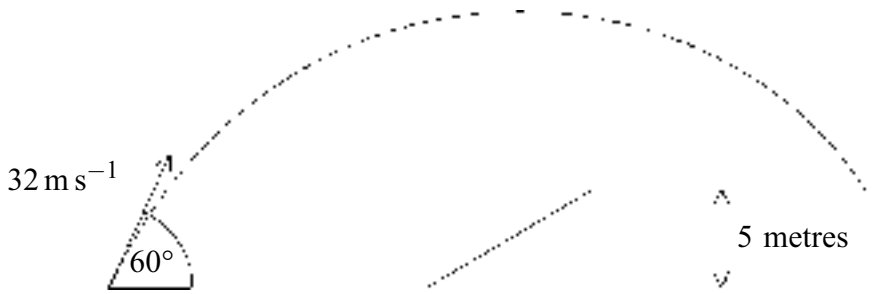
(a) (i) Find the acceleration of the particle. *(2 marks)*

(ii) Find the velocity of the particle at the end of the 20 second period. *(2 marks)*

(iii) Find the position of the particle at the end of the 20 second period. *(3 marks)*

(b) At the end of the 20 second period, the force $\mathbf{F}$ is removed. Find the distance of the particle from the origin after the particle has been in motion for a total of 45 seconds. *(5 marks)*

8 A golf ball is hit so that it initially travels at $32\,\text{m}\,\text{s}^{-1}$ at an angle of 60° above the horizontal. The ball lands on a horizontal surface 5 metres higher than the ground from which it was hit, as shown in the diagram below.



(a) Show that the ball is in the air for approximately 5.47 seconds. *(5 marks)*

(b) Calculate the horizontal distance travelled by the ball. *(2 marks)*

(c) Find the speed of the ball when it hits the ground. *(5 marks)*

END OF QUESTIONS

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