AQA

Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

AS MATHEMATICS

Unit Mechanics 1B

Tuesday 21 June 2016 Morning Time allowed: 1 hour 30 minutes

Materials
For this paper you must have:
- the blue AQA booklet of formulae and statistical tables.

You may use a graphics calculator.

Instructions
- Use black ink or black ball-point pen. Pencil should only be used for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- Write the question part reference (eg (a), (b)(i) etc) in the left-hand margin.
- You must answer each question in the space provided for that question. If you require extra space, use an AQA supplementary answer book; do **not** use the space provided for a different question.
- Do not write outside the box around each page.
- Show all necessary working; otherwise marks for method may be lost.
- Do all rough work in this book. Cross through any work that you do not want to be marked.
- The **final** answer to questions requiring the use of calculators should be given to three significant figures, unless stated otherwise.
- Take $g = 9.8 \text{ m s}^{-2}$, unless stated otherwise.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 75.

Advice
- Unless stated otherwise, you may quote formulae, without proof, from the booklet.
- You do not necessarily need to use all the space provided.

Answer **all** questions.

Answer each question in the space provided for that question.

1 Two particles, A and B, are moving directly towards each other on a straight line with speeds of $6\,\text{m s}^{-1}$ and $8\,\text{m s}^{-1}$ respectively. The mass of A is $3\,\text{kg}$ and the mass of B is $2\,\text{kg}$. When the particles collide, they coalesce to form a single particle which moves with speed $v\,\text{m s}^{-1}$.

(a) Find v.

[3 marks]

(b) This particle then collides with a stationary particle of mass $m\,\text{kg}$. Again, the particles coalesce to form a single particle which moves with a speed of $0.1\,\text{m s}^{-1}$.

Find m.

[3 marks]

QUESTION PART REFERENCE	**Answer space for question 1**

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2 Three forces $(4\mathbf{i} + 7\mathbf{j})$ N, $(p\mathbf{i} + 5\mathbf{j})$ N and $(-8\mathbf{i} + q\mathbf{j})$ N act on a particle of mass $5\,\text{kg}$ to produce an acceleration of $(2\mathbf{i} - \mathbf{j})\,\text{m s}^{-2}$. No other forces act on the particle.

(a) Find the resultant force acting on the particle in terms of p and q.

[1 mark]

(b) Find p and q.

[4 marks]

(c) Given that the particle is initially at rest, find the displacement of the particle from its initial position when these forces have been acting for 4 seconds.

[3 marks]

QUESTION PART REFERENCE

Answer space for question 2

QUESTION PART REFERENCE	**Answer space for question 2**

3 A toy car is placed at the top of a ramp. After the car has been released from rest, it travels a distance of 1.08 metres down the ramp, in a time of 1.2 seconds.

Assume that there is no resistance to the motion of the car.

(a) Find the magnitude of the acceleration of the car while it is moving down the ramp.

[3 marks]

(b) Find the speed of the car, when it has travelled 1.08 metres down the ramp.

[2 marks]

(c) Find the angle between the ramp and the horizontal, giving your answer to the nearest degree.

[4 marks]

QUESTION PART REFERENCE

Answer space for question 3

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Answer space for question 3

4 An aeroplane is flying in air that is moving due east at $V\,\mathrm{m\,s^{-1}}$. Relative to the air, the aeroplane has a velocity of $90\,\mathrm{m\,s^{-1}}$ due north. During a 20 second period, the motion of the air causes the aeroplane to move 240 metres to the east.

(a) Find V.

[2 marks]

(b) Find the magnitude of the resultant velocity of the aeroplane.

[2 marks]

(c) Find the direction of the resultant velocity, giving your answer as a three-figure bearing, correct to the nearest degree.

[3 marks]

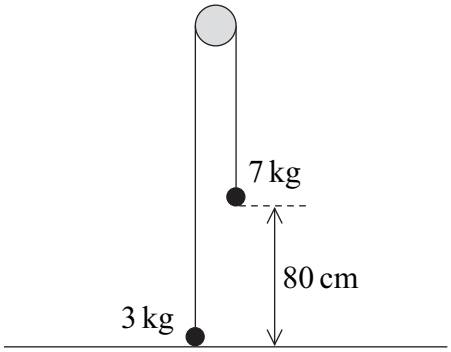
QUESTION PART REFERENCE

Answer space for question 4

QUESTION PART REFERENCE

Answer space for question 4

5 Two particles, of masses $3\,\text{kg}$ and $7\,\text{kg}$, are connected by a light inextensible string that passes over a smooth peg. The $3\,\text{kg}$ particle is held at ground level with the string above it taut and vertical. The $7\,\text{kg}$ particle is at a height of $80\,\text{cm}$ above ground level, as shown in the diagram.



The $3\,\text{kg}$ particle is then released from rest.

(a) By forming two equations of motion, show that the magnitude of the acceleration of the particles is $3.92\,\text{m s}^{-2}$.

[5 marks]

(b) Find the speed of the $7\,\text{kg}$ particle just before it hits the ground.

[3 marks]

(c) When the $7\,\text{kg}$ particle hits the ground, the string becomes slack and in the subsequent motion the $3\,\text{kg}$ particle does not hit the peg.

Find the maximum height of the $3\,\text{kg}$ particle above the ground.

[4 marks]

QUESTION PART REFERENCE

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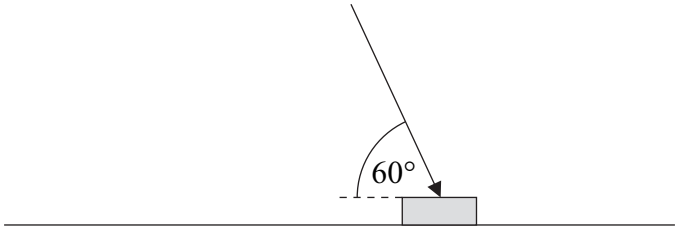
6 A floor polisher consists of a heavy metal block with a polishing cloth attached to the underside. A light rod is also attached to the block and is used to push the block across the floor that is to be polished. The block has mass $5\,\text{kg}$. Assume that the floor is horizontal. Model the block as a particle.

The coefficient of friction between the cloth and the floor is 0.2 .

A person pushes the rod to exert a force on the block. The force is at an angle of $60°$ to the horizontal and the block accelerates at $0.9\,\text{m}\,\text{s}^{-2}$. The diagram shows the block and the force exerted by the rod in this situation.



The rod exerts a force of magnitude T newtons on the block.

(a) Find, in terms of T, the magnitude of the normal reaction force acting on the block.

[2 marks]

(b) Find T.

[6 marks]

QUESTION PART REFERENCE

Answer space for question 6

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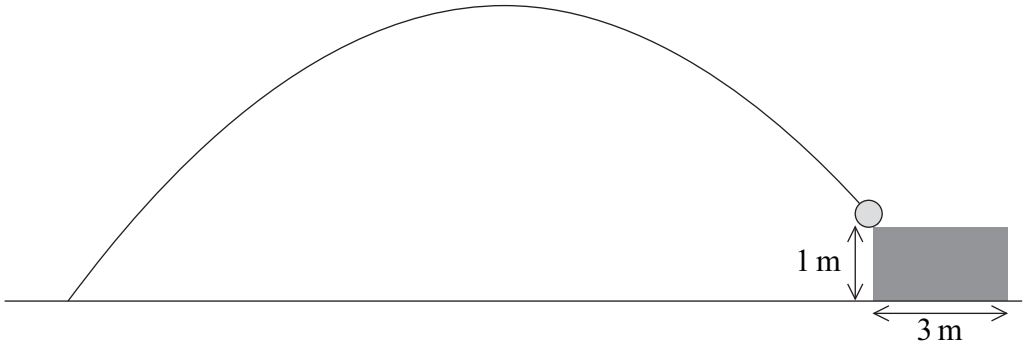
7 At a school fair, there is a competition in which people try to kick a football so that it lands in a large rectangular box. The height of the top of the box is 1 metre and its width is 3 metres.

One student kicks a football so that it initially moves at $12\,\text{m}\,\text{s}^{-1}$ at an angle of $50°$ above the horizontal. It hits the top front edge of the box, as shown in the diagram below.



Model the football as a particle that is not subject to any resistance forces as it moves.

(a) Find the time taken for the football to move from the point where it was kicked to the box.

[5 marks]

(b) Find the horizontal distance from the point where the football is kicked to the front of the box.

[2 marks]

(c) If the same student kicks the football at the same angle from the same initial position, what is the speed at which the student should kick the football if it is to hit the top **back** edge of the box?

[7 marks]

(d) Explain the significance of modelling the football as a particle in this context.

[1 mark]

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8 The unit vectors **i** and **j** are directed east and north respectively.

Two helicopters, A and B, are taking part in an air display. Both helicopters move in the same horizontal plane which is well above ground level. At the start of the display, A is at the origin, which is located in this horizontal plane, and B has position vector $(40\mathbf{i} + 50\mathbf{j})$ metres relative to this origin. The velocities of A and B at the start of the display are $(8\mathbf{i} + 4\mathbf{j})\,\mathrm{m\,s^{-1}}$ and $(6\mathbf{i} + 9\mathbf{j})\,\mathrm{m\,s^{-1}}$ respectively. Both helicopters move with constant acceleration. The acceleration of A is $(-0.2\mathbf{i} + 0.1\mathbf{j})\,\mathrm{m\,s^{-2}}$ and the acceleration of B is $(0.2\mathbf{i} - 0.1\mathbf{j})\,\mathrm{m\,s^{-2}}$.

Find the distance between A and B at the instant when their velocities are parallel.

[10 marks]

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