General Certificate of Education
January 2008
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

MATHEMATICS **MM1B**
Unit Mechanics 1B

Friday 11 January 2008 9.00 am to 10.30 am

For this paper you must have:
- an 8-page answer book
- the blue AQA booklet of formulae and statistical tables.

You may use a graphics calculator.

Time allowed: 1 hour 30 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 MM1B.
- Answer **all** questions.
- Show all necessary working; otherwise marks for method may be lost.
- The **final** answer to questions requiring the use of calculators should be given to three significant figures, unless stated otherwise.
- Take $g = 9.8\ \mathrm{m\,s^{-2}}$, unless stated otherwise.

Information
- The maximum mark for this paper is 75.
- The marks for questions are shown in brackets.
- Unit Mechanics 1B has a **written paper only**.

Advice
- Unless stated otherwise, you may quote formulae, without proof, from the booklet.

Answer **all** questions.

1 A crane is used to lift a crate, of mass 70 kg, vertically upwards. As the crate is lifted, it accelerates uniformly from rest, rising 8 metres in 5 seconds.

(a) Show that the acceleration of the crate is $0.64\,\text{m s}^{-2}$. *(2 marks)*

(b) The crate is attached to the crane by a single cable. Assume that there is no resistance to the motion of the crate.

Find the tension in the cable. *(3 marks)*

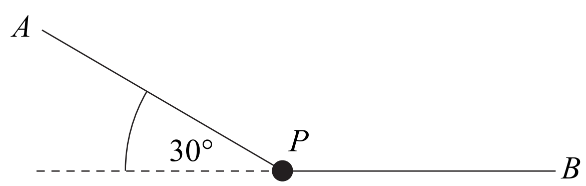
(c) Calculate the average speed of the crate during these 5 seconds. *(1 mark)*

2 The velocity of a ship, relative to the water in which it is moving, is $8\,\text{m s}^{-1}$ due north. The water is moving due east with a speed of $U\,\text{m s}^{-1}$. The resultant velocity of the ship has magnitude $10\,\text{m s}^{-1}$.

(a) Find U. *(2 marks)*

(b) Find the direction of the resultant velocity of the ship. Give your answer as a bearing to the nearest degree. *(2 marks)*

3 A particle, of mass 4 kg, is suspended in equilibrium by two light strings, *AP* and *BP*. The string *AP* makes an angle of 30° to the horizontal and the other string, *BP*, is horizontal, as shown in the diagram.



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

(b) Show that the tension in the string *AP* is 78.4 N. *(3 marks)*

(c) Find the tension in the horizontal string *BP*. *(2 marks)*

4 Two particles, A and B, are moving on a horizontal plane when they collide and coalesce to form a single particle. The mass of A is 5 kg and the mass of B is 15 kg. Before the collision, the velocity of A is $\begin{bmatrix} 2U \\ U \end{bmatrix}$ m s^{-1} and the velocity of B is $\begin{bmatrix} V \\ -1 \end{bmatrix}$ m s^{-1}. After the collision, the velocity of the combined particle is $\begin{bmatrix} V \\ 0 \end{bmatrix}$ m s^{-1}.

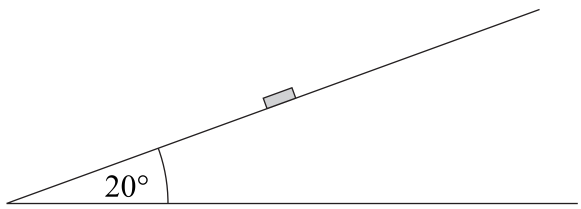
(a) Find:

(i) U; *(3 marks)*

(ii) V. *(2 marks)*

(b) Find the speed of A before the collision. *(2 marks)*

5 A puck, of mass 0.2 kg, is placed on a slope inclined at 20° above the horizontal, as shown in the diagram.



The puck is hit so that initially it moves with a velocity of 4 m s^{-1} directly up the slope.

(a) A simple model assumes that the surface of the slope is smooth.

(i) Show that the acceleration of the puck up the slope is -3.35 m s^{-2}, correct to three significant figures. *(3 marks)*

(ii) Find the distance that the puck will travel before it comes to rest. *(3 marks)*

(iii) What will happen to the puck after it comes to rest?

Explain why. *(2 marks)*

(b) A revised model assumes that the surface is rough and that the coefficient of friction between the puck and the surface is 0.5.

(i) Show that the magnitude of the friction force acting on the puck during this motion is 0.921 N, correct to three significant figures. *(3 marks)*

(ii) Find the acceleration of the puck up the slope. *(3 marks)*

(iii) What will happen to the puck after it comes to rest in this case?

Explain why. *(2 marks)*

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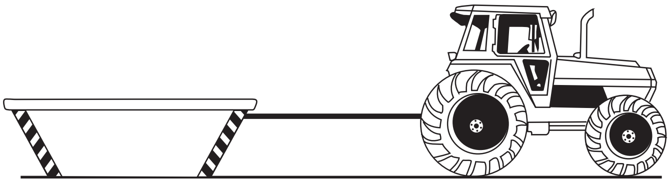
6 A tractor, of mass 4000 kg, is used to pull a skip, of mass 1000 kg, over a rough horizontal surface. The tractor is connected to the skip by a rope, which remains taut and horizontal throughout the motion, as shown in the diagram.



Assume that only **two** horizontal forces act on the tractor. One is a driving force, which has magnitude P newtons and acts in the direction of motion. The other is the tension in the rope.

The coefficient of friction between the skip and the ground is 0.4 .

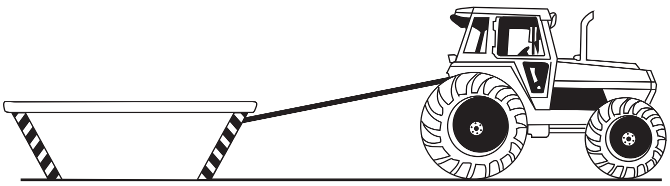
The tractor and the skip accelerate at $0.8\,\mathrm{m\,s^{-2}}$.

(a) Show that the magnitude of the friction force acting on the skip is 3920 N. *(2 marks)*

(b) Show that $P = 7920$. *(3 marks)*

(c) Find the tension in the rope. *(3 marks)*

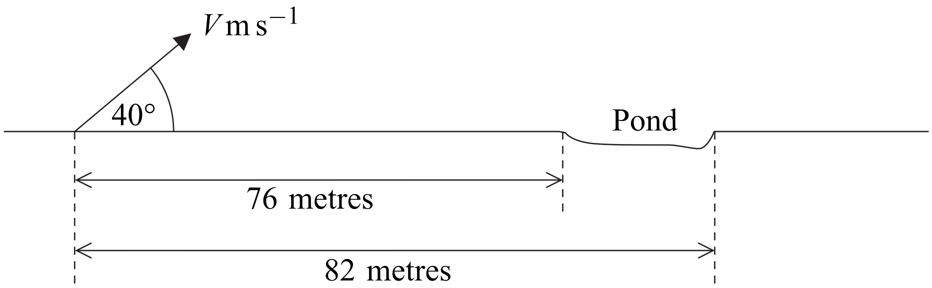
(d) Suppose that, during the motion, the rope is **not** horizontal, but inclined at a small angle to the horizontal, with the higher end of the rope attached to the tractor, as shown in the diagram.



How would the magnitude of the friction force acting on the skip differ from that found in part (a)?

Explain why. *(2 marks)*

7 A golfer hits a ball which is on horizontal ground. The ball initially moves with speed $V\,\mathrm{m\,s^{-1}}$ at an angle of 40° above the horizontal. There is a pond further along the horizontal ground. The diagram below shows the initial position of the ball and the position of the pond.



(a) State **two** assumptions that you should make in order to model the motion of the ball. *(2 marks)*

(b) Show that the horizontal distance, in metres, travelled by the ball when it returns to ground level is

$$\frac{V^2 \sin 40° \cos 40°}{4.9}$$ *(6 marks)*

(c) Find the range of values of V for which the ball lands in the pond. *(4 marks)*

8 A Jet Ski is at the origin and is travelling due north at $5\,\mathrm{m\,s^{-1}}$ when it begins to accelerate uniformly. After accelerating for 40 seconds, it is travelling due east at $4\,\mathrm{m\,s^{-1}}$. The unit vectors $\mathbf{i}$ and $\mathbf{j}$ are directed east and north respectively.

(a) Show that the acceleration of the Jet Ski is $(0.1\,\mathbf{i} - 0.125\,\mathbf{j})\,\mathrm{m\,s^{-2}}$. *(4 marks)*

(b) Find the position vector of the Jet Ski at the end of the 40 second period. *(3 marks)*

(c) The Jet Ski is travelling southeast t seconds after it leaves the origin.

(i) Find t. *(5 marks)*

(ii) Find the velocity of the Jet Ski at this time. *(2 marks)*

END OF QUESTIONS

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