WELSH JOINT EDUCATION COMMITTEE **CYD-BWYLLGOR ADDYSG CYMRU**

General Certificate of Education **Tystysgrif Addysg Gyffredinol**

Advanced Level/Advanced Subsidiary **Safon Uwch/Uwch Gyfrannol**

MATHEMATICS M2

Mechanics

Specimen Paper 2005/2006

(1 $\frac{1}{2}$ hours)

INSTRUCTIONS TO CANDIDATES

Answer **all** questions.

Take g as 9·8 ms^{-2}.

INFORMATION FOR CANDIDATES

A calculator may be used for this paper.

A formula booklet is available and may be used.

The number of marks is given in brackets at the end of each question or part-question.

You are reminded of the necessity for good English and orderly presentation in your answers.

1. At time t s, the velocity v ms^{-1} of a particle moving on the x-axis is given by

$$v = 3t^2 + 10t^4.$$

(a) Find the acceleration of the particle at time t s. [2]

(b) Given that when $t = 0$, $x = -3$, find the displacement of the particle at time $t = 2$ s. [4]

2. A vehicle, of mass 8000 kg, is travelling on a straight road. The resistance to motion of the vehicle is constant at 600 N.

(a) Find the power developed by the vehicle's engine when the road is horizontal and the vehicle is moving at a constant speed of 25 ms^{-1}. [3]

(b) The vehicle now climbs a hill inclined at angle α to the horizontal, where $\sin\alpha = \frac{1}{14}$, with its engine working at a rate of 36 kW. Find the acceleration of the vehicle at the instant when its speed is 3 ms^{-1}. [5]

3. A small block, of mass 0·4 kg, lies on a smooth plane inclined at an angle α to the horizontal, where $\sin\alpha = \frac{3}{5}$. The block is attached to one end of a light elastic string of natural length 0·7 m and modulus 19·6 N. The other end of the string is attached to a fixed point A. The block is below the level of A and the string is parallel to a line of greatest slope of the plane. Initially, the block is held with the string extended by 0·5 m.

(a) Find the initial tension in the string. [2]

(b) Calculate the initial energy stored in the string. [2]

The block is now released.

(c) Calculate the speed of the block when the string just becomes slack. [6]

4. A ball is kicked from a point A on a horizontal field with an initial speed of 24·5 ms^{-1} at an angle of 30° above the horizontal. The ball first hits the ground again at the point B.

(a) Calculate the time of flight of the ball. [4]

(b) Calculate the distance AB. [2]

(c) Calculate the greatest height reached by the ball. [2]

(d) Find the speed and direction of motion of the ball after 2s. [6]

5. A particle moves with constant acceleration. Initially, the particle is moving with velocity $(\mathbf{i} + 2\mathbf{j})$ ms^{-1}. The velocity of the particle at $t = 2$ s is $(3\mathbf{i} - 2\mathbf{j})$ ms^{-1}.

(a) Show that its acceleration is $\mathbf{i} - 2\mathbf{j}$. [2]

(b) Find the velocity of the particle at time t s. [4]

(c) Determine the time when the velocity vector is perpendicular to the acceleration vector. [3]

(d) Given that the initial position vector of the particle is $(2\mathbf{i} - \mathbf{j})$m, find the position vector of the particle at time t. [4]

(e) Evaluate the distance of the particle from the origin at time $t = 2$ s. [3]

6. A smooth hemispherical bowl, of radius a m, placed upside down and fixed on a horizontal table. A ball bearing, of mass m kg, is placed at A, the top of the bowl, and projected with a horizontal speed u ms^{-1}. A short time after projection, the ball bearing is still in contact with the bowl at a point P and moving with speed v ms^{-1}. The point O is the centre of the circular rim of the bowl and angle AOP is denoted by θ.

(a) Find an expression for v^2 in terms of a, g and θ. [4]

(b) Show that the reaction, R, of the bowl on the ball bearing, is given by

$$R = mg(3\cos\theta - 2) - \frac{mu^2}{a}.$$ [5]

(c) Given that $a = 0{\cdot}5$ and $u = 2$, calculate the value of θ at which the ball bearing leaves the bowl. [3]

7. One end A of a light inextensible rope AB, of length 0·8 m, is attached to the top of a fixed vertical pole. The other end B is attached to a small ball of mass 0·2 kg. A boy holds the ball so that the rope makes an angle of 30° with the pole. He then hits the ball so that the point B moves with speed u ms^{-1} in a horizontal circle, with the rope remaining at 30° to the vertical throughout the motion.

(a) Calculate the magnitude of the tension in the rope. [3]

(b) Find the value of u, correct to two decimal places. [5]

(c) What assumption does the word 'light' enable you to make in your solution. [1]