

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 $(\mathbf{i} + 2\mathbf{j}) \text{ ms}^{-1}$. The velocity of the particle at $t = 2 \text{ s}$ is $(3\mathbf{i} - 2\mathbf{j}) \text{ ms}^{-1}$.
- (a) Show that its acceleration is $\mathbf{i} - 2\mathbf{j}$. [2]
- (b) Find the velocity of the particle at time $t \text{ s}$. [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 $(2\mathbf{i} - \mathbf{j})\text{m}$, find the position vector of the particle at time t . [4]
- (e) Evaluate the distance of the particle from the origin at time $t = 2 \text{ s}$. [3]
6. A smooth hemispherical bowl, of radius $a \text{ m}$, placed upside down and fixed on a horizontal table. A ball bearing, of mass $m \text{ kg}$, is placed at A , the top of the bowl, and projected with a horizontal speed $u \text{ ms}^{-1}$. A short time after projection, the ball bearing is still in contact with the bowl at a point P and moving with speed $v \text{ ms}^{-1}$. 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
- $$R = mg(3\cos\theta - 2) - \frac{mu^2}{a}. \quad [5]$$
- (c) Given that $a = 0.5$ 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]