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MATHEMATICS M2

Mechanics 2

A.M. THURSDAY, 7 June 2007

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

ADDITIONAL MATERIALS

In addition to this examination paper, you will need:

- a 12 page answer book;
- a Formula Booklet;
- a calculator.

INSTRUCTIONS TO CANDIDATES

Answer **all** questions.

Take g as 9·8 ms $^{-2}$.

INFORMATION FOR CANDIDATES

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. A particle P is projected from the origin O so that it moves along the x-axis. At time t s after projection, the velocity of the particle, $v\,\text{ms}^{-1}$, is given by

$$v = 3t^2 - 24t + 45.$$

(a) Show that P first comes to instantaneous rest when $t = 3$. [2]

(b) Find an expression for the acceleration of P at time t s. [2]

(c) Find an expression for the displacement of P from O at time t s. [3]

(d) Find the distance travelled by the particle in the first 3 seconds of its motion. [2]

(e) Find the distance travelled by the particle in the first 4 seconds of its motion. [2]

2. A car of mass 900 kg can produce a maximum power of 45 kW. The car experiences a constant resistance to motion of magnitude 1800 N.

(a) Calculate the maximum speed of the car when travelling on a horizontal road. [3]

(b) The car travels up a slope inclined at an angle of 4° to the horizontal. Assuming maximum power is employed, calculate, correct to two decimal places, the acceleration of the car at the instant when its speed is $15\,\text{ms}^{-1}$. [5]

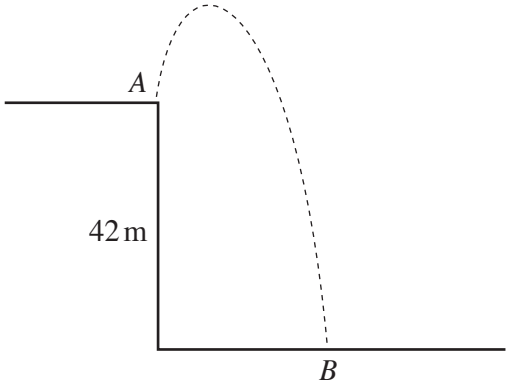
(c) The car travels a distance of 800 m. Calculate the work done against resistance. [2]

3. The end A of a light elastic string AB, of natural length 0·8 m, is fixed. A particle P, of mass 3 kg, is attached to the end B of the string. Initially, P is held at rest at the point A. It is then released and allowed to fall. The greatest extension of the string in the subsequent motion is 0·4 m.

(a) Show that the modulus of elasticity of the string is 352·8 N. [7]

(b) Find the tension in the string when P is at its lowest point and deduce the magnitude of the acceleration of P in this position. [5]

4. A stone is projected from point A on the top of a vertical cliff and it hits the sea at point B. The height of A above sea level is 42 m.



The horizontal and vertical components of the stone's initial velocity are $4{\cdot}5\ \text{ms}^{-1}$ and $22{\cdot}4\ \text{ms}^{-1}$ respectively.

(a) Find the speed of the stone 2 s after projection. [5]

(b) Calculate the time of flight of the stone. [4]

(c) Determine the distance of B from the foot of the cliff. [2]

5. Vectors **a** and **b** are given by

$$\mathbf{a} = 2\mathbf{i} + 13\mathbf{j} - 10\mathbf{k},$$
$$\mathbf{b} = -\mathbf{i} + y\mathbf{j} + 5\mathbf{k}.$$

(a) If **a** and **b** are perpendicular, find the value of y. [4]

(b) If **a** and **b** are parallel, find the value of y. [2]

6. A particle of mass 0·8 kg is attached to one end of a light inextensible string of length 0·4 m. The other end of the string is fixed to a point O of a smooth horizontal surface. The particle moves on the surface with constant speed $3\ \text{ms}^{-1}$ in a horizontal circle with centre O.

(a) Find the angular velocity about O of the particle. [2]

(b) Calculate the tension in the string. [2]

TURN OVER

7. A particle, of mass 3 kg, is attached to one end of a light rod of length 0·9 m. The other end of the rod is freely pivoted at a fixed point O. The particle moves in a vertical circle with centre O, such that its speed at the lowest point of its path is three times its speed at the highest point of its path.

(a) Show that the speed of the particle at the lowest point of its path is $6{\cdot}3\,\text{ms}^{-1}$. [5]

(b) Calculate the thrust in the rod when the particle is at the highest point of its path. [4]

(c) If a string replaced the rod, state, with a reason, whether the particle would still move in complete circles. [2]

8. A toy plane A is moving with constant velocity $(3\mathbf{i} - 2\mathbf{j} + 5\mathbf{k})\,\text{ms}^{-1}$ and at time $t = 0$, its position vector is $(3\mathbf{j} - 140\mathbf{k})$ m. Another toy plane B is moving with constant velocity $(-2\mathbf{i} + 6\mathbf{j} + 3\mathbf{k})\,\text{ms}^{-1}$ and at time $t = 0$, its position vector is $(-9\mathbf{i} - 4\mathbf{j} - 6\mathbf{k})$ m.

(a) Write down the position vectors of A and B at time t s. [3]

(b) Find an expression for the square of the distance between A and B at time t s. [3]

(c) Determine the time when A and B are closest together. [4]