



GCE AS/A level

981/01

MATHEMATICS M2
Mechanics 2

P.M. FRIDAY, 5 June 2009

1½ 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} .

Sufficient working must be shown to demonstrate the **mathematical** method employed.

INFORMATION FOR CANDIDATES

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

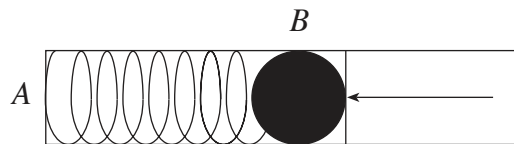
You are reminded of the necessity for good English and orderly presentation in your answers.

1. A particle moves along the x -axis and its velocity $v \text{ ms}^{-1}$ at time $t \text{ s}$ is given by

$$v = \cos 2t - 3 \sin t.$$

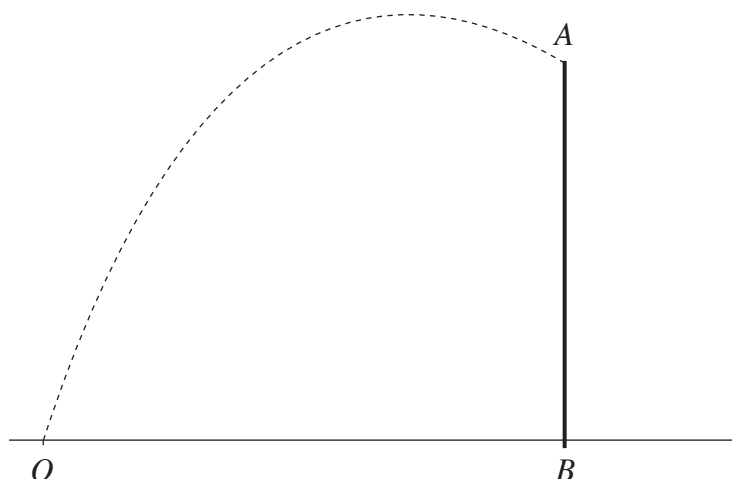
- (a) Find the acceleration of the body when $t = \pi$. [4]
- (b) Given that $x = 4$ when $t = 0$, calculate the distance of the particle from the origin O when $t = \frac{\pi}{4}$. [6]

2. The diagram shows a spring of natural length of 0.25 m in a smooth horizontal tube with one end A fixed and a small ball bearing B of mass 0.36 kg held in equilibrium by a force of magnitude 80 N compressing it against the free end of the spring. The length of the compressed spring is 0.2 m .



- (a) Find the modulus of elasticity of the spring. [3]
- (b) The ball bearing is released by removing the force. Find, by using energy considerations, the speed of the ball bearing just as the spring attains its natural length. [5]
3. A point A is situated at the bottom of a rough plane inclined at an angle α to the horizontal where $\tan \alpha = \frac{3}{4}$. An object, of mass 3.5 kg , is projected from A with speed of $u \text{ ms}^{-1}$ up the plane along a line of greatest slope of the plane. The object comes to rest at point B where $AB = 2 \text{ m}$. The coefficient of friction between the object and the plane is $\frac{1}{4}$.
- (a) Calculate the work done against friction as the object travels from A to B . [5]
- (b) By using energy considerations, find the value of u . [6]
4. A vehicle of mass 5000 kg travels along a straight horizontal road. The resistance to motion is modelled as a constant force of 1500 N .
- (a) Find the power which is developed at the instant when the speed of the vehicle is 12 ms^{-1} and the acceleration is 0.2 ms^{-2} . [4]
- (b) The maximum power of the vehicle's engine is 45 kW . Calculate the maximum speed of the vehicle along the road. [4]

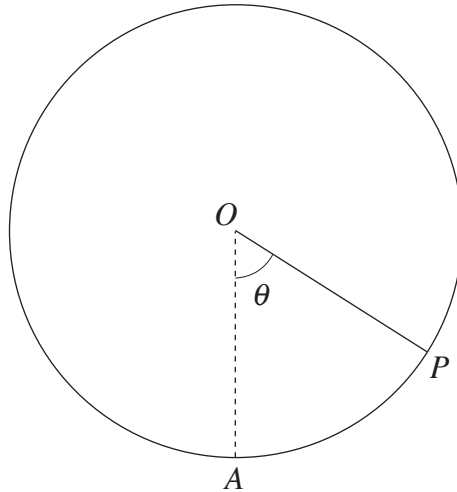
5. The diagram shows a vertical wall AB and a point O on the same horizontal level as B where $OB = 25.2$ m. At time $t = 0$, a ball is projected from O with speed 17.5 ms^{-1} in a direction inclined at an angle α above the horizontal, where $\tan \alpha = \frac{4}{3}$. The ball just clears the top of the wall at A .



- (a) Find the time at which the ball passes over the wall. [3]
- (b) Calculate the height of the wall AB . [4]
- (c) Find the time when the ball reaches its greatest height. [3]
6. A particle, of mass 2 kg, moves in a horizontal plane such that its position vector \mathbf{r} m at time t s is given by
- $$\mathbf{r} = (1 - 4t^2) \mathbf{i} + (3t^2 - 5t) \mathbf{j}.$$
- (a) Find, in terms of t , an expression for the momentum of the particle at time t s. [3]
- (b) Show that the acceleration of the particle is constant and find its magnitude. [4]
- (c) Find the time when the velocity of the particle is perpendicular to its acceleration. [4]
7. A car, of mass 1000 kg, is travelling in a horizontal circle of radius 250 m on a track which is banked at an angle α to the horizontal. When the car is travelling at 28 ms^{-1} , it has no tendency to slip sideways. Calculate the value of α . [7]

TURN OVER

8. In the diagram below, A is the lowest point on the smooth inside surface of a sphere, with centre O and radius 2m . The point P is on the inside surface of the sphere such that $\hat{AOP} = \theta$. A particle, of mass 5 kg , is projected horizontally from A with speed 9 ms^{-1} so that it moves in the vertical circle with centre O which passes through P .



- (a) Calculate, in terms of θ , the speed of the particle at P . [4]
- (b) Find, in terms of θ , the reaction between the particle and the sphere at P . [4]
- (c) Will the particle move in complete circles? Give a reason for your answer. [2]