



GCE AS/A level

0981/01

MATHEMATICS M2
Mechanics 2

P.M. THURSDAY, 21 June 2012

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

Use black ink or black ball-point pen.

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 in a straight line with velocity $v \text{ ms}^{-1}$ at time $t \text{ s}$, where

$$v = 4 \cos 2t.$$

Calculate the distance travelled by the particle between $t = 0$ and $t = \frac{\pi}{6} \text{ s}$. [3]

2. One end of a light elastic string, of natural length $\frac{5}{3} \text{ m}$ and modulus of elasticity 245 N , is attached to a fixed point O . The other end of the string is attached to a particle of mass 7.5 kg . The particle hangs in equilibrium vertically below O .

(a) Calculate the extension of the string. [3]

(b) Determine the elastic energy stored in the string. [2]

3. A particle moves on a horizontal plane so that at time t seconds its position vector \mathbf{r} metres relative to a fixed origin O is given by

$$\mathbf{r} = (t + 2t^2)\mathbf{i} + (1.5t^2 - 2t)\mathbf{j}.$$

(a) Determine the time when the velocity of the particle is perpendicular to the vector $(-\mathbf{i} + 2\mathbf{j})$. [5]

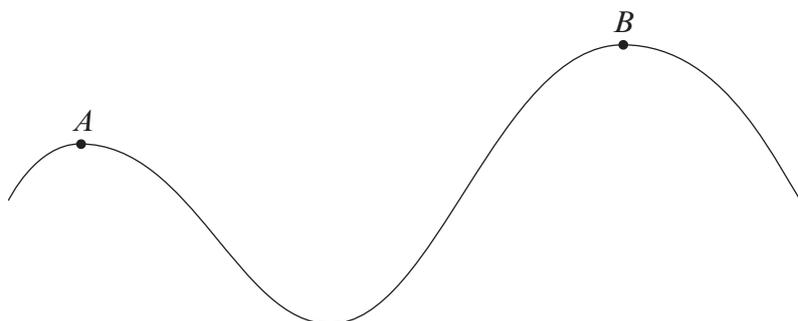
(b) Show that the acceleration of the particle is constant and find its magnitude. [3]

4. A vehicle of mass 1200 kg is moving up a slope inclined at an angle of α to the horizontal, where $\sin \alpha = 0.1$. The resistance to motion is modelled as a constant force of magnitude 600 N .

(a) The vehicle's engine is working at the rate of 75 kW . Calculate the magnitude of the acceleration of the vehicle when its velocity is 25 ms^{-1} . [5]

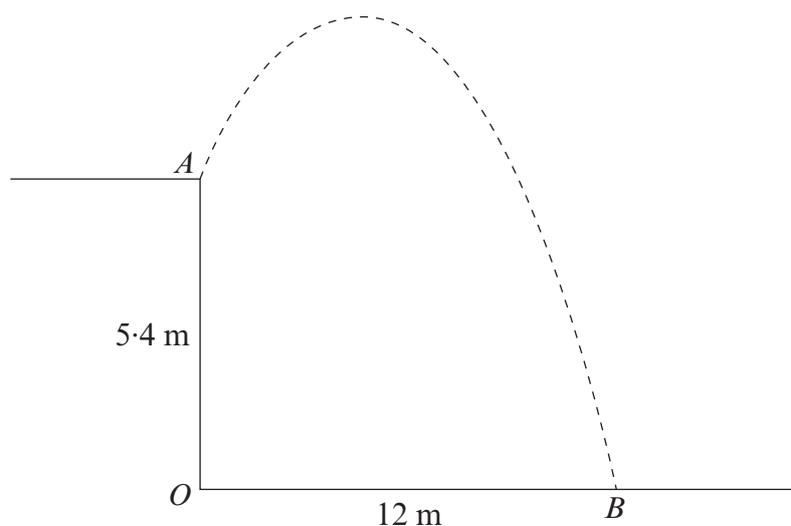
(b) When the vehicle's engine is working at the rate of 90 kW , calculate the constant speed which can be sustained by the vehicle. Give your answer correct to 3 significant figures. [4]

5. The diagram shows two points A and B on a track. A toy car of mass 0.1 kg travels on the track from A to B .



The heights of A and B above floor level are 0.5 m and 1.4 m respectively. The length of the track between A and B is 1.2 m. The resistance to motion of the toy car is assumed to have a constant magnitude of 6 N. The toy car is given a velocity of v ms^{-1} at A and comes to rest at B . Calculate the value of v . Give your answer correct to 3 significant figures. [7]

6. A pebble is projected from a point A which is 5.4 m vertically above a point O on horizontal ground.



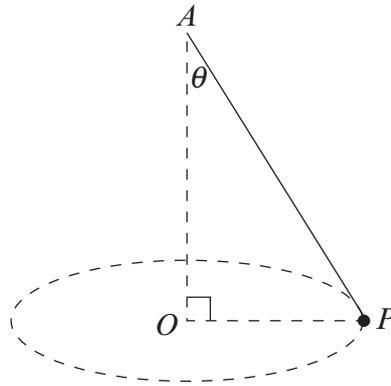
The initial velocity of the pebble is V ms^{-1} at an angle α above the horizontal, where $\tan \alpha = \frac{3}{4}$. The pebble hits the ground at the point B which is at a distance of 12 m from O .

The time of flight of the pebble is T s.

- (a) Write down the horizontal component and the vertical component of the initial velocity of the pebble in terms of V . [2]
- (b) Show that $VT = 15$. [2]
- (c) Find the value of T and hence find the value of V . [4]
- (d) Determine the speed of the pebble as it hits the ground at B . [5]

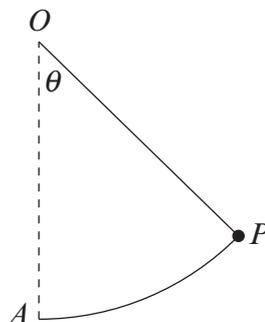
TURN OVER

7. One end of a light inextensible string is attached to a fixed point A . The other end is attached to a particle P of mass 3 kg. The point O is vertically below A and P moves in a horizontal circle of centre O with a uniform angular speed of 2.8 radians per second. The tension in the string is 88.2 N and \widehat{OAP} is θ .



- (a) Find the value of θ . [3]
- (b) Calculate the length of the string. [5]
8. A ship S is moving in a straight line with constant velocity. At time $t = 0$, its position vector relative to a fixed origin O is $(8\mathbf{i} + 7\mathbf{j})$. At time $t = 3$, its position vector is $(14\mathbf{i} - 5\mathbf{j})$.
- (a) Show that the velocity of S is $(2\mathbf{i} - 4\mathbf{j})$. [2]
- (b) Find an expression, in terms of t , for the position vector of S at time t . [2]
- At time $t = 10$, a boat B leaves O and travels with constant velocity $x\mathbf{i} + y\mathbf{j}$, intercepting S at time $t = 50$.
- (c) Calculate the value of x and the value of y . [6]

9. A particle of mass 3 kg is attached to one end of a light inextensible string of length 1.2 m. The other end of the string is attached to a fixed point O . Initially, the particle hangs vertically below O at the point A . The particle is then projected horizontally with speed $u \text{ ms}^{-1}$ from A . When the particle is at the point P , the string makes an angle θ with the vertical OA as shown in the diagram.



The particle comes to instantaneous rest when $\cos\theta = \frac{2}{3}$.

- (a) Calculate the value of u and find an expression for v^2 in terms of $\cos\theta$, where v is the velocity of the particle at P . [6]
- (b) Find an expression, in terms of θ , for the tension in the string when the particle is at P . [4]
- (c) Determine the greatest value and the least value of the tension in the string. [2]