



GCE AS/A level

0981/01



S15-0981-01

MATHEMATICS M2
Mechanics

A.M. FRIDAY, 5 June 2015

1 hour 30 minutes

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. The vectors \mathbf{x} and \mathbf{y} are given by

$$\begin{aligned}\mathbf{x} &= \sin\theta\mathbf{i} + 2\cos2\theta\mathbf{j}, \\ \mathbf{y} &= 2\mathbf{i} - \mathbf{j}.\end{aligned}$$

Find the values of θ between 0 and 2π such that \mathbf{x} is perpendicular to \mathbf{y} . [6]

2. An object of mass 50 kg moves in a straight horizontal line under the action of a constant horizontal force of magnitude 1600 N acting along the line. The resistance to motion of the object is proportional to time t seconds. At time t seconds, the velocity of the object is v ms⁻¹ and at time $t = 2$, it is moving with velocity 41 ms⁻¹ and acceleration -4 ms⁻².

- (a) Show that v satisfies the differential equation

$$\frac{dv}{dt} = 32 - 18t. \quad [4]$$

- (b) Find an expression for v in terms of t and determine the times when the velocity of the object is 28 ms⁻¹. [6]

3. A vehicle of mass 6000 kg is moving up a slope inclined at an angle α to the horizontal, where $\sin \alpha = \frac{6}{49}$. The vehicle's engine exerts a constant power of P W. The constant resistance to motion of the vehicle is R N. At the instant the vehicle is moving with velocity $\frac{16}{5}$ ms⁻¹, its acceleration is 2 ms⁻².

The maximum velocity of the vehicle is $\frac{16}{3}$ ms⁻¹.

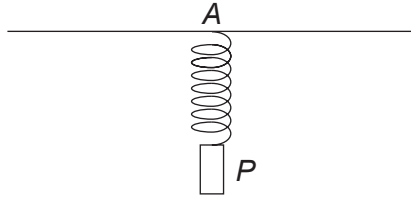
Determine the value of P and the value of R . [9]

4. A particle of mass 0.5 kg is moving under the action of a single force \mathbf{F} N, where $\mathbf{F} = (4t - 3)\mathbf{i} + (3t^2 - 5t)\mathbf{j}$.

- (a) The velocity of the particle at time t s is \mathbf{v} ms⁻¹. When $t = 0$, $\mathbf{v} = 8\mathbf{i} - 7\mathbf{j}$. Find an expression for \mathbf{v} in terms of t . [5]

- (b) When $t = 3$, the particle receives an impulse of $2\mathbf{i} - 9\mathbf{j}$ Ns. Find the speed of the particle immediately after the impulse. [5]

5. The diagram shows a light spring of natural length 0.4 m and modulus of elasticity 1470 N with one end A fixed and the other end attached to an object P of mass 15 kg .



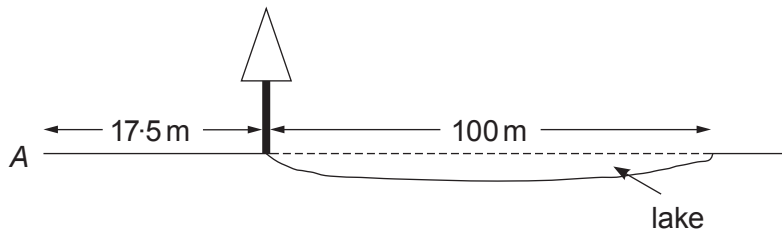
Initially, P hangs in equilibrium with the spring vertical.

- (a) Determine the extension of the spring. [3]

The object P is pulled downwards so that the total length of the spring is 0.56 m . It is then released.

- (b) Calculate the speed of P when it is at a distance 0.45 m from A . [8]

6. A golfer hits a ball from a point A with initial velocity of 35 ms^{-1} at an angle α above the horizontal where $\sin \alpha = 0.8$. The ball passes over a tree which is growing in front of a lake. The lake is 100 m wide, as shown in the diagram. The tree is at a horizontal distance of 17.5 m from A .



- (a) Determine whether or not the golf ball will fall into the lake. [6]

- (b) Find the magnitude and direction of the velocity of the ball as it passes over the tree. [7]

7. A car of mass 1200 kg is moving in a horizontal circle of radius 80 m on a road banked at an angle of 12° to the horizontal. When the car is moving with a constant speed of $v\text{ ms}^{-1}$, there is no tendency to sideslip. Calculate the normal reaction of the road on the car and find the value of v . [5]

TURN OVER

8. One end of a light inextensible string of length 0.8 m is attached to a fixed point. The other end of the string is attached to a particle P of mass 3 kg . Initially P hangs at rest with the string vertical. The particle P is then projected horizontally with speed 5 ms^{-1} , so that it starts to describe a vertical circle. When the string is inclined at an angle θ to the downwards vertical, P has speed $v\text{ ms}^{-1}$ and the tension in the string is $T\text{ N}$.
- (a) Find, in terms of θ ,
- (i) an expression for v^2 ,
 - (ii) an expression for T . [8]
- (b) Find the greatest possible value of θ and briefly describe the subsequent motion of P . [3]

END OF PAPER