

GCE AS/A level

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 $9.8 \,\mathrm{ms}^{-2}$.

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.

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

$$\mathbf{x} = \sin\theta \,\mathbf{i} + 2\cos 2\theta \,\mathbf{j},$$

$$\mathbf{y} = 2\mathbf{i} - \mathbf{j}.$$

Find the values of θ between 0 and 2π such that x is perpendicular to 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 t 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

$$\frac{\mathrm{d}v}{\mathrm{d}t} = 32 - 18t. \tag{4}$$

- (b) Find an expression for v in terms of t and determine the times when the velocity of the object is $28 \,\mathrm{ms}^{-1}$.
- 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} .

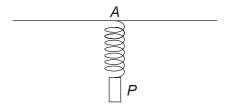
The maximum velocity of the vehicle is $\frac{16}{3}$ ms⁻¹.

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 FN, where $\mathbf{F} = (4t 3)\mathbf{i} + (3t^2 5t)\mathbf{j}$.
 - (a) The velocity of the particle at time ts 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 $0.4 \,\mathrm{m}$ 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.

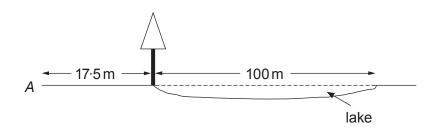
[3]

The object P is pulled downwards so that the total length of the spring is $0.56\,\mathrm{m}$. 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 $35\,\text{ms}^{-1}$ at an angle α above the horizontal where sin α = 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 $0.8\,\mathrm{m}$ is attached to a fixed point. The other end of the string is attached to a particle P of mass $3\,\mathrm{kg}$. Initially P hangs at rest with the string vertical. The particle P is then projected horizontally with speed $5\,\mathrm{ms}^{-1}$, 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 $v\,\mathrm{ms}^{-1}$ and the tension in the string is $T\mathrm{N}$.
 - (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