GCE AS/A Level – LEGACY

0981/01

S19-0981-01

MATHEMATICS – M2
Mechanics

TUESDAY, 18 JUNE 2019 – MORNING

1 hour 30 minutes

ADDITIONAL MATERIALS

In addition to this examination paper, you will need:

- a WJEC pink 16-page answer booklet;
- a Formula Booklet;
- a calculator.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen.

Answer **all** questions.

Take g as $9{\cdot}8\,\text{ms}^{-2}$.

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.

© WJEC CBAC Ltd.

1. A particle, of mass 5 kg, moves in a straight line so that its velocity, v ms^{-1}, at time t seconds is given by

$$v = 3t^2 - 4t - 7, \qquad \text{for} \quad t \geqslant 0.$$

When $t = 0$, $x = 2$, where x metres is the displacement of the particle from the origin *O*.

(a) Find an expression for the acceleration of the particle at time t seconds. [2]

(b) Find an expression for the displacement x of the particle from *O* at time t seconds. [4]

(c) Determine the time when the particle is instantaneously at rest and the displacement of the particle from *O* at this time. [3]

(d) Given that $t = 2$,

(i) calculate the velocity of the particle,

(ii) determine whether the speed of the particle is increasing or decreasing,

(iii) find the kinetic energy of the particle. [5]

2. A car of mass 1000 kg is towing a trailer of mass 600 kg up a slope inclined at an angle α to the horizontal, where $\sin\alpha = \frac{1}{20}$. The resistance to motion acting on the car is 260 N and that acting on the trailer is 140 N. The car's engine is working at 48 kW.

(a) Calculate the acceleration of the car and the trailer when the speed is 24 ms^{-1}. [5]

(b) Determine the tension in the rigid tow-bar connecting the car and the trailer when the speed is 24 ms^{-1}. [4]

3. The end *A* of a light elastic string *AB*, of natural length 0·6 m, is fixed. A particle *P*, of mass 2 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 0·5 m.

(a) Determine the modulus of elasticity of the string. [6]

(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 particle is projected from a point *A* on horizontal ground so that its initial horizontal velocity is 12 ms^{-1} and its initial vertical velocity is 15·75 ms^{-1}. After it has reached its highest point and is on its way down, it just clears a hedge which is 8·75 m high.

(a) Find the horizontal distance of the hedge from *A*. [6]

(b) Determine the speed and direction of motion of the particle as it clears the hedge. [7]

© WJEC CBAC Ltd.

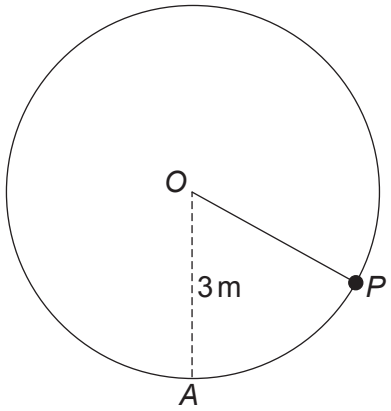
5. A car, of mass 1200 kg, is travelling in a horizontal circle of radius 180 m on a track which is banked at an angle α to the horizontal. When the car is travelling at 24 ms^{-1}, it has no tendency to slip sideways. Calculate the value of α. [7]

6. At time t, the position vectors of two particles A and B relative to a fixed origin O, are given by $\mathbf{OA} = 4\mathbf{i} + 3\mathbf{j} - 2\mathbf{k} + t(\mathbf{i} - 6\mathbf{j} + 5\mathbf{k})$ and $\mathbf{OB} = 4\mathbf{i} - 8\mathbf{j} + 7\mathbf{k} + t(3\mathbf{i} - \mathbf{j} + 4\mathbf{k})$.

(a) Find the speed of particle A. [3]

(b) Show that the distance AB at time t is given by $AB^2 = 30t^2 - 128t + 202$.
Determine the time at which the particles A and B are closest together. [7]

7. The diagram shows a particle P, of mass 2 kg, attached by a light inextensible string of length 3 m to a fixed point O. Initially, P is projected from its lowest point A with a horizontal speed of 15 ms^{-1} so that it starts to move in a vertical circle with centre O.



(a) When OP is inclined at an angle θ to OA, the speed of P is v ms^{-1}.

(i) Find an expression for v^2 in terms of θ.

(ii) Find the speed of P when $\theta = 60°$. [5]

(b) Find an expression, in terms of θ, for the tension in the string when OP makes an angle θ with OA. [4]

(c) Determine whether or not P describes complete circles. [2]

END OF PAPER

© WJEC CBAC Ltd.