

Name:

Date:

Further Kinematics

AS-Level Edexcel Mathematics

Mark

Score (%)

— 88

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Materials

For this paper you must have:

- Ruler
- Pencil, Rubber, Protractor and Compass
- Scientific calculator, which you are expected to use when appropriate

Instructions

- Answer all questions
- Answer questions in the space provided
- All working must be shown
- Do all rough work in this book. Cross out any rough work you don't want to be marked

Information

- The marks for the questions are shown in brackets

- 1 A particle moves in a horizontal plane, in which the unit vectors \mathbf{i} and \mathbf{j} are directed east and north respectively. At time t seconds, its position vector, \mathbf{r} metres, is given by

$$\mathbf{r} = (2t^3 - t^2 + 6)\mathbf{i} + (8 - 4t^3 + t)\mathbf{j}$$

- (a) Find an expression for the velocity of the particle at time t . (3)
- (b) Find the velocity of the particle when $t = \frac{1}{3}$. (2)
- (c) State the direction in which the particle is travelling at this time. (1)
- (d) Find the acceleration of the particle when $t = 4$. (3)
- (e) The mass of the particle is 6 kg. Find the magnitude of the resultant force on the particle when $t = 4$. (3)

(Total for question 1 is 12 marks)

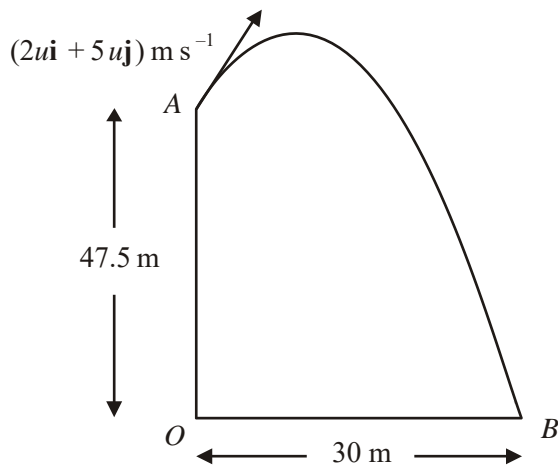
- 2 A particle moves in a horizontal plane under the action of a single force, F newtons. The unit vectors \mathbf{i} and \mathbf{j} are directed east and north respectively. At time t seconds, the position vector, \mathbf{r} metres, of the particle is given by

$$\mathbf{r} = (t^3 - 3t^2 + 4)\mathbf{i} + (4t + t^2)\mathbf{j}$$

- (a) Find an expression for the velocity of the particle at time t . (2)
- (b) Find an expression for F at time t . (3)
- The mass of the particle is 3 kg.
- (c) Find the magnitude of F when $t = 3$. (2)
- (d) Find the value of t when F acts due north. (2)

(Total for question 2 is 9 marks)

3



[In this question, the unit vectors \mathbf{i} and \mathbf{j} are in a vertical plane, \mathbf{i} being horizontal and \mathbf{j} being vertical.]

A particle P is projected from the point A which has position vector $47.5\mathbf{j}$ metres with respect to a fixed origin O . The velocity of projection of P is $(2\mathbf{i} + 5\mathbf{j})\text{ m s}^{-1}$. The particle moves freely under gravity passing through the point B with position vector $30\mathbf{i}$ metres, as shown in the diagram above.

- (a) Show that the time taken for P to move from A to B is 5 s. (6)
- (b) Find the value of u . (2)
- (c) Find the speed of P at B . (5)

(Total for question 3 is 13 marks)

4 A particle has mass 200 kg and moves on a smooth horizontal plane. A single horizontal force, $(400 \cos(\frac{\pi}{2} t)\mathbf{i} + 600t^2\mathbf{j})$ newtons, acts on the particle at time t seconds.

The unit vectors \mathbf{i} and \mathbf{j} are directed east and north respectively.

- (a) Find the acceleration of the particle at time t . (2)
- (b) When $t = 4$, the velocity of the particle is $(-3\mathbf{i} + 56\mathbf{j})\text{ m s}^{-1}$.
Find the velocity of the particle at time t . (5)
- (c) Find t when the particle is moving due west. (3)
- (d) Find the speed of the particle when it is moving due west. (2)

(Total for question 4 is 12 marks)

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- 5 A particle moves on a horizontal plane, in which the unit vectors \mathbf{i} and \mathbf{j} are directed east and north respectively.

At time t seconds, the position vector of the particle is r metres, where

$$\mathbf{r} = \left(2e^{\frac{1}{2}t} - 8t + 5\right)\mathbf{i} + (t^2 - 6t)\mathbf{j}$$

- (a) Find an expression for the velocity of the particle at time t . (3)
- (b) Find the speed of the particle when $t = 3$. (2)
- (c) State the direction in which the particle is travelling when $t = 3$. (1)
- (d) Find the acceleration of the particle when $t = 3$. (3)
- (e) The mass of the particle is 7 kg.
Find the magnitude of the resultant force on the particle when $t = 3$. (3)

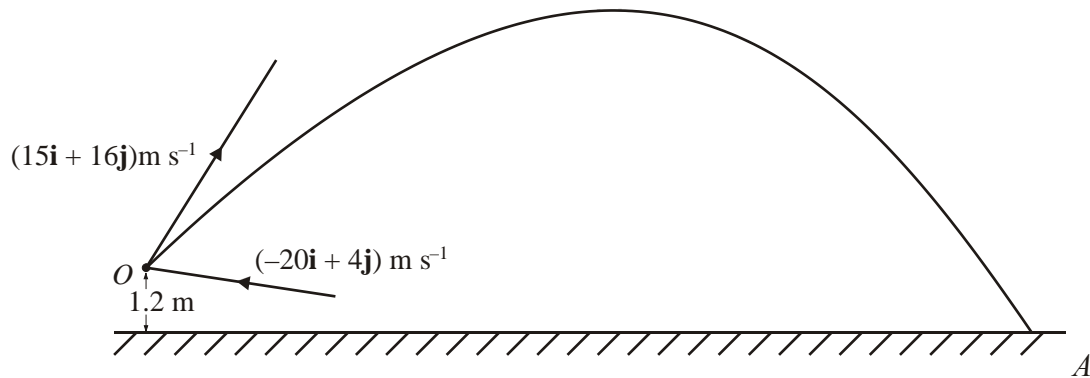
(Total for question 5 is 12 marks)

- 6 A particle moves in a horizontal plane under the action of a single force, F newtons. The unit vectors \mathbf{i} and \mathbf{j} are directed east and north respectively. At time t seconds, the velocity of the particle, v ms⁻¹, is given by:

$$\mathbf{v} = 4e^{-2t}\mathbf{i} + (6t - 3t^2)\mathbf{j}$$

- (a) Find an expression for the acceleration of the particle at time t . (3)
The mass of the particle is 5 kg.
- (b) Find an expression for the force F acting on the particle at time t . (2)
- (c) Find the magnitude of F when $t = 0$. (2)
- (d) Find the value of t when F acts due west. (2)
- (e) When $t = 0$, the particle is at the point with position vector $(6\mathbf{i} + 5\mathbf{j})$ m.
Find the position vector, r metres, of the particle at time t . (5)

(Total for question 6 is 14 marks)



A ball B of mass 0.4 kg is struck by a bat at a point O which is 1.2 m above horizontal ground. The unit vectors \mathbf{i} and \mathbf{j} are respectively horizontal and vertical. Immediately before being struck, B has velocity $(-20\mathbf{i} + 4\mathbf{j}) \text{ m s}^{-1}$. Immediately after being struck it has velocity $(15\mathbf{i} + 16\mathbf{j}) \text{ m s}^{-1}$.

After B has been struck, it moves freely under gravity and strikes the ground at the point A , as shown in the diagram above. The ball is modelled as a particle.

- Calculate the magnitude of the impulse exerted by the bat on B . (4)
- By using the principle of conservation of energy, or otherwise, find the speed of B when it reaches A . (6)
- Calculate the angle which the velocity of B makes with the ground when B reaches A . (4)
- State two additional physical factors which could be taken into account in a refinement of the model of the situation which would make it more realistic. (2)

(Total for question 7 is 16 marks)

