OXFORD AQA
INTERNATIONAL QUALIFICATIONS

INTERNATIONAL A-LEVEL
FURTHER MATHEMATICS
(9665/FM05) Unit FM2 Mechanics

Thursday 12 June 2025   07:00 GMT   Time allowed: 1 hour 30 minutes

Materials
- For this paper you must have the OxfordAQA Booklet of Formulae and Statistical Tables (enclosed).
- You may use a graphical calculator.

Instructions
- Use black ink or black ball-point pen. Pencil should only be used for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- Do all rough work in this book. Cross through any work you do not want to be marked.
- The **final** answer to questions requiring the use of calculators should be given to two significant figures, unless stated otherwise.
- Unless stated otherwise, the acceleration due to gravity, g, should be taken as 9.8 m s^{-2}

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 80.

Advice
- Unless stated otherwise, you may quote formulae, without proof, from the booklet.
- Show all necessary working; otherwise marks may be lost.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
9	
TOTAL	

Answer **all** questions in the spaces provided.

1 Two particles A and B are moving on a smooth horizontal surface.

The two particles collide.

Particle A has mass 2 kg and before the collision has velocity $\begin{bmatrix} 4 \\ 7 \end{bmatrix}$ m s^{-1}

Particle B has mass m kg and before the collision has velocity $\begin{bmatrix} -2 \\ -4 \end{bmatrix}$ m s^{-1}

After the collision particle A has velocity $\begin{bmatrix} 2 \\ 1 \end{bmatrix}$ m s^{-1}

After the collision particle B has velocity $\begin{bmatrix} k \\ 0 \end{bmatrix}$ m s^{-1} where k is a constant.

1 (a) Find the value of m

[2 marks]

Answer _____

1 (b) Find the value of k

[2 marks]

Answer _____

1 (c) Find the magnitude of the impulse exerted on *A* by *B* during the collision.

Give your answer in an exact form.

[3 marks]

Answer _____

Turn over for the next question

2 A light elastic string has modulus of elasticity 80 newtons and natural length 1.6 metres.

One end of the string is attached to a fixed point O

A particle of mass 5 kg is attached to the other end of the string.

2 (a) Find the extension of the string when the particle hangs in equilibrium vertically below O

[2 marks]

Answer

2 (b) The particle is pulled down and held at the point Y

The point Y is 4 metres vertically below O

2 (b) (i) Find the elastic potential energy of the string.

[2 marks]

Answer

2 (b) (ii) The particle is released from rest at *Y*

Find the speed of the particle when it passes through its equilibrium position.

[4 marks]

Answer _____

Turn over for the next question

Turn over ▶

3   A disc of mass 0.1 kg is moving on a smooth horizontal surface when it hits a smooth vertical wall.

The coefficient of restitution between the disc and the wall is 0.5

When the disc hits the wall it has a velocity of 6 m s^{-1} at an angle α to the wall.

When the disc leaves the wall it has a velocity of 4 m s^{-1} at an angle β to the wall, as shown in the diagram.

3 (a)   Find the value of α

Give your answer to the nearest degree.

[5 marks]

Answer _____

3 (b)   Find the value of β

Give your answer to the nearest degree.

[2 marks]

Answer

3 (c)   Find the magnitude of the impulse exerted on the disc by the wall.

Give your answer in the form $\dfrac{\sqrt{n}}{p}$ where n is an integer and p is a prime.

[3 marks]

Answer

10

Turn over ▶

4   A ball of mass 0.4 kg is allowed to fall vertically from rest.

The ball experiences an air resistance force as it falls.

The air resistance force has magnitude $\dfrac{v}{10}$ newtons when the speed of the ball is $v \text{ m s}^{-1}$

The ball hits the ground when it has been falling for 12 seconds.

Find the speed at which the ball hits the ground.

[6 marks]

Answer _____

6

Turn over for the next question

5 A particle moves with simple harmonic motion between the points A and B which are 1.2 metres apart.

The period of the motion is 4π seconds.

The particle is released from rest at the point A at time $t = 0$

5 (a) Find an expression for the displacement of the particle from A at time t seconds.

[3 marks]

Answer _____

5 (b) Find the maximum speed of the particle.

[2 marks]

Answer _____

5 (c) Find the maximum acceleration of the particle.

[2 marks]

Answer _____

5 (d) Find the speed of the particle when its displacement from *A* is 1.1 metres.

Give your answer in an exact form.

[3 marks]

Answer _____

Question 5 continues on the next page

Turn over ▶

5 (e) The mass of the particle is 0.3 kg

Find the possible displacements of the particle from *A* when the resultant force acting on the particle has magnitude 0.036 newtons.

[5 marks]

Answer _____

15

Turn over for the next question

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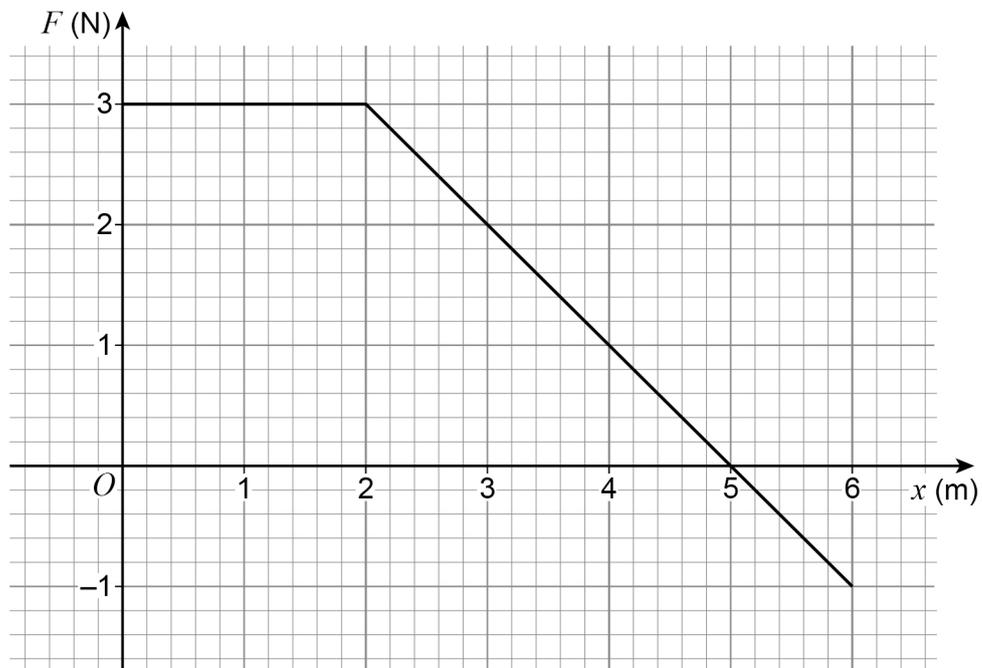ANSWER IN THE SPACES PROVIDED**

Turn over ▶

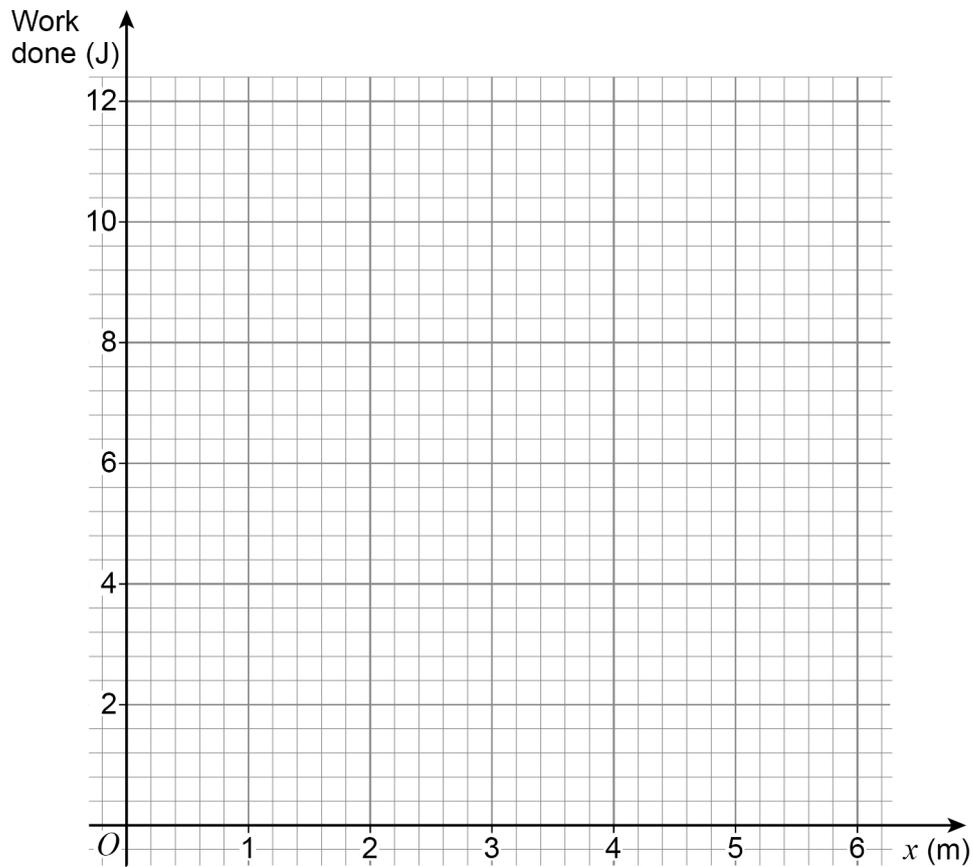**6**   A particle is moving on a straight line.

A force F newtons acts on the particle, parallel to the straight line.

The graph shows how the force F newtons varies as the displacement x metres of the particle increases from 0 to 6 metres.

On the axes below sketch a graph to show how the work done by the force F newtons varies as the displacement x metres of the particle increases from 0 to 6 metres.

[4 marks]

Turn over for the next question

7 A spring has stiffness 210 N m^{-1}

One end of the spring is attached to a fixed point O

A particle of mass 6 kg is attached to the other end of the spring.

When the particle hangs in equilibrium, it is at the point P which is vertically below O

The particle is pulled down and released from rest at a point Q which is 0.4 metres vertically below P

7 (a) Show that the particle moves with simple harmonic motion.

[7 marks]

7 (b) Find the time that it takes for the particle to move 0.5 metres upwards from Q

Give your answer to three significant figures.

[3 marks]

Answer _____

10

Turn over for the next question

Turn over ▶

8 A plane is inclined at an angle α to the horizontal.

A ball is projected **up** the plane from a point A on the plane.

The initial velocity of the ball is u m s^{-1} at an angle θ above the plane.

The ball hits the plane for the first time at the point B
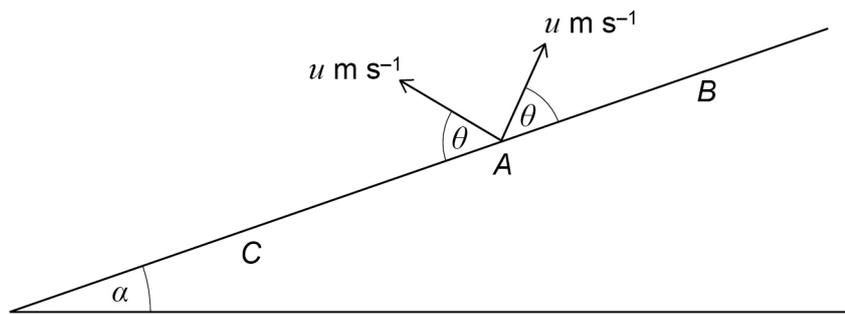
A second ball is projected **down** the plane from the point A

The initial velocity of this ball is u m s^{-1} at an angle θ above the plane.

The second ball hits the plane for the first time at the point C

The straight line CAB is a line of greatest slope of the plane.

The points A, B and C and the initial velocities are shown in the diagram.

Find the greatest possible distance between the points B and C

Give your answer in terms of u, g and α

[8 marks]

Answer

Turn over for the next question

8

9 A smooth wire in the shape of a circle of radius a is fixed in a vertical plane.

A bead of mass m kg is threaded on to the wire and is free to move on the wire.

The bead is set in motion with a speed U m s^{-1} at the highest point of the wire.

9 (a) Show that the normal reaction force on the bead is always directed towards the centre of the circle if $U^2 > ag$

[4 marks]

9 (b) In the case when $U = \sqrt{\dfrac{ag}{2}}$ find the percentage of one complete circumference that the bead travels with the normal reaction force directed towards the centre of the circle.

[8 marks]

Answer _____

END OF QUESTIONS