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Surname	Other names

Pearson Edexcel Level 3 GCE

Centre Number | Candidate Number

Mathematics

Advanced

Mechanics

Practice Questions

Paper Reference **9MA0/32**

You must have:
Mathematical Formulae and Statistical Tables, calculator

Total Marks

This is a collection of stand alone Mechanics practice questions written as an additional resource for the GCE 2017 Mathematics specification.

- There are **10 questions** in this document.
- The marks for each question are shown in brackets.
- The questions are ramped in order of difficulty.
- Mark schemes can be found in the accompanying document on the Pearson website and Emporium.

This **is not** an exam paper so there is no time allocation or a set number of total marks. Teachers can use the questions as they wish to support teaching and learning. If any of the questions are being set as a test, students should be advised to follow the standard guidance for A Level Mechanics exams:

Instructions

- Use black ink or ball-point pen.
- If a pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.

Information

- The marks for each question are shown in brackets - use this as a guide as to how much time to spend on each question.
- Unless otherwise stated, whenever a value of g is required, take g = 9.8 m s^{-2} and give your answer to either 2 significant figures or 3 significant figures.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

1. A car of mass 900 kg pulls a trailer of mass 200 kg up a straight road.

The road is inclined to the horizontal at an angle α, where $\sin \alpha = \frac{1}{14}$

The trailer is attached to the car by a light inextensible tow bar.
The tow bar is parallel to the direction of motion of the car.

The engine of the car exerts a constant driving force of D newtons.

The resistance to the motion of the car from non-gravitational forces is modelled as a constant force of magnitude 500 N.

The resistance to the motion of the trailer from non-gravitational forces is modelled as a constant force of magnitude 100 N.

The car is travelling at a constant speed of $15\ \text{m s}^{-1}$

The car and trailer are modelled as particles.

(a) Find the value of D.

(3)

(b) Find the magnitude of the force exerted on the car by the tow bar.

(3)

At the instant when the car reaches the point A on the road, the tow bar suddenly breaks.

The car continues to travel up the road and 10 seconds after the tow bar breaks, the car reaches the point B on the road.

The resistance to the motion of the car from non-gravitational forces is still modelled as a constant force of magnitude 500 N.

The driving force exerted by the engine of the car remains constant and of magnitude D newtons.

(c) Find the distance AB.

(4)

(d) Describe the motion of the trailer after the tow bar breaks.

(2)

(Total for Question 1 is 12 marks)

2. A ladder AB, of weight W and length $2a$, has one end A resting on rough horizontal ground.

The other end B rests against a vertical wall.

A man of weight $6W$ stands on the ladder at a point C.

The coefficient of friction between the ladder and the ground is $\frac{1}{3}$

The ladder rests in limiting equilibrium at an angle θ to the ground, where $\tan\theta = \frac{12}{5}$

The ladder is modelled as a uniform rod which lies in a vertical plane perpendicular to the wall.

The man is modelled as a particle and the vertical wall is modelled as smooth.

(a) Find, in terms of W, the magnitude of the normal reaction exerted by the wall on the ladder at B.

(4)

(b) Find the length AC.

(4)

(c) State how you have used the modelling assumption that the ladder is a rod.

(1)

In a refinement of the model, the vertical wall is considered to be rough.
The ladder is still in limiting equilibrium.

(d) State, giving a reason, how this would affect your answer to part (a).

(2)

(Total for Question 2 is 11 marks)

3.

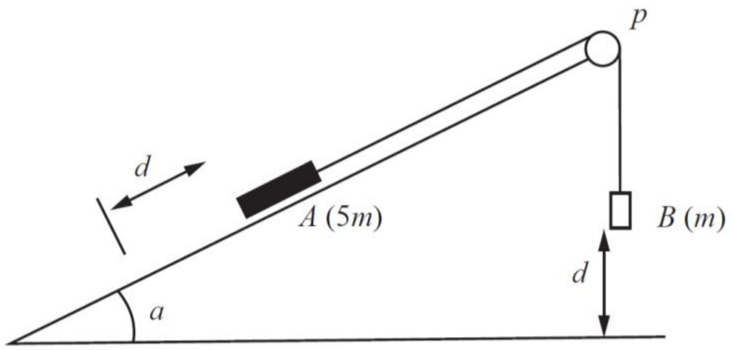

Figure 1

Two blocks, *A* of mass 5*m* and *B* of mass *m*, are connected by a string.

Block *A* is held at rest on a fixed rough plane that is inclined to the horizontal at an angle α , where tan $\alpha = \frac{3}{4}$

The string passes over a pulley *P* which is fixed at the top of the plane.

The part of the string from *A* to *P* is parallel to a line of greatest slope of the plane.

Block *B* hangs vertically below *P*, with $BP > d$, at a height *d* above the ground, as shown in Figure 1.

Block *A* is released from rest with the string taut and *A* begins to slide down the plane.

The coefficient of friction between *A* and the plane is $\frac{1}{4}$

The string is modelled as light and inextensible.

The blocks are modelled as particles.

The pulley at *P* is modelled as being small and smooth.

(a) Write down an equation of motion for *A*

(2)

(b) Write down an equation of motion for *B*

(2)

(c) Hence show that the acceleration of *A* is $\frac{1}{6}g$

(4)

At the instant when A has travelled a distance d down the plane the string breaks.

In the subsequent motion B does not reach P.

(d) Find, in terms of g and d, the speed of B at the instant before it hits the ground.

(4)

(e) If the mass of block B was changed to $2m$, describe what would happen when A is initially released.

(2)

(Total for Question 3 is 14 marks)

4. A particle P of mass 0.5 kg moves under the action of two forces $\mathbf{F}_1$ and $\mathbf{F}_2$

$\mathbf{F}_1 = (2\mathbf{i} + 5\mathbf{j})$ N and $\mathbf{F}_2 = (-\,\mathbf{i} - 2\mathbf{j})$ N.

(a) Find the acceleration of P.

(2)

At time $t = 0$, the velocity of P is $-10\mathbf{j}\ \mathrm{m\,s^{-1}}$

At time $t = 2$ seconds, P passes through the point A. At that instant, the force $\mathbf{F}_1$ is removed and P moves under the action of $\mathbf{F}_2$ only.

At time $t = 5$ seconds, P passes through the point B.

(b) Find the exact distance AB.

(6)

(c) Explain why the distance travelled by P, as it moves from A to B, is not the same as the distance AB.

(1)

(Total for Question 4 is 9 marks)

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5. A particle P moves so that at time t seconds, where $t \ldots 0$, its velocity $\mathbf{v}_P$ m s^{-1} is given by

$$\mathbf{v}_P = (4t^2 + 2t - 1)\mathbf{i} + (2t - 1)\mathbf{j}$$

A particle Q moves so that at time t seconds, where $t \ldots 0$, its velocity $\mathbf{v}_Q$ m s^{-1} is given by

$$\mathbf{v}_Q = (1 - 6t)\mathbf{i} - \mathbf{j}$$

(a) Find the acceleration of P when $t = 3$

(3)

At time T seconds, P and Q are both moving in the same direction.

(b) Find the value of T, justifying your answer carefully.

(6)

(Total for Question 5 is 9 marks)

6. A particle P is moving with constant acceleration $\mathbf{a}\ \mathrm{m\,s^{-2}}$

At time $t = 0$, P is at the point with position vector $(5\mathbf{i} + 7\mathbf{j})$ m and P is moving with velocity $\mathbf{U}\ \mathrm{m\,s^{-1}}$

At time t seconds, where $t \ldots 0$, P is at the point with position vector $\mathbf{r}$ m and P is moving with velocity $\mathbf{v}\ \mathrm{m\,s^{-1}}$

At $t = 2$, $\mathbf{r} = 17\mathbf{i} + 7\mathbf{j}$ and $\mathbf{v} = 4\mathbf{i} + 3\mathbf{j}$

At $t = T$, $\mathbf{r} = -4\mathbf{i} + c\mathbf{j}$ where c is a constant

Find

(a) $\mathbf{a}$

(2)

(b) $\mathbf{U}$

(2)

(c) the speed of P at $t = T$

(6)

(Total for Question 6 is 10 marks)

7. A particle P moves in the xy plane.

At time t seconds, where $t \ldots 0$, the position vector of P is $\mathbf{r}_P$ m where

$\mathbf{r}_P = (3 - 2t^3)\mathbf{i} + (2t^2 - 5t)\mathbf{j}$

(a) Calculate the value of t when the direction of motion of P is parallel to $(-15\mathbf{i} + 2\mathbf{j})$.

(5)

(b) Find the acceleration of P at this instant.

(2)

Another particle Q moves in the same plane as P.

At time t seconds, where $t \ldots 0$, the velocity of Q is $\mathbf{v}_Q$ $\mathrm{m\,s^{-1}}$ where

$$\mathbf{v}_Q = 6t^{\frac{1}{2}}\mathbf{i} + (5 - 3t)\mathbf{j}$$

Given that when $t = 0$, Q is at the origin

(c) find the exact distance between P and Q when $t = 1$

(4)

(Total for Question 7 is 11 marks)

8. [*In this question the unit vectors* **i** *and* **j** *are in a vertical plane,* **i** *being horizontal and* **j** *being vertically upwards.*]

At $t = 0$, a small ball B is projected from a fixed point O with velocity

$(5\mathbf{i} + 8\mathbf{j})\ \text{m s}^{-1}$

The position vector of a point on the path of B is $(x\mathbf{i} + y\mathbf{j})$ m relative to O.

The ball is modelled as a particle moving freely under gravity.

The acceleration due to gravity is modelled as having magnitude $10\ \text{m s}^{-2}$

(a) Show that

$$y = 1.6x - 0.2x^2$$

(4)

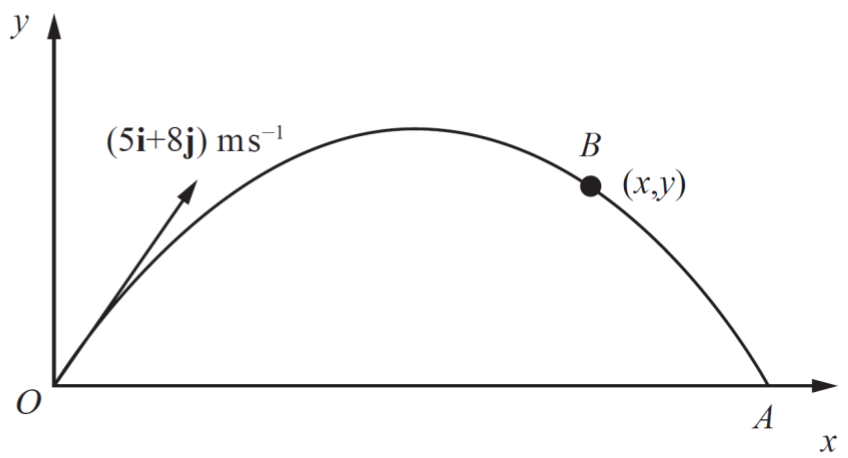

Figure 2

The ball passes through a point A which is on the same horizontal level as O, as shown in Figure 2.

(b) Using part (a), find the distance OA.

(2)

(c) Find the speed and the direction of motion of B as it passes through the point on the path where $x = 6$, giving your answers to 2 significant figures.

(6)

In reality, the acceleration due to gravity is less than $10\ \text{m s}^{-2}$

(d) State, giving a reason, how using a more accurate value for g would affect your answer to part (b).

(2)

(e) Suggest a possible improvement, apart from using a more accurate value for g, which could be made to the model.

(1)

(Total for Question 8 is 15 marks)

9.

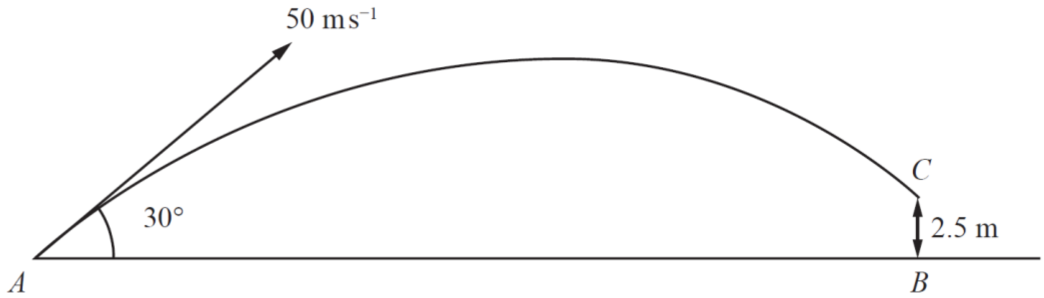

Figure 3

The points A and B lie on horizontal ground.

At time $t = 0$, a small ball P is launched from the point A with speed 50 m s^{-1} at an angle of 30° to the horizontal, as shown in Figure 3.

The ball P is moving downwards when it hits a target at the point C which is 2.5 m vertically above B.

The ball P is modelled as a particle moving freely under gravity.

(a) Find the distance AB to the nearest metre.

(6)

(b) Find the direction of motion of the ball P at C, giving your answer as an angle to the downward vertical.

(5)

At time $t = 1$ s, another small ball Q is projected from A with speed U m s^{-1} at an angle of θ° to the horizontal.

The ball Q hits the target at C at the same instant as ball P.

The ball Q is also modelled as a particle moving freely under gravity.

(c) Find the value of

(i) U

(ii) θ

(6)

(d) State one limitation of the model, apart from neglecting air resistance, that could affect the accuracy of your answers to part (c).

(1)

(Total for Question 9 is 18 marks)

10.

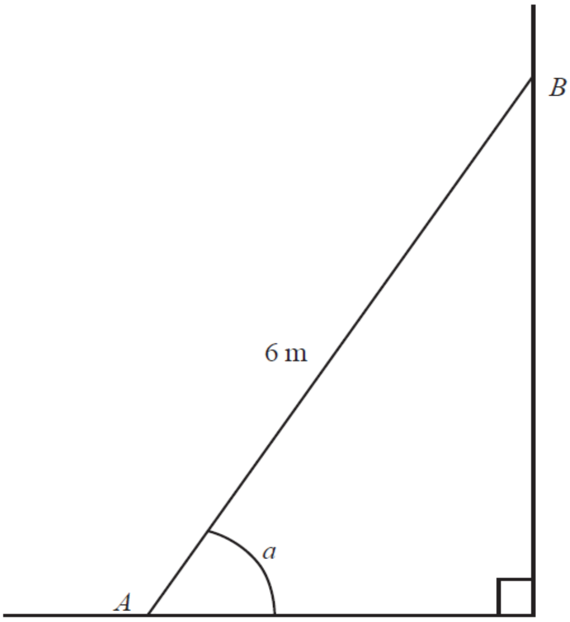

Figure 4

Figure 4 shows a ladder *AB*.

The end *A* is in contact with rough horizontal ground and the end *B* rests against a smooth vertical wall.

The ladder *AB* has weight $2W$ and length 6 m.

A man of weight $5W$ stands on the ladder at a point which is 2 m from *A*.

The magnitude of the total reaction force from the ground on the ladder at *A* is kW, where k is a constant.

The ladder rests in equilibrium at an angle α with the horizontal, where $\tan \alpha = \frac{4}{3}$

The ladder is modelled as a uniform rod which lies in a vertical plane perpendicular to the wall.

The man is modelled as a particle.

Using the model,

(a) find the value of k to 2 decimal places.

(7)

The man now stands 0.5 m from the top of the ladder and, to keep the ladder in equilibrium, a horizontal force of magnitude P is applied to the ladder at a point on the ladder which is 1.5 m above the ground.

The ladder remains at an angle α with the horizontal, where $\tan \alpha = \frac{4}{3}$

The line of action of the force and the rod lie in a vertical plane which is perpendicular to the wall.

The coefficient of friction between the ladder and the ground is $\frac{4}{7}$

Using the model,

(b) show that the minimum value of P is $\frac{3}{11}W$

(7)

(c) Explain how you have used the fact that the ladder has been modelled as uniform in your ` solution to parts (a) and (b).

(1)

(Total for Question 10 is 15 marks)