Paper Reference 9MA0 − 32
Pearson Edexcel
Level 3 GCE

Mathematics
Advanced
Paper 32: Mechanics

Friday 14 June 2019 – Afternoon

MATERIALS REQUIRED FOR EXAMINATION

Mathematical Formulae and Statistical Tables, calculator

ITEMS INCLUDED WITH QUESTION PAPERS

Diagram Book

Answer Book

Y63359A

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Candidates may use any calculator allowed by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

INSTRUCTIONS

In the boxes on the Answer Book and on the Diagram Book, write your name, centre number and candidate number.

Answer ALL questions and ensure that your answers to parts of questions are clearly labelled.

Answer the questions in the Answer Book or on the separate diagrams – there may be more space than you need.

Do NOT write on the Question Paper.

You should show sufficient working to make your methods clear. Answers without working may not gain full credit.

Answers should be given to three significant figures unless otherwise stated.

INFORMATION

A booklet 'Mathematical Formulae and Statistical Tables' is provided.

The total mark for this part of the examination is 50
There are 5 questions.

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 $g = 9{\cdot}8\ \text{m s}^{-2}$ 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.

Answer ALL questions.

Write your answers in the Answer Book.

1. **[In this question position vectors are given relative to a fixed origin O]**

At time t seconds, where $t \geq 0$, a particle, P, moves so that its velocity $\underline{v}$ m s^{-1} is given by

$$\underline{v} = 6t\underline{i} - 5t^{\frac{3}{2}}\underline{j}$$

When $t = 0$, the position vector of P is $(-20\underline{i} + 20\underline{j})$ metres.

(continued on the next page)

1. continued.

(a) Find the acceleration of P when $t = 4$

(3 marks)

(b) Find the position vector of P when $t = 4$

(3 marks)

(Total for Question 1 is 6 marks)

2. A particle, P, moves with constant acceleration $(2\underline{i} - 3\underline{j})\,m\,s^{-2}$

At time $t = 0$, the particle is at the point A and is moving with velocity $(-\underline{i} + 4\underline{j})\,m\,s^{-1}$

At time $t = T$ seconds, P is moving in the direction of vector $(3\underline{i} - 4\underline{j})$

(a) Find the value of T

(4 marks)

(continued on the next page)

2. continued.

At time $t = 4$ seconds, P is at the point B

(b) Find the distance AB

(4 marks)

(Total for Question 2 is 8 marks)

3. Refer to the diagram for Question 3 in the Diagram Book.

Two blocks, A and B, of masses $2m$ and $3m$ respectively, are attached to the ends of a light string.

Initially A is held at rest on a fixed rough plane.

The plane is inclined at angle α to the horizontal ground, where

$$\tan \alpha = \frac{5}{12}$$

(continued on the next page)

3. continued.

The string passes over a small smooth pulley, **P**, 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 freely below **P**, as shown in the diagram.

The coefficient of friction between **A** and the plane is $\frac{2}{3}$

(continued on the next page)

3. continued.

The blocks are released from rest with the string taut and A moves up the plane.

The tension in the string immediately after the blocks are released is T

The blocks are modelled as particles and the string is modelled as being inextensible.

(a) Show that

$$T = \frac{12mg}{5}$$

(8 marks)

(continued on the next page)

3. continued.

After **B** reaches the ground, **A** continues to move up the plane until it comes to rest before reaching **P**

(b) Determine whether **A** will remain at rest, carefully justifying your answer.

(2 marks)

(c) Suggest two refinements to the model that would make it more realistic.

(2 marks)

(Total for Question 3 is 12 marks)

4. Refer to the diagram for Question 4 in the Diagram Book.

A ramp, **AB**, of length **8** metres and mass **20 kg**, rests in equilibrium with the end **A** on rough horizontal ground.

The ramp rests on a smooth solid cylindrical drum which is partly under the ground.

The drum is fixed with its axis at the same horizontal level as **A**

(continued on the next page)

4. continued.

The point of contact between the ramp and the drum is C, where $AC = 5$ metres, as shown in the diagram.

The ramp is resting in a vertical plane which is perpendicular to the axis of the drum, at an angle θ to the horizontal, where

$$\tan \theta = \frac{7}{24}$$

The ramp is modelled as a uniform rod.

(continued on the next page)

4. continued.

(a) Explain why the reaction from the drum on the ramp at point **C** acts in a direction which is perpendicular to the ramp.
(1 mark)

(b) Find the magnitude of the resultant force acting on the ramp at **A**
(9 marks)

(continued on the next page)

4. continued.

The ramp is still in equilibrium in the position shown in the diagram but the ramp is not now modelled as being uniform.

Given that the centre of mass of the ramp is assumed to be closer to **A** than to **B**,

(c) state how this would affect the magnitude of the normal reaction between the ramp and the drum at **C**

(1 mark)

(Total for Question 4 is 11 marks)

5. Refer to the diagram for Question 5 in the Diagram Book.

The points A and B lie 50 metres apart on horizontal ground.

At time $t = 0$ two small balls, P and Q, are projected in the vertical plane containing AB

(continued on the next page)

5. continued.

Ball P is projected from A with speed $20\,m\,s^{-1}$ at $30°$ to AB

Ball Q is projected from B with speed $u\,m\,s^{-1}$ at angle θ to BA, as shown in the diagram.

At time $t = 2$ seconds, P and Q collide.

Until they collide, the balls are modelled as particles moving freely under gravity.

(continued on the next page)

5. continued.

(a) Find the velocity of P at the instant before it collides with Q

(6 marks)

(b) Find

(i) the size of angle θ,

(ii) the value of u

(6 marks)

(continued on the next page)

5. continued.

(c) State one limitation of the model, other than air resistance, that could affect the accuracy of your answers.

(1 mark)

(Total for Question 5 is 13 marks)

TOTAL FOR MECHANICS IS 50 MARKS

END OF PAPER
