Paper Reference 9MA0/32
Pearson Edexcel
Level 3 GCE

Mathematics
Advanced
Paper 32: Mechanics

Monday 19 October 2020 – Afternoon

MATERIALS REQUIRED FOR EXAMINATION
Mathematical Formulae and Statistical Tables (Green), calculator

ITEMS INCLUDED WITH QUESTION PAPER
Diagram Book
Answer Book

V66789A

Pearson

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.

Unless otherwise indicated, whenever a value of g is required, take $g = 9{\cdot}8\ ms^{-2}$, and give your answer to either 2 significant figures or 3 significant figures.

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.

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 rough plane is inclined to the horizontal at an angle α, where $\tan\alpha = \frac{3}{4}$

A brick P of mass m is placed on the plane.

The coefficient of friction between P and the plane is μ

Brick P is in equilibrium and on the point of sliding down the plane.

Brick P is modelled as a particle.

(continued on the next page)

1. continued.

Using the model,

(a) find, in terms of m and g, the magnitude of the normal reaction of the plane on brick P

(2 marks)

(b) show that $\mu = \frac{3}{4}$

(4 marks)

(continued on the next page)

1. continued.

For parts (c) and (d), you are not required to do any further calculations.

Brick P is now removed from the plane and a much heavier brick Q is placed on the plane.

The coefficient of friction between Q and the plane is also $\frac{3}{4}$

(c) Explain briefly why brick Q will remain at rest on the plane.

(1 mark)

(continued on the next page)

1. continued.

Brick Q is now projected with speed $0 \cdot 5 \, m \, s^{-1}$ down a line of greatest slope of the plane.

Brick Q is modelled as a particle.

Using the model,

(d) describe the motion of brick Q, giving a reason for your answer.

(2 marks)

(Total for Question 1 is 9 marks)

2. A particle P moves with acceleration $(4\underline{i} - 5\underline{j})\,m\,s^{-2}$

At time $t = 0$, P is moving with velocity $(-2\underline{i} + 2\underline{j})\,m\,s^{-1}$

(a) Find the velocity of P at time $t = 2$ seconds.

(2 marks)

(continued on the next page)

2. continued.

At time $t = 0$, P passes through the origin O

At time $t = T$ seconds, where $T > 0$, the particle P passes through the point A

The position vector of A is $(\lambda\underline{i} - 4{\cdot}5\underline{j})$ metres relative to O, where λ is a constant.

(b) Find the value of T

(4 marks)

(continued on the next page)

2. continued.

(c) Hence find the value of λ

(2 marks)

(Total for Question 2 is 8 marks)

3. (i) At time t seconds, where $t \geq 0$, a particle P moves so that its acceleration $\underline{a}\ \text{m s}^{-2}$ is given by

$$\underline{a} = (1 - 4t)\underline{i} + (3 - t^2)\underline{j}$$

At the instant when $t = 0$, the velocity of P is $36\underline{i}\ \text{m s}^{-1}$

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

(3 marks)

(continued on the next page)

3. (i) continued.

(b) Find the value of t at the instant when P is moving in a direction perpendicular to $\underline{i}$ (3 marks)

(continued on the next page)

3. continued.

(ii) At time t seconds, where $t \geq 0$, a particle Q moves so that its position vector $\underline{r}$ metres, relative to a fixed origin O, is given by

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

Find the value of t at the instant when the speed of Q is $5\,m\,s^{-1}$

(6 marks)

(Total for Question 3 is 12 marks)

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

A ladder AB has mass M and length $6b$

The end A of the ladder is on rough horizontal ground.

The ladder rests against a fixed smooth horizontal rail at the point C

The point C is at a vertical height $4b$ above the ground.

(continued on the next page)

4. continued.

The vertical plane containing AB is perpendicular to the rail.

The ladder is inclined to the horizontal at an angle α, where $\sin\alpha = \frac{4}{5}$, as shown in the diagram.

The coefficient of friction between the ladder and the ground is μ

The ladder rests in limiting equilibrium.

(continued on the next page)

4. continued.

The ladder is modelled as a uniform rod.

Using the model,

(a) show that the magnitude of the force exerted on the ladder by the rail at C is $\frac{9Mg}{25}$

(3 marks)

(b) Hence, or otherwise, find the value of μ

(7 marks)

(Total for Question 4 is 10 marks)

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

A small ball is projected with speed $U\,m\,s^{-1}$ from a point O at the top of a vertical cliff.

The point O is 25 metres vertically above the point N which is on horizontal ground.

The ball is projected at an angle of $45°$ above the horizontal.

(continued on the next page)

5. continued.

The ball hits the ground at a point **A**, where **AN = 100** metres, as shown in the diagram.

The motion of the ball is modelled as that of a particle moving freely under gravity.

Using this initial model,

(a) show that **U = 28**

(6 marks)

(continued on the next page)

5. continued.

(b) find the greatest height of the ball above the horizontal ground NA

(3 marks)

(continued on the next page)

5. continued.

In a refinement to the model of the motion of the ball from O to A, the effect of air resistance is included.

This refined model is used to find a new value of U

(c) How would this new value of U compare with 28, the value given in part (a)?

(1 mark)

(continued on the next page)

5. continued.

(d) State one further refinement to the model that would make the model more realistic.

(1 mark)

(Total for Question 5 is 11 marks)

TOTAL FOR MECHANICS IS 50 MARKS

END OF PAPER