Please check the examination details below before entering your candidate information

Candidate surname	Other names

Pearson Edexcel GCE

Centre Number | Candidate Number

Tuesday 18 June 2019

Morning (Time: 1 hour 30 minutes) | Paper Reference **6681/01**

Mechanics M5

Advanced/Advanced Subsidiary

You must have:
Mathematical Formulae and Statistical Tables (Pink)

Total Marks

Candidates may use any calculator permitted 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

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B). Coloured pencils and highlighter pens must not be used.
- **Fill in the boxes** at the top of this page with 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 spaces provided – *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Whenever a numerical value of g is required, take $g = 9.8$ m s^{-2}, and give your answer to either two significant figures or three significant figures.
- When a calculator is used, the answer should be given to an appropriate degree of accuracy.

Information

- The total mark for this paper is 75.
- 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.

Turn over ▶

P55859A

1/1/1/1/1/1/

P 5 5 8 5 9 A 0 1 2 4

Pearson

Leave blank

1. [*In this question* **i** *and* **j** *are perpendicular unit vectors in a horizontal x-y plane.*]

A bead of mass 0.05 kg is threaded on a smooth straight horizontal wire which passes through the point $A(2, 1)$ and the point $B(6, 5)$. The unit of length on both axes is the metre. The bead is initially at rest at A. Two forces, $(5\mathbf{i} + \mathbf{j})$ N and $\mathbf{F} = (p\mathbf{i} + q\mathbf{j})$ N, act on the bead and move it along the wire. At the instant when the bead passes through the point B, the speed of the bead is $40\,\text{m s}^{-1}$. Given that the line of action of $\mathbf{F}$ is parallel to the line with equation, $3x + y = 1$, find the value of p and the value of q.

(7)

Leave blank

Question 1 continued

Q1

(Total 7 marks)

Leave blank

2. A particle moves in a plane such that its position vector **r** metres at time t seconds satisfies the differential equation

$$\frac{d\mathbf{r}}{dt} - \frac{3}{(t+1)}\mathbf{r} = 5\mathbf{j} \quad \text{for } t \geqslant 0$$

When $t = 0$, the particle is at the point with position vector $(\mathbf{i} + 0.5\mathbf{j})$ m.

Find **r** in terms of t.

(8)

Leave blank

Question 2 continued

Q2

(Total 8 marks)

Leave blank

3. The points A, B and C lie on a rigid body and have position vectors $(4\mathbf{i} - 6\mathbf{j} - 8\mathbf{k})$ m, $(\mathbf{i} - 2\mathbf{j} + 4\mathbf{k})$ m and $(2\mathbf{i} - 4\mathbf{j} + 2\mathbf{k})$ m respectively, relative to a fixed origin O.

Three forces, $\mathbf{F}_1$, $\mathbf{F}_2$ and $\mathbf{F}_3$, act along $\overrightarrow{AB}$, $\overrightarrow{BC}$ and $\overrightarrow{CA}$ respectively and have magnitudes 26 N, 6 N and $12\sqrt{3}$ N respectively.

(a) Show that the system of forces $\mathbf{F}_1$, $\mathbf{F}_2$ and $\mathbf{F}_3$ is equivalent to a couple and find its magnitude.

(8)

When a fourth force $\mathbf{F}_4$ also acts on the rigid body, the system of four forces is equivalent to a single force $(\mathbf{i} - 2\mathbf{j} - 2\mathbf{k})$ N acting at the point with position vector $(\mathbf{i} + \mathbf{j} - 2\mathbf{k})$ m.

(b) Find a vector equation for the line of action of $\mathbf{F}_4$, giving your answer in the form $\mathbf{r} = \mathbf{a} + t\mathbf{b}$, where $\mathbf{a}$ and $\mathbf{b}$ are constant vectors and t is a scalar parameter.

(5)

Leave blank

Question 3 continued

Leave blank

Question 3 continued

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

Leave blank

Question 3 continued

(Total 13 marks)

Q3

Leave blank

4. A space rocket starts from rest and moves in a straight line. The mass of the rocket, excluding fuel, is M and initially the mass of the fuel is $0.5M$. The rocket moves by ejecting burnt fuel backwards at a constant speed U relative to the rocket. It is assumed that there are no external forces acting. Find the fraction of the initial mass of the fuel which is unburnt when the speed of the rocket is $U\ln\frac{6}{5}$

(7)

Leave blank

Question 4 continued

Q4

(Total 7 marks)

Leave blank

5. A uniform rod AB, of mass $2m$ and length $4a$, is free to rotate in a vertical plane about a fixed smooth horizontal axis. The axis is perpendicular to the rod and passes through the end A of the rod. The rod hangs at rest in equilibrium with B vertically below A. A particle P of mass m is moving in a plane which is perpendicular to the axis when it strikes the rod at its midpoint. Immediately before the impact, P is moving horizontally with speed u. Immediately after the impact, P rebounds horizontally. The coefficient of restitution between P and the rod is 0.5

Find the angular speed of the rod immediately after the collision.

(8)

Leave blank

Question 5 continued

Leave blank

Question 5 continued

Leave blank

Question 5 continued

Q5

(Total 8 marks)

Leave blank

6. A uniform plane circular disc has mass m and radius a. The disc is free to rotate in a vertical plane about a fixed smooth horizontal axis. The axis is perpendicular to the plane of the disc and passes through a point A on the edge of the disc. The disc hangs at rest with the centre of the disc vertically below A. The disc is then given an angular speed $2\sqrt{\frac{g}{a}}$

(a) Find the angular speed of the disc after it has turned through an angle β, where $\cos\beta = \frac{4}{5}$

(5)

(b) Find the magnitude of the resultant force exerted by the axis on the disc at A at the instant when the disc has turned through the angle β.

(11)

Leave blank

Question 6 continued

Leave blank

Question 6 continued

Leave blank

Question 6 continued

Q6

(Total 16 marks)

Leave blank

7.

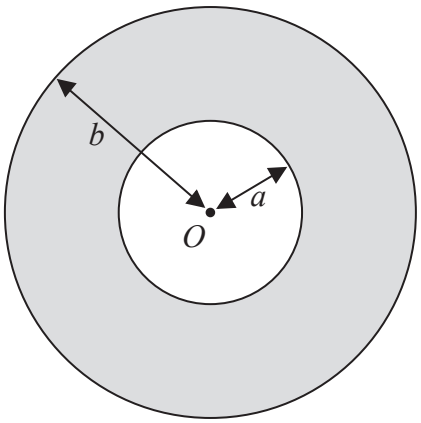

Figure 1

A uniform lamina L, shown shaded in Figure 1, is formed by removing a uniform circular disc with centre O and radius a from a uniform circular disc with centre O and radius $b (b > a)$. The mass of L is M.

(a) Show that the moment of inertia of L about an axis through O, perpendicular to the plane of L, is $\frac{1}{2} M (a^2 + b^2)$.

[*You may assume without proof that the moment of inertia of a uniform circular disc, of mass m and radius r, about an axis through its centre, perpendicular to the plane of the disc, is* $\frac{1}{2} mr^2$.]

(5)

The lamina L is free to rotate about a fixed smooth horizontal axis. The axis is tangential to the outer edge of L and lies in the same plane as L, so that the centre O of L moves in a vertical plane which is perpendicular to the axis.

(b) By first writing down an equation of rotational motion, show that the period of small oscillations of L about its position of stable equilibrium is approximately $\pi \sqrt{\frac{a^2 + 5b^2}{gb}}$.

(8)

The lamina L is held with its plane making a small angle α with the downward vertical and released from rest.

(c) Find the approximate time it takes L to turn through an angle $\frac{1}{2} \alpha$.

(3)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

Leave blank

Question 7 continued

Leave blank

Question 7 continued

Leave blank

Question 7 continued

Leave blank

Question 7 continued

Q7

(Total 16 marks)

TOTAL FOR PAPER: 75 MARKS

END

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA