Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number

Candidate Number

Pearson Edexcel International Advanced Level

Tuesday 6 June 2023

Morning (Time: 1 hour 30 minutes)

Paper reference **WME03/01**

Mathematics

International Advanced Subsidiary/Advanced Level
Mechanics M3

You must have:
Mathematical Formulae and Statistical Tables (Yellow), calculator

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).
- **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.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 7 questions in this question paper. 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.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

Turn over

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Pearson

1. **In this question you must show all stages in your working.**

Solutions relying on calculator technology are not acceptable.

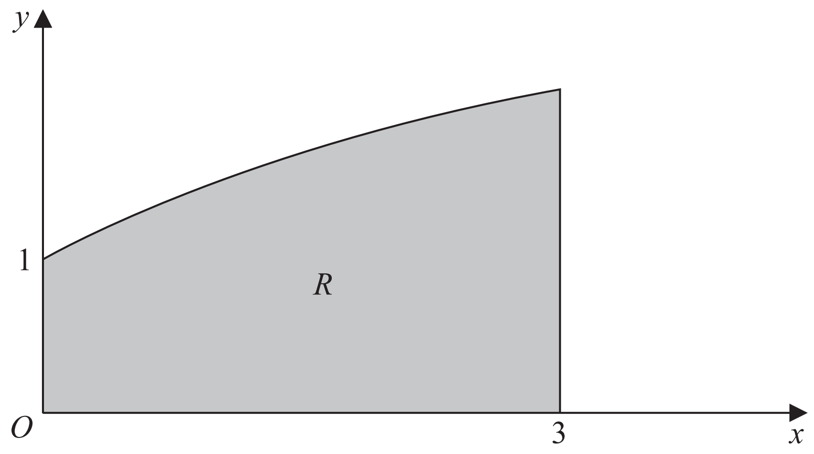

Figure 1

The finite region R, shown shaded in Figure 1, is bounded by the x-axis, the line with equation $x = 3$, the curve with equation $y = \sqrt{(x+1)}$ and the y-axis.

Find the ***y* coordinate** of the centre of mass of a uniform lamina in the shape of R.

(5)

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Question 1 continued

(Total for Question 1 is 5 marks)

2.

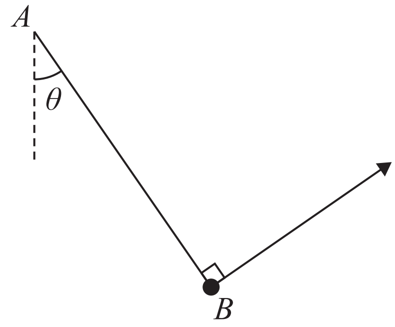

Figure 2

A light elastic string AB has modulus of elasticity $2mg$ and natural length ka, where k is a constant.
The end A of the elastic string is attached to a fixed point. The other end B is attached to a particle of mass m. The particle is held in equilibrium, with the elastic string taut, by a force that acts in a direction that is perpendicular to the string. The line of action of the force and the elastic string lie in the same vertical plane. The string makes an angle θ with the downward vertical at A, as shown in Figure 2.

Given that the length $AB = \dfrac{21}{10}a$ and $\tan\theta = \dfrac{3}{4}$, find the value of k.

(6)

Question 2 continued

Question 2 continued

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Question 2 continued

(Total for Question 2 is 6 marks)

3. A uniform solid right circular cone C has base radius r, height H and vertex V.
A uniform solid S, shown in Figure 3, is formed by **removing** from C a uniform solid right circular cone of height h ($h < H$) that has the same base and axis of symmetry as C.

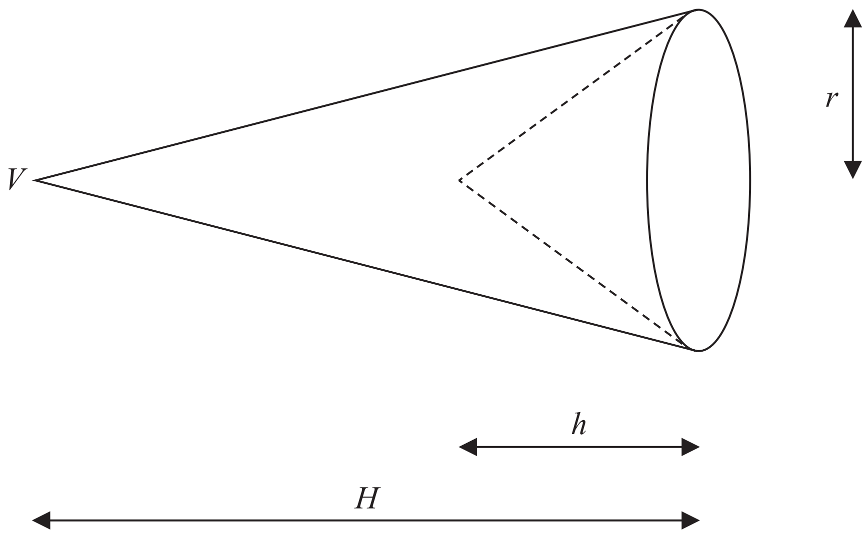

Figure 3

(a) Show that the distance of the centre of mass of S from V is

$$\frac{1}{4}(3H - h)$$

(5)

The solid S is suspended by two vertical light strings. The first string is attached to S at V and the second string is attached to S at a point on the circumference of the circular base of S.
The solid S hangs freely in equilibrium with its axis of symmetry horizontal.
The tension in the first string is T_1 and the tension in the second string is T_2

(b) Find $\frac{T_1}{T_2}$, giving your answer in terms of H and h, in its simplest form.

(3)

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Question 3 continued

Question 3 continued

Question 3 continued

(Total for Question 3 is 8 marks)

4.

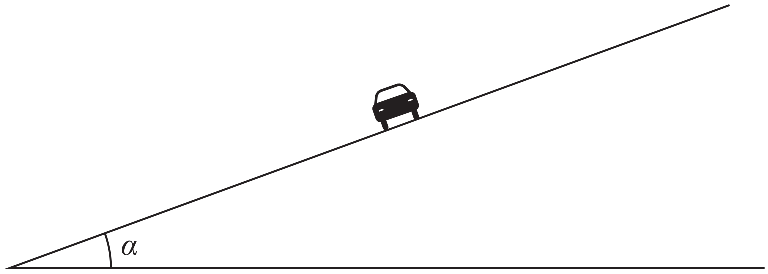

Figure 4

A car is travelling round a circular track. The track is **banked** at an angle α to the horizontal, as shown in Figure 4.

The car and driver are modelled as a particle.

The car moves round the track with constant speed in a horizontal circle of radius r.

When the car is moving with speed $\frac{1}{2}\sqrt{gr}$ round the circle, there is **no** sideways friction between the tyres of the car and the track.

(a) Show that $\tan\alpha = \frac{1}{4}$

(5)

The sideways friction between the tyres of the car and the track has coefficient of friction μ, where $\mu < 4$

The maximum speed at which the car can move round the circle without slipping sideways is V.

(b) Find V in terms of μ, r and g.

(7)

Question 4 continued

Question 4 continued

Question 4 continued

(Total for Question 4 is 12 marks)

5. The centre of the Earth is the point O and the Earth is modelled as a fixed sphere of radius R.
At time $t = 0$, a particle P is projected vertically upwards with speed U from a point A on the surface of the Earth.

At time t seconds, where $t \geqslant 0$

- P is a distance x from O
- P is moving with speed v
- P has acceleration of magnitude $\frac{gR^2}{x^2}$ directed towards O

Air resistance is modelled as being negligible.

(a) Show that $v^2 = \frac{2gR^2}{x} + U^2 - 2gR$

(6)

Particle P is first moving with speed $\frac{1}{2}\sqrt{gR}$ at the point B.

(b) Given that $U = \sqrt{gR}$ find, in terms of R, the distance AB.

(3)

(c) Find, in terms of g and R, the smallest value of U that would ensure that P never comes to rest, explaining your reasoning.

(3)

Question 5 continued

Question 5 continued

Question 5 continued

(Total for Question 5 is 12 marks)

6.

Figure 5

A particle P of mass m is attached to one end of a light inextensible string of length a. The other end of the string is attached to a fixed point O. The particle P is held at rest with the string taut and horizontal and is then projected vertically downwards with speed u, as shown in Figure 5.

Air resistance is modelled as being negligible.

At the instant when the string has turned through an angle θ and the string is taut, the tension in the string is T.

(a) Show that $T = \dfrac{mu^2}{a} + 3mg\sin\theta$

(7)

Given that $u = 2\sqrt{\dfrac{3ag}{5}}$

(b) find, in terms of a and g, the speed of P at the instant when the string goes slack.

(4)

(c) Hence find, in terms of a, the maximum height of P above O in the subsequent motion.

(5)

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Question 6 continued

Question 6 continued

Question 6 continued

(Total for Question 6 is 16 marks)

7. A particle P of mass m is attached to one end of a light elastic string of natural length l. The other end of the string is attached to a fixed point on a ceiling. The particle P hangs in equilibrium at a distance D below the ceiling.

The particle P is now pulled vertically downwards until it is a distance $3l$ below the ceiling and released from rest.

Given that P comes to instantaneous rest just before it reaches the ceiling,

(a) show that $D = \dfrac{5l}{3}$

(6)

(b) Show that, while the elastic string is stretched, P moves with simple harmonic motion, with period $2\pi\sqrt{\dfrac{2l}{3g}}$

(6)

(c) Find, in terms of g and l, the exact time from the instant when P is released to the instant when the elastic string first goes slack.

(4)

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Question 7 continued

Question 7 continued

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Question 7 continued

Question 7 continued

(Total for Question 7 is 16 marks)

TOTAL FOR PAPER IS 75 MARKS