

Please check the examination details below before entering your candidate information

Candidate surname		Other names	
Centre Number		Candidate Number	
<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>		<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>	

**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  $g = 9.8 \text{ m s}^{-2}$ , 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 ►

P74308A

©2023 Pearson Education Ltd.  
N:1/1/1/



  
**Pearson**

1.

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

Solutions relying on calculator technology are not acceptable.

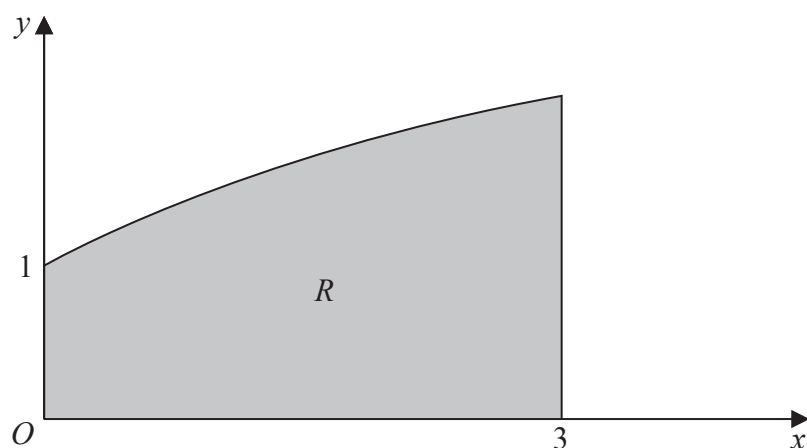


Figure 1

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)



DO NOT WRITE IN THIS AREA

Question 1 continued

Lined area for writing answers.

(Total for Question 1 is 5 marks)



2.

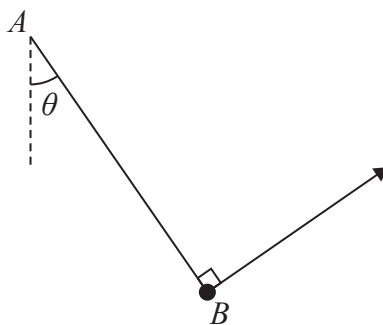


Figure 2

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  $\theta$  with the downward vertical at  $A$ , as shown in Figure 2.

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

(6)



DO NOT WRITE IN THIS AREA

Question 2 continued

Lined area for writing the answer to Question 2.



Question 2 continued

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA



DO NOT WRITE IN THIS AREA

Question 2 continued

Lined area for writing answers.

(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  $C$ .

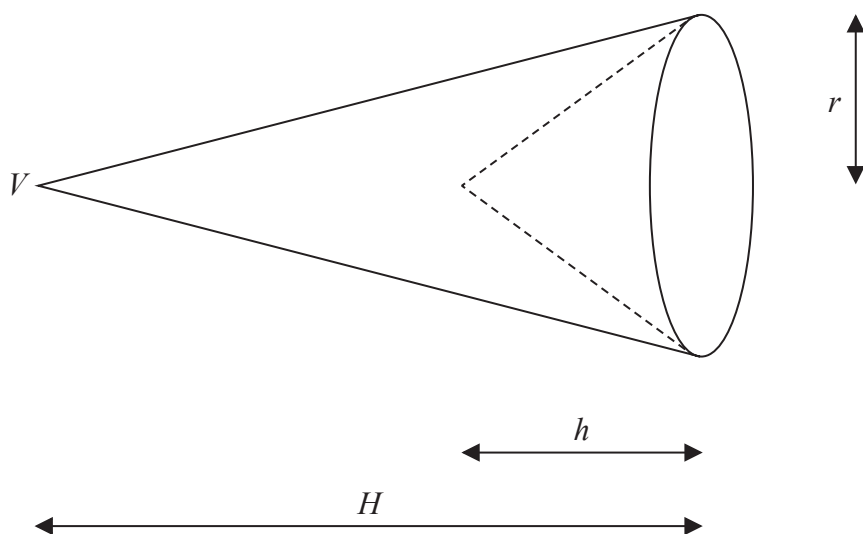


Figure 3

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

$$\frac{1}{4}(3H - h) \quad (5)$$

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)





DO NOT WRITE IN THIS AREA

Question 3 continued

Lined area for writing the answer to Question 3.



Question 3 continued

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA



DO NOT WRITE IN THIS AREA

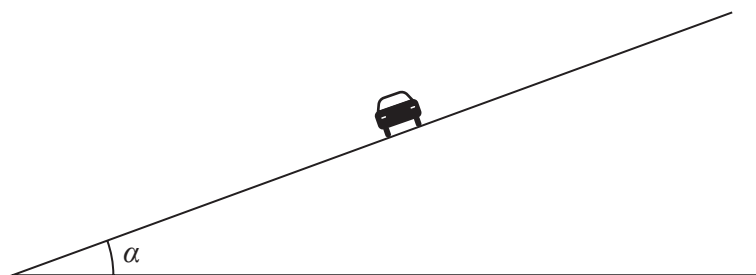
Question 3 continued

Lined area for writing answers.

(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  $\alpha$  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  $\mu$ , 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  $\mu$ ,  $r$  and  $g$ . (7)



DO NOT WRITE IN THIS AREA

Question 4 continued

Lined area for writing the answer to Question 4.



Question 4 continued

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA



DO NOT WRITE IN THIS AREA

Question 4 continued

Lined area for writing answers.

(Total for Question 4 is 12 marks)







DO NOT WRITE IN THIS AREA

Question 5 continued

Lined area for writing the answer to Question 5.



Question 5 continued

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA



DO NOT WRITE IN THIS AREA

Question 5 continued

Lined area for writing answers.

(Total for Question 5 is 12 marks)



6.

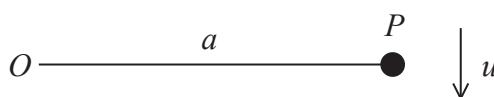


Figure 5

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  $\theta$  and the string is taut, the tension in the string is  $T$ .

(a) Show that  $T = \frac{mu^2}{a} + 3mg \sin \theta$  (7)

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

(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)



DO NOT WRITE IN THIS AREA

Question 6 continued

Lined area for writing the answer to Question 6.



Question 6 continued

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA



DO NOT WRITE IN THIS AREA

Question 6 continued

Lined area for writing answers.

(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  $D = \frac{5l}{3}$  (6)

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





DO NOT WRITE IN THIS AREA

Question 7 continued

Lined area for writing the answer to Question 7.



Question 7 continued

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA



DO NOT WRITE IN THIS AREA

Question 7 continued

Lined area for writing the answer to Question 7.



**Question 7 continued**

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

**(Total for Question 7 is 16 marks)**

**TOTAL FOR PAPER IS 75 MARKS**

