

Please check the examination details below before entering your candidate information

Candidate surname

Other names

**Pearson Edexcel  
Level 3 GCE**

Centre Number

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Candidate Number

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**Tuesday 23 June 2020**

Afternoon (Time: 1 hour 30 minutes)

Paper Reference **9FM0/4C**

**Further Mathematics**

**Advanced**

**Paper 4C: Further Mechanics 2**

**You must have:**

Mathematical Formulae and Statistical Tables (Green), 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.
- Unless otherwise indicated, whenever a value of  $g$  is required, take  $g = 9.8 \text{ m s}^{-2}$  and give your answer to either 2 significant figures or 3 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.

Turn over ►

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P 6 2 6 8 4 R A 0 1 2 8



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1. Three particles of masses  $3m$ ,  $4m$  and  $2m$  are placed at the points  $(-2, 2)$ ,  $(3, 1)$  and  $(p, p)$  respectively.

The value of  $p$  is such that the distance of the centre of mass of the three particles from the point  $(0, 0)$  is as small as possible.

Find the value of  $p$ .

(7)

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3. A particle  $P$  of mass  $0.5$  kg is moving along the positive  $x$ -axis in the direction of  $x$  increasing. At time  $t$  seconds ( $t \geq 0$ ),  $P$  is  $x$  metres from the origin  $O$  and the speed of  $P$  is  $v$   $\text{m s}^{-1}$ . The resultant force acting on  $P$  is directed towards  $O$  and has magnitude  $kv^2$  N, where  $k$  is a positive constant.

When  $x = 1$ ,  $v = 4$  and when  $x = 2$ ,  $v = 2$

(a) Show that  $v = ab^x$ , where  $a$  and  $b$  are constants to be found.

(6)

The time taken for the speed of  $P$  to decrease from  $4 \text{ m s}^{-1}$  to  $2 \text{ m s}^{-1}$  is  $T$  seconds.

(b) Show that  $T = \frac{1}{4 \ln 2}$

(4)



Question 3 continued

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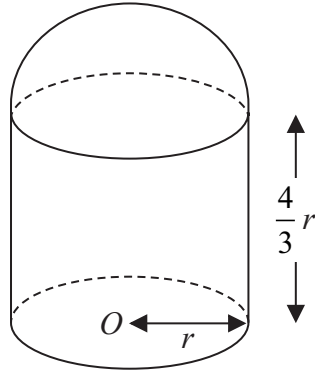


Figure 3

A uniform solid cylinder of base radius  $r$  and height  $\frac{4}{3}r$  has the same density as a uniform solid hemisphere of radius  $r$ . The plane face of the hemisphere is joined to a plane face of the cylinder to form the composite solid  $S$  shown in Figure 3. The point  $O$  is the centre of the plane face of  $S$ .

- (a) Show that the distance from  $O$  to the centre of mass of  $S$  is  $\frac{73}{72}r$  (4)

The solid  $S$  is placed with its plane face on a rough horizontal plane. The coefficient of friction between  $S$  and the plane is  $\mu$ . A horizontal force  $P$  is applied to the highest point of  $S$ . The magnitude of  $P$  is gradually increased.

- (b) Find the range of values of  $\mu$  for which  $S$  will slide before it starts to tilt. (5)



**Question 4 continued**

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Lined writing area for the answer to Question 4.



Question 4 continued

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Question 4 continued

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(Total for Question 4 is 9 marks)



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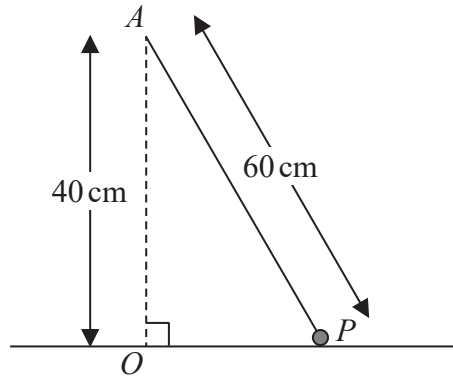


Figure 4

A particle  $P$  of mass  $0.75\text{ kg}$  is attached to one end of a light inextensible string of length  $60\text{ cm}$ . The other end of the string is attached to a fixed point  $A$  that is vertically above the point  $O$  on a smooth horizontal table, such that  $OA = 40\text{ cm}$ . The particle remains in contact with the table, with the string taut, and moves in a horizontal circle with centre  $O$ , as shown in Figure 4.

The particle is moving with a constant angular speed of  $3$  radians per second.

- (a) Find
- (i) the tension in the string,
  - (ii) the normal reaction between  $P$  and the table.
- (7)

The angular speed of  $P$  is now gradually increased.

- (b) Find the angular speed of  $P$  at the instant  $P$  loses contact with the table.
- (4)

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**Question 5 continued**

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**(Total for Question 5 is 11 marks)**



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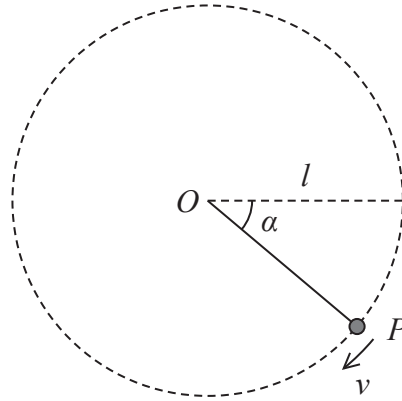


Figure 5

A particle  $P$  of mass  $m$  is attached to one end of a light inextensible string of length  $l$ . The other end of the string is attached to a fixed point  $O$ . The particle is held with the string taut and  $OP$  horizontal. The particle is then projected vertically downwards with speed  $u$ , where  $u^2 = \frac{9}{5}gl$ . When  $OP$  has turned through an angle  $\alpha$  and the string is still taut, the speed of  $P$  is  $v$ , as shown in Figure 5. At this instant the tension in the string is  $T$ .

- (a) Show that  $T = 3mg\sin\alpha + \frac{9}{5}mg$  (6)
- (b) Find, in terms of  $g$  and  $l$ , the speed of  $P$  at the instant when the string goes slack. (3)
- (c) Find, in terms of  $l$ , the greatest vertical height reached by  $P$  above the level of  $O$ . (4)



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Question 6 continued

Lined area for writing the answer to Question 6 continued.



**Question 6 continued**

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**Question 6 continued**

Lined writing area for Question 6 continuation.

**(Total for Question 6 is 13 marks)**



7. A light elastic spring has natural length  $l$  and modulus of elasticity  $4mg$ . A particle  $P$  of mass  $m$  is attached to one end of the spring. The other end of the spring is attached to a fixed point  $A$ . The point  $B$  is vertically below  $A$  with  $AB = \frac{7}{4}l$ . The particle  $P$  is released from rest at  $B$ .

(a) Show that  $P$  moves with simple harmonic motion with period  $\pi\sqrt{\frac{l}{g}}$  (7)

(b) Find, in terms of  $m$ ,  $l$  and  $g$ , the maximum kinetic energy of  $P$  during the motion. (3)

(c) Find the time within each complete oscillation for which the length of the spring is less than  $l$ . (5)





**Question 7 continued**

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**Question 7 continued**

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**Question 7 continued**

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**(Total for Question 7 is 15 marks)**

**TOTAL FOR PAPER IS 75 MARKS**

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