Write your name here Surname	Other nam	nes
Pearson Edexcel Level 3 GCE	Centre Number	Candidate Number
Further M Advanced Further Mathematic		tics
Paper 4: Further Mec	_	
_	hanics 2	Paper Reference <b>9FM0/4F</b>

Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for algebraic 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.
- Answers should be given to three significant figures unless otherwise stated.

## 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 ▶







## Answer ALL questions. Write your answers in the spaces provided.

Unless otherwise indicated, whenever a numerical value of g is required, take  $g = 9.8 \,\mathrm{m \, s^{-2}}$  and give your answer to either 2 significant figures or 3 significant figures.

1. A flag pole is 15 m long.

The flag pole is non-uniform so that, at a distance x metres from its base, the mass per unit length of the flag pole,  $m \log m^{-1}$  is given by the formula  $m = 10 \left( 1 - \frac{x}{25} \right)$ .

The flag pole is modelled as a rod.

(a) Show that the mass of the flag pole is 105 kg.

(3)

(b) Find the distance of the centre of mass of the flag pole from its base.

(4)

Question 1 continued
(Total for Question 1 is 7 marks)
(10tai ioi Question 1 is / marks)

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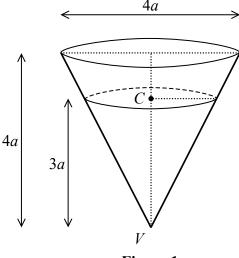


Figure 1

A hollow right circular cone, of base diameter 4a and height 4a is fixed with its axis vertical and vertex V downwards, as shown in Figure 1.

A particle of mass m moves in a horizontal circle with centre C on the rough inner surface of the cone with constant angular speed  $\omega$ .

The height of C above V is 3a.

The coefficient of friction between the particle and the inner surface of the cone is  $\frac{1}{4}$ .

Find, in terms of a and g, the greatest possible value of  $\omega$ .

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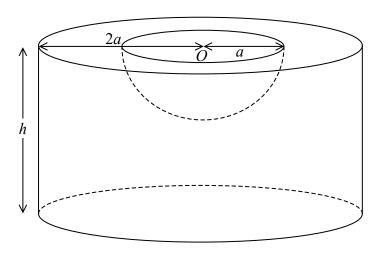


Figure 2

A uniform solid cylinder has radius 2a and height h (h > a).

A solid hemisphere of radius a is removed from the cylinder to form the vessel V.

The plane face of the hemisphere coincides with the upper plane face of the cylinder.

The centre O of the hemisphere is also the centre of the upper plane face of the cylinder, as shown in Figure 2.

(a) Show that the centre of mass of 
$$V$$
 is  $\frac{3(8h^2 - a^2)}{8(6h - a)}$  from  $O$ .

(5)

The vessel V is placed on a rough plane which is inclined at an angle  $\phi$  to the horizontal.

The lower plane circular face of V is in contact with the inclined plane.

Given that h = 5a, the plane is sufficiently rough to prevent V from slipping and V is on the point of toppling,

(b) find, to three significant figures, the size of the angle  $\phi$ .

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Question 3 continued	
	(Total for Question 3 is 9 marks)

**4.** A car of mass 500 kg moves along a straight horizontal road.

The engine of the car produces a constant driving force of 1800 N.

The car accelerates from rest from the fixed point O at time t = 0 and at time t seconds the car is t metres from t0, moving with speed t1 ms<sup>-1</sup>.

When the speed of the car is  $v \, \text{m s}^{-1}$ , the resistance to the motion of the car has magnitude  $2v^2 \, \text{N}$ .

At time T seconds, the car is at the point A, moving with speed  $10 \,\mathrm{m\,s^{-1}}$ .

(a) Show that  $T = \frac{25}{6} \ln 2$ 

(6)

(b) Show that the distance from O to A is  $125 \ln \frac{9}{8}$  m.

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Question 4 continued	
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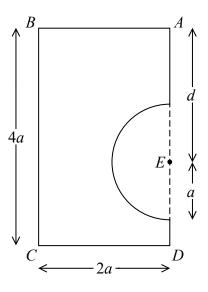


Figure 3

A shop sign is modelled as a uniform rectangular lamina ABCD with a semicircular lamina removed.

The semicircle has radius a, BC = 4a and CD = 2a.

The centre of the semicircle is at the point E on AD such that AE = d, as shown in Figure 3.

(a) Show that the centre of mass of the sign is 
$$\frac{44a}{3(16-\pi)}$$
 from AD.

The sign is suspended using vertical ropes attached to the sign at A and at B and hangs in equilibrium with AB horizontal.

The weight of the sign is W and the ropes are modelled as light inextensible strings.

(b) Find, in terms of W and  $\pi$ , the tension in the rope attached at B.

(2)

The rope attached at B breaks and the sign hangs freely in equilibrium suspended from A, with AD at an angle  $\alpha$  to the downward vertical.

Given that  $a = \frac{11}{18}$ 

(c) find d in terms of a and  $\pi$ .

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Question 5 continued	

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Question 5 continued
(Total for Question 5 is 12 marks)

**6.** A small bead B of mass m is threaded on a circular hoop.

The hoop has centre O and radius a and is fixed in a vertical plane.

The bead is projected with speed  $\sqrt{\frac{7}{2}} ga$  from the lowest point of the hoop.

The hoop is modelled as being smooth.

When the angle between OB and the downward vertical is  $\theta$ , the speed of B is v.

(a) Show that  $v^2 = ga\left(\frac{3}{2} + 2\cos\theta\right)$ 

(3)

(b) Find the size of  $\theta$  at the instant when the contact force between B and the hoop is first zero.

(5)

(c) Give a reason why your answer to part (b) is not likely to be the actual value of  $\theta$ .

(1)

(d) Find the magnitude and direction of the acceleration of B at the instant when B is first at instantaneous rest.

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Question 6 continued

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7.	Two points $A$ and $B$ are 6 m apart on a smooth horizontal surface.	
	A light elastic string of natural length $2  \text{m}$ and modulus of elasticity $20  \text{N}$ , has one end attached to the point $A$ .	
	A second light elastic string of natural length $2 \mathrm{m}$ and modulus of elasticity $50 \mathrm{N}$ , has one end attached to the point $B$ .	e
	A particle $P$ of mass 3.5 kg is attached to the free end of each string.	
	The particle $P$ is held at the point on $AB$ which is $2 \mathrm{m}$ from $B$ and then released from res	t.
	In the subsequent motion both strings remain taut.	
	(a) Show that $P$ moves with simple harmonic motion about its equilibrium position.	(7)
	(b) Find the maximum speed of <i>P</i> .	
		(2)
	(c) Find the length of time within each oscillation for which $P$ is closer to $A$ than to $B$ .	(5)

Question 7 continued		

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Question 7 continued
(Total for Question 7 is 14 marks)
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TOTAL FOR PAPER IS 75 MARKS