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Other names

**Pearson Edexcel**  
**Level 3 GCE**

Centre Number

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Candidate Number

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# Further Mathematics

**Advanced**

**Further Mathematics Option 2**

**Paper 4: Further Mechanics 2**

Sample Assessment Material for first teaching September 2017

**Time: 1 hour 30 minutes**

Paper Reference

**9FM0/4F**

**You must have:**

Mathematical Formulae and Statistical Tables, calculator

Total Marks

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**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 ►

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

Unless otherwise indicated, whenever a numerical value of  $g$  is required, take  $g = 9.8 \text{ m s}^{-2}$  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,  $m \text{ kg m}^{-1}$  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)

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**Question 1 continued**

Ruled area for writing answers.

**(Total for Question 1 is 7 marks)**

2.

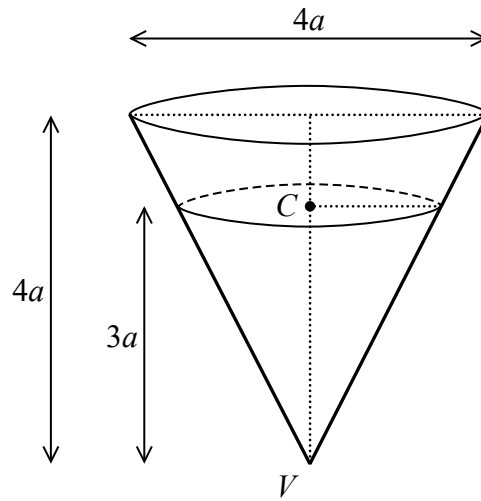


Figure 1

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  $\omega$ .

(8)

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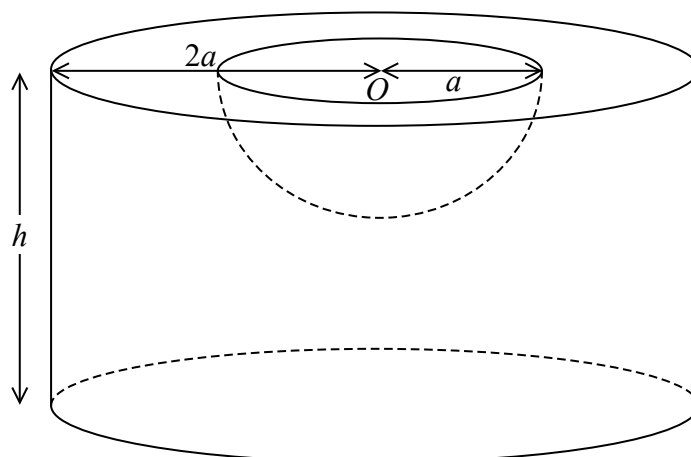


Figure 2

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  $\phi$ . (4)

**Question 3 continued**

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**Question 3 continued**

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**(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  $x$  metres from  $O$ , moving with speed  $v \text{ m s}^{-1}$ .

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  $10 \text{ m s}^{-1}$ .

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

(b) Show that the distance from  $O$  to  $A$  is  $125 \ln \frac{9}{8} \text{ m}$ . (5)



5.

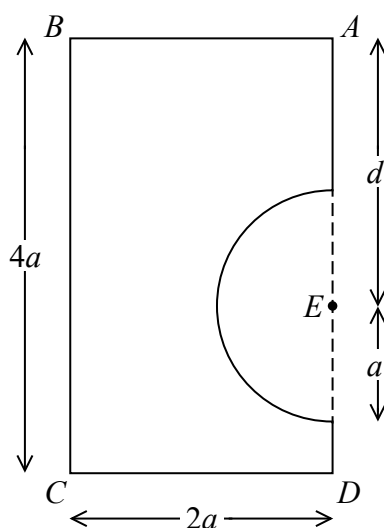


Figure 3

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  $AD$ . (4)

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  $\tan \alpha = \frac{11}{18}$

(c) find  $d$  in terms of  $a$  and  $\pi$ . (6)

**Question 5 continued**

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**Question 5 continued**

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**(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. (5)



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 m and modulus of elasticity 20 N, has one end attached to the point  $A$ .

A second light elastic string of natural length 2 m and modulus of elasticity 50 N, has one end attached to the point  $B$ .

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 m from  $B$  and then released from rest.

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  $P$ . (2)
- (c) Find the length of time within each oscillation for which  $P$  is closer to  $A$  than to  $B$ . (5)

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**Question 7 continued**

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