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Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Mechanics M3

Advanced/Advanced Subsidiary

Wednesday 17 May 2017 – Morning
Time: 1 hour 30 minutes

Paper Reference
WME03/01

You must have:
Mathematical Formulae and Statistical Tables (Blue)

Total Marks

Candidates may use any calculator allowed by the regulations of the Joint Council for Qualifications. 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). Coloured pencils and highlighter pens must not be used.
- **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.
- When a calculator is used, the answer should be given to an appropriate degree of accuracy.

Information

- 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.

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1. The region enclosed by the curve with equation $y = \frac{1}{2}\sqrt{x}$, the x-axis and the lines $x = 2$ and $x = 4$, is rotated through 2π radians about the x-axis to form a uniform solid S. Use algebraic integration to find the exact value of the x coordinate of the centre of mass of S.

(6)

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Question 1 continued

Q1

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2.

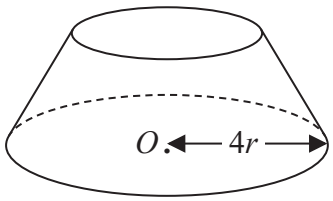

Figure 1

A uniform solid right circular cone R, with vertex V, has base radius $4r$ and height $4h$. A right circular cone S, also with vertex V and the same axis of symmetry as R, has base radius $3r$ and height $3h$. The cone S is cut away from the cone R leaving a solid T. The centre of the larger plane face of T is O. Figure 1 shows the solid T.

(a) Find the distance from O to the centre of mass of T.

(5)

The point A lies on the circumference of the smaller plane face of T. The solid is freely suspended from A and hangs in equilibrium. Given that $h = r$

(b) find the size of the angle between OA and the downward vertical.

(4)

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Question 2 continued

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Question 2 continued

Q2

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3. A particle P of mass 0.5 kg moves in a straight line with simple harmonic motion, completing 4 oscillations per second. The particle comes to instantaneous rest at the fixed points A and B, where $AB = 0.5$ m.

(a) Find the maximum magnitude of the acceleration of P.

(4)

When P is moving at its maximum speed it receives an impulse. The direction of this impulse is opposite to the direction in which P is moving when it receives the impulse. The impulse causes P to reverse its direction of motion but P continues to move with simple harmonic motion. The centre and period of this new simple harmonic motion are the same as the centre and period of the original simple harmonic motion. The amplitude is now half the original amplitude.

(b) Find the magnitude of the impulse.

(5)

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Question 3 continued

Q3

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4. A light elastic string has natural length 0.4 m and modulus of elasticity 49 N. A particle P of mass 0.3 kg is attached to one end of the string. The other end of the string is attached to a fixed point A on a ceiling. The particle is released from rest at A and falls vertically. The particle first comes to instantaneous rest at the point B.

(a) Find the distance AB.

(6)

The particle is now held at the point 0.6 m vertically below A and released from rest.

(b) Find the speed of P immediately before it hits the ceiling.

(5)

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Q4

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5. A particle P of mass 0.4 kg moves on the positive x-axis under the action of a single force.

The force is directed towards the origin O and has magnitude $\frac{k}{x^2}$ newtons, where $OP = x$ metres and k is a constant. Initially P is moving away from O. At $x = 2$ the speed of P is 5 m s^{-1} and at $x = 5$ the speed of P is 2 m s^{-1}.

(a) Find the value of k.

(8)

The particle first comes to instantaneous rest at the point A.

(b) Find the value of x at A.

(4)

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Question 5 continued

Q5

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6. The path followed by a motorcycle round a circular race track is modelled as a horizontal circle of radius 50 m. The track is banked at an angle θ to the horizontal, where $\sin\theta = \frac{3}{5}$.

The motorcycle travels round the track at constant speed. The motorcycle is modelled as a particle and air resistance can be ignored. In an initial model it is assumed that there is no sideways friction between the motorcycle tyres and the track.

(a) Find the speed, in m s^{-1}, of the motorcycle.

(5)

In a refined model it is assumed that there is sideways friction. The coefficient of friction between the motorcycle tyres and the track is $\frac{1}{4}$. It is still assumed that air resistance can be ignored and that the motorcycle is modelled as a particle. The motorcycle's path is unchanged. Using this model,

(b) find the maximum speed, in m s^{-1}, at which the motorcycle can travel without slipping sideways.

(8)

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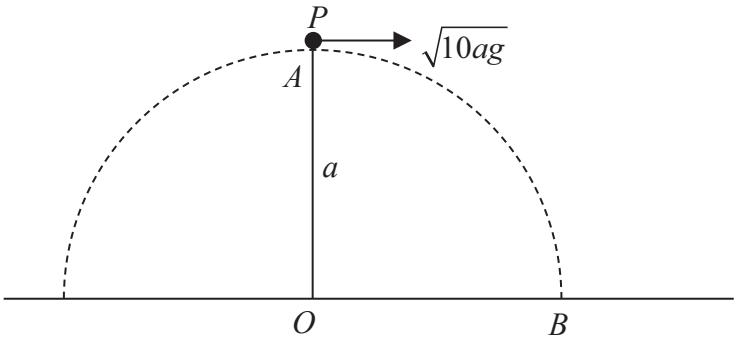

Figure 2

A light inextensible string of length a has one end attached to a fixed point O on a horizontal plane. A particle P is attached to the other end of the string. The particle is held at the point A, where A is vertically above O and $OA = a$. The particle is then projected horizontally with speed $\sqrt{10ag}$, as shown in Figure 2. The particle strikes the plane at the point B. After rebounding from the plane, P passes through A. The coefficient of restitution between the plane and P is e.

(a) Show that $e \geqslant \frac{1}{2}$

(9)

The point C is above the horizontal plane such that $OC = a$ and angle $COB = 120°$

As the particle reaches C, the string breaks. The particle now moves freely under gravity and strikes the plane at the point D.

Given that $e = \frac{\sqrt{3}}{2}$

(b) find the size of the angle between the horizontal and the direction of motion of P at D.

(6)

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Question 7 continued

Q7

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TOTAL FOR PAPER: 75 MARKS

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