Please check the examination details below before entering your candidate information

Candidate surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number	Candidate Number

Thursday 9 January 2020

Afternoon (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 (Blue), 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 $g = 9.8$ 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.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

Turn over ▶

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1. A rough disc is rotating at a constant angular speed of 5 revolutions per minute about a vertical axis. The axis is perpendicular to the plane of the disc and passes through the centre of the disc. A particle, P, of mass m kg is placed on the disc at distance 0.2 m from the axis. The particle does not move relative to the disc. The coefficient of friction between P and the disc is μ.

Find the smallest possible value of μ.

(6)

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Question 1 continued

Q1

(Total 6 marks)

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2. A particle, P, of mass 0.5 kg is moving along the positive x-axis. At time t seconds, $t \geqslant 0$, P is x metres from the origin O and is moving away from O with velocity $v\,\text{m}\,\text{s}^{-1}$, where $v = \dfrac{1}{(4x + 3)}$

When $t = 0$, P is at O.

(a) Find the distance of P from O when $t = 2$

(5)

(b) Find the magnitude of the resultant force acting on P when $t = 2$

(5)

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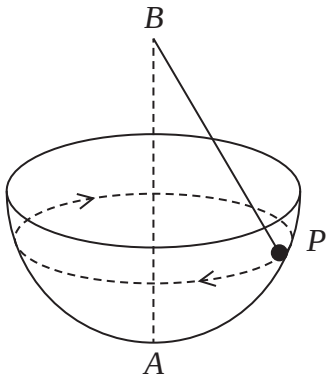

Figure 1

Figure 1 shows a hemispherical bowl of internal radius a fixed with its open plane face uppermost and horizontal. The lowest point of the bowl is A. A light inextensible string of length $a\sqrt{3}$ has one end fixed to the point B, where B is vertically above A and $AB = 2a$. A particle, P, of mass m is attached to the other end of the string.

The particle moves in a horizontal circle on the smooth inner surface of the bowl with constant angular speed ω. The string remains taut and the particle remains in contact with the bowl throughout the motion.

(a) Find, in terms of m, a, ω and g, the tension in the string.

(7)

(b) Show that $\omega \geqslant \sqrt{\dfrac{2g}{3a}}$

(4)

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Question 3 continued

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4. A light elastic string has modulus of elasticity $2mg$ and natural length l. One end of the string is fixed to a point A on a rough plane inclined to the horizontal at angle α, where $\sin\alpha = \frac{3}{5}$. A particle, P, of mass m is attached to the other end of the string. Initially P is held at rest on the plane at the point B, where B is above A and $AB = \frac{1}{2}l$. The string lies along a line of greatest slope of the plane.

The particle P is released from rest and moves down the plane along the line of greatest slope. The coefficient of friction between P and the plane is μ, where $\mu < \tan\alpha$.

Given that P comes to instantaneous rest at the point C, where $AC = l + e$,

(a) show that

$$\mu = \frac{9l^2 + 6le - 10e^2}{4l(3l + 2e)}$$

(6)

Given that $e = l$

(b) find the magnitude of the instantaneous change in the acceleration of P at C.

(5)

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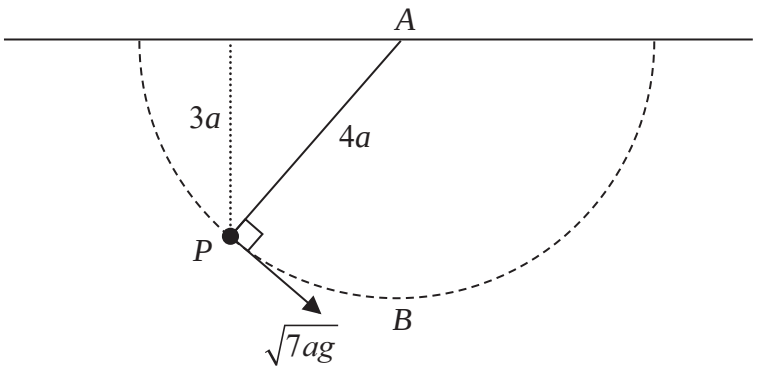

Figure 2

One end of a light inextensible string of length $4a$ is attached to a fixed point A on a horizontal ceiling. A particle, P, of mass m is attached to the other end of the string. The particle is held in equilibrium at a vertical distance $3a$ below the ceiling, with the string taut. The particle is then projected with speed $\sqrt{7ag}$, in the direction perpendicular to the string, in the vertical plane containing A and the string, as shown in Figure 2. In the subsequent motion the string remains taut.

(a) Find the speed of P at the instant before it hits the ceiling.

(4)

The point B is the lowest point of the path of P. The first time P passes through B the tension in the string is T_1 and the second time P passes through B the tension in the string is T_2

Given that the coefficient of restitution between P and the ceiling is $\frac{1}{2}$

(b) find the ratio $T_1 : T_2$ in its simplest form.

(7)

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Q5

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6. A particle, P, of mass 0.4 kg is attached to the midpoint of a light elastic spring of natural length 0.8 m and modulus of elasticity 20 N. The ends of the spring are attached to the fixed points A and B on a smooth horizontal table, where $AB = 1.2$ m. Initially P is at rest at the midpoint O of AB where AOB is a straight line. The particle P now receives an impulse of magnitude 2 Ns so that P starts to move directly towards B.

(a) Prove that P moves with simple harmonic motion.

(4)

(b) Write down, in terms of π, the period of the motion.

(1)

(c) Find the amplitude of the motion.

(3)

(d) Find the length of time in each complete oscillation for which AP is greater than 0.5 m.

(5)

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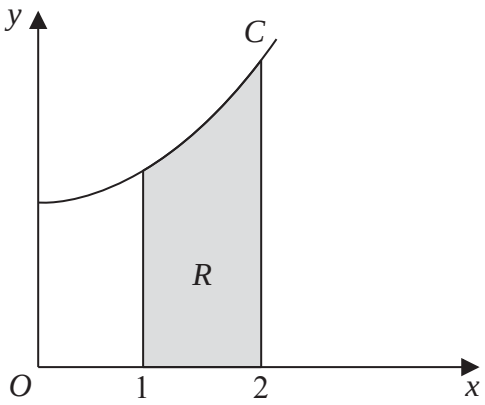

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Figure 3

Figure 3 shows part of the curve C with equation $y = x^2 + 4$. The shaded region R is bounded by C, the line with equation $x = 1$, the x-axis and the line with equation $x = 2$

The unit of length on each axis is one centimetre.

A uniform wooden solid, S, is made in the shape formed by rotating the region R through 360° about the x-axis.

(a) Using algebraic integration,

(i) show that the volume of S is $\frac{613\pi}{15}$ cm^3

(ii) find, to 3 significant figures, the distance of the centre of mass of S from O.

(8)

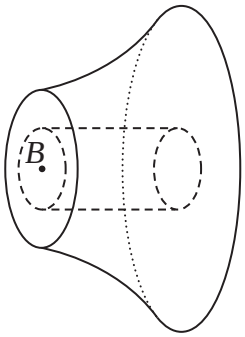

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Figure 4

A solid, S_1, is formed by removing a solid cylinder of radius 3 cm and length 1 cm from S. A metal cylinder, of radius 3 cm and length 1 cm is placed in the resulting hole to form a new solid T, as shown in Figure 4. The axis of the metal cylinder coincides with the axis of symmetry of S_1. The point B is the centre of the smaller plane face of T. The mass per unit volume of S_1 is M and the mass per unit volume of the metal cylinder is $5M$.

(b) Find the distance of the centre of mass of T from B.

(5)

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TOTAL FOR PAPER: 75 MARKS

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