Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number

Candidate Number

Mechanics M3

Advanced/Advanced Subsidiary

Wednesday 18 May 2016 – 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. A particle 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 A. The particle moves with constant angular speed ω in a horizontal circle. The centre of the circle is vertically below A and the radius of the circle is r.

Show that $\omega^2 = \dfrac{g}{\sqrt{l^2 - r^2}}$

(8)

Leave blank

2. A light elastic spring, of natural length $5a$ and modulus of elasticity $10mg$, has one end attached to a fixed point A on a ceiling. A particle P of mass $2m$ is attached to the other end of the spring and P hangs freely in equilibrium at the point O.

(a) Find the distance AO.

(3)

The particle is now pulled vertically downwards a distance $\frac{1}{2}a$ from O and released from rest.

(b) Show that P moves with simple harmonic motion.

(4)

(c) Find the period of the motion.

(2)

P 4 6 7 0 7 A 0 4 2 4

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3. A particle P of mass m is attached to one end of a light elastic string, of natural length l and modulus of elasticity $4mg$. The other end of the string is attached to a fixed point O on a rough horizontal plane. The coefficient of friction between P and the plane is $\frac{2}{5}$. The particle is held at a point A on the plane, where $OA = \frac{5}{4}l$, and released from rest. The particle comes to rest at the point B.

(a) Show that $OB < l$

(4)

(b) Find the distance OB.

(3)

Leave blank

4. A particle P of mass m is fired vertically upwards from a point on the surface of the Earth and initially moves in a straight line directly away from the centre of the Earth. When P is at a distance x from the centre of the Earth, the gravitational force exerted by the Earth on P is directed towards the centre of the Earth and has a magnitude which is inversely proportional to x^2. At the surface of the Earth the acceleration due to gravity is g. The Earth is modelled as a fixed sphere of radius R.

(a) Show that the magnitude of the gravitational force acting on P is $\dfrac{mgR^2}{x^2}$

(2)

The particle was fired with initial speed U and the greatest height above the surface of the Earth reached by P is $\dfrac{R}{20}$

Given that air resistance can be ignored,

(b) find U in terms of g and R.

(7)

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Question 4 continued

P 4 6 7 0 7 A 0 9 2 4

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5. A vertical ladder is fixed to a wall in a harbour. On a particular day the minimum depth of water in the harbour occurs at 0900 hours. The next time the water is at its minimum depth is 2115 hours on the same day. The bottom step of the ladder is 1 m above the lowest level of the water and 9 m below the highest level of the water. The rise and fall of the water level can be modelled as simple harmonic motion and the thickness of the step can be assumed to be negligible.

Find

(a) the speed, in metres per hour, at which the water level is moving when it reaches the bottom step of the ladder,

(7)

(b) the length of time, on this day, between the water reaching the bottom step of the ladder and the ladder being totally out of the water once more.

(4)

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Question 5 continued

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6.

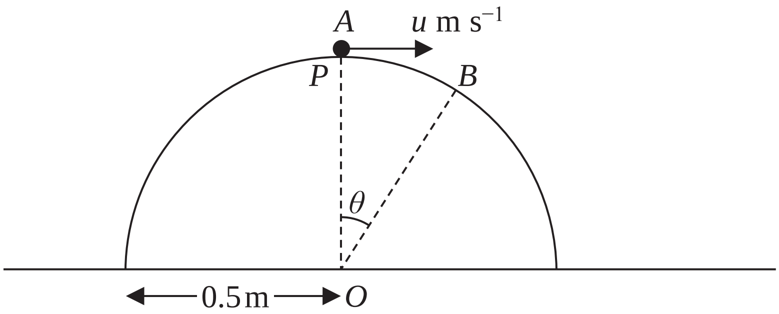

Figure 1

A smooth solid hemisphere of radius 0.5 m is fixed with its plane face on a horizontal floor. The plane face has centre O and the highest point of the surface of the hemisphere is A. A particle P has mass 0.2 kg. The particle is projected horizontally with speed u m s^{-1} from A and leaves the hemisphere at the point B, where OB makes an angle θ with OA, as shown in Figure 1. The point B is at a vertical distance of 0.1 m below the level of A. The speed of P at B is v m s^{-1}

(a) Show that $v^2 = u^2 + 1.96$

(3)

(b) Find the value of u.

(4)

The particle first strikes the floor at the point C.

(c) Find the length of OC.

(7)

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Question 6 continued

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7. (a) Use algebraic integration to show that the centre of mass of a uniform solid right circular cone of height h is at a distance $\frac{3}{4}h$ from the vertex of the cone.

[*You may assume that the volume of a cone of height h and base radius r is* $\frac{1}{3}\pi r^2 h$]

(5)

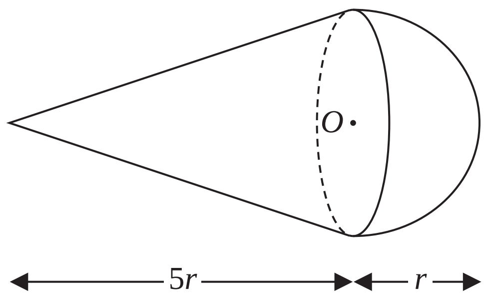

Figure 2

A uniform solid S consists of a right circular cone, of radius r and height $5r$, fixed to a hemisphere of radius r. The centre of the plane face of the hemisphere is O and this plane face coincides with the base of the cone, as shown in Figure 2.

(b) Find the distance of the centre of mass of S from O.

(5)

The point A lies on the circumference of the base of the cone. The solid is suspended by a string attached at A and hangs freely in equilibrium.

(c) Find the size of the angle between OA and the vertical.

(3)

The mass of the hemisphere is M. A particle of mass kM is fixed to the surface of the hemisphere on the axis of symmetry of S. The solid is again suspended by the string attached at A and hangs freely in equilibrium. The axis of symmetry of S is now horizontal.

(d) Find the value of k.

(4)

Leave blank

Question 7 continued