Paper Reference(s)

**6679**

# Edexcel GCE

## Mechanics M3

## Advanced Subsidiary

## Thursday 11 June 2009 – Afternoon

## Time: 1 hour 30 minutes

| Materials required for examination | Items included with question papers |
| --- | --- |
| Mathematical Formulae (Green) | Nil |

**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 formulas stored in them.**

### Instructions to Candidates

In the boxes on the answer book, write the name of the examining body (Edexcel), your centre number, candidate number, the unit title (Mechanics M3), the paper reference (6679), your surname, other name and signature.
Whenever a numerical value of $g$ is required, take $g = 9.8 \text{ m s}^{-2}$.
When a calculator is used, the answer should be given to an appropriate degree of accuracy.

### Information for Candidates

A booklet 'Mathematical Formulae and Statistical Tables' is provided.
Full marks may be obtained for answers to ALL questions.
There are 7 questions in this question paper.
The total mark for this paper is 75.

### Advice to Candidates

You must ensure that your answers to parts of questions are clearly labelled.
You must show sufficient working to make your methods clear to the Examiner.
Answers without working may not gain full credit.

**N34273A**

**1.** A light elastic string has natural length 8 m and modulus of elasticity 80 N. The ends of the string are attached to fixed points $P$ and $Q$ which are on the same horizontal level and 12 m apart. A particle is attached to the mid-point of the string and hangs in equilibrium at a point 4.5 m below $PQ$.

(*a*) Calculate the weight of the particle.

**(6)**

(*b*) Calculate the elastic energy in the string when the particle is in this position.

**(3)**

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**2.** [*The centre of mass of a uniform hollow cone of height h is* $\frac{1}{3}h$ *above the base on the line from the centre of the base to the vertex*.]

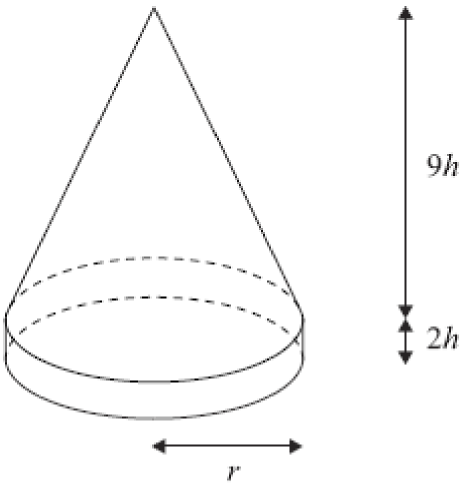


**Figure 1**

A marker for the route of a charity walk consists of a uniform hollow cone fixed on to a uniform solid cylindrical ring, as shown in Figure 1. The hollow cone has base radius $r$, height $9h$ and mass $m$. The solid cylindrical ring has outer radius $r$, height $2h$ and mass $3m$. The marker stands with its base on a horizontal surface.

(*a*) Find, in terms of $h$, the distance of the centre of mass of the marker from the horizontal surface.

**(5)**

When the marker stands on a plane inclined at arctan $\frac{1}{12}$ to the horizontal it is on the point of toppling over. The coefficient of friction between the marker and the plane is large enough to be certain that the marker will not slip.

(*b*) Find $h$ in terms of $r$.

**(3)**

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**3.**

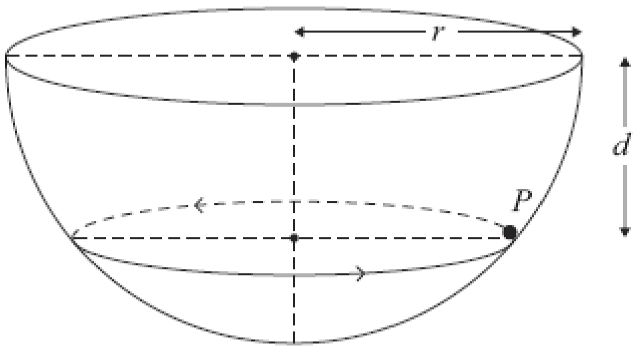


**Figure 2**

A particle $P$ of mass $m$ moves on the smooth inner surface of a hemispherical bowl of radius $r$. The bowl is fixed with its rim horizontal as shown in Figure 2. The particle moves with constant angular speed $\sqrt{\left(\frac{3g}{2r}\right)}$ in a horizontal circle at depth $d$ below the centre of the bowl.

($a$) Find, in terms of $m$ and $g$, the magnitude of the normal reaction of the bowl on $P$.

**(4)**

($b$) Find $d$ in terms of $r$.

**(4)**

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**4.** The finite region bounded by the $x$-axis, the curve $y = \frac{1}{x^2}$, the line $x = \frac{1}{4}$ and the line $x = 1$, is rotated through one complete revolution about the $x$-axis to form a uniform solid of revolution.

($a$) Show that the volume of the solid is $21\pi$.

**(4)**

($b$) Find the coordinates of the centre of mass of the solid.

**(5)**

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**5.** One end of a light inextensible string of length $l$ is attached to a fixed point $A$. The other end is attached to a particle $P$ of mass $m$, which is held at a point $B$ with the string taut and $AP$ making an angle arccos $\frac{1}{4}$, with the downward vertical. The particle is released from rest. When $AP$ makes an angle $\theta$ with the downward vertical, the string is taut and the tension in the string is $T$.

(*a*) Show that

$$T = 3mg\cos\theta - \frac{mg}{2}.$$

**(6)**

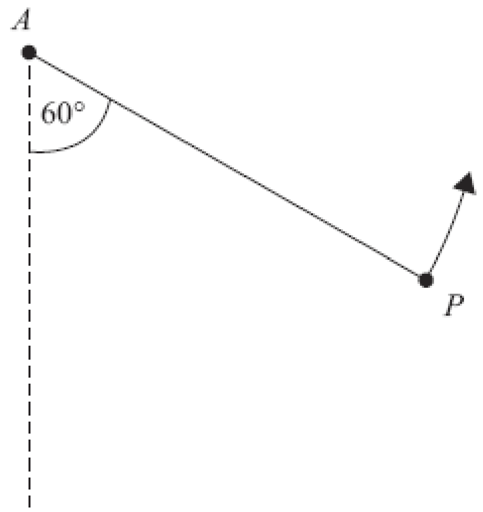


**Figure 3**

At an instant when $AP$ makes an angle of 60° to the downward vertical, $P$ is moving upwards, as shown in Figure 3. At this instant the string breaks. At the highest point reached in the subsequent motion, $P$ is at a distance $d$ below the horizontal through $A$.

(*b*) Find $d$ in terms of $l$.

**(5)**

**6.** A cyclist and her bicycle have a combined mass of 100 kg. She is working at a constant rate of 80 W and is moving in a straight line on a horizontal road. The resistance to motion is proportional to the square of her speed. Her initial speed is 4 m $s^{-1}$ and her maximum possible speed under these conditions is 20 m $s^{-1}$. When she is at a distance $x$ m from a fixed point $O$ on the road, she is moving with speed $v$ m $s^{-1}$ away from $O$.

(*a*) Show that

$$v\frac{dv}{dx} = \frac{8000 - v^3}{10000v}$$

**(5)**

(*b*) Find the distance she travels as her speed increases from 4 m $s^{-1}$ to 8 m $s^{-1}$.

**(5)**

(*c*) Use the trapezium rule, with 2 intervals, to estimate how long it takes for her speed to increase from 4 m $s^{-1}$ to 8 m $s^{-1}$.

**(4)**

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**7.**

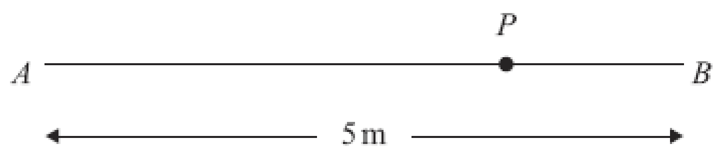


**Figure 4**

$A$ and $B$ are two points on a smooth horizontal floor, where $AB$ = 5 m.

A particle $P$ has mass 0.5 kg. One end of a light elastic spring, of natural length 2 m and modulus of elasticity 16 N, is attached to $P$ and the other end is attached to $A$. The ends of another light elastic spring, of natural length 1 m and modulus of elasticity 12 N, are attached to $P$ and $B$, as shown in Figure 4.

(*a*) Find the extensions in the two springs when the particle is at rest in equilibrium.

**(5)**

Initially $P$ is at rest in equilibrium. It is then set in motion and starts to move towards $B$. In the subsequent motion $P$ does not reach $A$ or $B$.

(*b*) Show that $P$ oscillates with simple harmonic motion about the equilibrium position.

**(4)**

(*c*) Given that the initial speed of $P$ is $\sqrt{10}$ m $s^{-1}$, find the proportion of time in each complete oscillation for which $P$ stays within 0.25 m of the equilibrium position.

**(7)**

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**TOTAL FOR PAPER: 75 MARKS**

**END**