# Edexcel GCE 

## Mechanics M3

## Advanced Level

# Friday 29 January 2010 - Afternoon Time: 1 hour 30 minutes 

\author{


#### Abstract

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 $g=9.8 \mathrm{~m} \mathrm{~s}^{-2}$.
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.

1. A particle $P$ of mass 0.5 kg is moving along the positive $x$-axis. At time $t$ seconds, $P$ is moving under the action of a single force of magnitude $[4+(\cos \pi t)] \mathrm{N}$, directed away from the origin. When $t=1$, the particle $P$ is moving away from the origin with speed $6 \mathrm{~m} \mathrm{~s}^{-1}$.

Find the speed of $P$ when $t=1.5$, giving your answer to 3 significant figures.
2. A particle $P$ moves in a straight line with simple harmonic motion of period 2.4 s about a fixed origin $O$. At time $t$ seconds the speed of $P$ is $v \mathrm{~m} \mathrm{~s}^{-1}$. When $t=0, P$ is at $O$. When $t=0.4, v=4$. Find
(a) the greatest speed of $P$,
(b) the magnitude of the greatest acceleration of $P$.
3.


Figure 1

A bowl $B$ consists of a uniform solid hemisphere, of radius $r$ and centre $O$, from which is removed a solid hemisphere, of radius $\frac{2}{3} r$ and centre $O$, as shown in Figure 1.
(a) Show that the distance of the centre of mass of $B$ from $O$ is $\frac{65}{152} r$.


Figure 2
The bowl $B$ has mass $M$. A particle of mass $k M$ is attached to a point $P$ on the outer rim of $B$. The system is placed with a point $C$ on its outer curved surface in contact with a horizontal plane. The system is in equilibrium with $P, O$ and $C$ in the same vertical plane. The line $O P$ makes an angle $\theta$ with the horizontal as shown in Figure 2. Given that $\tan \theta=\frac{4}{5}$,
(b) find the exact value of $k$.
4.


Figure 3

A particle $P$ of weight 40 N is attached to one end of a light elastic string of natural length 0.5 m . The other end of the string is attached to a fixed point $O$. A horizontal force of magnitude 30 N is applied to $P$, as shown in Figure 3. The particle $P$ is in equilibrium and the elastic energy stored in the string is 10 J .

Calculate the length $O P$.
5.


Figure 4
One end $A$ of a light inextensible string of length $3 a$ is attached to a fixed point. A particle of mass $m$ is attached to the other end $B$ of the string. The particle is held in equilibrium at a distance $2 a$ below the horizontal through $A$, with the string taut. The particle is then projected with speed $\sqrt{ }(2 a g)$, in the direction perpendicular to $A B$, in the vertical plane containing $A$ and $B$, as shown in Figure 4. In the subsequent motion the string remains taut. When $A B$ is at an angle $\theta$ below the horizontal, the speed of the particle is $v$ and the tension in the string is $T$.
(a) Show that $v^{2}=2 \operatorname{ag}(3 \sin \theta-1)$.
(b) Find the range of values of $T$.
6. A bend of a race track is modelled as an arc of a horizontal circle of radius 120 m . The track is not banked at the bend. The maximum speed at which a motorcycle can be ridden round the bend without slipping sideways is $28 \mathrm{~m} \mathrm{~s}^{-1}$. The motorcycle and its rider are modelled as a particle and air resistance is assumed to be negligible.
(a) Show that the coefficient of friction between the motorcycle and the track is $\frac{2}{3}$.

The bend is now reconstructed so that the track is banked at an angle $\alpha$ to the horizontal. The maximum speed at which the motorcycle can now be ridden round the bend without slipping sideways is $35 \mathrm{~m} \mathrm{~s}^{-1}$. The radius of the bend and the coefficient of friction between the motorcycle and the track are unchanged.
(b) Find the value of $\tan \alpha$.
7. A light elastic string has natural length $a$ and modulus of elasticity $\frac{3}{2} m g$. A particle $P$ of mass $m$ is attached to one end of the string. The other end of the string is attached to a fixed point $A$. The particle is released from rest at $A$ and falls vertically. When $P$ has fallen a distance $a+x$, where $x>0$, the speed of $P$ is $v$.
(a) Show that

$$
\begin{equation*}
v^{2}=2 g(a+x)-\frac{3 g x^{2}}{2 a} . \tag{4}
\end{equation*}
$$

(b) Find the greatest speed attained by $P$ as it falls.

After release, $P$ next comes to instantaneous rest at a point $D$.
(c) Find the magnitude of the acceleration of $P$ at $D$.

## END

