UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
Advanced Subsidiary Level and Advanced Level

**MATHEMATICS** **9709/43**

Paper 4 Mechanics 1 **(M1)** **May/June 2012**

**1 hour 15 minutes**

Additional Materials: Answer Booklet/Paper
Graph Paper
List of Formulae (MF9)

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**READ THESE INSTRUCTIONS FIRST**

If you have been given an Answer Booklet, follow the instructions on the front cover of the Booklet.
Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** the questions.
Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place in the case of angles in degrees, unless a different level of accuracy is specified in the question.
Where a numerical value for the acceleration due to gravity is needed, use $10\,\mathrm{m\,s^{-2}}$.
The use of an electronic calculator is expected, where appropriate.
You are reminded of the need for clear presentation in your answers.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.
The total number of marks for this paper is 50.
Questions carrying smaller numbers of marks are printed earlier in the paper, and questions carrying larger numbers of marks later in the paper.

This document consists of **4** printed pages.

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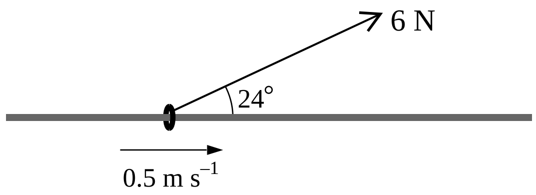
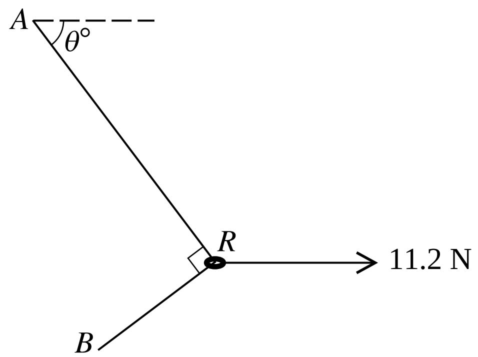
1




A ring is threaded on a fixed horizontal bar. The ring is attached to one end of a light inextensible string which is used to pull the ring along the bar at a constant speed of $0.5\,\mathrm{m\,s^{-1}}$. The string makes a constant angle of 24° with the bar and the tension in the string is 6 N (see diagram). Find the work done by the tension in a period of 8 s. [3]

2




A smooth ring $R$ of mass 0.16 kg is threaded on a light inextensible string. The ends of the string are attached to fixed points $A$ and $B$. A horizontal force of magnitude 11.2 N acts on $R$, in the same vertical plane as $A$ and $B$. The ring is in equilibrium. The string is taut with angle $ARB = 90°$, and the part $AR$ of the string makes an angle of $\theta°$ with the horizontal (see diagram). The tension in the string is $T$ N.

**(i)** Find two simultaneous equations involving $T\sin\theta$ and $T\cos\theta$. [3]

**(ii)** Hence find $T$ and $\theta$. [3]

3 A particle $P$ travels from a point $O$ along a straight line and comes to instantaneous rest at a point $A$. The velocity of $P$ at time $t$ s after leaving $O$ is $v\,\mathrm{m\,s^{-1}}$, where $v = 0.027(10t^2 - t^3)$. Find

**(i)** the distance $OA$, [4]

**(ii)** the maximum velocity of $P$ while moving from $O$ to $A$. [3]

**4** A car of mass 1230 kg increases its speed from $4 \text{ m s}^{-1}$ to $21 \text{ m s}^{-1}$ in 24.5 s. The table below shows corresponding values of time $t$ s and speed $v \text{ m s}^{-1}$.

| $t$ | 0 | 0.5 | 16.3 | 24.5 |
|---|---|---|---|---|
| $v$ | 4 | 6 | 19 | 21 |

**(i)** Using the values in the table, find the average acceleration of the car for $0 < t < 0.5$ and for $16.3 < t < 24.5$. [2]

While the car is increasing its speed the power output of its engine is constant and equal to $P$ W, and the resistance to the car's motion is constant and equal to $R$ N.

**(ii)** Assuming that the values obtained in part **(i)** are approximately equal to the accelerations at $v = 5$ and at $v = 20$, find approximations for $P$ and $R$. [5]

**5** A lorry of mass 16 000 kg moves on a straight hill inclined at angle $\alpha°$ to the horizontal. The length of the hill is 500 m.

**(i)** While the lorry moves from the bottom to the top of the hill at constant speed, the resisting force acting on the lorry is 800 N and the work done by the driving force is 2800 kJ. Find the value of $\alpha$. [4]

**(ii)** On the return journey the speed of the lorry is $20 \text{ m s}^{-1}$ at the top of the hill. While the lorry travels down the hill, the work done by the driving force is 2400 kJ and the work done against the resistance to motion is 800 kJ. Find the speed of the lorry at the bottom of the hill. [4]

**6**

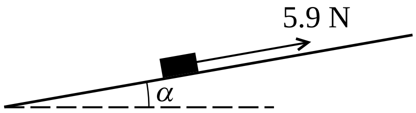



**Fig. 1**

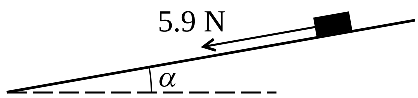



**Fig. 2**

A block of weight 6.1 N is at rest on a plane inclined at angle $\alpha$ to the horizontal, where $\tan \alpha = \frac{11}{60}$. The coefficient of friction between the block and the plane is $\mu$. A force of magnitude 5.9 N acting parallel to a line of greatest slope is applied to the block.

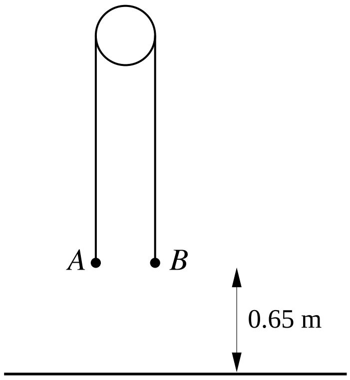
**(i)** When the force acts up the plane (see Fig. 1) the block remains at rest. Show that $\mu \geqslant \frac{4}{5}$. [5]

**(ii)** When the force acts down the plane (see Fig. 2) the block slides downwards. Show that $\mu < \frac{7}{6}$. [2]

**(iii)** Given that the acceleration of the block is $1.7 \text{ m s}^{-2}$ when the force acts down the plane, find the value of $\mu$. [2]

**[Question 7 is printed on the next page.]**

7




Two particles $A$ and $B$ have masses 0.12 kg and 0.38 kg respectively. The particles are attached to the ends of a light inextensible string which passes over a fixed smooth pulley. $A$ is held at rest with the string taut and both straight parts of the string vertical. $A$ and $B$ are each at a height of 0.65 m above horizontal ground (see diagram). $A$ is released and $B$ moves downwards. Find

**(i)** the acceleration of $B$ while it is moving downwards, [2]

**(ii)** the speed with which $B$ reaches the ground and the time taken for it to reach the ground. [3]

$B$ remains on the ground while $A$ continues to move with the string slack, without reaching the pulley. The string remains slack until $A$ is at a height of 1.3 m above the ground for a second time. At this instant $A$ has been in motion for a total time of $T$ s.

**(iii)** Find the value of $T$ and sketch the velocity-time graph for $A$ for the first $T$ s of its motion. [3]

**(iv)** Find the total distance travelled by $A$ in the first $T$ s of its motion. [2]