Section G (Mechanics 1)

Marks

Answer all the questions.

Answer these questions in a separate answer book, showing clearly the section chosen.

Where appropriate, candidates should take the magnitude of the acceleration due to gravity as $9{\cdot}8\ \text{m s}^{-2}$.

G1. A particle, initially at rest, is projected from the origin with acceleration $(12 - 3t^2)\mathbf{i}\ \text{m s}^{-2}$, where $\mathbf{i}$ is the unit vector in the direction of motion, and t is the time measured in seconds from the start of the motion.

Determine the position of the particle when it next comes to rest. **4**

G2. Motorcyclist A has uniform acceleration $-2\mathbf{j}\ \text{m s}^{-2}$, initial velocity $\mathbf{i}\ \text{m s}^{-1}$ and initial position $-\mathbf{i}$ metres relative to a rectangular coordinate system with unit vectors $\mathbf{i}$, $\mathbf{j}$ in the x, y directions respectively.

(*a*) Find the position $\mathbf{r}_A(t)$ of the motorcyclist A at time t seconds, where t is measured from the start of the motion. **2**

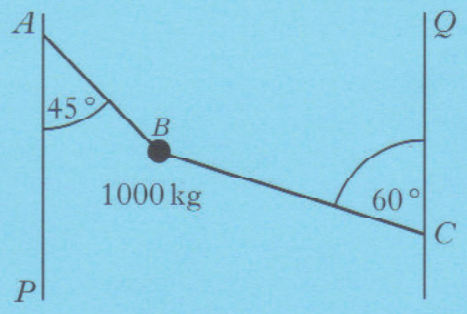
The position of a second motorcyclist B relative to the same coordinate system as A is

$$\mathbf{r}_B(t) = (2t - 3)\mathbf{i} + (1 - t^2)\mathbf{j}.$$

(*b*) (i) Find the position of A relative to B. **1**

(ii) Calculate the minimum distance between the motorcyclists. **3**

G3. On a construction site, a 1000 kg concrete block is supported in equilibrium by two light inextensible chains AB and BC, attached to the block at B, as shown below.



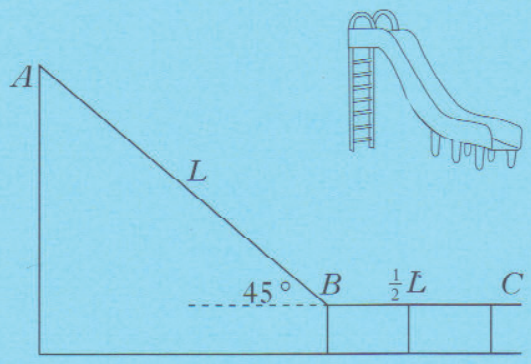
PA and CQ are vertical with $\angle PAB = 45°$ and $\angle BCQ = 60°$. The tensions in the chains over sections AB and BC are denoted by T_1 and T_2 respectively.

(*a*) By resolving the forces horizontally, find a relationship between T_1 and T_2. **2**

(*b*) Calculate the tension T_2. **3**

Marks

G4. The diagram below shows a slide in a playground. The section AB of the chute has length L metres and is inclined at an angle of 45° to the horizontal, whereas section BC is horizontal and has length $\frac{1}{2}L$ metres.



Starting from rest, Jill slides down the chute from A to C. Over both sections of the chute a frictional force acts on Jill where the coefficient of friction between her and the chute is $\frac{1}{2}$.

(*a*) Find the speed of Jill at the point B. **4**

(*b*) Assuming that there is no change of speed as Jill moves from the sloping part of the slide to its horizontal part, show that her speed at C is given by

$$\sqrt{\frac{gL(\sqrt{2}-1)}{2}} \text{ m s}^{-1},$$

where g m s^{-2} is the magnitude of the acceleration due to gravity. **3**

G5. A missile is launched from ground level with speed V m s^{-1} at an angle of 30° to the horizontal.

(*a*) Show that the height y metres of the missile at time t is given by

$$y = \tfrac{1}{2}t\,(V - gt),$$

where g m s^{-2} is the magnitude of the acceleration due to gravity, and t is measured in seconds from the moment of launch. **3**

(*b*) Find the maximum height H attained by the missile, giving your answer in terms of V and g. **2**

(*c*) A missile is detected on radar if $y \geq \frac{1}{4}H$. Show that the missile appears on radar for $\dfrac{\sqrt{3}V}{2g}$ seconds. **5**

[END OF SECTION G]

[END OF QUESTION PAPER]