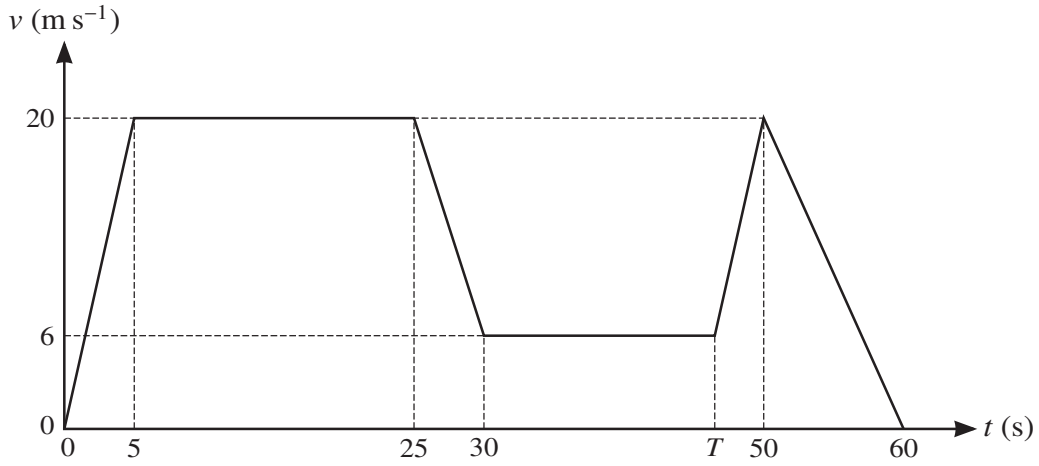
**1**




The diagram shows a velocity-time graph which models the motion of a car. The graph consists of six straight line segments. The car accelerates from rest to a speed of $20\,\text{m s}^{-1}$ over a period of 5 s, and then travels at this speed for a further 20 s. The car then decelerates to a speed of $6\,\text{m s}^{-1}$ over a period of 5 s. This speed is maintained for a further $(T - 30)$ s. The car then accelerates again to a speed of $20\,\text{m s}^{-1}$ over a period of $(50 - T)$ s, before decelerating to rest over a period of 10 s.

**(a)** Given that during the two stages of the motion when the car is accelerating, the accelerations are equal, find the value of $T$. [2]

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**(b)** Find the total distance travelled by the car during the motion. [2]

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**2** A van of mass 3600 kg is towing a trailer of mass 1200 kg along a straight horizontal road using a light horizontal rope. There are resistance forces of 700 N on the van and 300 N on the trailer.

**(a)** The driving force exerted by the van is 2500 N.

Find the tension in the rope. [4]

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The driving force is now removed and the van driver applies a braking force which acts only on the van. The resistance forces remain unchanged.

**(b)** Find the least possible value of the braking force which will cause the rope to become slack. [2]

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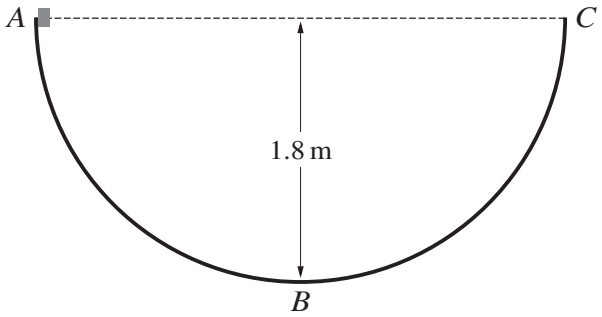
**3**




The diagram shows a semi-circular track $ABC$ of radius 1.8 m which is fixed in a vertical plane. The points $A$ and $C$ are at the same horizontal level and the point $B$ is at the bottom of the track. The section $AB$ is smooth and the section $BC$ is rough. A small block is released from rest at $A$.

**(a)** Show that the speed of the block at $B$ is $6\,\text{m}\,\text{s}^{-1}$. [2]

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The block comes to instantaneous rest for the first time at a height of 1.2 m above the level of $B$. The work done against the resistance force during the motion of the block from $B$ to this point is 4.5 J.

**(b)** Find the mass of the block. [3]

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**4** A cyclist starts from rest at a point $A$ and travels along a straight road $AB$, coming to rest at $B$. The displacement of the cyclist from $A$ at time $t$ s after the start is $s$ m, where

$$s = 0.004(75t^2 - t^3).$$

**(a)** Show that the distance $AB$ is 250 m. [4]

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**(b)** Find the maximum velocity of the cyclist. [3]

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**5** A railway engine of mass 75 000 kg is moving up a straight hill inclined at an angle $\alpha$ to the horizontal, where $\sin\alpha = 0.01$. The engine is travelling at a constant speed of $30\,\text{m}\,\text{s}^{-1}$. The engine is working at 960 kW. There is a constant force resisting the motion of the engine.

**(a)** Find the resistance force. [3]

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The engine comes to a section of track which is horizontal. At the start of the section the engine is travelling at $30\,m\,s^{-1}$ and the power of the engine is now reduced to 900 kW. The resistance to motion is no longer constant, but in the next 60 s the work done against the resistance force is 46 500 kJ.

**(b)** Find the speed of the engine at the end of the 60 s. [4]

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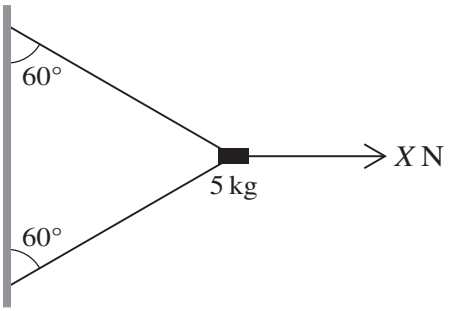
**6**




A block of mass 5 kg is held in equilibrium near a vertical wall by two light strings and a horizontal force of magnitude $X$ N, as shown in the diagram. The two strings are both inclined at 60° to the vertical.

**(a)** Given that $X = 100$, find the tension in the lower string. [4]

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**(b)** Find the least value of $X$ for which the block remains in equilibrium in the position shown. [4]

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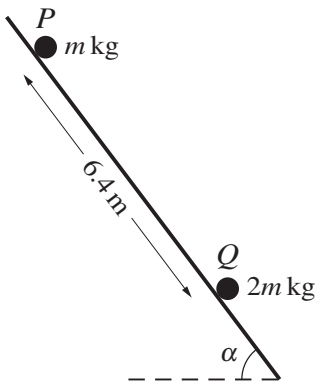
**7**




Particles $P$ and $Q$ have masses $m$ kg and $2m$ kg respectively. The particles are initially held at rest 6.4 m apart on the same line of greatest slope of a rough plane inclined at an angle $\alpha$ to the horizontal, where $\sin\alpha = 0.8$ (see diagram). Particle $P$ is released from rest and slides down the line of greatest slope. Simultaneously, particle $Q$ is projected up the same line of greatest slope at a speed of $10\,\text{m s}^{-1}$. The coefficient of friction between each particle and the plane is 0.6.

**(a)** Show that the acceleration of $Q$ up the plane is $-11.6\,\text{m s}^{-2}$. [4]

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**(b)** Find the time for which the particles are in motion before they collide. [5]

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**(c)** The particles coalesce on impact.

Find the speed of the combined particle immediately after the impact. [4]

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