1 A crane is used to raise a block of mass 600 kg vertically upwards at a constant speed through a height of 15 m. There is a resistance to the motion of the block, which the crane does 10 000 J of work to overcome.

(a) Find the total work done by the crane. [2]

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(b) Given that the average power exerted by the crane is 12.5 kW, find the total time for which the block is in motion. [2]

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

2 A particle P is projected vertically upwards from horizontal ground with speed $u\,\text{m s}^{-1}$. P reaches a maximum height of 20 m above the ground.

(a) Find the value of u. [2]

.....

.....

.....

.....

.....

.....

.....

.....

.....

(b) Find the total time for which P is at least 15 m above the ground. [3]

.....

.....

.....

.....

.....

.....

.....

.....

.....

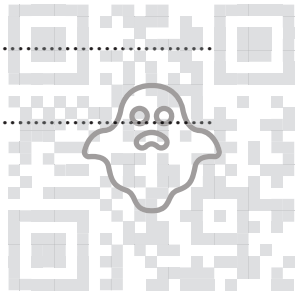
.....

.....

.....

.....

.....



3 A car of mass m kg is towing a trailer of mass 300 kg down a straight hill inclined at 3° to the horizontal at a constant speed. There are resistance forces on the car and on the trailer, and the total work done against the resistance forces in a distance of 50 m is 40 000 J. The engine of the car is doing no work and the tow-bar is light and rigid.

(a) Find the value of m. [3]

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

The resistance force on the trailer is 200 N.

(b) Find the tension in the tow-bar between the car and the trailer. [2]

.....

.....

.....

.....

.....

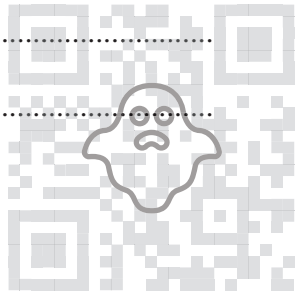
.....

.....

.....

.....

.....

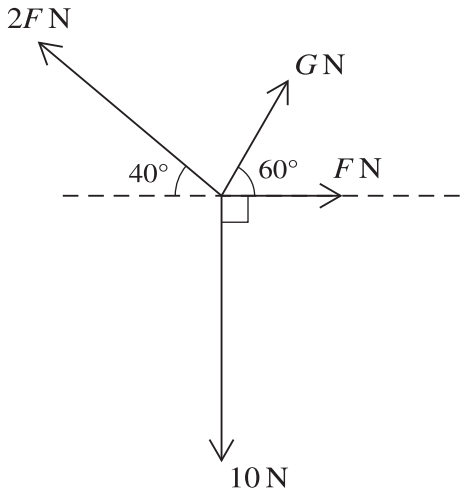


4 The total mass of a cyclist and her bicycle is 70 kg. The cyclist is riding with constant power of 180 W up a straight hill inclined at an angle α to the horizontal, where $\sin\alpha = 0.05$. At an instant when the cyclist's speed is $6\,\text{m s}^{-1}$, her acceleration is $-0.2\,\text{m s}^{-2}$. There is a constant resistance to motion of magnitude F N.

(a) Find the value of F. [4]

(b) Find the steady speed that the cyclist could maintain up the hill when working at this power. [2]

5



Four coplanar forces act at a point. The magnitudes of the forces are 10 N, F N, G N and $2F$ N. The directions of the forces are as shown in the diagram.

(a) Given that the forces are in equilibrium, find the values of F and G. [5]

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(b) Given instead that $F = 3$, find the value of G for which the resultant of the forces is perpendicular to the 10 N force. [2]

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

6 A cyclist starts from rest at a fixed point O and moves in a straight line, before coming to rest k seconds later. The acceleration of the cyclist at time t s after leaving O is $a\,\text{m s}^{-2}$, where $a = 2t^{-\frac{1}{2}} - \frac{3}{5}t^{\frac{1}{2}}$ for $0 < t \leqslant k$.

(a) Find the value of k. [4]

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

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

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(c) Find an expression for the displacement from O in terms of t. Hence find the total distance travelled by the cyclist from the time at which she reaches her maximum speed until she comes to rest. [4]

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

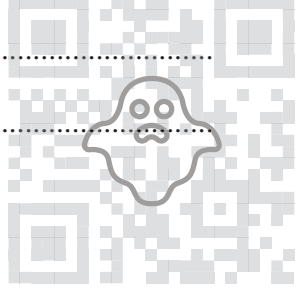
.....

.....

.....

.....

.....



7 A bead, A, of mass 0.1 kg is threaded on a long straight rigid wire which is inclined at $\sin^{-1}\left(\frac{7}{25}\right)$ to the horizontal. A is released from rest and moves down the wire. The coefficient of friction between A and the wire is μ. When A has travelled 0.45 m down the wire, its speed is 0.6 m s^{-1}.

(a) Show that $\mu = 0.25$. [6]

Another bead, B, of mass 0.5 kg is also threaded on the wire. At the point where A has travelled 0.45 m down the wire, it hits B which is instantaneously at rest on the wire. A is brought to instantaneous rest in the collision. The coefficient of friction between B and the wire is 0.275.

(b) Find the time from when the collision occurs until A collides with B again. [6]