1 A crate of mass 200 kg is being pulled at constant speed along horizontal ground by a horizontal rope attached to a winch. The winch is working at a constant rate of 4.5 kW and there is a constant resistance to the motion of the crate of magnitude 600 N.

(a) Find the time that it takes for the crate to move a distance of 15 m. [2]

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

The rope breaks after the crate has moved 15 m.

(b) Find the time taken, after the rope breaks, for the crate to come to rest. [3]

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

2 A particle P is projected vertically upwards from horizontal ground with speed $15\,\text{m}\,\text{s}^{-1}$.

(a) Find the speed of P when it is 10 m above the ground. [2]

At the same instant that P is projected, a second particle Q is dropped from a height of 18 m above the ground in the same vertical line as P.

(b) Find the height above the ground at which the two particles collide. [3]

3 A particle moves in a straight line starting from rest from a point O. The acceleration of the particle at time t s after leaving O is a m s^{-2}, where $a = 4t^{\frac{1}{2}}$.

(a) Find the speed of the particle when $t = 9$. [2]

.....

.....

.....

.....

.....

.....

.....

.....

.....

(b) Find the time after leaving O at which the speed (in metres per second) and the distance travelled (in metres) are numerically equal. [3]

.....

.....

.....

.....

.....

.....

.....

.....

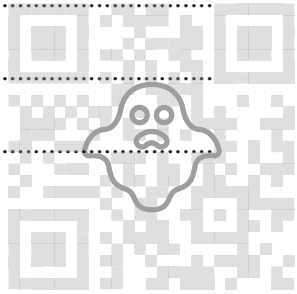
.....

.....

.....

.....

.....



4 A toy railway locomotive of mass 0.8 kg is towing a truck of mass 0.4 kg on a straight horizontal track at a constant speed of $2\,m\,s^{-1}$. There is a constant resistance force of magnitude 0.2 N on the locomotive, but no resistance force on the truck. There is a light rigid horizontal coupling connecting the locomotive and the truck.

(a) State the tension in the coupling. [1]

.....

.....

(b) Find the power produced by the locomotive's engine. [1]

.....

.....

.....

The power produced by the locomotive's engine is now changed to 1.2 W.

(c) Find the magnitude of the tension in the coupling at the instant that the locomotive begins to accelerate. [5]

.....

.....

.....

.....

.....

.....

.....

.....

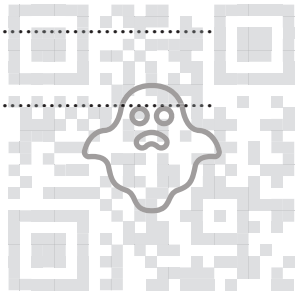
.....

.....

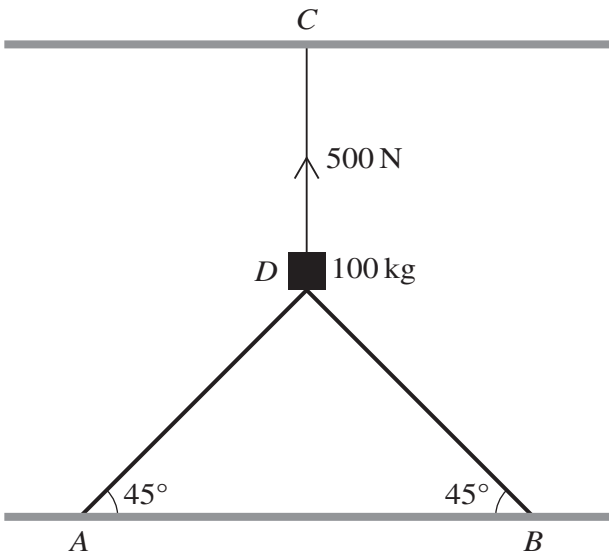
.....

.....

.....



5



The diagram shows a block D of mass 100 kg supported by two sloping struts AD and BD, each attached at an angle of 45° to fixed points A and B respectively on a horizontal floor. The block is also held in place by a vertical rope CD attached to a fixed point C on a horizontal ceiling. The tension in the rope CD is 500 N and the block rests in equilibrium.

(a) Find the magnitude of the force in each of the struts AD and BD. [3]

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

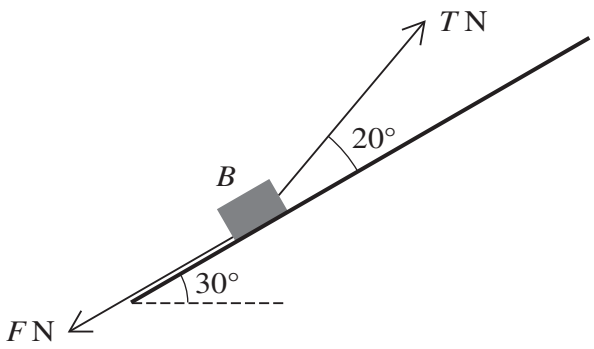
.....

.....

A horizontal force of magnitude F N is applied to the block in a direction parallel to AB.

(b) Find the value of F for which the magnitude of the force in the strut AD is zero. [3]

6



A block B, of mass 2 kg, lies on a rough inclined plane sloping at 30° to the horizontal. A light rope, inclined at an angle of 20° above a line of greatest slope, is attached to B. The tension in the rope is T N. There is a friction force of F N acting on B (see diagram). The coefficient of friction between B and the plane is μ.

(a) It is given that $F = 5$ and that the acceleration of B up the plane is $1.2\,\text{m s}^{-2}$.

(i) Find the value of T. [3]

.....

.....

.....

.....

.....

.....

.....

(ii) Find the value of μ. [3]

.....

.....

.....

.....

.....

.....

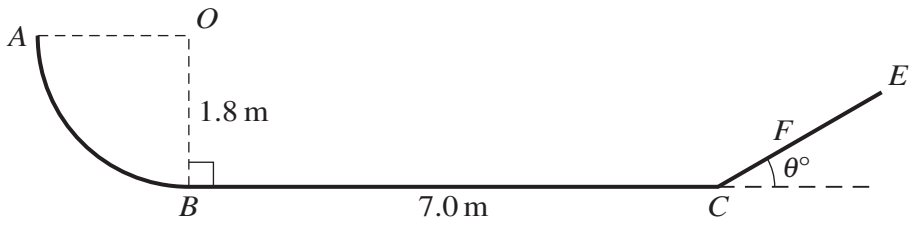
.....

.....

(b) It is given instead that $\mu = 0.8$ and $T = 15$.

Determine whether B will move up the plane. [3]

7



The diagram shows a smooth track which lies in a vertical plane. The section AB is a quarter circle of radius 1.8 m with centre O. The section BC is a horizontal straight line of length 7.0 m and OB is perpendicular to BC. The section CFE is a straight line inclined at an angle of $\theta°$ above the horizontal.

A particle P of mass 0.5 kg is released from rest at A. Particle P collides with a particle Q of mass 0.1 kg which is at rest at B. Immediately after the collision, the speed of P is $4\,\text{m s}^{-1}$ in the direction BC. You should assume that P is moving horizontally when it collides with Q.

(a) Show that the speed of Q immediately after the collision is $10\,\text{m s}^{-1}$. [4]

When Q reaches C, it collides with a particle R of mass 0.4 kg which is at rest at C. The two particles coalesce. The combined particle comes instantaneously to rest at F. You should assume that there is no instantaneous change in speed as the combined particle leaves C, nor when it passes through C again as it returns down the slope.

(b) Given that the distance CF is 0.4 m, find the value of θ. [4]

[Question 7 continues on the next page.]

(c) Find the distance from B at which P collides with the combined particle. [5]