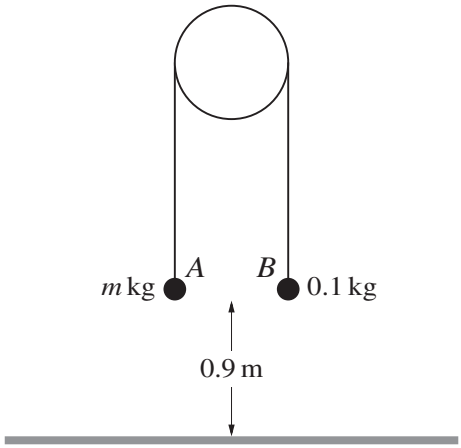
1 A winch operates by means of a force applied by a rope. The winch is used to pull a load of mass 50 kg up a line of greatest slope of a plane inclined at 60° to the horizontal. The winch pulls the load a distance of 5 m up the plane at constant speed. There is a constant resistance to motion of 100 N.

Find the work done by the winch. [3]

2



Two particles A and B have masses m kg and 0.1 kg respectively, where $m > 0.1$. The particles are attached to the ends of a light inextensible string. The string passes over a fixed smooth pulley and the particles hang vertically below it. Both particles are at a height of 0.9 m above horizontal ground (see diagram). The system is released from rest, and while both particles are in motion the tension in the string is 1.5 N. Particle B does not reach the pulley.

(a) Find m. [4]

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(b) Find the speed at which A reaches the ground. [2]

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3 Three particles P, Q and R, of masses 0.1 kg, 0.2 kg and 0.5 kg respectively, are at rest in a straight line on a smooth horizontal plane. Particle P is projected towards Q at a speed of 5 m s^{-1}. After P and Q collide, P rebounds with speed 1 m s^{-1}.

(a) Find the speed of Q immediately after the collision with P. [3]

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Q now collides with R. Immediately after the collision with Q, R begins to move with speed V m s^{-1}.

(b) Given that there is no subsequent collision between P and Q, find the greatest possible value of V. [3]

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4 Two cyclists, Isabella and Maria, are having a race. They both travel along a straight road with constant acceleration, starting from rest at point A.

Isabella accelerates for 5 s at a constant rate $a\,\text{m s}^{-2}$. She then travels at the constant speed she has reached for 10 s, before decelerating to rest at a constant rate over a period of 5 s.

Maria accelerates at a constant rate, reaching a speed of $5\,\text{m s}^{-1}$ in a distance of 27.5 m. She then maintains this speed for a period of 10 s, before decelerating to rest at a constant rate over a period of 5 s.

(a) Given that $a = 1.1$, find which cyclist travels further. [5]

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(b) Find the value of a for which the two cyclists travel the same distance. [2]

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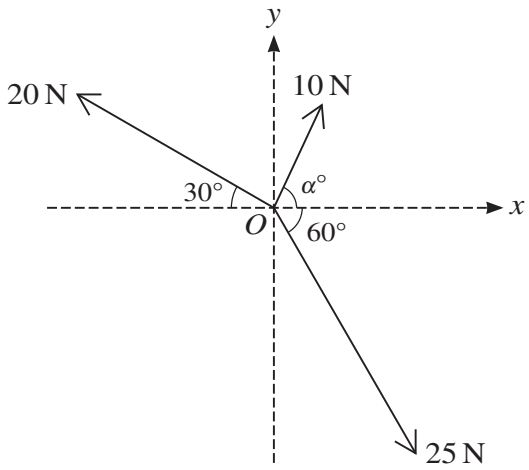
5 A particle moving in a straight line starts from rest at a point A and comes instantaneously to rest at a point B. The acceleration of the particle at time t s after leaving A is a m s^{-2}, where

$$a = 6t^{\frac{1}{2}} - 2t.$$

(a) Find the value of t at point B. [3]

(b) Find the distance travelled from A to the point at which the acceleration of the particle is again zero. [5]

6

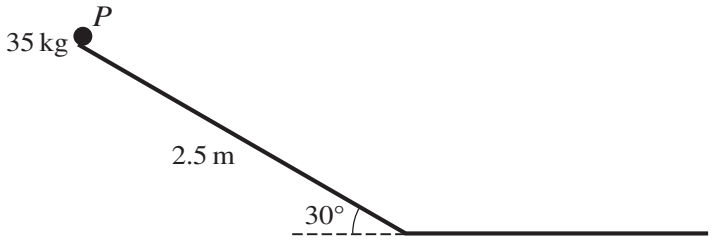


Three coplanar forces of magnitudes 10 N, 25 N and 20 N act at a point O in the directions shown in the diagram.

(a) Given that the component of the resultant force in the x-direction is zero, find α, and hence find the magnitude of the resultant force. [4]

(b) Given instead that $\alpha = 45$, find the magnitude and direction of the resultant of the three forces. [5]

7



A slide in a playground descends at a constant angle of 30° for 2.5 m. It then has a horizontal section in the same vertical plane as the sloping section. A child of mass 35 kg, modelled as a particle P, starts from rest at the top of the slide and slides straight down the sloping section. She then continues along the horizontal section until she comes to rest (see diagram). There is no instantaneous change in speed when the child goes from the sloping section to the horizontal section.

The child experiences a resistance force on the horizontal section of the slide, and the work done against the resistance force on the horizontal section of the slide is 250 J per metre.

(a) It is given that the sloping section of the slide is smooth.

(i) Find the speed of the child when she reaches the bottom of the sloping section. [3]

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(ii) Find the distance that the child travels along the horizontal section of the slide before she comes to rest. [2]

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(b) It is given instead that the sloping section of the slide is rough and that the child comes to rest on the slide 1.05 m after she reaches the horizontal section.

Find the coefficient of friction between the child and the sloping section of the slide. [6]