1 Small smooth spheres A and B, of equal radii and of masses 5 kg and 3 kg respectively, lie on a smooth horizontal plane. Initially B is at rest and A is moving towards B with speed $8.5\,\text{m s}^{-1}$. The spheres collide and after the collision A continues to move in the same direction but with a quarter of the speed of B.

(a) Find the speed of B after the collision. [3]

(b) Find the loss of kinetic energy of the system due to the collision. [2]

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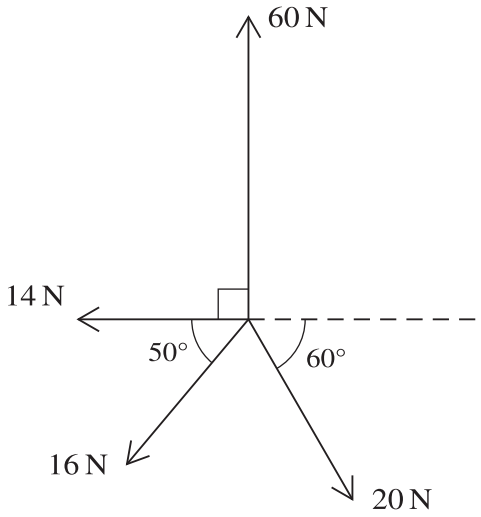

Coplanar forces of magnitudes 60 N, 20 N, 16 N and 14 N act at a point in the directions shown in the diagram.

Find the magnitude and direction of the resultant force. [6]

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3 Two particles A and B, of masses 2.4 kg and 1.2 kg respectively, are connected by a light inextensible string which passes over a fixed smooth pulley. A is held at a distance of 2.1 m above a horizontal plane and B is 1.5 m above the plane. The particles hang vertically and are released from rest. In the subsequent motion A reaches the plane and does not rebound and B does not reach the pulley.

(a) Show that the tension in the string before A reaches the plane is 16 N and find the magnitude of the acceleration of the particles before A reaches the plane. [4]

(b) Find the greatest height of B above the plane. [3]

4 A particle A, moving along a straight horizontal track with constant speed $8\,\text{m}\,\text{s}^{-1}$, passes a fixed point O. Four seconds later, another particle B passes O, moving along a parallel track in the same direction as A. Particle B has speed $20\,\text{m}\,\text{s}^{-1}$ when it passes O and has a constant deceleration of $2\,\text{m}\,\text{s}^{-2}$. B comes to rest when it returns to O.

(a) Find expressions, in terms of t, for the displacement from O of each particle t seconds after B passes O. [3]

(b) Find the values of t when the particles are the same distance from O. [3]

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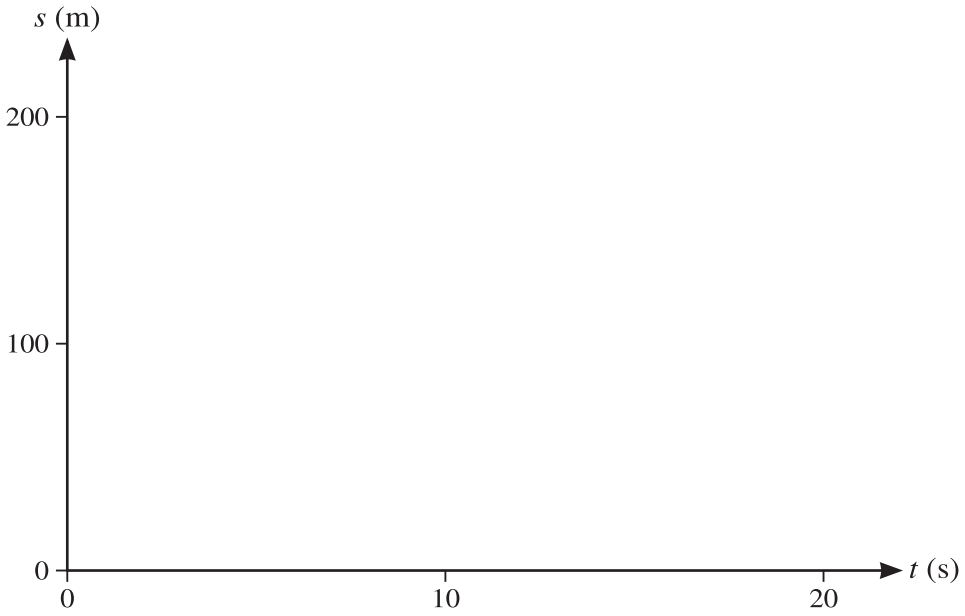
(c) On the given axes, sketch the displacement-time graphs for both particles, for values of t from 0 to 20. [3]



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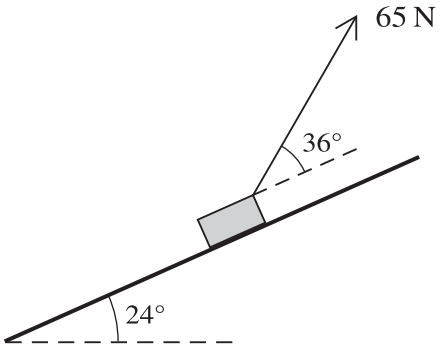

A block of mass 12 kg is placed on a plane which is inclined at an angle of 24° to the horizontal. A light string, making an angle of 36° above a line of greatest slope, is attached to the block. The tension in the string is 65 N (see diagram). The coefficient of friction between the block and plane is μ. The block is in limiting equilibrium and is on the point of sliding up the plane.

Find μ. [6]

6 A car of mass 900 kg is moving up a hill inclined at $\sin^{-1} 0.12$ to the horizontal. The initial speed of the car is $11\,\text{m s}^{-1}$. After 12 s, the car has travelled 150 m up the hill and has speed $16\,\text{m s}^{-1}$. The engine of the car is working at a constant rate of 24 kW.

(a) Find the work done against the resistive forces during the 12 s. [5]

The car then travels along a straight horizontal road. There is a resistance to the motion of the car of $(1520 + 4v)$ N when the speed of the car is $v\,\text{m}\,\text{s}^{-1}$. The car travels at a constant speed with the engine working at a constant rate of 32 kW.

(b) Find this speed. [3]

7 A particle P moves in a straight line. The velocity $v\,\text{m s}^{-1}$ at time t seconds is given by

$$v = 0.5t \qquad \text{for} \quad 0 \leqslant t \leqslant 10,$$
$$v = 0.25t^2 - 8t + 60 \qquad \text{for} \quad 10 \leqslant t \leqslant 20.$$

(a) Show that there is an instantaneous change in the acceleration of the particle at $t = 10$. [3]

(b) Find the total distance covered by P in the interval $0 \leqslant t \leqslant 20$. [6]