Mixed practice 22

1. Two skaters, of masses 58 kg and M kg, stand facing each other on ice. They push away from each other and move with initial accelerations of 3.6 m s^{-2} and 4.1 m s^{-2}. Find the value of M.

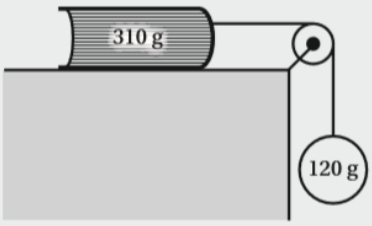
2. A car of mass 850 kg is pulling a trailer of mass 320 kg. The driving force on the car has magnitude 1800 N. The resistance forces acting on the car and the trailer are 450 N and 220 N, respectively. Find:

   a the acceleration of the car

   b the tension in the tow bar.

3. A crate of mass 80 kg lies on a horizontal platform. The platform is being raised and decelerates at 2.6 m s^{-2}. Find the magnitude of the normal reaction force between the crate and the platform.

4. A book of mass 310 g lies on a rough horizontal table. A light inextensible string is attached to the book. The string passes over a smooth pulley fixed at the edge of the table. A ball of mass 120 g is attached to the other end of the string.

   The system is in equilibrium with the string taut. Find the magnitude of the friction force between the book and the table.

5. Two balls are connected and suspended from the ceiling by two light inextensible strings, as shown in the diagram.

   Given that both balls have mass 3 kg, find the tension in each string.

6. A man of mass 70 kg stands on the floor of a lift which is moving with an upward acceleration of 0.3 m s^{-2}. Calculate the magnitude of the force exerted by the floor on the man.

7 A car is pulling a trailer using a light rigid tow bar. The mass of the car is 1200 kg and the mass of the trailer is 350 kg. Assume that any resistances to motion can be ignored.

a The car is moving with a speed of $9.2\ \text{m s}^{-1}$ when it starts to accelerate at $1.8\ \text{m s}^{-2}$. Find the driving force acting on the car.

b The car continues to accelerate uniformly for 4 seconds. It then starts to brake, with uniform deceleration, until it comes to rest. During the braking phase, it travels 26 m. Find the magnitude of the thrust in the tow bar during the braking phase.

8 A person of mass 75 kg stands in a lift of mass 450 kg. The lift is suspended by a light inextensible cable and moving downwards.

a The lift is decelerating at $5.2\ \text{m s}^{-2}$. Find the normal reaction force between the person's feet and the floor of the lift.

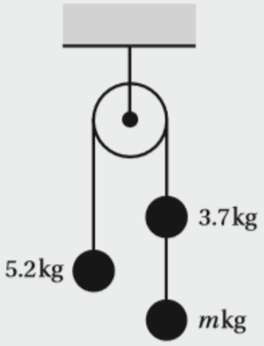
b Given instead that the normal reaction force between the person's feet and the floor of the lift is 577.5 N:

i find the magnitude and direction of the acceleration of the lift

ii calculate the tension in the cable.

9 Two skaters stand on ice 5 m from each other, holding onto the ends of a light inextensible rope. They pull at the rope with a constant force and come together in 1.5 seconds. Any friction can be ignored. Given that the mass of the first skater is 62 kg, and that he moves with acceleration $1.8\ \text{m s}^{-2}$, find the mass of the second skater.

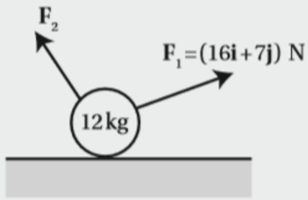
10 In the diagram the three strings can be modelled as light and inextensible and the pulley can be modelled as smooth. The masses of the balls are 5.2 kg, 3.7 kg and m kg. The system hangs in equilibrium in the vertical plane.



a Find the value of m.

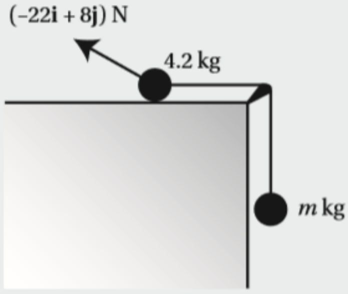
b Find the tension in each string.

11 A particle of mass 12 kg rests in equilibrium on a rough horizontal table, under the action of two forces, $\mathbf{F}_1 = (16\mathbf{i} + 7\mathbf{j})$ N and $\mathbf{F}_2$, as shown in the diagram.



The magnitude of the normal reaction force between the particle and the table is 72 N and the magnitude of the friction force is 9 N. Find the two possible values for the magnitude of $\mathbf{F}_2$.

12 A particle of mass 4.2 kg rests on a rough horizontal table. The magnitude of the frictional force between the particle and the table is 4N. The particle is attached to one end of a light inextensible string which passes over a smooth peg at the edge of the table. Another particle, of mass m kg, is attached to the other end of the string. The system is held in equilibrium by a force $(-22\mathbf{i} + 8\mathbf{j})$ N, as shown in the diagram.



a Find the magnitude of the normal reaction force exerted on the table by the particle.

b Find two possible values for the magnitude of the tension in the string.

c Hence find two possible values of m.

13 A trailer of mass 500 kg is attached to a car of mass 1250 kg by a light rigid horizontal tow-bar. The car and trailer are travelling along a horizontal straight road. The resistance to motion of the trailer is 400 N and the resistance to motion of the car is 900 N. Find both the tension in the tow-bar and the driving force of the car in each of the following cases.

i The car and trailer are travelling at constant speed.

ii The car and trailer have acceleration $0.6\ \mathrm{m\,s^{-2}}$.

14 Particles P and Q, of masses 0.45 kg and m kg respectively, are attached to the ends of a light inextensible string which passes over a small smooth pulley. The particles are released from rest with the string taut and both particles 0.36 m above a horizontal surface. Q descends with acceleration $0.98\ \mathrm{m\,s^{-2}}$. When Q strikes the surface, it remains at rest.

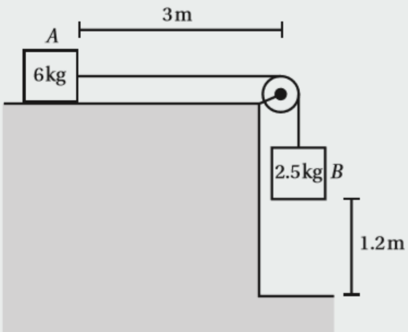
i Calculate the tension in the string while both particles are in motion.

ii Find the value of m.

iii Calculate the speed at which Q strikes the surface.

iv Calculate the greatest height of P above the surface. (You may assume that P does not reach the pulley.)

15 Box A of mass 6 kg is held at rest at one end of a rough horizontal table. The box is attached to one end of a light inextensible string which passes over a smooth pulley fixed to the other end of the table. The length of that part of the string extending from A to the pulley is 3 m. Box B, of mass 2.5 kg, is attached to the other end of the string and hangs 1.2 m above the ground.

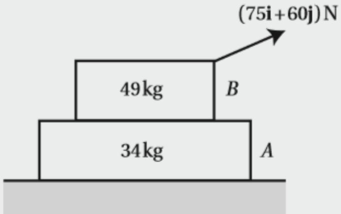


The system is released from rest and moves with acceleration $0.3\ \text{m s}^{-2}$.

a Find the magnitude of the friction force between box A and the table.

b Box B reaches the floor and remains at rest. The magnitude of the friction force between box A and the table remains unchanged. Will box A reach the pulley?

16 Box A, of mass 34 kg, rests on rough horizontal ground. Box B, of mass 49 kg, rests on top of box A. A string is attached to box B and the tension in the string is $(75\mathbf{i} + 60\mathbf{j})$ N. The system is in equilibrium.



Find:

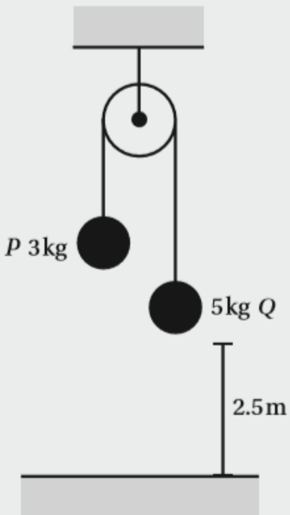
a the magnitude of the normal reaction force between box A and the ground

b the magnitude of the friction force between box A and the ground.

The tension in the string is now changed to $(75k\mathbf{i} + 60k\mathbf{j})$ N and the value of k is increased from 1. The maximum possible friction force between box A and box B is 120 N and the maximum possible friction force between box A and the ground is 180 N.

c Describe how the equilibrium is broken.

17 Particles P and Q, of masses 3 kg and 5 kg, are connected by a light inextensible string. The string passes over a smooth pulley and the particles hang in the vertical plane with Q 2.5 m above the ground.



At time $t = 0$ the system is released from rest with the string taut.

a Find the time required for Q to hit the ground.

Once Q is on the ground, P continues to move. Assume that in subsequent motion, neither particle reaches the pulley.

b Find the greatest height of P above its start point.

c Find the time when the string becomes taut again.

Mixed practice 22

1 50.9 kg

2 a 0.966 m s^{-2} b 529 N

3 576 N

4 1.18 N

5 29.4 N, 58.8 N

6 707 N

7 a 2790 N b 1810 N

8 a 1130 N
b i 2.1 m s^{-2} downwards ii 4040 N

9 42.2 kg

10 a 1.5 b 51.0 N, 14.7 N

11 39.2 N, 46.0 N

12 a 33.16 N b 18 N or 26 N
c 1.84 kg or 2.65 kg

13 a 400 N, 1300 N b 700 N, 2350 N

14 a 4.85 N b 0.55
c 0.84 m s^{-1} d 0.756 m

15 a 22.0 N
b No (stops after total distance of 1.30 m)

16 a 753 N b 75 N
c Box *B* moves on top of box *A*.

17 a 1.43 s b 3.13 m
c 2.14 s