Chapter 2.5

Q1 (a) One possibility is to have the mass of the body decrease as in the case of a rocket where the fuel is being burned and ejected from the rocket.
(b) The question was meant to ask about a decreasing acceleration. That happens when the mass increases as for example cart that is being filled with water or sand while being pulled with a constant force.

Q2 The maximum force can only be 575 N and so the maximum acceleration is $a = \frac{575}{1354} = 0.425 \text{ m s}^{-2}$.

Q3 The acceleration on the body is $a = \frac{1}{1} = 1 \text{ m s}^{-2}$ and so in 1 s the velocity will become $v = at = 1 \text{ m s}^{-1}$.

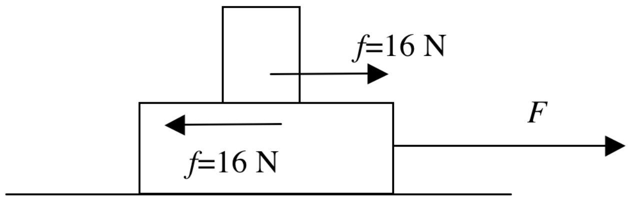
Q4 The largest resultant force is 14.0 N and the least is 6.00 N. The accelerations are therefore $a = \frac{14.0}{2.00} = 7.00 \text{ m s}^{-2}$ and $a = \frac{6.00}{2.00} = 3.00 \text{ m s}^{-2}$.

Q5 The forces on the man are his weight, mg and the reaction force R from the floor.
(a) The acceleration is zero and so $R - mg = 0$, i.e. $R = mg$.
(b) The acceleration is zero and so $R - mg = 0$, i.e. $R = mg$.
(c) The net force is in the downward direction and equals $mg - R$. Hence, $mg - R = ma$ and so $R = mg - ma$.
(d) From (c) we have that $R = mg - mg = 0$.
(e) The man will be hit by the ceiling of the elevator that is coming down faster than the man.

Q6 In cases (a), (b) and (e) the reading is the same and equals the weight of the cage plus the weight of the bird. In (c) it will be greater by an amount *ma* where *m* is the mass of the bird and in (d) less by *ma*.

Q7 As the elevator goes up the force that must be supplied by the arm on the book upwards must increase. Because you are not aware that you have to do that the book "feels" heavier and so moves down a bit. As the elevator comes to a stop the force necessary to keep it up decreases and so the book "fells" less heavy and so moves up a bit. The same thing happens when you start going down. As the elevator comes to a stop on the way down, the force needed to keep it up is again greater than the weight so the book falls.

Q8 The force on the top block pushing it forward is the frictional force between the two blocks. (The top block has a tendency to slide backwards so the frictional force opposes this tendency by being exerted in the forward direction.) By Newton's third law a force of 16 N then acts on the bottom block to the left.



The acceleration of the trop block is then $a = \frac{16}{2.0} = 8.0 \text{ m s}^{-2}$ and that is also the acceleration of the bottom block (since they move together). The net force on the bottom block is $F - 16$ and so $F - 16 = ma = 10.0 \times 8.0 = 80 \Rightarrow F = 96 \text{ N}$.

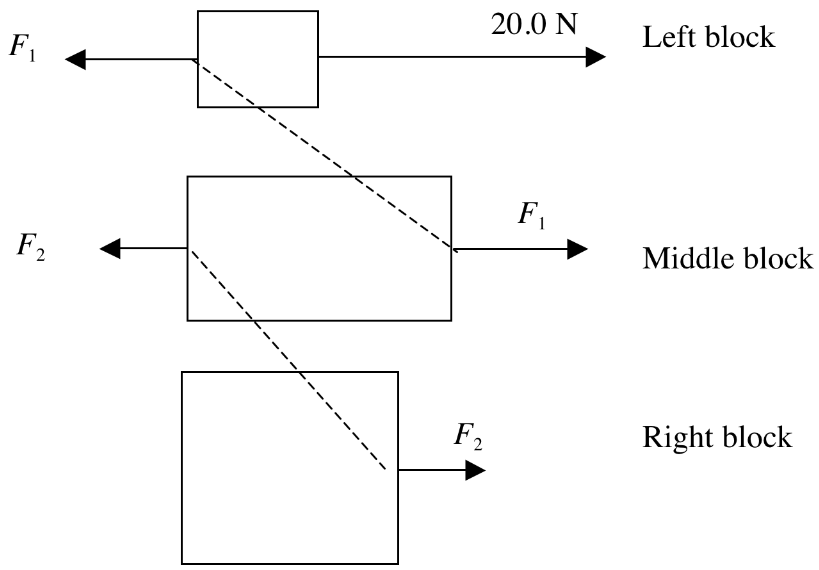
Q9 Three forces are shown.
The first is the tension in the top string acting on the elevator. The reaction to this is a force acting downwards on the pulley.
The second is the reaction from the floor on the man. The reaction to this is a force on the elevator floor vertically downwards.
The third force shown is the force the man exerts on the string. Thus the string pulls the man upwards with the same force.

Q10 The forces on the man *and* the elevator are $2T$ upwards (one T on the elevator at the top and one T on the man from the string). Thus
$2T - 1000 = 100a = 100 \times 0.5 \Rightarrow T = 525 \text{ N}$
The forces on the man give
$R + T - 700 = 70a = 35 \Rightarrow R = 700 - 525 + 35 \Rightarrow T = 210 \text{ N}$

Q11 Both vehicles experience the same force (but the smaller one having the smaller mass experiences a larger acceleration).

Q12 A force of about 800 N upwards on the earth.

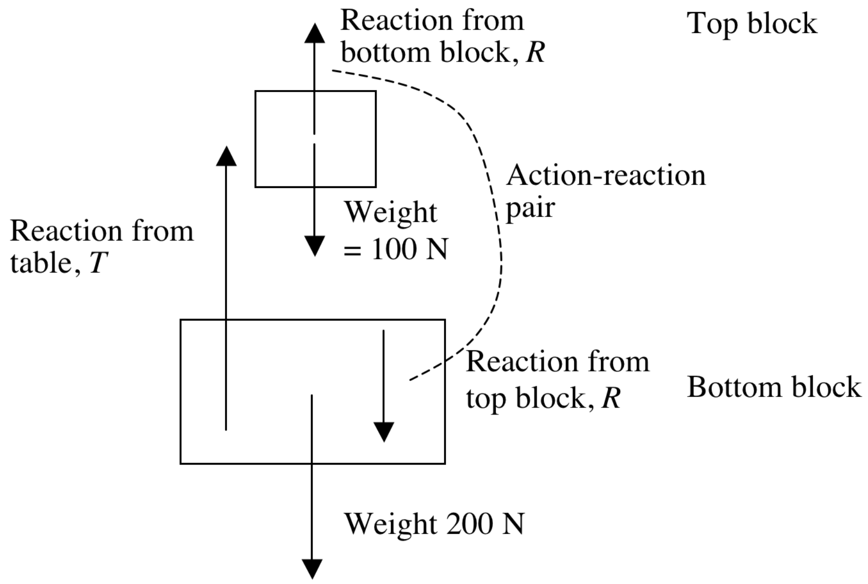
Q13 Treating the three blocks as one of mass 10 kg we see that the acceleration of the blocks is $a = \frac{20.0}{10} = 2.0 \text{ m s}^{-2}$. Now the mass on the right is acted upon by just one force horizontally and so that force is $F_2 = 5.0 \times 2.0 = 10 \text{ N}$. The *net* force on the middle block is $F_1 - F_2 = 3.0 \times 2.0 = 6.0 \text{ N}$ hence $F_1 = 16 \text{ N}$ and that on the left block is $20 - F_1 = 2.0 \times 2.0 = 4.0 \text{ N}$. Hence $F_1 = 24 \text{ N}$. Action reaction pairs are joined by a dotted line.



Q14 The string exerts on the support a force equal to the tension in the string, i.e. about 100 N.

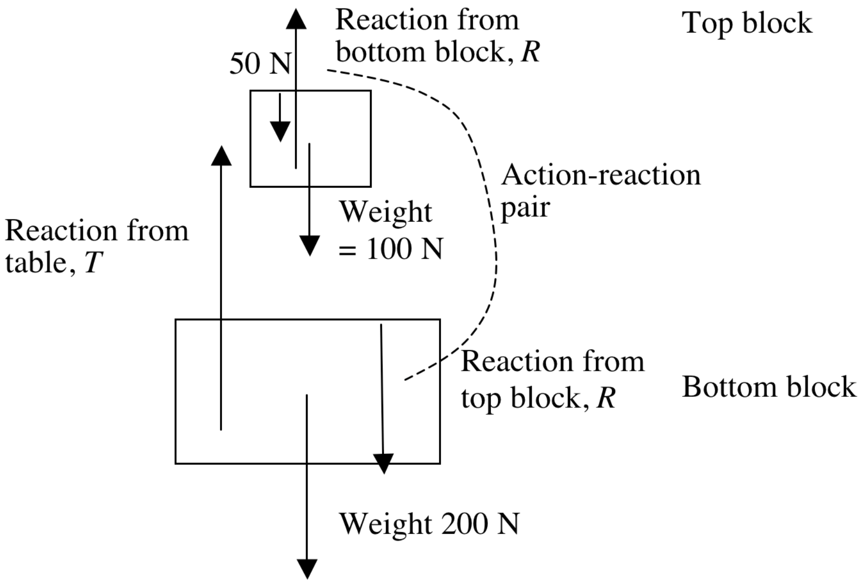
Q15 The downward force on the block is $50+150=200$ N. To have equilibrium this must be the force the table exerts on the block upwards. By Newton's third law this is also the force the block exerts on the table.

Q16 The forces are as shown.



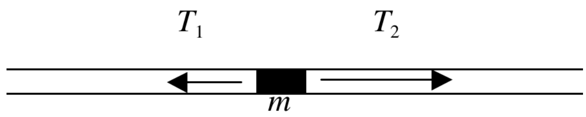
Equilibrium of top block: $R=100$ N.
Equilibrium of bottom block: $R+200=T \Rightarrow T=300$ N.

Q17 The forces are as shown.



Equilibrium of top block: $R = 50 + 100 = 150$ N .
Equilibrium of bottom block: $R + 200 = T \Rightarrow T = 350$ N .

Q18 Suppose the tensions at some point were different.



The net force on the bit of string of mass m is $T_2 - T_1 = ma$. But the string is massless, $m = 0$ and so $T_2 - T_1 = 0$ meaning that the tensions are the same.

Q19 As in Q10,

$$2T - 1000 = 100a \Rightarrow T - 500 = 50a$$
$$300 + T - 700 = 70a$$

These two equations simplify to

$$T - 500 = 50a$$
$$T - 400 = 70a$$

Subtracting gives $100 = 20a$ hence $a = \frac{100}{20} = 5.0 \text{ m s}^{-2}$.

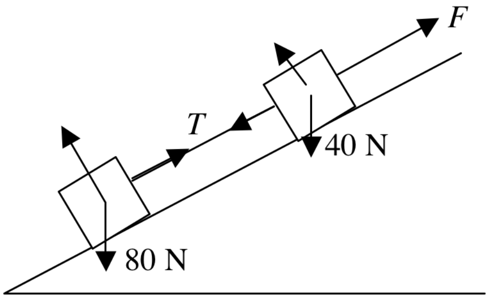
Q20 (a) Treat the two masses as one body. The net force is 60.0 N and so the acceleration is $a = \frac{60.0}{40.0} = 1.50 \text{ m s}^{-2}$. The net force on the back block is the tension in the string and so $T = ma = 10.0 \times 1.50 = 15.0$ N . (b) The tension would now be $T = Ma = 30.0 \times 1.50 = 45.0$ N .

Q21 Treat the balls as one body. The acceleration of this body (and hence of each of the balls) is $a = \frac{100}{100} = 1.0\ \text{m s}^{-2}$. The string in between the 60th and 61st ball accelerates a total mass of 40 kg (the balls from the 61st to the 100th) and so that tension is $T = ma = 40 \times 1.0 = 40\ \text{N}$.

Q22 For three (planar) forces to be in equilibrium, any one force must have a magnitude that is in between the sum and the difference of the other two forces. This is the case here. Now, the resultant of the 4.0 N and the 6.0 N forces must have a magnitude of 9.0 N. This when the 9.0 N force is suddenly removed, the net force on the body is 9.0 N. The acceleration is therefore $a = \frac{9.0}{3.0} = 3.0\ \text{m s}^{-2}$.

Q23 Treating the two blocks as one of mass 12 kg we see that the acceleration of the combined body (and hence of each block) is $a = \frac{24}{12} = 2.0\ \text{m s}^{-2}$. The tension in the string is the net force on the left block and so $T = ma = 10.0 \times 2.0 = 20\ \text{N}$.

Q24 The forces are as shown. The reaction forces on the blocks are irrelevant.



(a) Taking components along the plane we find for the lower body:
$T - 80\sin 30^\circ = 0 \Rightarrow T = 40\ \text{N}$.
(b) Taking components along the plane we find for the lower body:
$T - 80\sin 30^\circ = 8.0 \times 2.0 \Rightarrow T = 56\ \text{N}$.
(c) For the case of no acceleration looking at the top body and using $T = 40\ \text{N}$ we have that $F - T - 40\sin 30^\circ = 0 \Rightarrow F = 60\ \text{N}$. For acceleration, similarly, $T = 56\ \text{N}$ and $F - T - 40\sin 30^\circ = 4.0 \times 2.0 \Rightarrow F = 84\ \text{N}$.

Q25 (a) The graph starts out almost straight indicating that a constant force (only gravity) is acting on the person. However later on the graph starts deviating from a straight line indicating a small air resistance force on the person. At the peak the velocity starts changing abruptly indicating that this is when the parachute opens. The slope of the graph after the peak is greatest just after the peak indicating that this is when we have the maximum acceleration i.e. the parachute opens completely. The slope is never constant after this point indicating that the force of air resistance is not constant.