SUVAT - HORIZONTAL

Exercise 2A

1 A particle is moving in a straight line with constant acceleration $3\,\text{m s}^{-2}$. At time $t = 0$, the speed of the particle is $2\,\text{m s}^{-1}$. Find the speed of the particle at time $t = 6\,\text{s}$.

2 A particle is moving in a straight line with constant acceleration. The particle passes a point with speed $1.2\,\text{m s}^{-1}$. Four seconds later the particle has speed $7.6\,\text{m s}^{-1}$. Find the acceleration of the particle.

3 A car is approaching traffic lights. The car is travelling with speed $10\,\text{m s}^{-1}$. The driver applies the brakes to the car and the car comes to rest with constant deceleration in 16 s. Modelling the car as a particle, find the deceleration of the car.

4 A particle moves in a straight line from a point A to point B with constant acceleration. The particle passes A with speed $2.4\,\text{m s}^{-1}$. The particle passes B with speed $8\,\text{m s}^{-1}$, five seconds after it passed A. Find the distance between A and B.

5 A car accelerates uniformly while travelling on a straight road. The car passes two signposts 360 m apart. The car takes 15 s to travel from one signpost to the other. When passing the second signpost, it has speed $28\,\text{m s}^{-1}$. Find the speed of the car at the first signpost.

6 A particle is moving along a straight line with constant deceleration. The points X and Y are on the line and $XY = 120\,\text{m}$. At time $t = 0$, the particle passes X and is moving towards Y with speed $18\,\text{m s}^{-1}$. At time $t = 10\,\text{s}$, the particle is at Y. Find the velocity of the particle at time $t = 10\,\text{s}$.

7 A cyclist is moving along a straight road from A to B with constant acceleration $0.5\,\text{m s}^{-2}$. Her speed at A is $3\,\text{m s}^{-1}$ and it takes her 12 seconds to cycle from A to B. Find **a** her speed at B, **b** the distance from A to B.

8 A particle is moving along a straight line with constant acceleration from a point A to a point B, where $AB = 24\,\text{m}$. The particle takes 6 s to move from A to B and the speed of the particle at B is $5\,\text{m s}^{-1}$. Find **a** the speed of the particle at A, **b** the acceleration of the particle.

9 A particle moves in a straight line from a point A to a point B with constant deceleration $1.2\,\text{m s}^{-2}$. The particle takes 6 s to move from A to B. The speed of the particle at B is $2\,\text{m s}^{-1}$ and the direction of motion of the particle has not changed. Find **a** the speed of the particle at A, **b** the distance from A to B.

10 A train, travelling on a straight track, is slowing down with constant deceleration $0.6\,\text{m s}^{-2}$. The train passes one signal with speed $72\,\text{km h}^{-1}$ and a second signal 25 s later. Find **a** the speed, in km h^{-1}, of the train as it passes the second signal, **b** the distance between the signals.

11 A particle moves in a straight line from a point A to a point B with a constant deceleration of $4\,\text{m s}^{-2}$. At A the particle has speed $32\,\text{m s}^{-1}$ and the particle comes to rest at B. Find **a** the time taken for the particle to travel from A to B, **b** the distance between A and B.

Ex 2A (cont.)

12 A skier travelling in a straight line up a hill experiences a constant deceleration. At the bottom of the hill, the skier has a speed of $16\,\text{m s}^{-1}$ and, after moving up the hill for 40 s, he comes to rest. Find **a** the deceleration of the skier, **b** the distance from the bottom of the hill to the point where the skier comes to rest.

13 A particle is moving in a straight line with constant acceleration. The points A, B and C lie on this line. The particle moves from A through B to C. The speed of the particle at A is $2\,\text{m s}^{-1}$ and the speed of the particle at B is $7\,\text{m s}^{-1}$. The particle takes 20 s to move from A to B.

a Find the acceleration of the particle.

The speed of the particle is C is $11\,\text{m s}^{-1}$. Find

b the time taken for the particle to move from B to C,

c the distance between A and C.

14 A particle moves in a straight line from A to B with constant acceleration $1.5\,\text{m s}^{-2}$. It then moves, along the same straight line, from B to C with a different acceleration. The speed of the particle at A is $1\,\text{m s}^{-1}$ and the speed of the particle at C is $43\,\text{m s}^{-1}$. The particle takes 12 s to move from A to B and 10 s to move from B to C. Find

a the speed of the particle at B,

b the acceleration of the particle as it moves from B to C,

c the distance from A to C.

15 A cyclist travels with constant acceleration $x\,\text{m s}^{-2}$, in a straight line, from rest to $5\,\text{m s}^{-1}$ in 20 s. She then decelerates from $5\,\text{m s}^{-1}$ to rest with constant deceleration $\frac{1}{2}x\,\text{m s}^{-2}$. Find **a** the value of x, **b** the total distance she travelled.

16 A particle is moving with constant acceleration in a straight line. It passes through three points, A, B and C with speeds $20\,\text{m s}^{-1}$, $30\,\text{m s}^{-1}$ and $45\,\text{m s}^{-1}$ respectively. The time taken to move from A to B is t_1 seconds and the time taken to move from B to C is t_2 seconds.

a Show that $\frac{t_1}{t_2} = \frac{2}{3}$.

Given also that the total time taken for the particle to move from A to C is 50 s,

b find the distance between A and B.

Exercise 2B

1 A particle is moving in a straight line with constant acceleration $2.5\,\text{m s}^{-2}$. It passes a point A with speed $3\,\text{m s}^{-1}$ and later passes through a point B, where $AB = 8\,\text{m}$. Find the speed of the particle as it passes through B.

2 A car is accelerating at a constant rate along a straight horizontal road. Travelling at $8\,\text{m s}^{-1}$, it passes a pillar box and 6 s later it passes a sign. The distance between the pillar box and the sign is 60 m. Find the acceleration of the car.

Ex 2B (cont)

3 A cyclist travelling at $12\,\text{m s}^{-1}$ applies her brakes and comes to rest after travelling 36 m in a straight line. Assuming that the brakes cause the cyclist to decelerate uniformly, find the deceleration.

4 A particle moves along a straight line from P to Q with constant acceleration $1.5\,\text{m s}^{-2}$. The particle takes 4 s to pass from P to Q and $PQ = 22\,\text{m}$. Find the speed of the particle at Q.

5 A particle is moving along a straight line OA with constant acceleration $2\,\text{m s}^{-2}$. At O the particle is moving towards A with speed $5.5\,\text{m s}^{-1}$. The distance OA is 20 m. Find the time the particle takes to move from O to A.

6 A train is moving along a straight horizontal track with constant acceleration. The train passes a signal at $54\,\text{km h}^{-1}$ and a second signal at $72\,\text{km h}^{-1}$. The distance between the two signals is 500 m. Find, in m s^{-2}, the acceleration of the train.

7 A particle moves along a straight line, with constant acceleration, from a point A to a point B where $AB = 48\,\text{m}$. At A the particle has speed $4\,\text{m s}^{-1}$ and at B it has speed $16\,\text{m s}^{-1}$. Find **a** the acceleration of the particle, **b** the time the particle takes to move from A to B.

8 A particle moves along a straight line with constant acceleration $3\,\text{m s}^{-2}$. The particle moves 38 m in 4 s. Find **a** the initial speed of the particle, **b** the final speed of the particle.

9 The driver of a car is travelling at $18\,\text{m s}^{-1}$ along a straight road when she sees an obstruction ahead. She applies the brakes and the brakes cause the car to slow down to rest with a constant deceleration of $3\,\text{m s}^{-2}$. Find **a** the distance travelled as the car decelerates, **b** the time it takes for the car to decelerate from $18\,\text{m s}^{-1}$ to rest.

10 A stone is sliding across a frozen lake in a straight line. The initial speed of the stone is $12\,\text{m s}^{-1}$. The friction between the stone and the ice causes the stone to slow down at a constant rate of $0.8\,\text{m s}^{-2}$. Find **a** the distance moved by the stone before coming to rest, **b** the speed of the stone at the instant when it has travelled half of this distance.

11 A particle is moving along a straight line OA with constant acceleration $2.5\,\text{m s}^{-2}$. At time $t = 0$, the particle passes through O with speed $8\,\text{m s}^{-1}$ and is moving in the direction OA. The distance OA is 40 m. Find **a** the time taken for the particle to move from O to A, **b** the speed of the particle at A. Give your answers to one decimal place.

12 A particle travels with uniform deceleration $2\,\text{m s}^{-2}$ in a horizontal line. The points A and B lie on the line and $AB = 32\,\text{m}$. At time $t = 0$, the particle passes through A with velocity $12\,\text{m s}^{-1}$ in the direction $\overrightarrow{AB}$. Find **a** the values of t when the particle is at B, **b** the velocity of the particle for each of these values of t.

13 A particle is moving along the x-axis with constant deceleration $5\,\text{m s}^{-2}$. At time $t = 0$, the particle passes through the origin O with velocity $12\,\text{m s}^{-1}$ in the positive direction. At time t seconds the particle passes through the point A with x-coordinate 8. Find **a** the values of t **b** the velocity of the particle as it passes through the point with x-coordinate -8.

14 A particle P is moving on the x-axis with constant deceleration $4\,\text{m s}^{-2}$. At time $t = 0$, P passes through the origin O with velocity $14\,\text{m s}^{-1}$ in the positive direction. The point A lies on the axis and $OA = 22.5\,\text{m}$. Find **a** the difference between the times when P passes through A, **b** the total distance travelled by P during the interval between these times.

15 A car is travelling along a straight horizontal road with constant acceleration. The car passes over three consecutive points A, B and C where $AB = 100\,\text{m}$ and $BC = 300\,\text{m}$. The speed of the car at B is $14\,\text{m s}^{-1}$ and the speed of the car at C is $20\,\text{m s}^{-1}$. Find **a** the acceleration of the car, **b** the time take for the car to travel from A to C.

16 Two particles P and Q are moving along the same straight horizontal line with constant accelerations $2\,\text{m s}^{-2}$ and $3.6\,\text{m s}^{-2}$ respectively. At time $t = 0$, P passes through a point A with speed $4\,\text{m s}^{-1}$. One second later Q passes through A with speed $3\,\text{m s}^{-1}$, moving in the same direction as P.

a Write down expressions for the displacements of P and Q from A, in terms of t, where t seconds is the time after P has passed through A.

b Find the value of t where the particles meet.

c Find the distance of A from the point where the particles meet.

VERTICAL MOTION

Exercise 2C

1 A ball is projected vertically upwards from a point O with speed $14\,\text{m s}^{-1}$. Find the greatest height above O reached by the ball.

2 A well is 50 m deep. A stone is released from rest at the top of the well. Find how long the stone takes to reach the bottom of the well.

3 A book falls from the top shelf of a bookcase. It takes 0.6 s to reach the floor. Find how far it is from the top shelf to the floor.

4 A particle is projected vertically upwards with speed $20\,\text{m s}^{-1}$ from a point on the ground. Find the time of flight of the particle.

5 A ball is thrown vertically downward from the top of a tower with speed $18\,\text{m s}^{-1}$. It reaches the ground in 1.6 s. Find the height of the tower.

6 A pebble is catapulted vertically upwards with speed $24\,\text{m s}^{-1}$. Find **a** the greatest height above the point of projection reached by the pebble, **b** the time taken to reach this height.

7 A ball is projected upwards from a point which is 4 m above the ground with speed $18\,\text{m s}^{-1}$. Find **a** the speed of the ball when it is 15 m above its point of projection, **b** the speed with which the ball hits the ground.

8 A particle P is projected vertically downwards from a point 80 m above the ground with speed $4\,\text{m s}^{-1}$. Find **a** the speed with which P hits the ground, **b** the time P takes to reach the ground.

9 A particle P is projected vertically upwards from a point X. Five seconds later P is moving downwards with speed $10\,\text{m s}^{-1}$. Find **a** the speed of projection of P, **b** the greatest height above X attained by P during its motion.

10 A ball is thrown vertically upwards with speed $21\,\text{m s}^{-1}$. It hits the ground 4.5 s later. Find the height above the ground from which the ball was thrown.

Ex 2C (cont)

11 A stone is thrown vertically upward from a point which is 3 m above the ground, with speed $16\,\text{m s}^{-1}$. Find **a** the time of flight of the stone, **b** the total distance travelled by the stone.

12 A particle is projected vertically upwards with speed $24.5\,\text{m s}^{-1}$. Find the total time for which it is 21 m or more above its point of projection.

13 A particle is projected vertically upwards from a point O with speed $u\,\text{m s}^{-1}$. Two seconds later it is still moving upwards and its speed is $\frac{1}{3}u\,\text{m s}^{-1}$. Find **a** the value of u, **b** the time from the instant that the particle leaves O to the instant that it returns to O.

14 A ball A is thrown vertically downwards with speed $5\,\text{m s}^{-1}$ from the top of a tower block 46 m above the ground. At the same time as A is thrown downwards, another ball B is thrown vertically upwards from the ground with speed $18\,\text{m s}^{-1}$. The balls collide. Find the distance of the point where A and B collide from the point where A was thrown.

15 A ball is released from rest at a point which is 10 m above a wooden floor. Each time the ball strikes the floor, it rebounds with three-quarters of the speed with which it strikes the floor. Find the greatest height above the floor reached by the ball **a** the first time it rebounds from the floor, **b** the second time it rebounds from the floor.

16 A particle P is projected vertically upwards from a point O with speed $12\,\text{m s}^{-1}$. One second after P has been projected from O, another particle Q is projected vertically upwards from O with speed $20\,\text{m s}^{-1}$. Find **a** the time between the instant that P is projected from O and the instant when P and Q collide, **b** the distance of the point where P and Q collide from O.

F = ma

Exercise 3A

Remember that g should be taken as $9.8\,\text{m s}^{-2}$.

1 Find the weight in newtons of a particle of mass 4 kg.

2 Find the mass of a particle whose weight is 490 N.

3 The weight of an astronaut on the Earth is 686 N. The acceleration due to gravity on the Moon is approximately $1.6\,\text{m s}^{-2}$. Find the weight of the astronaut when he is on the Moon.

4 Find the force required to accelerate a 1.2 kg mass at a rate of $3.5\,\text{m s}^{-2}$.

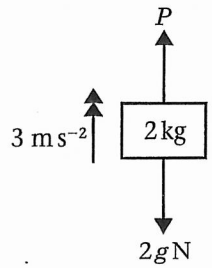
5 Find the acceleration when a particle of mass 400 kg is acted on by a resultant force of 120 N.

6 An object moving on a rough surface experiences a constant frictional force of 30 N which decelerates it at a rate of $1.2\,\text{m s}^{-2}$. Find the mass of the object.

Ex 3A (cont)

7 In each of the following scenarios, the forces acting on the body cause it to accelerate as shown. Find the magnitude of the unknown forces P and Q.

a



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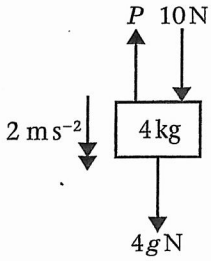

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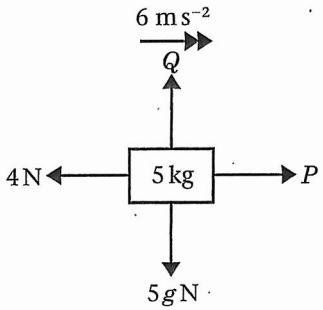
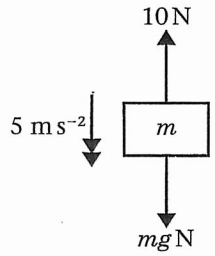
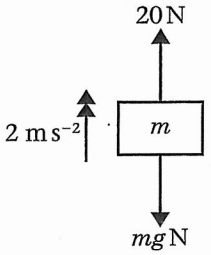


8 In each of the following situations, the forces acting on the body cause it to accelerate as shown. In each case find the mass of the body, m.

a



b



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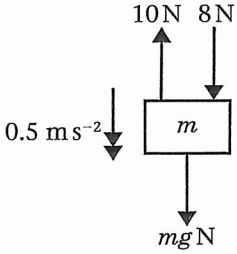
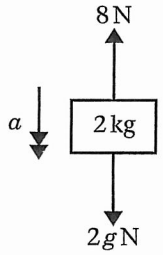
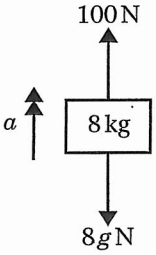


9 In each of the following situations, the forces acting on the body cause it to accelerate as shown with magnitude $a\,\text{m s}^{-2}$. In each case find the value of a.

a



b



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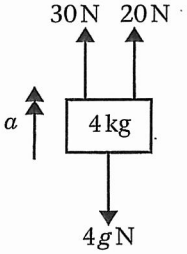
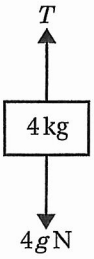


10 The diagram shows a block of mass 4 kg attached to a vertical rope.



Find the tension in the rope when the block moves downwards **a** with an acceleration of $2\,\text{m s}^{-2}$, **b** at a constant speed of $4\,\text{m s}^{-1}$, **c** with a deceleration of $0.5\,\text{m s}^{-2}$.

More F = ma

Exercise 3B

1 A ball of mass 200 g is attached to the upper end of a vertical light rod. Find the thrust in the rod when it raises the ball vertically with an acceleration of 1.5 m s^{-2}.

2 A small pebble of mass 50 g is dropped into a pond and falls vertically through it with an acceleration of 2.8 m s^{-2}. Assuming that the water produces a constant resistance, find its magnitude.

3 A lift of mass 500 kg is lowered or raised by means of a metal cable attached to its top. The lift contains passengers whose total mass is 300 kg. The lift starts from rest and accelerates at a constant rate, reaching a speed of 3 m s^{-1} after moving a distance of 5 m. Find

a the acceleration of the lift,

b the tension in the cable if the lift is moving vertically downwards,

c the tension in the cable if the lift is moving vertically upwards.

4 A block of mass 1.5 kg falls vertically from rest and hits the ground 16.6 m below after falling for 2 s. Assuming that the air resistance experienced by the block as it falls is constant, find its magnitude.

5 A trolley of mass 50 kg is pulled from rest in a straight line along a horizontal path by means of a horizontal rope attached to its front end. The trolley accelerates at a constant rate and after 2 s its speed is 1 m s^{-1}. As it moves, the trolley experiences a resistance to motion of magnitude 20 N. Find

a the acceleration of the trolley, **b** the tension in the rope.

6 A trailer of mass 200 kg is attached to a car by a light tow-bar. The trailer is moving along a straight horizontal road and decelerates at a constant rate from a speed of 15 m s^{-1} to a speed of 5 m s^{-1} in a distance of 25 m. Assuming there is no resistance to the motion, find

a the deceleration of the trailer, **b** the thrust in the tow-bar.

7 A woman of mass 60 kg is in a lift which is accelerating upwards at a rate of 2 m s^{-2}.

a Find the magnitude of the normal reaction of the floor of the lift on the woman.

The lift then moves at a constant speed and then finally decelerates to rest at 1.5 m s^{-2}.

b Find the magnitude of the normal reaction of the floor of the lift on the woman during the period of deceleration.

c Hence explain why the woman will feel heavier during the period of acceleration and lighter during the period of deceleration.

8 The engine of a van of mass 400 kg cuts out when it is moving along a straight horizontal road with speed 16 m s^{-1}. The van comes to rest without the brakes being applied.

In a model of the situation it is assumed that the van is subject to a resistive force which has constant magnitude of 200 N.

a Find how long it takes the van to stop.

b Find how far the van travels before it stops.

c Comment on the suitability of the modelling assumption.

9 Albert and Bella are both standing in a lift. The mass of the lift is 250 kg. As the lift moves upward with constant acceleration, the floor of the lift exerts forces of magnitude 678 N and 452 N respectively on Albert and Bella. The tension in the cable which is pulling the lift upwards is 3955 N.

a Find the acceleration of the lift.

b Find the mass of Albert.

c Find the mass of Bella.

10 A small stone of mass 400 g is projected vertically upwards from the bottom of a pond full of water with speed $10\,\text{m s}^{-1}$. As the stone moves through the water it experiences a constant resistance of magnitude 3 N. Assuming that the stone does not reach the surface of the pond, find

a the greatest height above the bottom of the pond that the stone reaches,

b the speed of the stone as it hits the bottom of the pond on its return,

c the total time taken for the stone to return to its initial position on the bottom of the pond.

Exercise 2A

1 $20\,\text{m s}^{-1}$
2 $1.6\,\text{m s}^{-2}$
3 $0.625\,\text{m s}^{-2}$
4 26 m
5 $20\,\text{m s}^{-1}$
6 $6\,\text{m s}^{-1}$ in direction $\overrightarrow{XY}$
7 **a** $9\,\text{m s}^{-1}$ **b** 72 m
8 **a** $3\,\text{m s}^{-1}$ **b** $\frac{1}{3}\,\text{m s}^{-2}$
9 **a** $9.2\,\text{m s}^{-1}$ **b** 33.6 m
10 **a** $18\,\text{km h}^{-1}$ **b** 312.5 m
11 **a** 8 s **b** 128 m
12 **a** $0.4\,\text{m s}^{-2}$ **b** 320 m
13 **a** $0.25\,\text{m s}^{-2}$ **b** 16 s **c** 234 m
14 **a** $19\,\text{m s}^{-1}$ **b** $2.4\,\text{m s}^{-2}$ **c** 430 m
15 **a** $x = 0.25$ **b** 150 m
16 **b** 500 m

Exercise 2B

1 $7\,\text{m s}^{-1}$
2 $\frac{2}{3}\,\text{s}^{-2}$
3 $2\,\text{m s}^{-2}$
4 $8.5\,\text{m s}^{-1}$
5 2.5 s
6 $0.175\,\text{m s}^{-2}$
7 **a** $2.5\,\text{m s}^{-2}$ **b** 4.8 s
8 **a** $3.5\,\text{m s}^{-1}$ **b** $15.5\,\text{m s}^{-1}$
9 **a** 54 m **b** 6 s
10 **a** 90 m **b** $8.49\,\text{m s}^{-1}$ (3 s.f.)
11 **a** 3.3 s (1 d.p.) **b** $16.2\,\text{m s}^{-1}$ (1 d.p.)
12 **a** 4, 8
b $t = 4$: $4\,\text{m s}^{-1}$ in direction $\overrightarrow{AB}$, $t = 8$: $4\,\text{m s}^{-1}$ in direction $\overrightarrow{BA}$
13 **a** 0.8, 4 **b** $15.0\,\text{m s}^{-1}$ (3 s.f.)
14 **a** 2 s **b** 4 m
15 **a** $0.34\,\text{m s}^{-1}$ **b** 25.5 s (3 s.f.)
16 **a** P: $(4t + t^2)$ m Q: $[3(t - 1) + 1.8(t - 1)^2]$ m
b $t = 6$ **c** 60 m

Exercise 2C

1 10 m
2 3.2 s (2 s.f.)
3 1.8 m (2 s.f.)
4 4.1 s (2 s.f.)
5 41 m (2 s.f.)
6 **a** 29 m (2 s.f.) **b** 2.4 s (2 s.f.)
7 **a** 5.5 m s−1 (2 s.f.) **b** 20 m s−1 (2 s.f.)
8 **a** 40 m s−1 (2 s.f.) **b** 3.7 s (2 s.f.)
9 **a** 39 m s−1 **b** 78 m (2 s.f.)
10 4.7 m (2 s.f.)
11 **a** 3.4 s (2 s.f.) **b** 29 m (2 s.f.)
12 2.8 s (2 s.f.)
13 **a** 29 (2 s.f.) **b** 6 s
14 30 m (2 s.f.)
15 **a** 5.6 m (2 s.f.) **b** 3.1 m (2 s.f.)
18 **a** 1.4 s (2 s.f.) **b** 7.2 m (2 s.f.)

Exercise 3A

1 39.2 N
2 50 kg
3 112 N
4 4.2 N
5 $0.3\,\text{m s}^{-2}$
6 25 kg
7 **a** 25.6 N **b** 41.2 N **c** P is 34 N, Q is 49 N
8 **a** 2.1 kg (2 s.f.) **b** 1.7 kg (2 s.f.)
c 0.22 kg (2 s.f.)
9 **a** $5.8\,\text{m s}^{-2}$ **b** $2.7\,\text{m s}^{-2}$ **c** $2.7\,\text{m s}^{-2}$
10 **a** 31.2 N **b** 39.2 N **c** 41.2 N

Exercise 3B

1 2.3 N (2 s.f.)
2 0.35 N
3 **a** $0.9\,\text{m s}^{-2}$ **b** 7120 N **c** 8560 N
4 2.25 N
5 **a** $0.5\,\text{m s}^{-2}$ **b** 45 N
6 **a** $4\,\text{m s}^{-2}$ **b** 800 N
7 **a** 708 N **b** 498 N
c Her perception of her weight is the reaction force that she feels from the floor of the lift.
8 **a** 32 s **b** 256 m
c Air resistance unlikely to be constant.
9 **a** $1.5\,\text{m s}^{-2}$ **b** 60 kg **c** 40 kg
10 **a** 2.9 m (2 s.f.) **b** $3.6\,\text{m s}^{-1}$ (2 s.f.)
c 2.17 s (3 s.f.)