Chapter 2 Answers

Exercise 2A

1 20 m s^{-1}
2 1.6 m s^{-2}
3 0.625 m s^{-2}
4 26 m
5 20 m s^{-1}
6 6 m s^{-1} in direction $\overrightarrow{XY}$

7 **a** 9 m s^{-1} **b** 72 m
8 **a** 3 m s^{-1} **b** $\frac{1}{3}$ m s^{-2}

9 **a** 9.2 m s^{-1} **b** 33.6 m
10 **a** 18 km h^{-1} **b** 312.5 m
11 **a** 8 s **b** 128 m
12 **a** 0.4 m s^{-2} **b** 320 m
13 **a** 0.25 m s^{-2} **b** 16 s **c** 234 m
14 **a** 19 m s^{-1} **b** 2.4 m s^{-2} **c** 430 m
15 **a** $x = 0.25$ **b** 150 m
16 **b** 500 m

Exercise 2B

1 7 m s^{-1}
2 $\frac{2}{3}$ m s^{-2}

3 2 m s^{-2}
4 8.5 m s^{-1}
5 2.5 s
6 0.175 m s^{-2}
7 **a** 2.5 m s^{-2} **b** 4.8 s
8 **a** 3.5 m s^{-1} **b** 15.5 m s^{-1}
9 **a** 54 m **b** 6 s
10 **a** 90 m **b** 8.49 m s^{-1} (3 s.f.)
11 **a** 3.3 s (1 d.p.) **b** 16.2 m s^{-1} (1 d.p.)
12 **a** 4, 8 **b** $t = 4$: 4 m s^{-1} in direction $\overrightarrow{AB}$, $t = 8$: 4 m s^{-1} in direction $\overrightarrow{BA}$

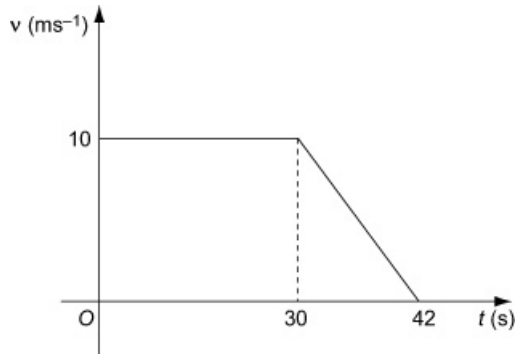
13 **a** 0.8, 4 **b** 15.0 m s^{-1} (3 s.f.)
14 **a** 2 s **b** 4 m
15 **a** 0.34 m s^{-1} **b** 25.5 s (3 s.f.)
16 **a** P: $(4t + t^2)$ m Q: $[3(t - 1) + 1.8(t - 1)^2]$ m
b $t = 6$ **c** 60 m

Exercise 2C

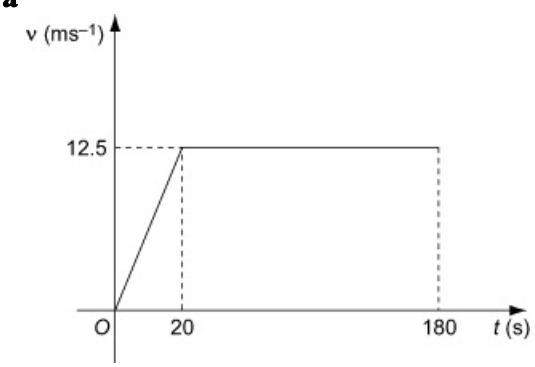
1 10 m
2 3.2 s (2 s.f.)
3 1.8 m (2 s.f.)
4 4.1 s (2 s.f.)
5 41 m (2 s.f.)
6 **a** 29 m (2 s.f.) **b** 2.4 s (2 s.f.)
7 **a** 5.5 m s^{-1} (2 s.f.) **b** 20 m s^{-1} (2 s.f.)
8 **a** 40 m s^{-1} (2 s.f.) **b** 3.7 s (2 s.f.)
9 **a** 39 m s^{-1} **b** 78 m (2 s.f.)
10 4.7 m (2 s.f.)
11 **a** 3.4 s (2 s.f.) **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 2D

1 **a** 2.25 m s^{-2} **b** 90 m
2 **a**

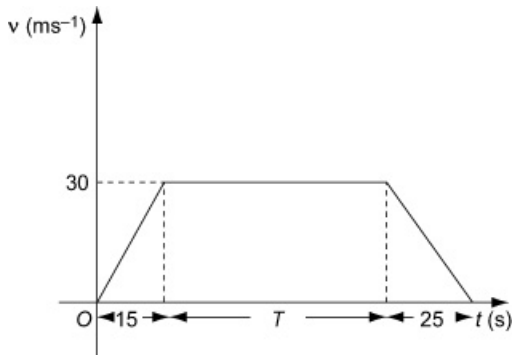


b 360 m
3 **a** 0.4 m s^{-2} **b** $\frac{8}{15}$ m s^{-2} **c** 460 m
4 **a**



b 2125 m

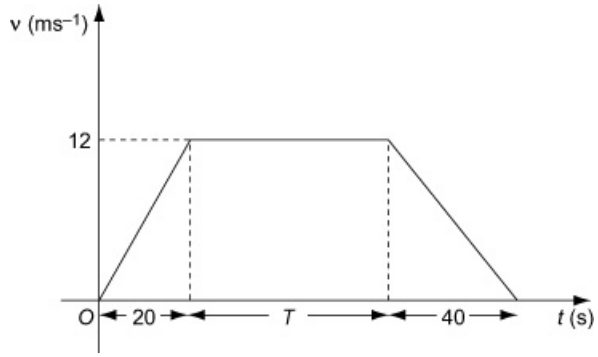
5 **a**



b 100 s

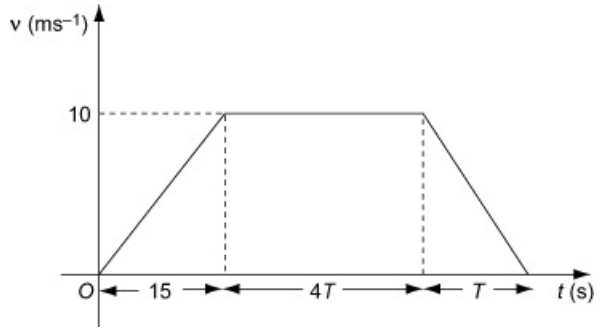
6 **a** 0.8 m s^{-2} **b** 1960 m

7 **a**



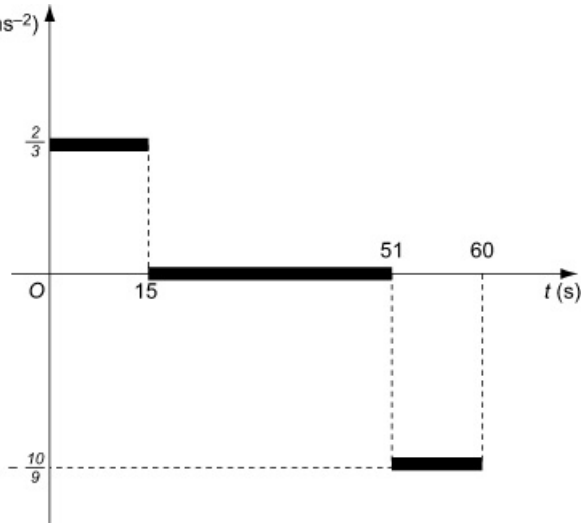
b $T = 320$ **c** 3840 m

8 **a**



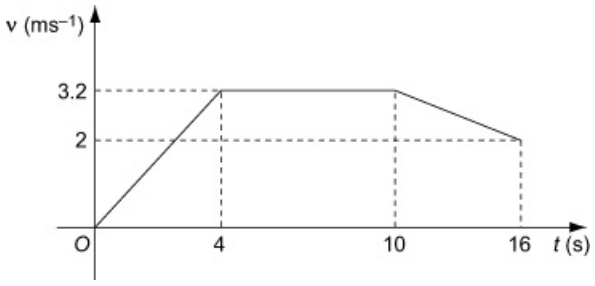
b 60 s

c

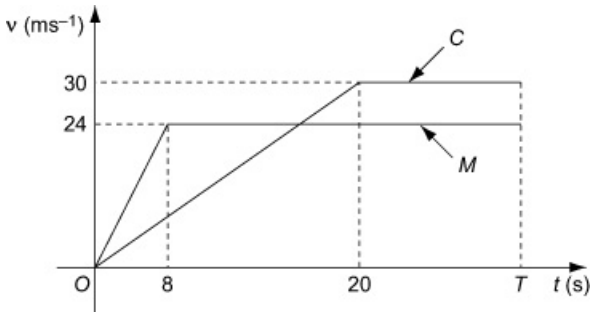


9 **a** $\frac{10}{3}$ **b** $\frac{20}{9}$ m s^{-2}

10

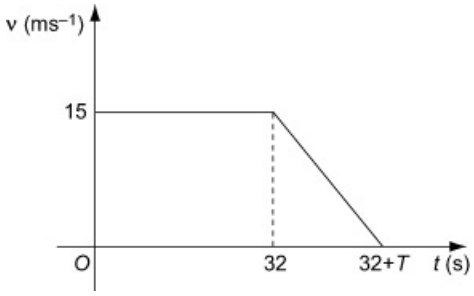


11 **a**



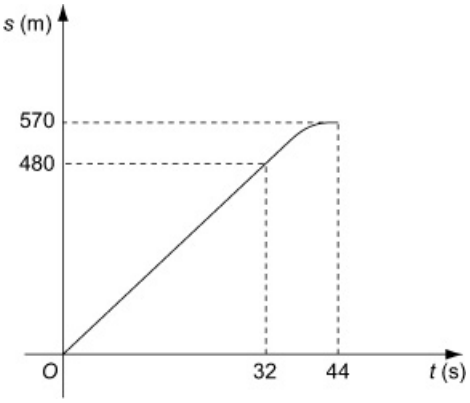
b 720 m

12 **a**



b $T = 12$

c



Exercise 2E

1 2 m s^{-2}

2 1.9 s (2 s.f.)

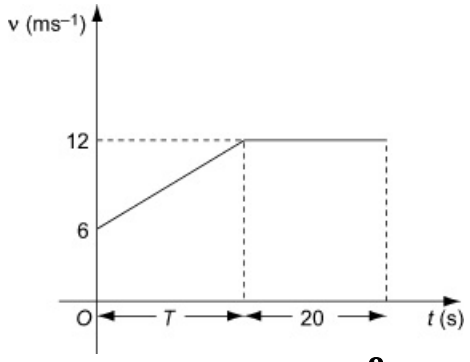
3 $u = 8$

4 **a** 23 m (2 s.f.) **b** 2.1 S (2 s.f.)

5 **a** 28 m s^{-1} **b** 208 m

6 0.165 m s^{-2} (3 d.p.)

7 **a**



8 **a**

b 315 m **c** 30 s

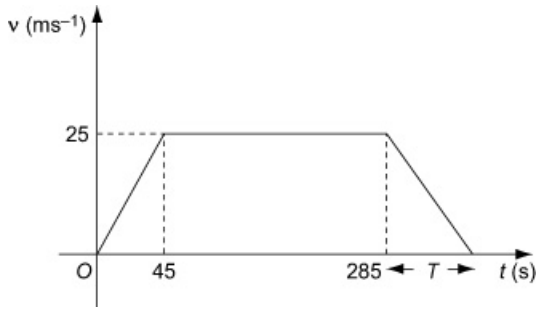
8 **a** 4.1 s (2 s.f.) **b** 40 m s^{-1} (2 s.f.) **c** air resistance

9 **a** 8 m s^{-1} **b** **1.25** m s^{-2} **c** 204.8 m

10 **a** 33 m s^{-1} (2 s.f.) **b** 3.4 s (2 s.f.)

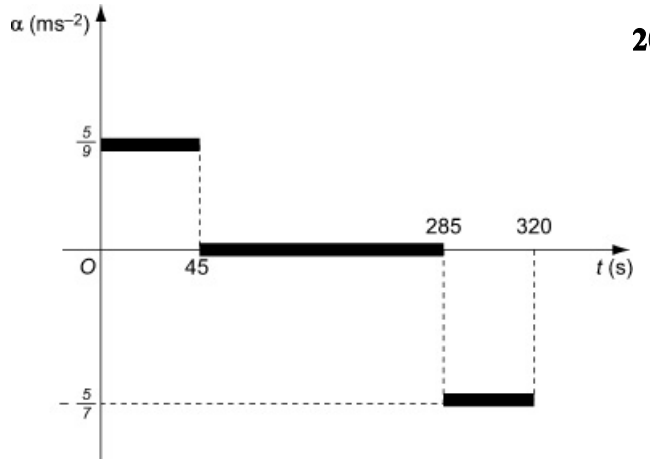
11 **a** 60 m **b** 100 m

12 **a**



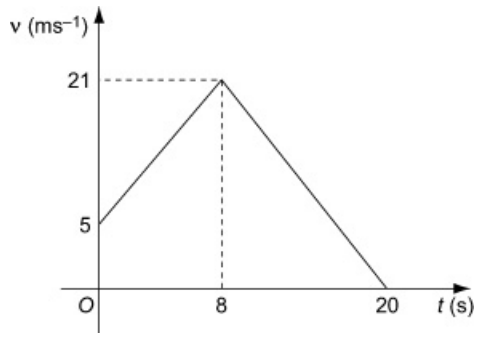
b $\frac{5}{7}$ m s^{-2}

c



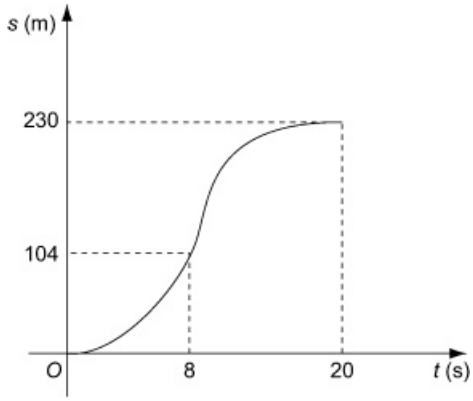
13 **a** $u = 11$ **b** 22 m

14 **a**



b 230 m

c



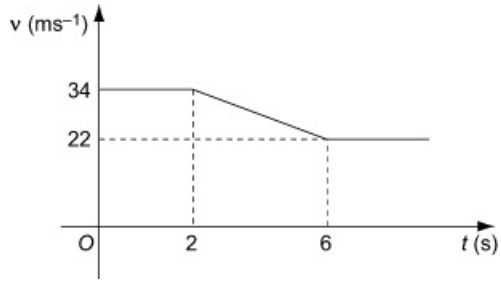
15 1.2 s (2 s.f.)

16 **a** 50 s **b** 24.2 m s^{-1} (3 s.f.)

17 $h = 39$ (2 s.f.)

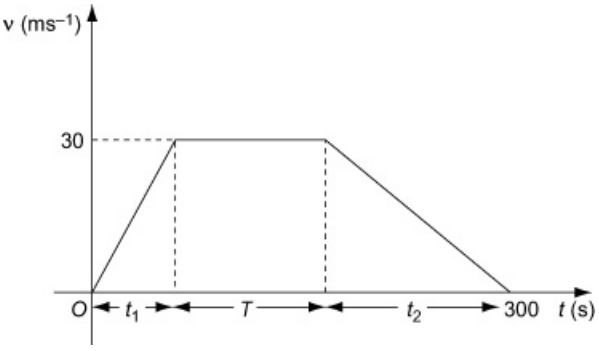
18 **a** 32 m s^{-1} **b** 90 m **c** 10 s

19 **a**



b 180 m

20 **a**



c $x = 0.2$ **d** 3 km **e** 125 s

Chapter 3 Answers

Exercise 3A

1 39.2 N
2 50 kg
3 112 N
4 4.2 N
5 0.3 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** 1.7kg (2 s.f.)
c 0.22kg (2 s.f.)
9 **a** 5.8 m s^{-2} **b** 2.7 m s^{-2} **c** 2.7 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 m s^{-2} **b** 7120 N **c** 8560 N
4 2.25 N
5 **a** 0.5 m s^{-2} **b** 45 N
6 **a** 4 m s^{-2} **b** 800 N
7 **a** 708 N **b** 498 N **c** She feels lighter.
8 **a** 32 s **b** 256 m
c Air resistance unlikely to be constant.
9 **a** 1.5 m s^{-2} **b** 60 kg **c** 40 kg
10 **a** 2.9 m (2 s.f.) **b** 3.6 m s^{-1} (2 s.f.)
c 2.17 s (3 s.f.)

Exercise 3C

1 **a i** 11.3 N (3 s.f.) **ii** 4.10 N (3 s.f.)
b i 0 N **ii** –5 N
c i –5.14 N (3 s.f.) **ii** 6.13 N (3 s.f.)
d i 8.66 N (3 s.f.) **ii** –5 N
e i –3.86 N (3 s.f.) **ii** –4.60 N (3 s.f.)
f i $F\cos\theta$ N **ii** $F\sin\theta$ N
2 **a i** –2 N **ii** 6.93 N (3 s.f.)
b i 8.13 N (3 s.f.) **ii** 10.3 N (3 s.f.)
c i $P\cos\alpha + Q - R\sin\beta$ **ii** $P\sin\alpha - R\cos\beta$

Exercise 3D

1 **a i** 3 N **ii** F = 3 N and body remains at rest
b i b7 N **ii** F = 7 N and body remains at rest
c i 7 N **ii** F = 7 N and body accelerates
iii 1 m s^{-2}
d i 6 N **ii** F = 6 N and body remains at rest
e i 9 N **ii** F = 9 N and body remains at rest in limiting equilibrium
f i 9 N **ii** F = 9 N and body accelerates
iii 0.6 m s^{-2}
g i 3 N **ii** F = 3 N and body remains at rest
h i 5 N **ii** F = 5 N and body remains at rest in limiting equilibrium
i i 5 N **ii** F = 5 N and body accelerates
iii 0.2 m s^{-2}
j i 6 N **ii** F = 6 N and body accelerates
iii 1.22 m s^{-2} (3 s.f.)
k i 5 N **ii** F = 5 N and body accelerates
iii 3.85 m s^{-2} (3 s.f.)
l i 12.7 N (3 s.f.) **ii** The body accelerates.
iii 5.39 m s^{-2} (3 s.f.)
2 **a** $R = 88$ N, $\mu = 0.083$ (3 s.f.)
b $R = 80.679$ N, $\mu = 0.062$ (2 s.f.)
c $R = 118$ N, $\mu = 0.13$ (2 s.f.)

Exercise 3E

1 3.35 m s^{-2} (3 s.f.)
2 **a** 27.7 N (3 s.f.) **b** 2.12 m s^{-2}
3 **a** 2.43 m s^{-2} (3 s.f.) **b** 4.93 m s^{-1} (3 s.f.)
4 28 N
5 0.20 (2 s.f.)
6 0.15 (2 s.f.)
7 **a** 88.8 N (3 s.f.) **b** 0.24 (2 s.f.)
8 **a** $\frac{13g}{15}$ **b** 23.5 m (3 s.f.) **c** 2.35 s (3 s.f.)
d 12 .4 m s^{-1} (3 s.f.)

Exercise 3F

1 **a** 4 N **b** 0.8 N
2 **a** $R = 45$ **b** 100 N
3 **a** 3 m s^{-2} **b** 2500 N
4 **a** 33.6 N (3 s.f.) **b** 2$\frac{3}{7}$ m

5 **a** 0.613 m s^{-2} (3 s.f.) **b** 27.6 N (3 s.f.)
c 39.0 N (3 s.f.)
6 2.8 m s^{-1}
7 **a** 0.569 m s^{-2} (3 s.f.) **b** 0.56 mg
8 **a** 1.12 m s^{-2} **b** 4100 N
9 **a** 21.9 N **b** 0.418 (3 s.f.) **c** 38 N (2 s.f.)
10 **a** 2 m s^{-2} **b** 600 N **c** 100 m

Exercise 3G

1 30 m s^{-1}
2 2.5 m s^{-1}
3 2.59 N s
4 6.5m s^{-1}
5 3 m s^{-1}

Exercise 3H

1 4 m s^{-1}
2 $2\frac{2}{9}$ m s^{-1}
3 4.5 m s^{-1}
4 **a** $2\frac{2}{3}$ m s^{-1} **b** $2\frac{2}{3}$ N s
5 **a** 1 m s^{-1} and direction unchanged **b** 15 N s
6 10
7 **a** $\frac{2u}{3}$ **b** 8 mu
8 Larger 8 m s^{-1} and smaller 4 m s^{-1}
9 **a** 3 **b** $\frac{9mu}{2}$
10 **a** 3 m s^{-1} **b** 4.5
11 **a** 4 m s^{-1} in same direction **b** 3 m s^{-1} in opposite direction
12 **a** 3 m s^{-1} **b** 6 kg

Exercise 3I

1 **a** 0.103 kg **b** 4.103 kg
2 0.14 (2 s.f.)
3 **a** $\frac{1}{2}u = v$ **b** $6mu$
4 **a** 0.22 m (2 s.f.) **b** $\frac{14g}{25}$ **c** 1.1 m s^{-1} (2 s.f.)
5 0.12 (2 s.f.)
6 **a** 9.8 N **b** 9.8 N
7 **a** 14 m s^{-1} **b** $\frac{35}{3}$ m s^{-1} **c** 0.75 m (2 s.f.)
8 **a** $\frac{1}{3}g$ **b** 3.6 m s^{-1} (2 s.f.) **c** $2\frac{2}{3}$ **m**
d i acceleration both masses equal
ii same tension in string either side of pulley
9 **a** 540 N **b** 180 N **c** 450 N
10 1000 N vertically downwards
11 **a** 2000 **b** 36 m
12 **a** 1.75 m s^{-1} **b** 0.45 N s
13 **a** 2.5 m s^{-1} **b** 15 000 N s
14 **a** 0.7 m s^{-1} **b** unchanged **c** 8.25 N s
15 $\frac{4}{5}$
16 **a** 1.25 m s^{-1} **b** 0.77 (2 s.f.)
17 0.44 (2 s.f.)
18 **a** 1.3 N (2 s.f.) **b** 19 m (2 s.f.)
19 $\frac{5}{28}$
20 **a** 830 N (2 s.f.) **b** 1500 N (2 s.f.) **c** 1700 N (2 s.f.)
d Air resistance would reduce speed of lift as it falls and so impulse would be reduced.
21 **a** 18 N (2 s.f.) **b** 0.12 m s^{-2} (2 s.f.)
22 **a** 243 N (3 s.f.) **b** 3.08 m s^{-2} (3 s.f.)
c 36.7 m (3 s.f.)
23 **a** 7.5 m s^{-1} **b** 11 000 (2 s.f.)
c R could be modelled as varying with speed.
24 **a** $\frac{12}{7}g$ N **b** 1.2
25 **a** 3.2 m s^{-2} **b** 5.3 N (2 s.f.) **c** 0.75 (2 s.f.)
d The information that the string is inextenible has been used when, in part **c** the acceleration of A has been taken as equal to the acceleration of B obtained in part **a**.
26 **a** 18 N (2 s.f.) **b** 2 **c** 4.2 N s **d** $\frac{2}{7}$ s

Chapter 4 Answers

Exercise 4A

1 **a** $Q - 5\cos30° = 0$
b $P - 5\sin30° = 0$
c $Q = 4.33$ N $P = 2.5$ N
2 **a** $Q - P\cos60° = 0$
b $P\sin60° - 4\sqrt{3} = 0$
c $Q = 4$ N $P = 8$ N
3 **a** $9 - P\cos30° = 0$
b $Q + P\sin30° - 8 = 0$
c $Q = 2.80$ N $P = 10.4$ N
4 **a** $9 - P\cos30° = 0$
b $Q + P\sin30° - 8 = 0$
c $Q = 2.80$ N $P = 10.4$ N
5 **a** $4\cos45° + P\cos\theta - 7 = 0$
b $4\sin45° - P\sin\theta = 0$ **c** $\theta = 34.1°$ $P = 5.04$ N
6 **a** $6\cos45° - 2\cos60° - P\sin\theta = 0$
b $6\sin45° + 2\sin60° - P\cos\theta - 4 = 0$
c $\theta = 58.7°$ $P = 3.80$ N
7 **a** $P\cos\theta + 8\sin40° - 7\cos35° = 0$
b $P\sin\theta + 7\sin35° - 8\cos40° = 0$
c $\theta = 74.4°$ (allow 74.3°) $P = 2.20$ (allow 2.19)
8 **a** $9\cos40° + 3 - P\cos\theta - 8\sin20° = 0$
b $P\sin\theta + 9\sin40° - 8\cos20° = 0$
c $\theta = 13.6°$ $P = 7.36$
9 **a** $P\cos30° - Q\cos45° - 8\cos45° = 0$
b $P\sin30° + Q\sin45° - 8\sin45° - 4 = 0$
c $P = 11.2$ (3 s.f.) $Q = 5.73$ (3 s.f.)
10 **a** $Q\cos60° - P\cos60° + 5\sin45° - 6\sin45° = 0$
b $P\sin60° + Q\sin60° - 5\cos45° - 6\cos45° = 0$
c $P = 3.784$ N $Q = 5.198$ N
11 **a** $Q - 10\sin45° = 0$
b $P - 10\cos45° = 0$
c $P = 7.07$ N $Q = 7.07$ N
12 **a** $Q + 2\cos60° - 6\sin60° = 0$
b $P - 2\sin60° - 6\cos60° = 0$
c $P = 4.73$ $Q = 4.20$
13 **a** $8\sin30° - Q\cos30° = 0$
b $P - Q\sin30° - 8\cos30° = 0$
c $P = 9.24$ N $Q = 4.62$ N
14 **a** $8\cos45° - 10\sin30° - Q° = 0$
b $P + 8\sin45° - 10\cos30° = 0$
c $P = 3.00$ N $Q = 0.657$ N
15 **a** $2 + 8\sin30° - P\cos\theta = 0$
b $4 - 8\cos30° + P\sin\theta = 0$
c $\theta = 26.0°$ $P = 6.68$ N

Exercise 4B

1 34.7 N
2 **a** 20 N **b** 1.77
3 14.4
4 $S = 30.4$ or 30.5, $T = 43.0$
5 **a** 5.46 N **b** 0.762 kg
6 **a** 1.46 **b** 55g
7 **a** 3 N **b** 2 N
8 **a** 2.6 **b** 4.4
9 **a** $F = 19.6m$, $R = 9.8m$
b $F = 17m$ (3 s.f.), $R = 0$
c $P = 11.2$ (3 s.f.) $Q = 5.73$ (3 s.f.)
10 13.9 N
11 39.2
12 37.2 N (3 s.f.)
13 $F = 12.25$, $R = 46.6$ (3 s.f.)
14 $P = 20.4$ (3 s.f), $R = 0.400$

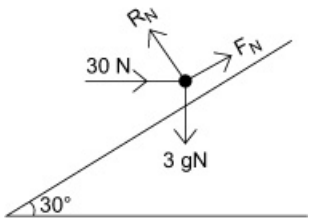
Exercise 4C

1 0.446
2 0.123
3 **a** 1.5 N **b** not limiting
4 **a** 40
b The assumption is that the crate and books may be modelled as a particle.
5 **a** 11.9 **b** 6.40
6 0.601 (accept 0.6)
7 **a** 13.3 **b** $F = 3.33$, $X = 9.54$
8 **a** 9.97 N down the plane **b** 22.7 N
c $\mu \geq 0.439$
9 **a** and **b** $X = 44.8$ (accept 44.7), $R = 51.3$
10 $F = 22.1$, $T = 102$ (3 s.f.)
11 **a** $T = 3.87$ **b** $T = 2.75$
12 0.758

Exercise 4D

1 $\alpha = 52.6°$, $T = 24.7$
2 **a** and **b** The weight of the particle is 80 N and the tension in the second string is 69.3 N (3 s.f.).
3 **a** 6.93 (3 s.f.) **b** 3.46 (3 s.f.)
4 **a** 43° (to nearest degree)
b 53 N (to nearest Newton)
5 **a** 138.2° (1 d.p.) **b** 8.95 (2 d.p.)
6 $T = 17.3$, $S = 21.3$

7 $R = 20.7$, $\mu = 0.24$ (2 s.f.)
8 $\mu = 0.296$ (3 s.f.)
9 363
10 11°
11 **a** 0.577
b The book was modelled as a particle.
12 **a** $W = 11.4$ **b** $R = 13.9$
13 2.2 (1 d.p.)
14 0.75 (2 d.p.)
15 0.262 (3 s.f.)
16 **a**



b 40.46 **c** 0.279 (3 s.f.)
17 **a** $R = 88.3$ **b** $P = 74.7$
c resultant force 9 N down plane and box will move
18 11.0
19 $\dfrac{\mu\cos\alpha - \sin\alpha}{\cos\alpha - \mu\sin\alpha}$
20 **a** 15.7 (3 s.f.) **b** 0.625
21 0.577 (3 s.f.)
22 0.399 (3 s.f.)
23 **a** 0.684 (3 s.f.) **b** 2.33
c As 2.425 > 1.596 the ring is not in equilibrium.

Chapter 5 Answers

Exercise 5A

1 6 Nm clockwise
2 10.5 Nm clockwise
3 13 Nm anticlockwise
4 0 Nm
5 10 Nm anticlockwise
6 11.6 Nm clockwise
7 30.5 Nm anticlockwise
8 0 Nm
9 13.3 Nm clockwise
10 33.8 Nm anticlockwise

Exercise 5B

1 **a** 5 Nm anticlockwise
b 13 Nm clockwise
c 19 Nm anticlockwise
d 11 Nm anticlockwise
e 4 Nm clockwise
f 7 Nm anticlockwise
2 **a** 16 Nm clockwise
b 1 Nm anticlockwise
c 10 Nm clockwise
d 7 Nm clockwise
e 0.5 Nm anticlockwise
f 9.59 Nm anticlockwise

Exercise 5C

1 **a** 10 N, 10 N **b** 15 N, 5 N
c 8.6 N, 11.4 N **d** 12.6 N, 7.4 N
2 **a** 7.5, 17.5 **b** 30, 35
c 245, $2\frac{2}{3}$ **d** 49, 1.5

3 0.5 m from *B*
4 59 N
5 31 cm from the broomhead
6 16.25 N, 13.75 N
7 1.71 m
8 5
9 $\frac{2}{3}$ **m**

10 2.05 m
11 **a** 15 N **b** rod will tilt **c** 3.17 m

Exercise 5D

1 2.4 N, 3.6 N
2 3.5 m from *A*
3 $\frac{1}{3}$ m from

4 **a** 29.4 N, 118 N **b** 4.25 m

Exercise 5E

1 **a** 105 N **b** 140 N **c** 1.03 m
2 **b** $0 \leq x < \frac{7}{4}$

3 **a** $40g$ **b** $x = \frac{1}{2}$

c **i** the weight acts at the centre of the plank
ii the plank remains straight
iii the man's weight acts at a single point
4 **b** $W = 790 - 300x$ **c** x = 2.53, $W = 30$
5 **a** 200 N **b** 21 cm
6 **a** 36 kg **b** 2.2 m
7 **a** 19.6 N **b** 5
8 **a** 588 N **b** $\frac{2}{3}$ m

9 **a** 125 N **b** 1.8 m

Chapter 6 Answers

Exercise 6A

1 8.60 km from starting point on bearing of 054°
2 10 km, 7.2 km on bearing of 326°
3 7.43 km, 062°
4 9.13 km, 340°
5 31.8 km, 261°
6 174°, 328.6°
7 3.01 km, 220°

Exercise 6B

1 **a** 2b **b** d **c** b **d** 2b **e** d + b **f** d + b
g –2d **h** –b **i** 2d + b **j** –b + 2d
k –b + d **l** –b – d
2 **a** 2m **b** 2p **c** m **d** m **e** p + m
f p + m **g** p +2m **h** p – m **i** –m – p
j –2m + p **k** –2p + m **l** –m – 2p
3 **a** 2p **b** 2r **c** –2p + 2r **d** –p + r
e p + r **f** r **g** –p **h** –2r + p
4 $\frac{2}{3}$a + $\frac{1}{3}$b
5 $\frac{3}{5}$a + $\frac{2}{5}$b

Exercise 6C

1 4**i**
2 5**i** + 2**j**
3 –3**i** + **j**
4 2**i** + 3**j**
5 –2**i** – **j**
6 –3**j**

Exercise 6D

1 **a** 6**i** + 2**j** **b** 10**i** + 8**j** **c** 7**j** **d** 10**i** + **j**
e –2**i** + **j** **f** –2**i** – 10**j** **g** 14**i** – 7**j** **h** –8**i** + 9**j**
2 **a** 5 **b** 10 **c** 13 **d** 4.47 (3 s.f.)
e 5.83 (3 s.f.) **f** 8.06 (3 s.f.) **g** 5.83 (3 s.f.)
h 4.12 (3 s.f.)
3 **a** 53.1° above **b** 53.1° below **c** 67.4° above
d 63.4° above
4 **a** 149° to the right **b** 29.7° to the right
c 31.0° to the left **d** 104° to the left
5 **a** $\lambda = 5$ **b** $\mu = -\frac{3}{2}$
6 **a** $\lambda = \frac{1}{3}$ **b** $\mu = -1$ **c** $s = -1$ **d** $t = -\frac{1}{17}$
7 **a** 3.61 (3 s.f.), 023° **b** 4.12 (3 s.f.), 104°
c 3.61 (3 s.f.), 304° **d** 2.24 (3 s.f.), 243°

Exercise 6E

1 **a** 5 m s^{-1} **b** 25 km h^{-1} **c** 5.39 m s^{-1}
d 8.06 cm s^{-1}
2 **a** 50 km^{1} **b** 51.0 m **c** 4.74 km **d** 967 cm
3 **a** 5 m s^{-1}, 75 m **b** 5.39 m s^{-1}, 16.2 m
c 5.39 km h^{-1}, 16.2 km **d** 13 km h^{-1}, 6.5 km

Exercise 6F

1 **a** 8**i** + 3**j** **b** 2**i** – 7**j** **c** –17**i** + 16**j** **d** 7**i** – 13**j**
2 **a** 2**i** + 5**j** **b** **i** + 3**j** **c** 2**i** + 4**j** **d** 2**i** – 5**j**
e –2**i** – 5**j**
3 **a** 6**i** – 8**j** **b** –12**i** + 9**j** **c** –4.5**i** + 6**j** **d** 5**i** + 5**j**
e –4**i** + 6**j** **f** $3\sqrt{2}$**i** – $5\sqrt{2}$**j** **g** –$4\sqrt{3}$**i** – $2\sqrt{3}$**j**
h –$3\sqrt{5}$**i** + $6\sqrt{5}$**j**
4 **a** 6**i** + 12**j** **b** –7**i** + 4**j** **c** –2**i** + 6**j** **d** 10**i** – 13**j**
e 2**i** – 3**j**, **f** 4.61 m s^{-1} **g** 4 **h** 2.5
5 **a** 5**i** + 12**j**, 13 m s^{-1} **b** 6**i** – 5**j**, 7.81 m s^{-1}
c –2**i** – 5**j**, 5.39 m s^{-1} **d** –3**i** – 2**j**, 3.61 m s^{-1}
e 7**i** + 9**j**, 11.4 m s^{-1}
6 4.8**i** – 6.4**j**
7 10.1 m
8 2.03 m s^{-1}
9 **a** 2*t***i** + (–500 + 3*t*)**j** **b** 721 m
10 **a** 7*t***i** + (400 + 7*t*)**j**, (500 – 3*t*)**i** + 15*t***j**
b 350**i** + 750**j**
11 **a** (1 + 2*t*)**i** + (3 – *t*)**j**, (5 – *t*)**i** + (–2 + 4*t*)**j** **b** 5.39 km
12 **a** 121 m s^{-1}, 6.08 m s^{-1} **b** 18**i** – 3**j** **c** 15**i** – 12**j**

Exercise 6G

1 **a** **i** – 8**j** **b** –5**i** + **j** **c** 2**i** + 5**j** **d** –3**i** + 2**j**
2 **a** 8.06, 82.9° below **b** 5.10, 169° above
c 5.39, 68.2° above **d** 3.61, 146° above
3 **a** 6**i**, 3**i** m s^{-2} **b** 3**i** – 2**j**, (**i** – $\frac{2}{3}$**j**) m s^{-2}
c 3**i** – 2**j**, ($\frac{3}{4}$**i** – $\frac{1}{2}$**j**) m s^{-2} **d** **i** – 6**j**, ($\frac{1}{2}$**i** – 3**j**) m s^{-2}

4 **a** 5.83 N, 59° **b** 6.32 N, 18.4°
c 6.40 N, 38.7°
5 **a** 5.83 N, 3.83 N **b** 4.39 N, 5.38 N
c 4.20 N, 6.53 N **d** 14.4 N, 12.7 N
e 4.54 N, 31.9°

Exercise 6H

1 **a** $p = 2$, $q = -6$ **b** 6.32 N **c** 18°
2 **a** $(-3 + t)\mathbf{i} + (10 + t)\mathbf{j}$ **b** 4.24 km **c** 1630
3 **a** $\mathbf{p} = 6t\mathbf{i}$, $\mathbf{q} = (12 - 3t)\mathbf{i} + (6 + 6t)\mathbf{j}$ **b** 38.4 km
c $1\frac{1}{3}$

4 **a** 3 **b** 10.2 m s^{-2} **c** 168.7°
5 **a** $-4\mathbf{i} + 2\mathbf{j}$ m s^{-2} **b** 22.4 N **c** 26 m
6 **a** 031° **b** $\mathbf{a} = 6t\mathbf{i}$, $\mathbf{b} = 3t\mathbf{i} + (-10 + 5t)\mathbf{j}$
c 1400 **d** 1456
7 **a** 108° **b** $(-2 + 9t)\mathbf{i} + (-4 - 3t)\mathbf{j}$ **c** 41, –23
8 **a** 124° **b** $(3 - 2t)\mathbf{i} + (-2 + 3t)\mathbf{j}$ **c** 11.2 m s^{-1}
d 1
9 **a** 9.85 m s^{-1} **b** $(3 + 4t)\mathbf{i} + (2 + 9t)\mathbf{j}$ **c** 6.5 s
d 7.46 m s^{-1}
10 **a** $(5\mathbf{i} + 3\mathbf{j})$ km h^{-1}
b $(10 + 5t)\mathbf{i} + (15 + 3t)\mathbf{j}$, $(-16 + 12t)\mathbf{i} + 26\mathbf{j}$
c 0525

Examination Style Paper

Exercise A

1 **a** $4\ \text{m s}^{-1}$

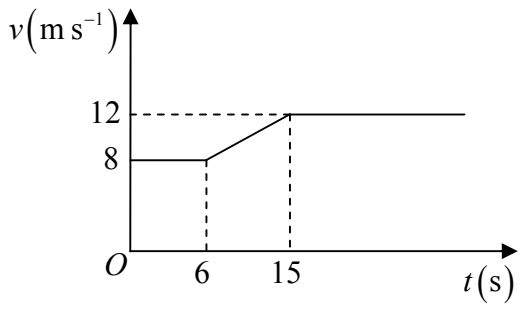
b The direction of motion of P has been changed by the collision.

c $3.2\ \text{N s}$.

2 **a** $12\sqrt{3}$ N.

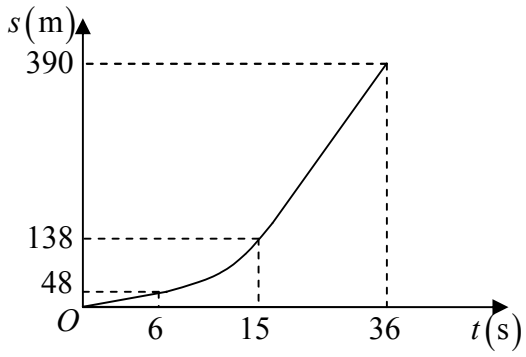
b 24

3 **a**



b 36 s.

c



4 **a** $\frac{3}{4}g$.

b For A $m = 28$

c The accelerations of the particles have the same magnitude.

5 **a** $70.9°$, to 3 significant figures.

b $7.46\ \text{m s}^{-2}$, to 3 significant figures.

6 **a** $\frac{1}{3}\ \text{m s}^{-2}$.

b 2.5 N,to 2 significant figures.

c 0.54, to 2 significant figures.

7 **a** 146.

b $\mathbf{s} = 8\mathbf{i} + (2\mathbf{i} - 3\mathbf{j})t$, $\mathbf{r} = 6t\mathbf{i}$

c $T = 8$

d $24\sqrt{2}$ km.

8 **a** $\left(\frac{400 + 6W}{6 - x}\right)$N.

b $W = \frac{600(2 - x)}{30 + x}$

c $W \geq 0 \Rightarrow x \geq 2$

Review Exercise 1

Exercise A

1 **a** 1.12 m s^{-2} **b** 31.25 s

2 **a** 3.6 m s^{-2} **b** $AC = 760$ m $BC = 440$ m

3 **a** 14.4 **b** 36 m s^{-1}

4 **a** 0.5 m s^{-2} **b** 7.5 m s^{-1}

5 $\frac{AB}{BC} = \frac{31}{40}$

6 10.8 m s^{-1} (3 s.f.)

7 **a** 24 **b** $OA = 96$ m **c** 4 s and 12 s

8 **a** 2.5 m s^{-2} **b** 31.7 m s^{-1} (3 s.f.)
c 1.69 s (3 s.f.)

9 **a** $6t - t^2$ **b** 7 m **c** $t = 5$

10 **a** 34 (2 s.f.) **b** 60 m (2 s.f.)

11 **a** 28 m s^{-1} **b** 5.7 s (2 s.f.)

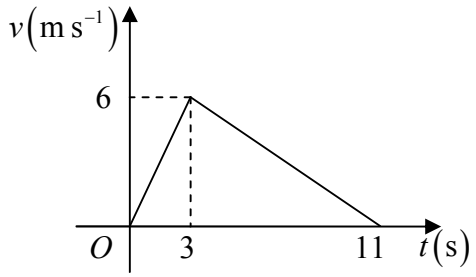
12 2 or 4

13 **a** 14 (2 s.f.) **b** 23 m s^{-1} (2 s.f.)

14 10 m (2 s.f.)

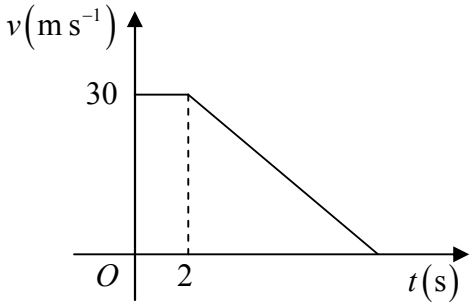
15 **a** 28 **b** $4\frac{2}{7}$ s

16 **a**



b 33 m

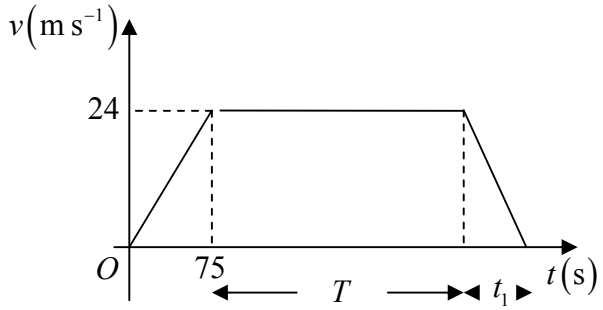
17 **a**



b 18 s

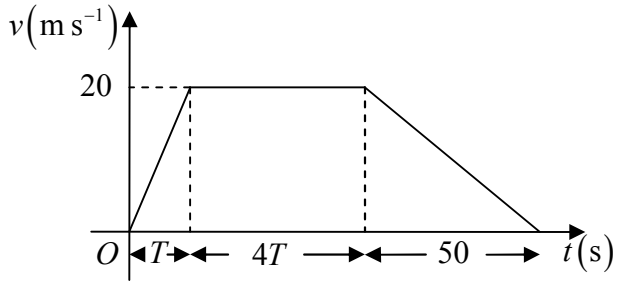
18 **a** constant acceleration **b** constant speed
c 30.5 m

19 **a**



b 0.48 m s^{-2} **c** 250 **d** 375 s

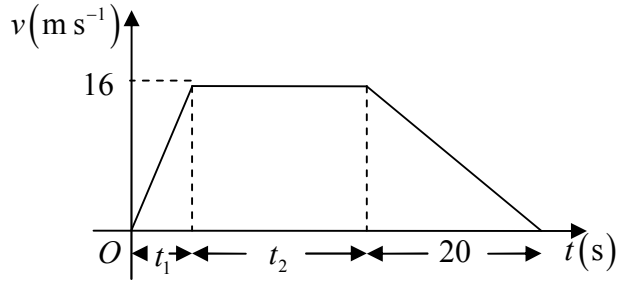
20 **a**



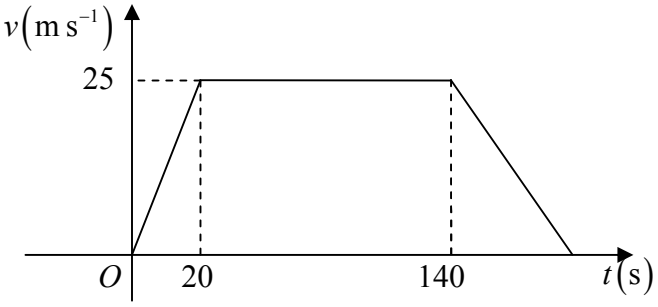
b 8 **c** 2.5 m s^{-2}

21 **a** 162 m **b** 6.2 **c** 0.56 m s^{-2}

22 **a** 185 s **b** 2480 m
c

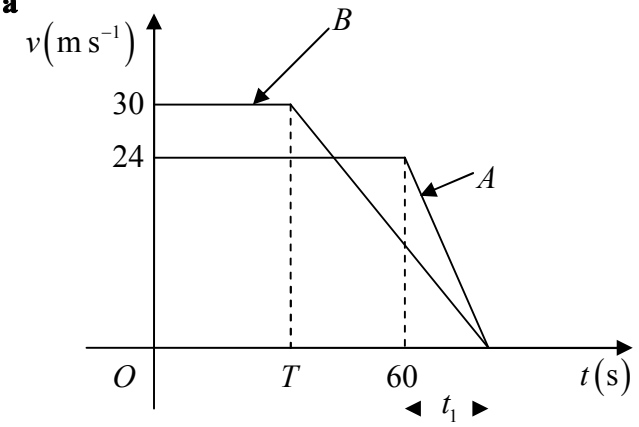


23 **a**



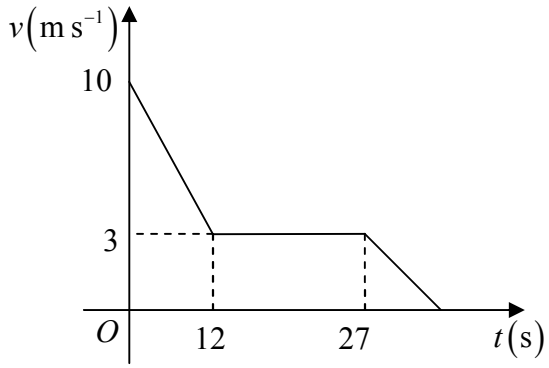
b 200 s **c** 60 s **d** 50 m s^{-1}

24 a



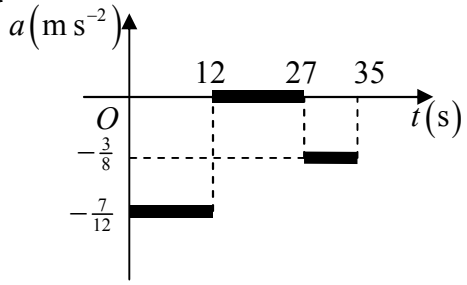
b 10 s **c** 34

25 a

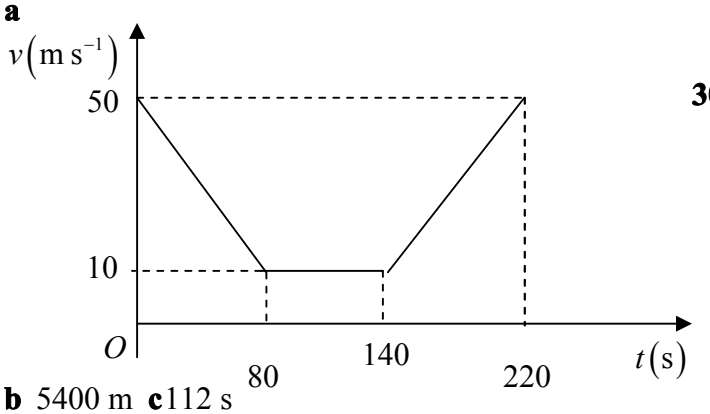


b 78 m **c** 35 s

d



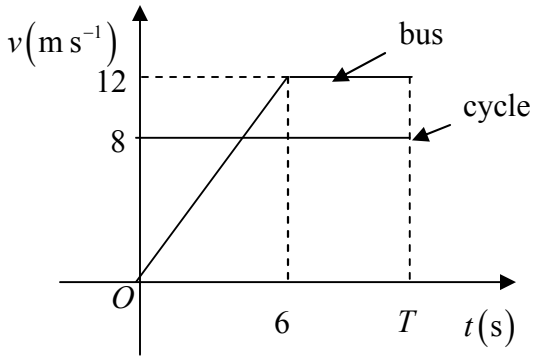
26 a



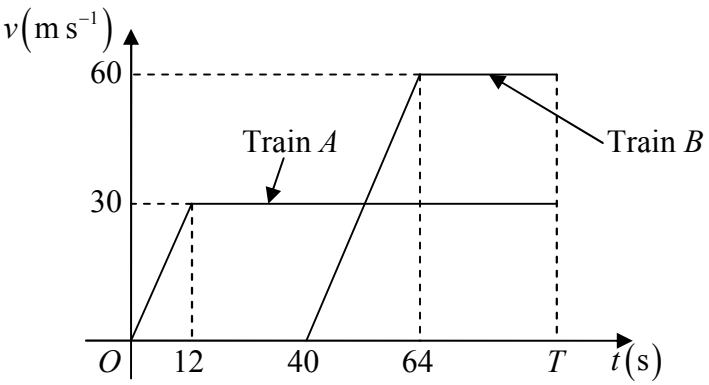
b 5400 m **c** 112 s

27 a bus has not overtaken cyclist

b

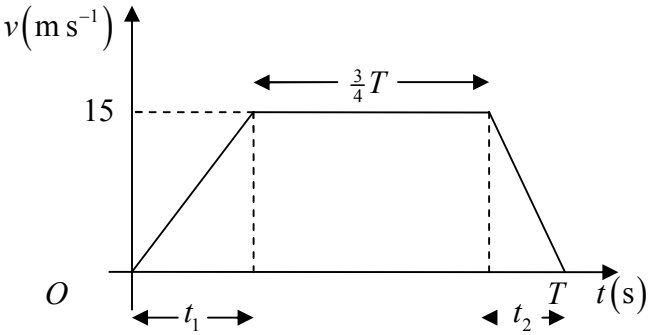


28 a



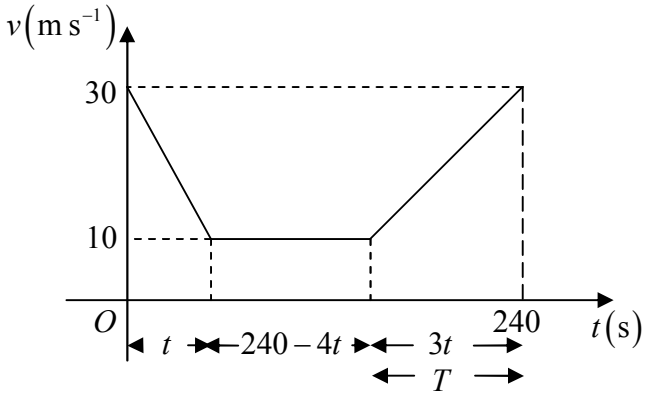
b 98

29 a



b 96 s **c** $\frac{15}{16}$ m s^{-2}

30 a



b $\frac{1}{6}$ **c** 800 m

31 $66\frac{2}{3}$ m s^{-1}

32 **a** 13 m s^{-1} **b** 2 m s^{-1} in direction $\overrightarrow{CB}$

33 6.3 N

34 **a** 2.25 m s^{-1} direction of motion unchanged
b 1.5 N s

35 **a** 2.4 m s^{-1} **b** due west **c** 3000 kg

36 **a** *A* 2.2 m s^{-1} *B* 3 m s^{-1} **b** 0.4 N s
c 1.6 N s

37 **a** 3 m s^{-1} **b** **i** $m = 3.6$ **ii** 18 N s

38 750 N

39 **a** 0.42 N **b** 2.5

40 **a** 2.45 m s^{-2} **b** 0.25

41 0.30 (2 s.f.)

42 0.37 (2 s.f.)

43 **a** 3 m s^{-2} **b** 14.8 m s^{-1} (3 s.f.) **c** 0.1 kg
d 3.06 s (3 s.f.)

44 **a** 8.6 m s^{-1} **b** 24 m **c** 79.2 m

45 520 (2 s.f.)

46 **a** 0.693 m s^{-2} (3 s.f.) **b** 7430 N (3 s.f.)
c 28 kN (2 s.f.)

47 **a** 3.6 m s^{-2} **b** 0.75 (2 s.f.) **c** 14 m (2 s.f.)

48 **a** 0.35 (2 s.f.) **b** normal reaction unchanged hence friction force unchanged
c 1500 N (2 s.f.)

49 **a** 15 m s^{-1} **b** 991 (3 s.f.)

50 **a** 22.4 **b** 4.64 (3 s.f.) **c** 6380 (3 s.f.)
d Consider air resistance due to motion under gravity

51 **a** 4.2 m s^{-2} **b** 3.4 N (2 s.f.) **c** 2.9 m s^{-1} (2 s.f.)
d 0.69 s (2 s.f.)

52 **a** 1.4 m s^{-2} **b** 3.4 N (2 s.f.), 4.2 N

53 **a** **i** 1050 N **ii** 390 N **b** 3 m s^{-}

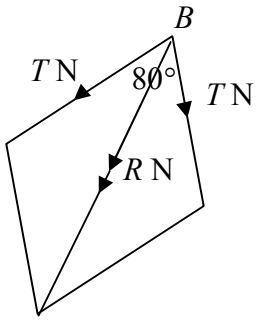
54 **a** 2.2 m s^{-2} (2 s.f.) **b** 22 N (2 s.f.)
c 4.4 m (2 s.f.)

55 **a** $\frac{6}{5}mg$ **b** 0.693 (3 s.f.)

c $\frac{6}{5}mg$ vertically downwards

56 **a** 1.2 m s^{-2} **b** 16 N
c The information that the string is inextensible has been used in assuming that the accelerations of *P* and *Q*, and hence of the whole system, are the same.
d 3 s
e 20 m s^{-1}

57 **a** 1.0 m (2 s.f.) **b** 17 N (2 s.f.)
c 26 N, direction bisecting angle *ABC*



d 0.55 (2 s.f.)

58 **a** 11 500 N **b** 6.2 m s^{-2} **c** 3700 N
d 31 m s^{-1} (2 s.f.)

59 **a** 0.24 6.2 m s^{-2} **b** 530 N (2 s.f.) **c** 54 m
d normal reaction of the road on the car is increased when the tow bar breaks

Review Exercise 2

1 **a** 48 **b** 41.6
2 **a** 40.8° **b** 22.7 N (3 s.f.)
3 **a** 42.9° **b** 52.8 N (3 s.f.)
4 **a** 35.1 N **b** 33.0 N (3 s.f.)
5 **a** 26.1 **b** 51.4 (3 s.f.)
6 **a** 7.5 **b** 12
7 **a** $\frac{5mg}{2}$ **b** $\frac{4}{7}$
8 **a** 86.6 **b** 100
9 47.5 (1 d.p.)
10 **a** 19.9 N **b** 3.46
11 **a** 23.0 **b** 17.6
c The friction is not limiting and so equilibrium is maintained.
12 **a** 18.7 **b** 0.60 (2 s.f.)
c Equilibrium is maintained and so the parcel does not move.
13 **a** 1.68 **b** 0.548
14 **a** 257 (3 s.f.) **b** 12.5 s
15 **a** 131 N **b** 209 N
c **i** Friction acts down the slope,. magnitude $0.4R$
ii No acceleration so net force on package is zero
16 **a** 0.270 **b** 3.76 m s^{-2} down the plane
17 **a** 125 **b** 1.46 m s^{-2}
18 5.6 m
19 **a** 88.2 N **b** 0.875 m
20 $\frac{7}{8}$ m

21 **a** 2 **b** 0.6 m
22 **a** 911 N **b** 1176 N **c** 2.25 m
23 **a** 784 N **b** 0.5 m
24 $1.6d$
25 **a** 50 N **b** 1.9 m
26 **a** 0.75 **b** 24 N **c** 144 N
d The weight of the rock acts precisely at B.
27 **a** 1.25
b The weight of the beam acts through its mid-point at C.
c 0.4 m
28 **a** 70 N **b** 120 cm **c** 30
29 **a** 0.8
b The weight acts through the mid-point of the rod.
30 **a** **i** 7.5 kg **ii** 477.75 N
b Assumed that the centre of mass acts at the point C.

31 **a** $90 - X$ **b** $2X - 30$ **c** $15 \leq X \leq 90$
d 75
32 **a** Model the plank as a uniform rod.
b $240g$ **c** $210g$
33 **a** 30 kg **b** 3.6 kg
c **i** plank is uniform so weight acts through mid-point
ii rock is a particle so mass of rock acts through end-point A
34 **a** $p = 2$, $q = -6$ **b** $2\sqrt{10}$ or 6.32 (3 s.f.)
c 18° (to nearest degree)
35 **a** 7.55 **b** 14.8°
36 **a** 14.8 **b** 144.2°
37 **a** 63.4° **b** $2\lambda - \mu + 1 = 0$ **c** 4.47 (3 s.f.)
38 **a** 17.5 (1 d.p.)° **b** 66°
c $P = 3\mathbf{i} + 12\mathbf{j}$ $Q = 4\mathbf{i} + 4\mathbf{j}$
39 **a** $2\mathbf{i} + \mathbf{j}$ **b** 26.6° **c** 12.6 m
40 **a** 5.83 **b** 9.43
41 **a** $(2\mathbf{i} + 6\mathbf{j})$ km h^{-1} **b** $(3\mathbf{i} - 4\mathbf{j}) + (2\mathbf{i} + 6\mathbf{j})t$
c $\lambda = 2$ **d** $\sqrt{40}$ km h^{-1}
42 **a** $3\mathbf{i} - 1.5\mathbf{j}$ **b** 6.71 **c** $21\mathbf{i} - 7\mathbf{j}$
43 **a** 6.5 km h^{-1} (2 s.f) **b** 337° **c** $8.5\mathbf{i} + 23\mathbf{j}$
d $11\mathbf{i} + (17 + 5t)\mathbf{j}$ **e** 1512 **f** 4.72 km
44 **a** 6.08 m s^{-1} **b** 3517° **c** $-5\mathbf{i} + 32\mathbf{j}$
d 21 m
45 **a** 9.43 m s^{-1} **b** $2\mathbf{i} + \mathbf{j} + t(5\mathbf{i} + 8\mathbf{j})$ **c** 1.6 s
d 4.25 m s^{-1}
e friction on field – so velocity of ball not constant *or* vertical component of ball's motion *or* time for player to accelerate
46 **a** **velocities** destroyer: $-10\mathbf{i}$ km h^{-1}, cruiser: $20\mathbf{j}$ km h^{-1}
b **position vectors** destroyer: $-10t\mathbf{i} = \mathbf{d}$
cruiser: $-50\mathbf{i} + 20t\mathbf{j} = \mathbf{c}$
c $d^2 = 500t^2 - 1000t + 2500$
d as $44.72 > 40$ cruiser will not be able to detect destroyer
47 **a** 031° (to nearest degree)
b $(3t - 10)\mathbf{i} + 5t\mathbf{j}$ **c** 15.20
d $d^2 = 25t^2 - 60t + 100$ **e** 14.24