

Answers

1 Motion in a straight line

1.1 The language of motion (Page 2)

1 (i) -100 m ; 900 m

(ii) $+1\text{ m}$; 9 m

2 (i)

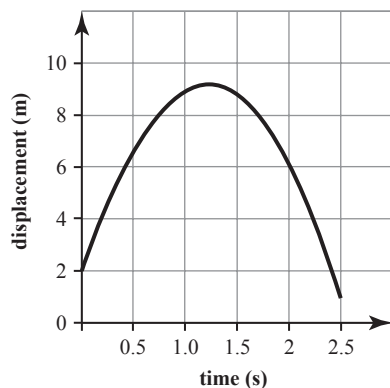
t	0	0.5	1	1.5	2	3	4	5
x	7	6.125	4	1.375	-1	-2	7	32

(ii) 25

(iii) $t = 5$; 32

(iv) $43\frac{26}{27}$

3 (i)



(ii) -1.25 m

(iii) 1.2 s ; 9.2 m

(iv) 15.65 m

4 (i) 1 m

(ii) 12 m

(iii) $1 < t < 5$

(iv) 1 s ; 5 s

(v) 18 m

1.2 Speed and velocity (Page 5)

1 (i) (a) 4 m , 0 m

(b) -4 m

(c) 12 m

(d) 4 ms^{-1} , 4 ms^{-1} ; -8 ms^{-1} , 8 ms^{-1}

(e) -2 ms^{-1}

(f) 6 ms^{-1}

(ii) (a) 0 m , -5 m

(b) -5 m

(c) 25 m

(d) $3\frac{1}{3}\text{ ms}^{-1}$, $3\frac{1}{3}\text{ ms}^{-1}$; 0 ms^{-1} , 0 ms^{-1} ;
 -7.5 ms^{-1} , 7.5 ms^{-1}

(e) $-\frac{5}{7}\text{ ms}^{-1}$

(f) $3\frac{4}{7}\text{ ms}^{-1}$

(iii) (a) 20 m , 10 m

(b) -10 m

(c) 50 m

(d) -6 ms^{-1} , 6 ms^{-1} ; 0 ms^{-1} , 0 ms^{-1} ; $6\frac{2}{3}\text{ ms}^{-1}$, $6\frac{2}{3}\text{ ms}^{-1}$

(e) -1 ms^{-1}

(f) 5 ms^{-1}

(iv) (a) 0 m , 20 m

(b) 20 m

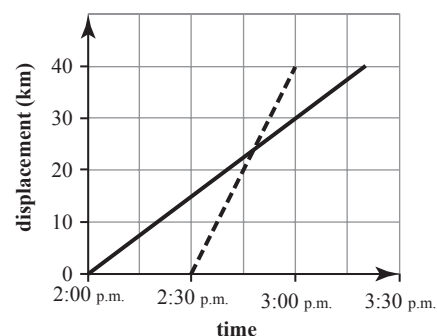
(c) 60 m

(d) 5 ms^{-1} , 5 ms^{-1} ; -5 ms^{-1} , 5 ms^{-1} ; 5 ms^{-1} , 5 ms^{-1}

(e) $1\frac{2}{3}\text{ ms}^{-1}$

(f) 5 ms^{-1}

2 (i)



(ii) 2:48 pm

(iii) 24 km

3 (i) 3 ms^{-1}

(ii) 2.25 m s^{-1}

4 (i) $1.958\bar{3}\text{ h} = 1\text{ h } 57\text{ min } 30\text{ sec}$

(ii) 51.06 km h^{-1}

(iii) 0 km h^{-1}

5 15 mph ; 6.71 m s^{-1}

1.3 Acceleration (Page 7)

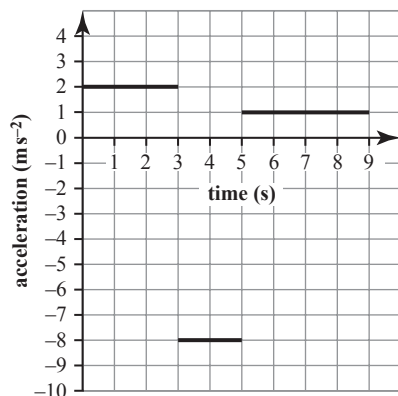
1 (i) 4 m s^{-2} , 0 , -4 m s^{-2}

(ii) 500 m

2 (i) 20 m s^{-1}

(ii) 5.5 s

- 3 (i)
- 2 m s^{-2}
- ;
- -8 m s^{-2}
- ;
- 1 m s^{-2}



- (ii)
- $+15 \text{ m}$
- ;
- $+19 \text{ m}$
- ;
- $+15 \text{ m}$
- ;
- -9 m

- 4 (i)
- 6 m s^{-2}

- (ii)
- 6 m s^{-1}

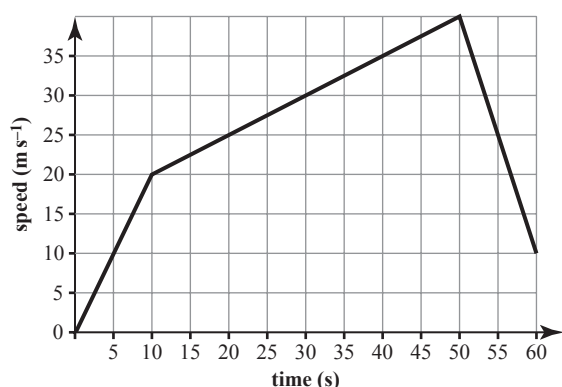
- (iii)
- $a = 3t$

- (iv)
- $t = 5$

- (v)
- 8 m s^{-1}
- ; increase

- 5 (i)
- 20 m s^{-1}
- ;
- 40 m s^{-1}
- ;
- 10 m s^{-1}

- (ii)



- (iii)
- 1550 m

Further practice (Page 13)

- 1 (i)

t	0	0.5	1	1.5	2	2.5	3
Position	3	8.75	12	12.75	11	6.75	0

- (ii)

t	0	0.5	1	1.5	2	2.5	3
Displacement	0	5.75	9	9.75	8	3.75	-3

- (iii) (a)
- 9.8 m

- (b)
- 22.5 m

- 2 (i)
- $t = 1 \text{ s}$
- ;
- $t = 3\frac{2}{3} \text{ s}$

- (ii)
- $t = 2\frac{1}{3} \text{ s}$

- (iii)
- $37\frac{2}{3} \text{ m}$

- 3 (i)

t	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5
x	5	4	1.5	-1.75	-5	-7.5	-8.5	-7.25	-3	5	17.5

- (ii)

t	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5
displacement	0	-1	-3.5	-6.75	-10	-12.5	-13.5	-12.25	-8	0	12.5

- (iii)
- $t = 3$

- (iv)
- 39.5 m

1.4 Using areas to find distances and displacements

(Page 10)

- 1 (i)
- $-1\frac{2}{3} \text{ m s}^{-2}$

- (ii)
- 187.5 m

- (iii)
- 500 m

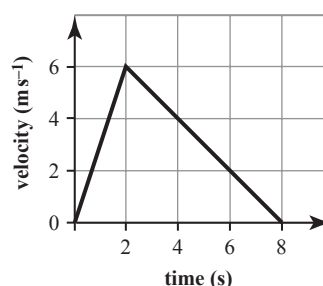
- 2 (i)
- 36 m

- (ii)
- 5 s

- (iii)
- -6 m s^{-2}
- ;
- 3 m s^{-2}

- (iv)
- 18 m s^{-1}
- ;
- 0.5 m s^{-2}

- 3 (i)



- (ii)
- 24 m

- (iii)
- -1 m s^{-2}

- (iv)
- 3 m s^{-1}

- 4 (i)
- 500 m
- ;
- 1500 m
- ;
- 1500 m
- ;
- -500 m

- (ii)
- 4000 m

- (iii)
- $t = 180 \text{ s}$

- 5 (i)
- 6000 m

- (ii)
- 125 s

- (iii)
- $24 \text{ min } 22.5 \text{ s}$

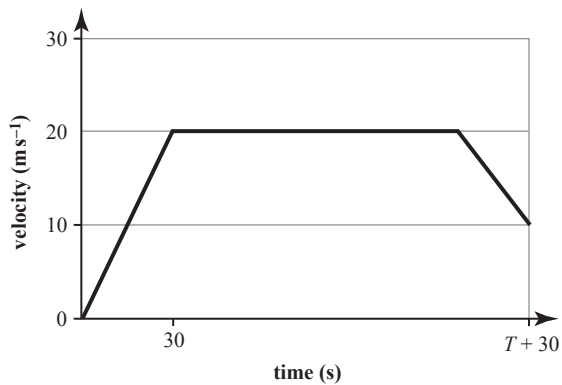
4 63.9 km h^{-1}

5 1020 m

6 (i) 40 km h^{-1}

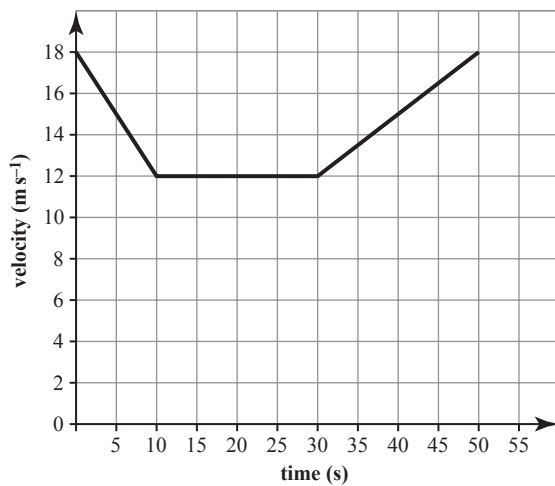
(ii) 0 km h^{-1}

7 (i)



(ii) $270 \text{ s} = 4 \text{ min } 30 \text{ sec}$

8 (i)



(ii) 13.8 m s^{-1}

9 (i) 200 m

(ii) 30 s

(iii) 150 m

10 (i) $28.5 \text{ km h}^{-1} = 7.92 \text{ m s}^{-1}$

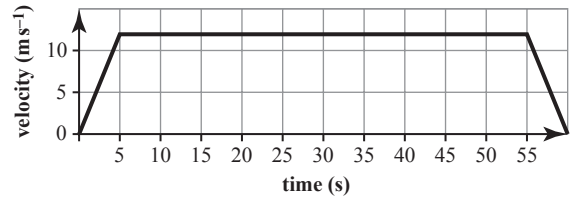
(ii) $43.0 \text{ km h}^{-1} = 12.0 \text{ m s}^{-1}$

11 560 s

12 (i) 8.77 s

(ii) 7.48 s

13 (i)



(ii) 660 m

14 (i) 20 s ; 60 m

(ii) 45 m

(iii) 75 m

15 (i) 5 m s^{-1} ; 3 m s^{-2}

(ii) 17 m s^{-1} ; 44 m

(iii) $v = 17 - 2t$

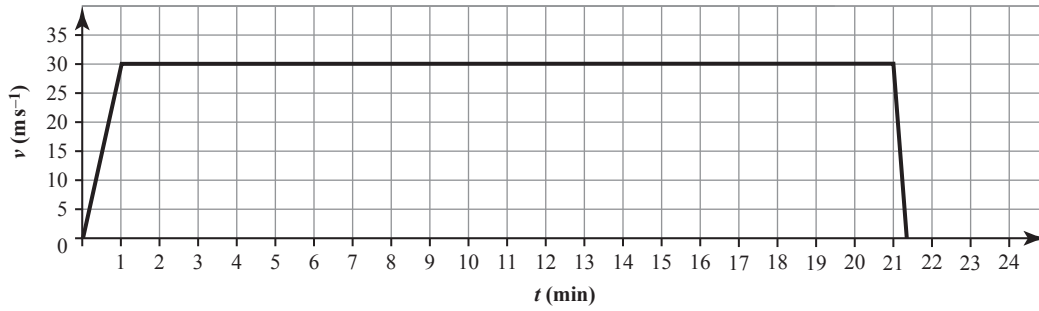
(iv) 116 m

16 12.5 m s^{-1}

17 5 min 57.5 sec

18 4 min 24 sec

19



37.125 km

20 (i) 25 m

 (ii) 2.5 m s^{-1}

(iii) 15 s

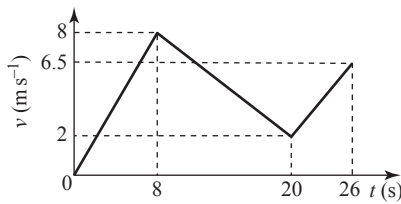
 (iv) 0.125 m s^{-2}
Past exam questions (Page 16)

 1 (i) 0.02 m s^{-2} ; -0.21 m s^{-2}

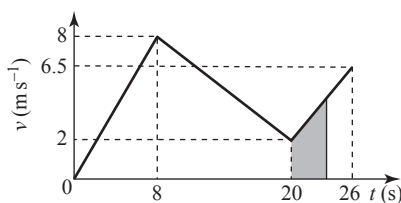
(ii) 42.5 m

(iii) 86.5 m

2 (i)



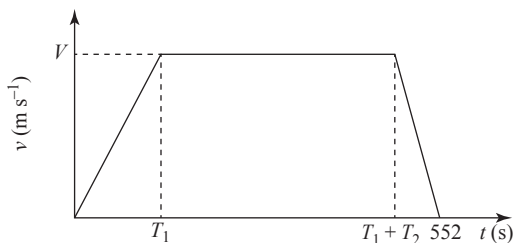
(ii)


 (iii) $s = \frac{1}{2} \times 8 \times 8 + \frac{1}{2} (8+2) \times 12$
 $+ \frac{1}{2} (t-20)(2+0.75t-13)$

$$s = 32 + 60 + 0.375t^2 - 13t + 110$$

$$s = 202 - 13t + 0.375t^2$$

3 (i)



$$\frac{10}{3}V; V$$

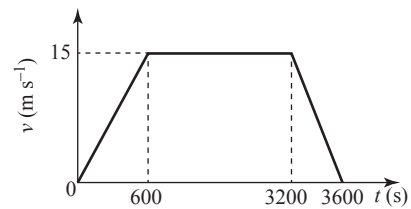
 (ii) $552V - \frac{13}{6}V^2$;

$$12\,000 = 552V - \frac{13}{6}V^2 \Rightarrow 13V^2 - 3312V + 72\,000 = 0;$$

$$V = 24$$

4 (i) 3600 s

(ii)

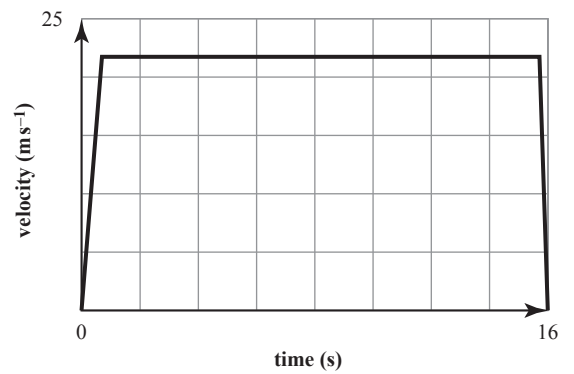


46 500 m

(iii) 300 s; 3400 s

Stretch and challenge (Page 17)

1 (i)


 (ii) 21.5 m s^{-1}

(iii) 40 s; 215 m

$$2 \quad D = \frac{1}{2} \times \frac{2}{3}aT \times T = \frac{1}{3}aT^2$$

$$3 \quad AB = \frac{1}{2} \times 3aT^2$$

$$BC = \frac{1}{2}(3aT + 4aT)T = \frac{7}{2}aT^2$$

$$\Rightarrow AC : BC = 3 : 7$$

$$T = \frac{V}{4a}$$

$$4 \quad (i) \quad \frac{5}{54} \text{ m s}^{-2}$$

$$(ii) \quad \frac{5}{18} \text{ m s}^{-2}$$

$$(iii) \quad 16\frac{2}{3} \text{ m s}^{-1}$$

2 The constant acceleration formulae

- 1 (i) 13 m s^{-1}
(ii) 37.5 m
(iii) -8 m
(iv) $\pm 5 \text{ m s}^{-1}$
- 2 0.9 m s^{-2} ; $2\frac{2}{9} \text{ s}$
- 3 (i) 0.75 s
(ii) 4.06 m
(iii) 1.5 s ; 7.5 m s^{-1}
- 4 (i) 7.11 m s^{-2}
(ii) 10.7 m s^{-1}
(iii) 10.1 s
(iv) 9.88 m s^{-1}
- 5 $a = 0.1 \text{ m s}^{-2}$; $u = -1.5 \text{ m s}^{-1}$
- 6 $25 - 10 T = 10 T \therefore T = 1.25 \text{ s}$; $V = 12.5 \text{ m s}^{-1}$;
 $X = 31.25 \text{ m}$
- 7 (i) $u = 18.75 \text{ m s}^{-1}$; $a = 0.25 \text{ m s}^{-2}$
(ii) 547 m
- 8 (i) $u = 10 \text{ m s}^{-1}$; $a = 2.5 \text{ m s}^{-2}$
(ii) 20 m s^{-1}
(iii) 131.25 m
- 9 (i) $0 = 8^2 + 2 \times -10 \times h \therefore h = 3.2 \text{ m}$
(ii) 6 m s^{-1}
(iii) $v_A = 8 - 7 = 1$; $v_B = 6 - 7 = -1$
- 10 (i) 16.7 m s^{-1}
(ii) 0.278 m s^{-2}
(iii) 50 m s^{-1}

Further practice (Page 22)

- 1 (i) 6 m s^{-2}
(ii) -1.5 m s^{-2}
(iii) -24 m
(iv) 15 m s^{-1}
(v) 6 m s^{-1}
- 2 2 m s^{-2} ; 225 m
- 3 Train does not reach obstacle.
- 4 (i) 4 m s^{-2}
(ii) 22.4 m s^{-1}
- 5 20 m s^{-1} ; 20 m

- 6 (i) 21.5 m s^{-1}
(ii) 1.8 s
- 7 3.46 s
- 8 0.849 m s^{-2} ; 382 m
- 9 8.94 m s^{-2}
- 10 (i) $T = 0.675 \text{ s}$
(ii) deceleration $= 6.35 \text{ m s}^{-2}$
(iii) 2.78 s
(iv) 21 m ; 76.2 m
(v) 5.58 s
- 11 (i) 45 m
(ii) $45 - 5t^2 = 18t - 5t^2 \therefore t = 2.5 \text{ s}$; 13.75 m
- 12 (i) 3.5 s ; 2.5 s
(ii) 61.25 m
- 13 $a = 0.1125 \text{ m s}^{-2}$; $u = -2 \text{ m s}^{-1}$
(i.e. initial direction is away from B)
- 14 (i) 3 s
(ii) 15 m
- 15 (i) $x_A = 0.4t^2$; $x_B = 10t$
(ii) 40 s ; 640 m
- 16 $a = 7.5 \text{ m s}^{-2}$; $u = -2.5 \text{ m s}^{-1}$

Past exam questions (Page 23)

- 1 11.25 m ; 2.1 s
- 2 (i) 7.5 m s^{-2}
(ii) 60 m
- 3 (i) 45 s
(ii) 33 s
- 4 (i) 5.66 m s^{-1}
(ii) 0.234 s
- 5 (i) 13 m ; 5.66 m s^{-1}
(ii) 3.25 m

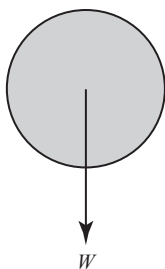
Stretch and challenge (Page 24)

- 1 8 m s^{-2} ; 50 m s^{-1}
- 2 30 s ; $x_A = 30u + 450a$; $x_B = 10u + 150a \therefore x_A = 3x_B$
- 3 109 m
- 4 20 m s^{-1}
- 5 125 m

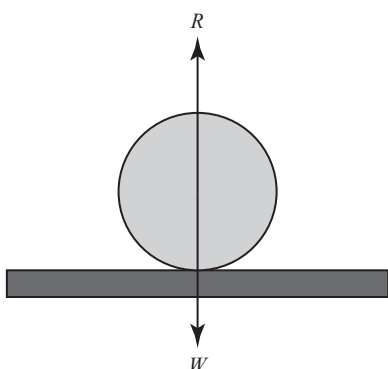
3 Forces and Newton's laws of motion

3.1 Force diagrams (Page 25)

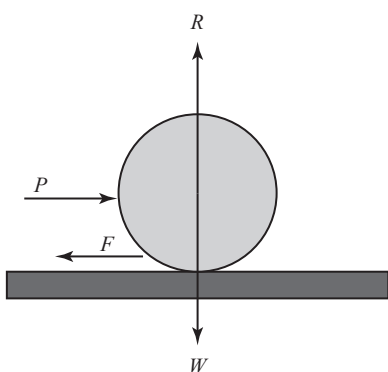
1 (i)



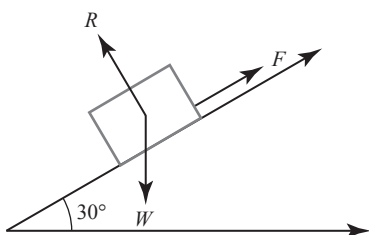
(ii)



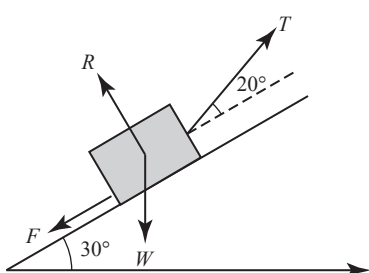
(iii)



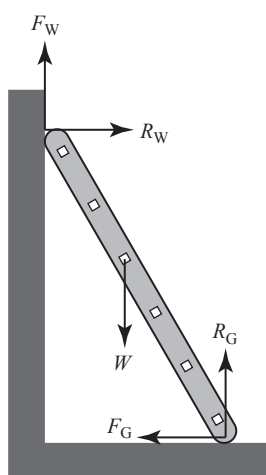
(iv)



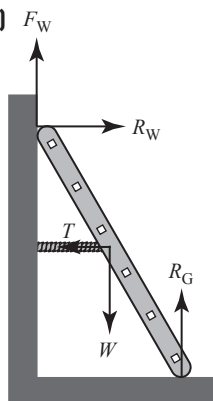
(v)



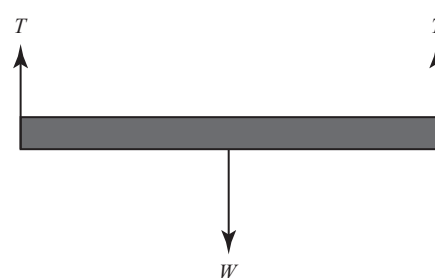
(vi)



(vii)

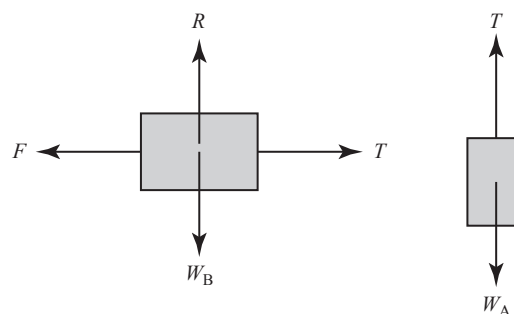


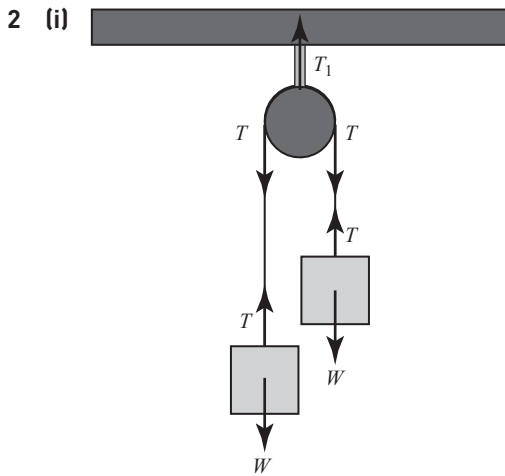
(viii)



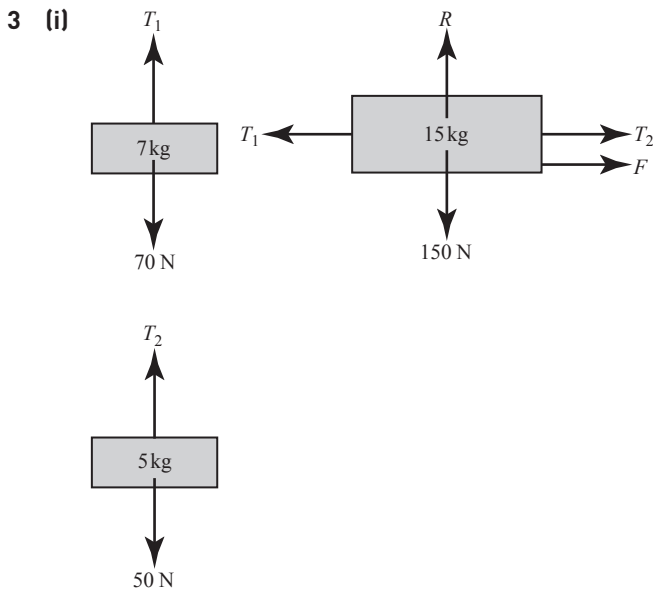
3.2 Force and motion; pulleys (Page 27)

1 (i)

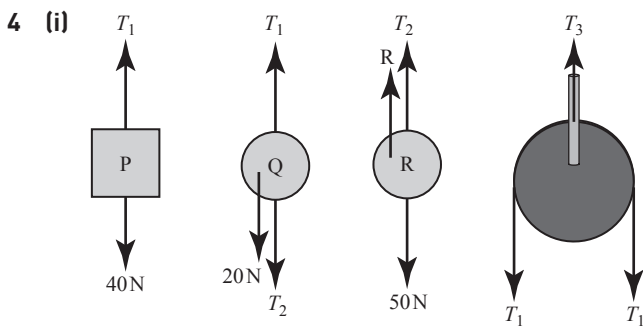
(ii) $R = W_B$; $F = T$; $T = W_A$ (iii) $T - F$



- (ii) W
 (iii) $2W$

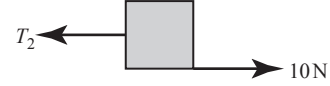
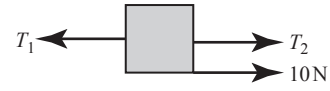
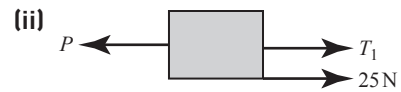


- (ii) $70 - T_1$; $T_1 - T_2 - F$; $T_2 - 50$



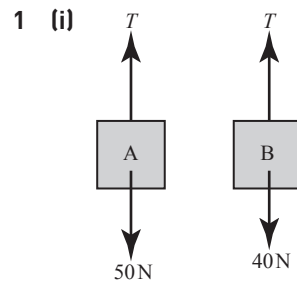
- (ii) The pulley is smooth; 40 N
 (iii) 20 N
 (iv) 30 N

- 5 (i) $R = W$; net force = 0 N
 (ii) $R > W$; net force = $R - W$
 (iii) $R < W$; net force = $W - R$
 (iv) $R > W$; net force = $R - W$

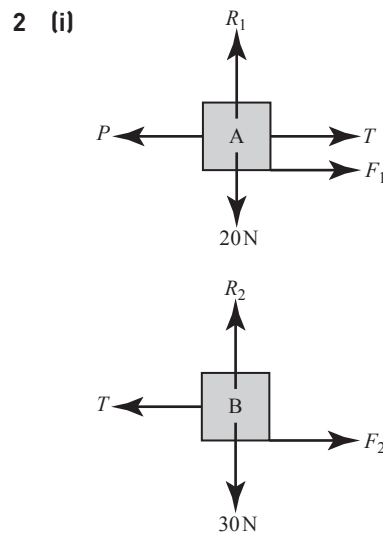


- (iii) $T_1 = 20 \text{ N}$
 (iv) $T_2 = 10 \text{ N}$
 (v) $T_1 = T_2 + 10$

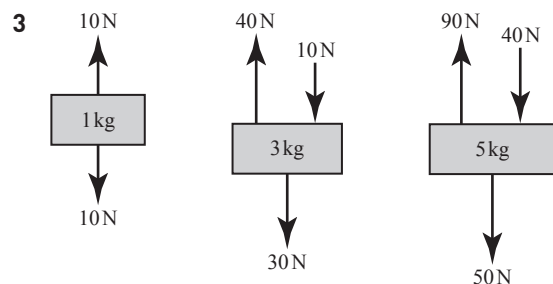
Further practice (Page 31)



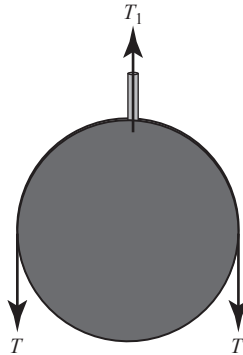
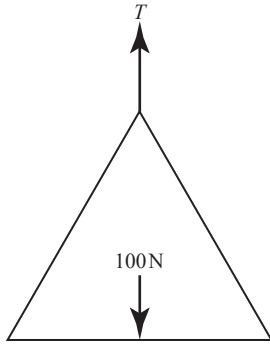
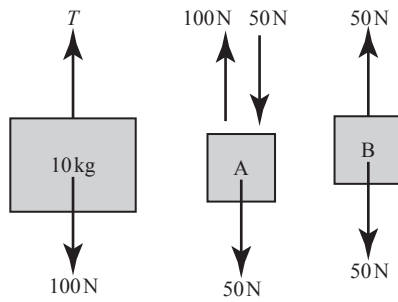
- (ii) 10 N



- (ii) $P - F_1 - F_2$



4 (i)



(ii) 100 N

(iii) 200 N

(iv) 50 N

5 (i) 30 N

(ii) 20 N

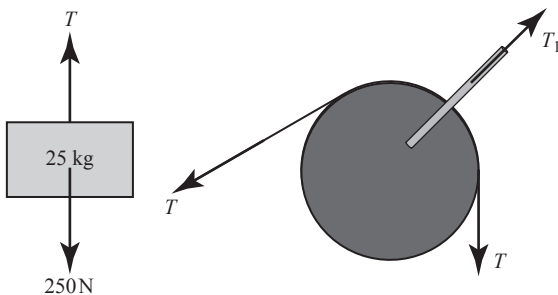
Past exam question (Page 32)

1 40 N; 10 N

Stretch and challenge (Page 32)

- 1 (i) 4000 N
 (ii) 100 N
 (iii) 200 N
 (iv) $T_n = 100 \times n$
 (v) 2500 N

2 (i)



(ii) 250 N

 (iii) 433 N ; 60° below the horizontal

4 Applying Newton's second law along a line

4.1 Newton's second law (Page 33)

- 1 (i) $X - 5g = 15$; $X = 65$ N
 (ii) $7g - X = 14$; $X = 56$ N
 (iii) $120 - mg = 5m$; $m = 8$ kg
 (iv) $Mg - 24 = 4M$; $M = 4$ kg
 (v) $240 - 15g = 15a$; $a = 6 \text{ m s}^{-2}$
 (vi) $25g - 50 = 25a$; $a = 8 \text{ m s}^{-2}$
- 2 (i) 100 N
 (ii) 50 N
- 3 1.5 m s^{-2}
- 4 $7\frac{1}{3} \text{ m s}^{-2}$
- 5 (i) $-\frac{5}{7} \text{ m s}^{-2}$
 (ii) 696.4 N

4.2 Newton's second law applied to connected objects (Page 35)

- 1 (i) 100 N
 (ii) 300 N
- 2 (i) $400a = -200 \Rightarrow a = -0.5$
 (ii) 50 N
 (iii) 350 m
- 3 (i) $1\frac{1}{9} \text{ m s}^{-2}$
 (ii) $\frac{5}{9} \text{ m s}^{-1}$
 (iii) $\frac{5}{18} \text{ m}$
- 4 (i) $140\,000a = 29\,000 - (500 + 100 + 100 + 100 + 100 + 100)$
 $\Rightarrow a = 0.2$
 (ii) 3900 N
 (iii) -0.1 m s^{-2}
 (iv) 100 N
- 5 0.2 m s^{-2} ; 2040 N ; 2550 N

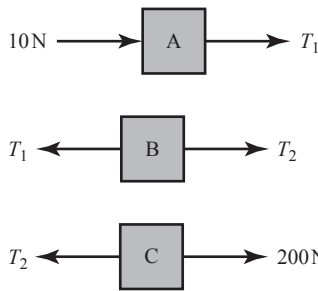
Further practice (Page 38)

- 1 10 N
 2 3760 N
 3 27.375 N
 4 424 N
 5 2 m s^{-2}
 6 2 m s^{-2}

7 (i) 950 N

(ii) 1950 N

8 (i)


 (ii) $4a = T_1 + 10$; $10a = T_2 - T_1$; $16a = 200 - T_2$

 (iii) 7 m s^{-2} ; 18 N; 88 N

 9 (i) $1\frac{1}{6} \text{ m s}^{-2}$; 1400 N

 (ii) deceleration = 0.5 m s^{-2} ; -100 N (compression)

 10 (i) (a) 2.5 m s^{-2} ; 37.5 N

 (b) 3.5 m s^{-1}

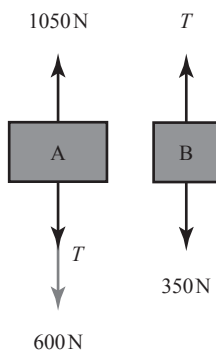
(c) 0.6125 m

 (ii) (a) $5\frac{5}{13} \text{ m s}^{-2}$; $46\frac{2}{13} \text{ N}$

 (b) 1.80 m s^{-1}

(c) 0.162 m

11 (i)

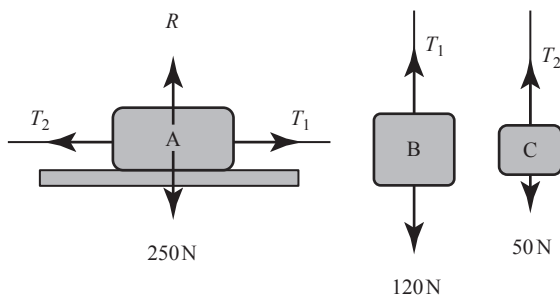

 (ii) $60a = 1050 - T - 600$; $35a = T - 350$

 (iii) 1.05 m s^{-2} ; 387 N

 12 (i) 2.24 m s^{-1}

(ii) 15 N

13 (i)


 (ii) $25a = T_1 - T_2$; $12a = 120 - T_1$; $5a = T_2 - 50$

 (iii) $1\frac{2}{3} \text{ m s}^{-2}$; $T_1 = 100 \text{ N}$; $T_2 = 58\frac{1}{3} \text{ N}$

(iv) 35 N

14 105 s

 15 (i) 0.25 m ; 1 m s^{-1}

 (ii) $s = \frac{0^2 - 1^2}{-2 \times 10} = 0.05$; total time = 0.6 s

 (iii) $m_A = 0.75 \text{ kg}$; $m_B = 0.5 \text{ kg}$

(iv) (a) 17 N

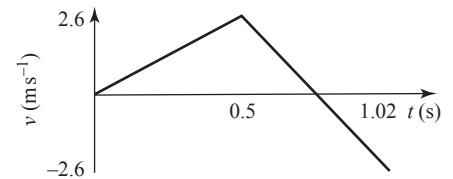
(b) 5 N

Past exam questions (Page 40)

 1 (i) 5.2 m s^{-2}

 (ii) 2.6 m s^{-1} ; 0.5 s

(iii) 1.02 s



(iv) 1.33 m

 2 (i) 4 m s^{-2} ; 1.92 N

(ii) 0.7 s

(iii) 0.85 s

3 0.8 m

4 (i) 0.5 m

(ii) 0.3 kg; 4.2 N

(iii) 0.9 s

Stretch and challenge (Page 42)

 1 (i) 0.125 m s^{-2}

(ii) 31 250 N

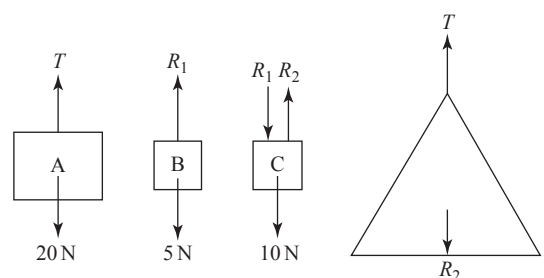
 (iii) $T_n - (25 - n)250 = (25 - n) \times 8000 \times 0.125$
 $\therefore T_n = 31\,250 - 1250n$

(iv) 1250 N

 2 (i) $\frac{10}{49} \text{ m s}^{-2}$

(ii) 0.2 kg

3 (i)


 (ii) A: $20 - T = 2a$; B: $R_1 - 5 = 0.5a$;

 C: $R_2 - R_1 - 10 = a$; scale-pan: $T - R_2 = 0$

 (iii) 1.43 m s^{-2} ; 17.1 N; 5.71 N; 17.1 N

5 Vectors

- 1 (i) 13 ; 67.4°
(ii) 2.24 ; -63.4°
(iii) 5 ; -36.9°
(iv) 5.39 ; 112°
- 2 (i) 1.41 ; 045°
(ii) 5.83 ; 149°
(iii) 20.5 ; 103°
(iv) 30.5 ; 280°
- 3 2.05 ; 52.3°
- 4 (i) $\begin{pmatrix} 8 \\ -6 \end{pmatrix}$; acceleration = $\begin{pmatrix} 4 \\ -3 \end{pmatrix}$
(ii) $\begin{pmatrix} -10 \\ 20 \end{pmatrix}$
(iii) 4 s
- 5 (i) $\mathbf{v}(1) = \begin{pmatrix} 2 \\ -2 \end{pmatrix}$; speed = 2.82 m s^{-1}
(ii) 140°
- 6 (i) $\mathbf{F}_1 = 205\mathbf{i} + 143\mathbf{j}$; $\mathbf{F}_2 = 350\mathbf{i}$; $\mathbf{F}_3 = 188\mathbf{i} - 68.4\mathbf{j}$
(3.s.f.)
(ii) 747 N ; 5.77°
(iii) -75.0 N
- 7 (i) 9.43 ; 148°
(ii) $\mathbf{G} = 1.5\mathbf{F}$
(iii) -11

Further practice (Page 46)

All angles are calculated anti-clockwise from the positive x -axis. Answers given as bearings equally acceptable.

- 1 5.83 N ; 149° (bearing 301°)
- 2 (5, -4)
- 3 6.40 ; 6.08
- 4 $|\mathbf{a} + \mathbf{b}| = |\mathbf{a} - \mathbf{b}| = 13$
- 5 22
- 6 5.83 ; 121°
- 7 (i) 9.43 ; -32°
(ii) 10.77 ; -21.80°
- 8 (i) 7.81 N
(ii) 26.3°
- 9 34.4 N ; -8.37°
- 10 (i) 36.25 N ; -6.73°
(ii) 94.25 N ; 60.7°

Past exam questions (Page 46)

- 1 1.23 N at 153° anticlockwise from positive x -axis.
- 2 (i) $25\cos\alpha - 30\cos\beta = 0$
(ii) 5 N in positive y -direction
(iii) 30 N in negative y -direction

Stretch and challenge (Page 47)

- 1 $P^2 + Q^2 + 2PQ\cos\theta = P^2 \therefore Q^2 = -2PQ\cos\theta$
 $4P^2 + Q^2 + 4PQ\cos\theta = 3P^2 \therefore P^2 + Q^2 = -4PQ\cos\theta$
 $P^2 + Q^2 = 2Q^2 \therefore Q = P ; \theta = 120^\circ$
- 2 3.40 N ; 12.9 N
- 3 (i) (a) $\overrightarrow{\mathbf{AM}} = \frac{1}{2}\mathbf{b} + \frac{1}{2}\mathbf{c} - \mathbf{a}$
(b) $\overrightarrow{\mathbf{AG}} = \frac{1}{3}\mathbf{b} + \frac{1}{3}\mathbf{c} - \frac{2}{3}\mathbf{a}$
(c) $\overrightarrow{\mathbf{BN}} = \frac{1}{2}\mathbf{a} + \frac{1}{2}\mathbf{c} - \mathbf{b}$
(d) $\overrightarrow{\mathbf{CP}} = \frac{1}{2}\mathbf{a} + \frac{1}{2}\mathbf{b} - \mathbf{c}$
(e) $\mathbf{g} = \frac{1}{3}(\mathbf{a} + \mathbf{b} + \mathbf{c})$
(ii) $\overrightarrow{\mathbf{BG}} = \mathbf{g} - \mathbf{b} = \frac{2}{3}\overrightarrow{\mathbf{BN}} ; \overrightarrow{\mathbf{CG}} = \mathbf{g} - \mathbf{c} = \frac{2}{3}\overrightarrow{\mathbf{CP}}$
- 4 $F = 800 \text{ kN}$; resultant = 1800 kN

6 Forces in equilibrium and resultant forces

6.1 Finding resultant forces (Page 48)

- 1 (i) (a) $\begin{pmatrix} 25.4 \\ 5.06 \end{pmatrix}$
(b) 25.9 N ; 11.3°
(ii) (a) $\begin{pmatrix} 6.46 \\ 5.27 \end{pmatrix}$
(b) 8.34 ; 39.2° from positive x -axis
(iii) (a) $\begin{pmatrix} -0.866 \\ -1.5 \end{pmatrix}$
(b) 1.73 N ; 210° clockwise from 1 N force

6.2 Forces in equilibrium (Page 49)

- 1 (i) $P = 16.6 \text{ N}$; $X = 6.99 \text{ N}$
(ii) $\theta = 60^\circ$; $W = 5.20 \text{ N}$
(iii) $R = 43.3 \text{ N}$; $F = 25 \text{ N}$
(iv) $\theta = 17.7^\circ$; $T = 18.5 \text{ N}$
(v) $\theta = 29.1^\circ$; $Z = 10.3 \text{ N}$
(vi) $P = 2.40 \text{ N}$; $R = 10.2 \text{ N}$

2 $T_1 = 64.6 \text{ N}$; $T_2 = 26.9 \text{ N}$

3 41.8° ; 20 N ; 22.4 N

4 (i) 57.1 N

(ii) 6.97 kg

6.3 Newton's second law in two dimensions (Page 51)

1 $a = 0.376 \text{ m s}^{-2}$; 72.6 N

2 (i) 1.10 m s^{-2}

(ii) 281 N

3 (i) 1.4 m s^{-2}

(ii) 3.74 m s^{-1}

(iii) 1.4 m s^{-2}

(iv) 0 m s^{-1}

4 (i) 1800 N

(ii) 400 N ; 800 N

(iii) 0.872 m s^{-2} ; 393 N ; 787 N

5 3.92 m s^{-2} ; 30.2 N in tension

6 0.94 m s^{-2} ; 564 N

Further practice (Page 53)

1 (i) 35.6 N

(ii) 39.9 N

2 0.476 N ; 80.5°

3 68.3 N ; 17.9°

4 234 N ; 168 N

5 (i) 70.5 N

(ii) 333 N

(iii) horizontal component is unchanged

(iv) 42.3 N

6 Tension in AB of 220 N . Compression of 333 N in AC.

7 (i) Horizontal components: $T_1 \sin 25^\circ = T_2 \sin 25^\circ$

$\therefore T_1 = T_2$

(ii) 27.6 N

(iii) 13.6 kg

8 $P = X(3 - \sqrt{2})$; $W = X\sqrt{2} \Rightarrow P = (3\sqrt{2} - 2)\frac{W}{2}$

9 $R_A = W$; $R_B = W\sqrt{2}$

10 (i) $T_{BC} = 250 \times 0.8 = 200 \text{ N}$; $T_{AB} = 250 \text{ N}$

(ii) 31.0° ; 233 N

11 (i) $T \sin 65^\circ + R = 750$

(ii) 828 N ; 82.8 kg

(iii) 350 N

12 1.83 m s^{-2} ; 34.2 N ; 48.3 N

13 (i) 2250 N ; 675 N

(ii) 3450 N ; 1035 N

14 (i) 2 kg ; 18 N

(ii) 2.59 m s^{-2} ; 25.9 N

15 (i) 18.7° ; 1350 N

(ii) 1330 N

(iii) 1.73 m s^{-1}

16 (i) 6 N at 30° to the horizontal

(ii) 3.6 m s^{-1} ; 5.4 m from O

17 58.5 N

18 (i) 3.20 m s^{-1}

(ii) 0.0147 N in tension

19 400 m

Past exam questions (Page 57)

1 (i) $T \cos \theta + T \sin \theta = 11.2$; $-T \cos \theta + T \sin \theta = 1.6$

(ii) 8 N ; 53.1°

2 13 N ; 20 N

3 73 N , 41.1°

4 (i) 2.16 N ; 5.85 m s^{-2}

(ii) 2.65 m s^{-1} ; 0.475 m

Stretch and challenge (Page 59)

1 $P \cos \theta = \frac{mg}{2}$; $P \sin \theta = \frac{mg}{2\sqrt{3}} \Rightarrow \theta = 30^\circ$; $P = \frac{mg}{\sqrt{3}}$

2 5 m

3 $W = 6.43 \text{ N}$; $\theta = 37.9^\circ$ or $W = 9.95 \text{ N}$; $\theta = 72.1^\circ$

7 General motion in a straight line

7.1 Using differentiation (Page 60)

1 (i) $v = -9 + 12t - 3t^2$

(ii) $v < 0$ for $0 \leq t < 1$; $v > 0$ for $1 < t \leq 3$

(iii) $a(1) = 6 \text{ m s}^{-2}$; $a(3) = -6 \text{ m s}^{-2}$

2 (i) $v = 4t^3 - 2t$

(ii) 2 ; 0

(iii) $t = 0$, $s = 2$; $t = \pm \frac{1}{\sqrt{2}}$, $s = \frac{7}{4}$

3 (i) 15 m

(ii) $v = 12 + 6t - 6t^2$

(iii) $a = 6 - 12t$

(iv) 13.5 m s^{-1}

(v) Once

(vi) 214 m

7.2 Finding displacement from velocity and finding**velocity from acceleration (Page 61)**

1 (i) $s = 2.5t^2 - 2t + 3$

(ii) $s = t^3 + 2t^2 - 1$

(iii) $s = -1.5t^2 + t - 2$

2 (i) $v = 6t^2 - 8t + 3$; $s = 2t^3 - 4t^2 + 3t + 5$

(ii) $v = 1.4t^{2.5} - 3t - 0.4$;

$s = 0.4t^{3.5} - 1.5t^2 - 0.4t + 4.5$

(iii) $v = 0.2t^3 - 0.15t^2 + t - 0.05$;

$s = 0.05t^4 - 0.05t^3 + 0.5t^2 - 0.05t + 0.05$

3 (i) $t = 0$ or $t = 2$

(ii) $t = 3$

(iii) 6.75 m

(iv) $t = 4$

4 (i) 12.15 m

(ii) 13.85 s

(iii) 26.33 s

5 (i) $s = 0.5t^3 - t^2$; $s(2) = 0$; $s(4) = 16 \text{ m}$

(ii) $1\frac{1}{3} \text{ s}$

(iii) $17\frac{5}{27} \text{ m}$

Further practice (Page 64)

1 76 m s^{-1} ; 42 m s^{-2}

2 (i) 42 m s^{-1} ; 54 m s^{-2}

(ii) 31.25 m

(iii) 54.5 m

3 (i) $v = -24 + 18t - 3t^2$; $t = 2$ and $t = 4$

(ii) $s(2) = -2$; $s(4) = 2$

(iii) 28 m

4 (i) $v = 1$, $a = -4$ when $t = 1$; $v = 0$, $a = 2$ when $t = 2$

(ii) $s = \frac{4}{27}$ when $t = \frac{4}{3}$; $s = 0$ when $t = 2$

(iii) $a = -8$ when $t = \frac{1}{3}$; $a = 8$ when $t = 3$

5 (i) $v(1) = 0$; $\frac{1}{12} \text{ m}$

(ii) $\frac{4}{27} \text{ m s}^{-1}$

6 (i) $a = 3 - \frac{1}{6}t$; $s = 1.5t^2 - \frac{1}{36}t^3 + 5$

(ii) 36 s ; 54 s

7 6.25 m

8 16 m

9 (i) $a = 0$; $v = 8 \text{ m s}^{-1}$

(ii) $10\frac{2}{3} \text{ m}$

(iii) $13\frac{1}{6} \text{ s}$

10 (i) 140.625 m s^{-1}

(ii) 1265.625 m

(iii) 20 s ; 150 m s^{-1}

11 3 m

12 (i) 3.6 m s^{-2}

(ii) 10 s

(iii) $26\frac{2}{3} \text{ m s}^{-1}$

(iv) $416\frac{2}{3} \text{ m}$

13 (i) 1 m s^{-2}

(ii) $s = 18t - \frac{27}{2}t^2 + \frac{10}{3}t^3 - \frac{1}{4}t^4$; 12.916 m

(iii) Particle goes backwards

(iv) 23.583 m

Past exam questions (Page 65)

1 (i) 22.5 m

(ii) 4 m s^{-1}

2 (i) $k_1 = 0.5$; $\frac{k_2}{\sqrt{60}} = 0.5 \times 60 - 0.005 \times 60^2 = 12$
 $\Rightarrow k_2 = 12\sqrt{60}$

(ii) $24\sqrt{60}t - 900$

(iii) 8 m s^{-1}

3 (i) $s = 0.00625t^4 - 0.25t^3 + 2.5t^2$

(ii) 20 s

4 (i) $\int_0^5 (0.6t - 0.03t^2) dt = 0.3 \times 25 - 0.01 \times 125 = 6.25$;
 0.3 m s^{-2}

(ii) 2.93 s or 17.1 s

5 (i) $AB = 3 \times 400 + 0.0025 \times 400^2 = 1600 \text{ m}$; 5 m s^{-1}

(ii) $k = 1\frac{1}{3}$; 5.33 m s^{-1}

(iii) 280 s ; 0.0262 m s^{-2}

6 (i) -4.8 m s^{-1} ; 1.6 m s^{-2}

(ii) 5 m s^{-1}

(iii) (a) 2.35 m s^{-1}

(b) 3.00 m s^{-1}

7 (i) 8 s

(ii) $0 < t < 4.62$

Stretch and challenge (Page 67)

- 1 (i) Sprinter A : 8.1 m s^{-1} ; Sprinter B : 8.64 m s^{-1}
 (ii) Sprinter A : 12.15 m ; Sprinter B : 17.28 m
 (iii) Sprinter A : 13.85 s ; Sprinter B : 13.57 s
 (iv) B wins by 0.27 s or 2.20 m
- 2 (i) 2.4 m s^{-1}
 (ii) 5.87 m
 (iii) 23.9 m
- 3 (i) 2.25 m s^{-2}
 (ii) 10 s
 (iii) 16.6 m s^{-1}
- 4 (i) $v = 10 \cos 2t + 24 \sin 2t$; $a = -20 \sin 2t + 48 \cos 2t$
 (ii) $a = -4(5 \sin 2t - 12 \cos 2t) = -4s$
 (iii) $v^2 = 100 \cos^2 2t + 480 \cos 2t \sin 2t + 576 \sin^2 2t$;
 $4(169 - s^2) = 4(25 - 25 \sin^2 2t + 120 \sin 2t \cos 2t$
 $+ 144 - 144 \cos^2 2t)$
- 3 (i) 3.75 m s^{-2}
 (ii) 0.375
 (iii) 83.3 m
- 4 (i) 2.5 m s^{-2}
 (ii) 1.10 s
 (iii) 2.35 m s^{-1}
- 5 (i) 21.3 N
 (ii) 0.190
 (iii) 65.8 mm
 (iv) Faster
- 6 0.346
- 7 (i) 67.6 N
 (ii) 182 N
 (iii) 230 N
- 8 (i) 149 N
 (ii) 19.8 N

8 A model for friction

- 1 (i) (a) 50 N
 (b) 0.4
 (ii) (a) 37.5 N
 (b) 0.577
 (iii) (a) 56.3 N
 (b) 0.241
- 2 (i) (a) 0.625 m s^{-2}
 (b) 46.9 N
 (c) 37.5 N
 (ii) (a) $2\frac{2}{3} \text{ m s}^{-2}$
 (b) $7\frac{1}{3} \text{ N}$
 (c) 2 N
 (iii) (a) $\frac{5}{16} \text{ m s}^{-2}$
 (b) 77.5 N, 41.25 N
 (c) 30 N
 (iv) (a) 0 m s^{-2}
 (b) 30 N, 10 N
 (c) 20 N
 (v) (a) 2.83 m s^{-2}
 (b) 28.7 N
 (c) 5.20 N

Further practice (Page 73)

- 1 0.0625
- 2 (i) 14.4 m s^{-2}
 (ii) 65.8 m s^{-2}
- 3 3.27 m s^{-2} ; 8.86 m s^{-1}
- 4 679 N
- 5 (i) $a = g \left[\frac{m - M \sin \alpha - \mu M \cos \alpha}{m + M} \right]$;
 $T = \frac{mMg}{m + M} (1 + \sin \alpha + \mu \cos \alpha)$
 (ii) $a = g \left[\frac{M \sin \alpha - \mu M \cos \alpha - m}{m + M} \right]$;
 $T = \frac{mMg}{m + M} (1 + \sin \alpha - \mu \cos \alpha)$
- 6 (i) 3.23 m s^{-2}
 (ii) 215 N
- 7 (i) 7 N
 (ii) 5.47 m s^{-2}
 (iii) 1 s
- 8 (i) 0.0979
 (ii) 43.4 N
 (iii) 5.66 m s^{-2}
- 9 0.569
- 10 0.353

- 11 $3X = mg \sin \alpha + \mu mg \cos \alpha$; $X = mg \sin \alpha - \mu mg \cos \alpha$
 $\Rightarrow \mu = 0.5 \tan \alpha$
- 12 (i) 4.5 m s^{-2}
 (ii) 2.16 N ; 18.79 N ; 0.115
 (iii) 2.34 m s^{-2} ; 4.33 m s^{-1}
- 13 (i) 20 N
 (ii) 4.4 kg
 (iii) 23.2 N
- 14 (i) (a) 50 N
 (b) 48.8 N
 (c) 58.5 N
 (ii) 90.8 N
- 15 0.128
- 3 $4P(\cos \theta - \mu \sin \theta) = Mg(\sin \theta + \mu \cos \theta)$
 $P(\cos \theta + \mu \sin \theta) = Mg(\sin \theta - \mu \cos \theta)$
 $4(\sin \theta - \mu \cos \theta)(\cos \theta - \mu \sin \theta)$
 $= (\cos \theta + \mu \sin \theta)(\sin \theta + \mu \cos \theta)$
 $3 \sin \theta \cos \theta (1 + \mu^2) = 5\mu$
 $\Rightarrow \mu = 0.6(1 + \mu^2) \sin \theta \cos \theta$
- 4 (i) $T = \frac{100}{\cos \alpha + 0.5 \sin \alpha}$
 (ii) 26.6° , 89.4 N

9 Energy, work and power

9.1 Work and energy (Page 79)

Past exam questions (Page 76)

- 1 (i) 10
 (ii) 0.367
- 2 (i) 0.8
 (ii) 2.55 m s^{-2}
- 3 (i) $a = -10\left(0.28 + \frac{1}{3} \times 0.96\right) = -6 \text{ m s}^{-2}$
 (ii) 2.43 m
- 4 (i) (a) 2.8 m s^{-2}
 (b) -2 m s^{-2}
 (ii) 2.5 m
 (iii) 2.21 s
- 5 (i) $T_{AJ} = 4.48 \text{ N}$; $T_{JR} = 3.36 \text{ N}$
 (ii) $F = 3.36 \cos \beta - 2 = 0.688$; $R = 3.36 \sin \beta = 2.016$;
 $\mu = \frac{0.688}{2.016} = 0.341$
 (iii) 0.138 kg
- 6 (i) 16.3°
 (ii) 0.292
- 7 $6.78 \leq m \leq 12.2$

Stretch and challenge (Page 78)

- 1 Time to descend distance X on smooth plane $= \sqrt{\frac{X}{3}}$;
 Time to descend X on rough plane $= \sqrt{\frac{4X}{3}}$
- 2 $T\left(\cos \beta + \frac{1}{7} \sin \beta\right) < 8500\left(\sin \alpha + \frac{1}{7} \cos \alpha\right)$
 $\Rightarrow T < 1300 + 1200 = 2500$
 $T\left(\cos \beta - \frac{1}{7} \sin \beta\right) > 8500\left(\cos \alpha - \frac{1}{7} \sin \alpha\right)$
 $\Rightarrow T > \frac{25}{23}(1300 - 1200) = 109$

- 1 (i) 12.5 J
 (ii) 6 m
 (iii) 1.25 J
 (iv) 0.278 N
 (v) 9.89 m s^{-1}
- 2 (i) 990 J
 (ii) 6875 J
 (iii) 10365 J
- 3 (i) (a) 20.8 J
 (b) 30 J
 (c) 50.8 J
 (d) 2.16 m s^{-1}
 (ii) 1.48 m
- 4 (i) Loss of 9.14 J
 (ii) 0.12 m
- 5 (i) 278 J
 (ii) 22.5 J
 (iii) 38.9 N

9.2 Power (Page 82)

- 1 (i) 0.0833 m s^{-2}
 (ii) 18.75 m s^{-1}
- 2 (i) 20 m s^{-1}
 (ii) 2000 N ; $1\frac{1}{9} \text{ m s}^{-2}$
 (iii) 53.3 m
- 3 (i) 600 N
 (ii) 18000 W
- 4 (i) $4.5 \times 10^4 \text{ N}$

(ii) 450 kW

(iii) 24 m s^{-1}

5 (i) 50.625 kW

(ii) 1.12 m s^{-2} (iii) 59.2 m s^{-1} **Further practice (Page 85)**1 $31\frac{2}{3} \text{ N}$

2 (i) 1160 J

(ii) 417 J

(iii) 3.77 m s^{-1}

3 1.94 m

4 (i) 25 J

(ii) 20 J

(iii) 5 J

(iv) 0.115

5 5.48 m s^{-1}

6 (i) 43 750 J

(ii) 875 N

7 3072 N

8 (i) 4.16 m s^{-1}

(ii) 0.6 m

9 (i) 0.746 m ; 1.87 J(ii) 3.86 m s^{-1} (iii) 4.15 m s^{-1} 10 20 m s^{-1}

11 (i) 2570 N

(ii) 0.386 m s^{-2}

12 (i) 2.9 m

(ii) 5 m s^{-1} 13 (i) $\frac{400\,000}{25\,000} = 16 \text{ m s}^{-1}$ (ii) $\frac{400\,000}{16\,000} = 25 \text{ m s}^{-1}$ (iii) 0.02 m s^{-2} 14 0.211 m s^{-2} 15 (i) $\frac{15\,000}{20} = 20k + 1000 \times 10 \times 0.05 \Rightarrow k = 12.5$ (ii) 24.7 m s^{-1} 16 (i) $33\frac{1}{3} \text{ m s}^{-1}$ (ii) $18\frac{2}{11} \text{ m s}^{-1}$ (iii) 0.8 m s^{-2} **Past exam questions (Page 87)**

1 (i) 2000 N

(ii) 30 kW

2 (i) 8.94 m s^{-1} (ii) 7.07 m s^{-1}

3 (i) 514 kW

(ii) 31.7 m s^{-1} 4 (i) 1.72° (ii) 30 m s^{-1}

5 (i) 240 J

(ii) 11.5 m

(iii) 21.2 N

6 (i) $v = \frac{144\,000}{12\,500 \times 0.096 + 4800} = 24 ; 0.336 \text{ m s}^{-2}$

(ii) 20 m

7 (i) (a) 1.89 J

(b) 2.7 J

(c) 0.81 J

(ii) 3.67 m s^{-1} **Stretch and challenge (Page 89)**

1 320 m

2 1.60 m s^{-2} 3 $v = \sqrt{\frac{2gd(M - \mu m)}{m + M}}$ 4 (i) $\frac{P}{V} = Mg \sin \theta + R \Rightarrow R = \frac{P}{V} - Mg \sin \theta$ (ii) $a = \frac{7P}{4MV} - \frac{3}{4}g \sin \theta$

10 Momentum

1 (i) 800 N s

(ii) $4\frac{1}{6} \text{ N s}$ (iii) $1.22 \times 10^6 \text{ N s}$ (iv) $3.2 \times 10^{-7} \text{ N s}$ 2 (i) $2\frac{2}{9} \text{ m s}^{-1}$ (ii) 0.8 m s^{-1} 3 1476 m s^{-1} 4 (i) 4.5 m s^{-1} and 6 m s^{-1}

(ii) 52 500 J

(iii) 40.5 m

5 (i) 1.68 m s^{-1}

(ii) 17 640 N

Further practice (Page 92)

- 1 2.1 m s^{-1}
- 2 3.48 m s^{-1}
- 3 (i) 19400 N s
(ii) 7.04 m s^{-1}
- 4 7.09 m s^{-1}
- 5 18.4 grams
- 6 (i) 3.5 m s^{-1}
(ii) 0.7875 J
- 7 4.25 m s^{-1} in the original direction
- 8 (i) 4.87 m s^{-1}
(ii) 1.83 mm
- 9 If P is overtaking Q, after 12 s, 72 m from the original position of P; $9\frac{2}{3} \text{ m s}^{-1}$.
If Q is overtaking P, after 4 s, 8 m from the original position of P; $4\frac{1}{3} \text{ m s}^{-1}$.
- 10 5 m s^{-1} ; 45000 J
- 11 (i) 9.68 m s^{-1}
(ii) 726 N
- 12 (i) 4.29 m s^{-2}
(ii) 1.2 s
(iii) 1.71 m s^{-1}

$$13 \text{ (i)} \quad \sqrt{\frac{E}{10m}}, -\sqrt{\frac{8E}{5m}}$$

$$\text{(ii)} \quad \sqrt{\frac{5E}{2m}}$$

$$14 \quad v = \frac{u}{5}; \frac{1}{2}5mu^2 - \frac{1}{2}5m\left(\frac{u}{5}\right)^2 = \frac{1}{2}5mu^2 \times \frac{24}{25} = \frac{12}{5}mu^2$$

Stretch and challenge (Page 93)

$$1 \quad \frac{g}{s} \left\{ \frac{M^2}{M+m}h + (M+m)s \right\}$$

$$2 \text{ (i)} \quad \frac{m}{2M}u; \frac{3M-m}{8M}mu^2$$

$$\text{(ii)} \quad \frac{mu^2}{8d}$$

3 99 collisions

$$4 \text{ (i)} \quad 6410 \text{ N} \qquad \text{(ii)} \quad 0.0606 \text{ s}$$

$$\text{(iii)} \quad 2140 \text{ J} \qquad \text{(iv)} \quad 7.33 \text{ m s}^{-1}$$

$$5 \quad \frac{\left\{ \sqrt{(m_A^2 u_A^2 + m_B^2 u_B^2 + 2m_A m_B u_A u_B \cos \theta)} \right\}}{m_A + m_B};$$

$$\tan^{-1} \left\{ \frac{m_B u_B \sin \theta}{m_A u_A + m_B u_B \cos \theta} \right\}$$