

Answers

Chapter 1

Exercise 1A

- 1** a 3 b 9 c 1 d -8
 e 5 f 2 g $\frac{5}{3}$ h $\frac{-7}{2}$
 i $\frac{7}{3}$ j $\frac{20}{3}$ k $\frac{-10}{3}$ l $\frac{14}{5}$
2 a $a+b$ b $a-b$ c $\frac{b}{a}$ d ab
 e $\frac{bc}{a}$
3 a $y=5$ b $t=5$ c $y=-\frac{3}{2}$ d $x=2$
 e $a=\frac{11}{2}$ f $a=\frac{8}{3}$ g $y=136$ h $t=1$
 i $x=12$ j $y=-\frac{9}{5}$ k $x=-7$ l $y=2$
4 a $\frac{4}{3}$ b -5 c 2
5 a -1 b 18 c $\frac{6}{5}$ d 23
 e 0 f 10 g 12 h 8
 i $-\frac{14}{5}$ j $\frac{12}{5}$ k $\frac{7}{2}$
6 a $\frac{-b}{a}$ b $\frac{e-d}{c}$ c $\frac{c}{a}-b$ d $\frac{b}{c-a}$
 e $\frac{ab}{b+a}$ f $a+b$ g $\frac{b-d}{a-c}$ h $\frac{bd-c}{a}$
7 a -18 b -78.2 c 16.75 d 28
 e 34 f $\frac{3}{26}$
8 $x = \frac{a^2 + b^2 + 2ab}{ac + bc} = \frac{a + b}{c}$
9 $x = \frac{ab}{a - b - c}$

Exercise 1B

- 1** a $x+2=6$, 4 b $3x=10$, $\frac{10}{3}$
 c $3x+6=22$, $\frac{16}{3}$ d $3x-5=15$, $\frac{20}{3}$
 e $6(x+3)=56$, $\frac{19}{3}$ f $\frac{x+5}{4}=23$, 87
2 A = \$8, B = \$24, C = \$16 **3** 14 and 28
4 8 kg **5** 1.3775 m² **6** 49, 50, 51
7 17, 19, 21, 23 **8** 4200 L **9** 21
10 3 km **11** 9 and 12 dozen
12 7.5 km/h **13** 3.6 km **14** 30, 6

Exercise 1C

- 1** a $x=-1, y=-1$ b $x=5, y=21$
 c $x=-1, y=5$ d $x=5, y=19$
 e $x=-4, y=-13$ f $x=-\frac{8}{5}, y=-\frac{2}{5}$
2 a $x=8, y=-2$ b $x=-1, y=4$
 c $x=7, y=\frac{1}{2}$
3 a $x=2, y=-1$ b $x=2.5, y=-1$
 c $m=2, n=3$ d $x=2, y=-1$
 e $s=2, t=5$ f $x=10, y=13$
 g $x=\frac{4}{3}, y=\frac{7}{2}$ h $p=1, q=-1$
 i $x=-1, y=\frac{5}{2}$
4 a No solutions b Infinitely many solutions
 c One solution d One solution

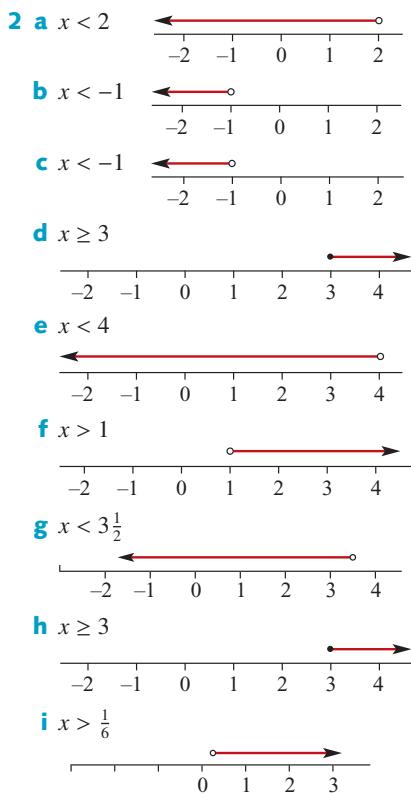
Exercise 1D

- 1** 25, 113 **2** 22.5, 13.5
3 a \$70 b \$12 c \$3
4 a \$168 b \$45 c \$15

- 5** 17 and 28 **6** 44 and 12
7 5 pizzas, 25 hamburgers
8 Started with 60 and 50; finished with 30 each
9 134 adults, 16 children **10** $\frac{7}{10}$
11 26 **12** 420 adults, 540 children
13 \$17 000 **14** 120 shirts, 300 ties
15 360 Outbacks, 300 Bush Walkers
16 2800 in Mydney, 3200 in Selbourne
17 20 kg at \$10, 40 kg at \$11 and 40 kg at \$12

Exercise 1E

- 1 a** $x < 1$ **b** $x > 13$ **c** $x \geq 3$ **d** $x \leq 12$
e $x \leq -6$ **f** $x > 3$ **g** $x < -2$ **h** $x \geq -8$
i $x \leq \frac{3}{2}$



- 3 a** $x > -\frac{1}{2}$ **b** $x < 2$ **c** $x > -5$
4 $3x < 20$, $x < \frac{20}{3}$, 6 pages **5** 87

Exercise 1F

- 1 a** 18 **b** 9 **c** 3 **d** -18
e 3 **f** 81 **g** 5 **h** 20
2 a $S = a + b + c$ **b** $P = xy$ **c** $C = 5p$
d $T = dp + cq$ **e** $T = 60a + b$
3 a 15 **b** 31.4 **c** 1000 **d** 12
e 314 **f** 720

4 a $V = \frac{c}{p}$ **b** $a = \frac{F}{m}$ **c** $P = \frac{I}{rt}$
d $r = \frac{w - H}{C}$ **e** $t = \frac{S - P}{Pr}$ **f** $r = \frac{R(V - 2)}{V}$

5 a $T = 48$ **b** $b = 8$ **c** $h = 3.82$ **d** $b = 10$

6 a $(4a + 3w)$ m **b** $(h + 2b)$ m
c $3wh$ m² **d** $(4ah + 8ab + 6wb)$ m²

7 a i $T = 2\pi(p + q) + 4h$ **ii** $88\pi + 112$
b $p = \frac{A}{\pi h} - q$

8 a $D = \frac{2}{3}$ **b** $b = 2$ **c** $n = \frac{60}{29}$ **d** $r = 4.8$

9 a $D = \frac{1}{2}bc(1 - k^2)$ **b** $k = \sqrt{1 - \frac{2D}{bc}}$
c $k = \sqrt{\frac{2}{3}} = \frac{\sqrt{6}}{3}$

10 a $P = 4b$ **b** $A = 2bc - c^2$ **c** $b = \frac{A + c^2}{2c}$

11 a $b = \frac{a^2 - a}{2}$ **b** $x = \frac{-ay}{b}$
c $r = \pm\sqrt{3q - p^2x^2}$ **d** $v = \pm\sqrt{u^2\left(1 - \frac{x^2}{y^2}\right)}$

Chapter 1 review**Short-answer questions**

1 a 1 **b** $\frac{-3}{2}$ **c** $\frac{-2}{3}$ **d** -27

e 12 **f** $\frac{44}{13}$ **g** $\frac{1}{8}$ **h** 31

2 a $t = a - b$ **b** $\frac{cd - b}{a}$ **c** $\frac{d}{a} + c$
d $\frac{cb - a}{c - 1}$ **e** $\frac{2b}{c - a}$ **f** $\frac{1 - cd}{ad}$

3 a $x < \frac{2}{3}$ **b** $x \leq -148\frac{1}{2}$ **c** $x < \frac{22}{29}$ **d** $x \geq \frac{-7}{17}$

4 $x = 2(z + 3t)$, -10

5 a $d = e^2 + 2f$ **b** $f = \frac{d - e^2}{2}$ **c** $f = \frac{1}{2}$

6 400π cm²

7 a 196π **b** $\frac{975\pi}{2}$

8 a $r = \frac{A}{\pi s}$ **b** $w = \frac{T - P}{Pr}$
c $r = \frac{n - p}{v^2}$ **d** $x = \frac{ac - b^2}{b}$

9 a $s = 75$ **b** $t = 8$

10 $5\sqrt{2}$ cm

11 12 m and 17 m

12 $m = 2$ and $n = 15$

13 Mr Apollo earns \$100 000, Mr Adonis earns \$107 200 and Ms Aphrodite earns \$96 000

14 a $a = \frac{28}{11}, b = -\frac{9}{11}$ **b** $a = -\frac{11}{5}, b = -\frac{33}{5}$

15 5 hours travelling on highways

Multiple-choice questions

- 1** D **2** D **3** C **4** A **5** C **6** C
7 B **8** B **9** A **10** B **11** E **12** B

Extended-response questions

- 1** a $C = \frac{-10}{9}$ b $F = 86$ c $x = -40$
d $x = -62.5$ e $x = \frac{-160}{13}$ f $k = 5$

2 a $r = \frac{2uv}{u+v}$ b $m = \frac{v}{u}$

3 a $T = 6w + 6\ell$
b i $T = 8w$ ii $\ell = \frac{25}{6}, w = 12\frac{1}{2}$
c i $y = \frac{L-6x}{8}$ ii $y = 22$
d $x = 10, y = 5$

4 a Distance Tom travelled = ut km

Distance Julie travelled = vt km

b i $t = \frac{d}{u+v}$ h

ii Distance from $A = \frac{ud}{u+v}$ km

c $t = 1.25$ h, distance from $A = 37.5$ km

5 a Average speed = $\frac{2uv}{u+v}$

b i $\frac{uT}{v}$ ii $\frac{vT+uT}{v}$

6 a $\frac{3}{a} + \frac{3}{b}$ c i $c = \frac{2ab}{a+b}$ ii $\frac{40}{3}$

7 a $\frac{x}{8}, \frac{y}{10}$ b $\frac{80(x+y)}{10x+8y}$

c $x = \frac{320}{9}, y = \frac{310}{9}$

8 The three lines intersect at the point $(4, 3)$

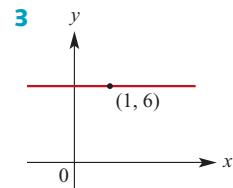
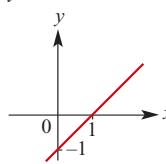
Chapter 2**Exercise 2A**

- 1** a $(5, 8)$ b $(\frac{1}{2}, \frac{1}{2})$ c $(1.6, 0.7)$
d $(-0.7, 0.85)$
2 $M_{AB}(3, 3), M_{BC}(8, 3\frac{1}{2}), M_{AC}(6, 1\frac{1}{2})$
3 Coordinates of C are $(6, 8.8)$
4 a $(4, 4)$ b $(2, -0.2)$ c $(-2, 5)$ d $(-4, -3)$
5 $\left(\frac{1+a}{2}, \frac{4+b}{2}\right), a = 9, b = -6$
6 a $5\sqrt{2} \approx 7.07$ b $\sqrt{17} \approx 4.12$
c $\sqrt{34} \approx 5.83$ d 13
7 $\sqrt{97} + \sqrt{85} + \sqrt{104} \approx 29.27$
8 $PM = \sqrt{145} \approx 12.04$ **9** DN

Exercise 2B

- 1** a 4 b 2 c $\frac{1}{4}$ d -4 e 1 f -1
g $\frac{5}{4}$ h -2 i $-\frac{5}{4}$ j $\frac{4}{3}$ k 0

- 2** Any line parallel to the one shown
 $y = x - 1$



- 4** a $-\frac{1}{4}$ b $-\frac{5}{2}$ c -2 d -8 e 0 f -1
g 7 h 11 i -13 j 11 k 111 l 61
5 a -2 b $\frac{2}{5}$
6 a 54 b $\frac{5}{6}$
7 a 45° b 45° c 26.57° d 135°
8 a 45° b 26.57° c 161.57° d 49.4°
e 161.57° f 135°
9 a 1 b -1 c $\sqrt{3}$ d $-\sqrt{3}$

Exercise 2C

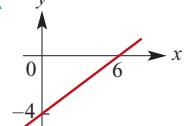
- 1** a $m = 3, c = 6$ b $m = -6, c = 7$
c $m = 3, c = -6$ d $m = -1, c = -4$
2 a $y = 3x + 5$ b $y = -4x + 6$ c $y = 3x - 4$
3 a $m = 3, c = -6$ b $m = 2, c = -4$
c $m = \frac{1}{2}, c = -2$ d $m = \frac{1}{3}, c = -\frac{5}{3}$
4 a $m = 2, c = -9$ b $m = -\frac{3}{4}, c = \frac{5}{2}$
c $m = -\frac{1}{3}, c = -2$ d $m = \frac{5}{2}, c = -2$
5 a $y = 3x - 11$ b $y = -2x + 9$
6 a $y = -\frac{1}{3}x + \frac{11}{3}$ b $y = -\frac{7}{5}x + 4$
c $y = -2x + 4$ d $y = \frac{11}{3}x - \frac{61}{3}$
7 a 2 b $y = 2x + 6$
8 a $y = 2x + 4$ b $y = -2x + 8$
9 a $y = 2x + 6$ b $y = -2x + 4$
c $y = -5x + 15$
10 a $y = -\frac{2}{3}x + 4$ b $y = -2x - 6$
c $y = -x + 4$ d $y = -\frac{3}{2}x + 3$
11 a $y = \frac{2}{3}x + 4$ b $y = \frac{2}{3}x - \frac{2}{3}$
c $y = \frac{1}{2}x + 1\frac{1}{2}$ d $y = -\frac{1}{2}x + 2$
e $y = x + 3.5$ f $y = -0.5x + 0.25$
12 a $y = 4x + 4$ b $y = -\frac{2}{3}x$ c $y = -x - 2$
d $y = \frac{1}{2}x - 1$ e $y = 3\frac{1}{2}$ f $x = -2$
13 Yes **14** Only c
15 a $x = 4$ b $y = 11$ c $x = 11$ d $y = -1$

Exercise 2D

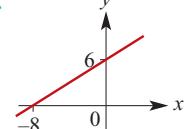
1 a $(0, 4), (4, 0)$

c $(0, -6), (-6, 0)$

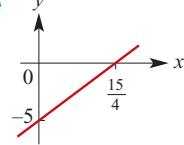
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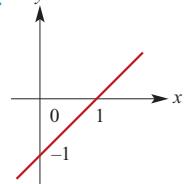
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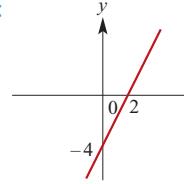
e



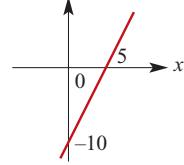
3 a



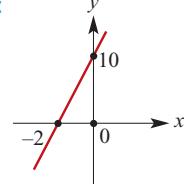
c



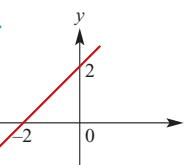
4 a



c



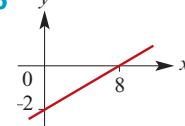
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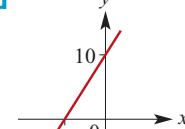
b $(0, -4), (4, 0)$

d $(0, 8), (-8, 0)$

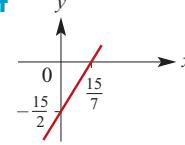
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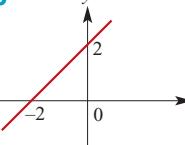
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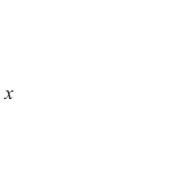
f



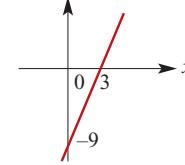
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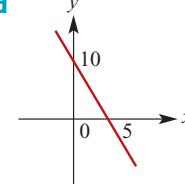
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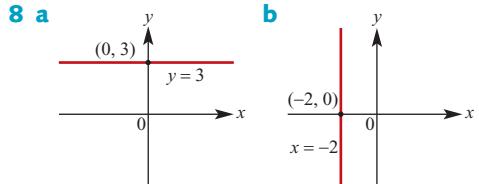
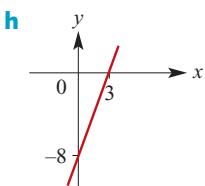
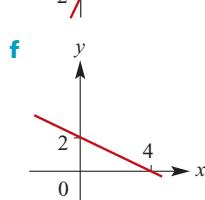
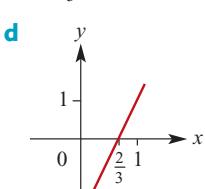
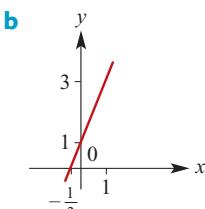
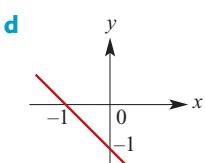
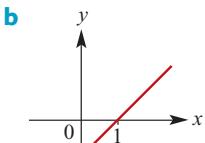
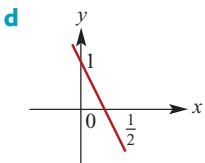
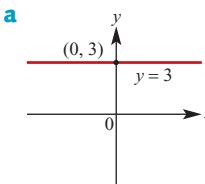
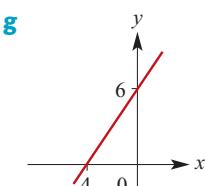
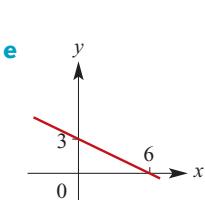
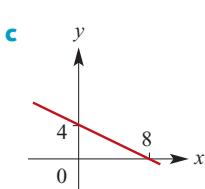
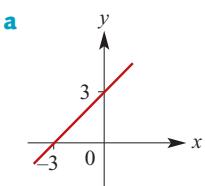
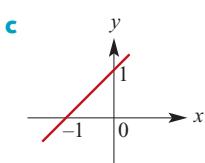
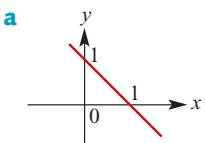
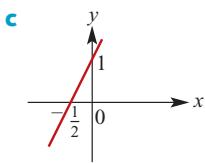
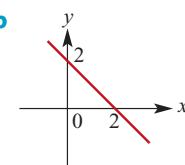
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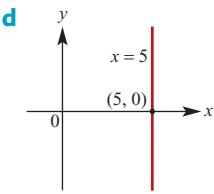
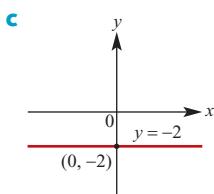


d



b





9 a 45° **b** 135°
e 63.43° (to 2 d.p.)

c 45° **d** 135°
f 116.57° (to 2 d.p.)

10 a 71.57° **b** 135° **c** 45° **d** 161.57°

11 $a = -4, b = \frac{4}{3}, d = -1, e = \frac{14}{3}$

Exercise 2E

- 1 a** $y = 2x - 10$ **b** $y = -\frac{1}{2}x$
c $y = -2x + 6$ **d** $y = \frac{1}{2}x - 4$
e $y = \frac{2}{3}x - \frac{14}{3}$ **f** $y = -\frac{3}{2}x + 4$
g $y = -\frac{1}{3}x - \frac{2}{3}$ **h** $y = 3x - 14$

2 Parallel lines: a, b, c; non-parallel lines: d

3 a $y = 4$ **b** $x = 2$ **c** $y = 4$ **d** $x = 3$

4 $y = 2x + 2$

5 Midpoint of AB is $(-1, 6)$; $y = 2x + 8$

6 $m_{BC} = -\frac{3}{5}$, $m_{AB} = \frac{5}{3}$
 $\therefore m_{BC} \times m_{AB} = -\frac{3}{5} \times \frac{5}{3} = -1$

$\therefore \triangle ABC$ is a right-angled triangle

7 $m_{AB} = -2, m_{BC} = \frac{1}{2}$

8 $m_{RS} = -\frac{1}{2}, m_{ST} = 2 \therefore RS \perp ST$
 $m_{UT} = -\frac{1}{2}, m_{ST} = 2 \therefore UT \perp ST$
(Also need to show SR = UT.)
 $\therefore RSTU$ is a rectangle

9 $\ell = -\frac{16}{3}, m = \frac{80}{3}$

10 a $y = -\frac{1}{2}x + \frac{11}{2}$ **b** $B(1, 5)$ **c** $C(2, 7)$

Exercise 2F

- 1** $m = 5$
2 $c = 5$
3 a $y = -\frac{1}{m}x + 3$ **b** $m = \frac{1}{7}$
4 $m = 2$
5 a $x = \frac{3}{m}$ **b** $m = \frac{9}{5}$ **c** $m \geq 3$
d $y = -\frac{x}{m} - 3$
6 a $x = -\frac{c}{2}$ **b** $c = -4$ **c** $c \geq -2$
d $y = -\frac{1}{2}x + c$

7 a $x = 4a$ **b** $m = \frac{12}{a}$ **c i** $a = 6$ **ii** $a = -6$

8 a $x = \frac{c}{2}$ **b** $c = 9$ **c** $c \leq 2$ **d** $y = \frac{1}{2}x + c$
e i $c = 12$ **ii** $c = 4$ **iii** $c = 8$

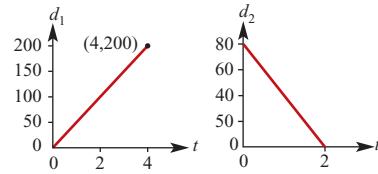
9 a $\frac{12}{b}$ **b** $-\frac{3}{b}$ **c i** $b = -3$ **ii** $b = \frac{3}{2}$

d $y = \frac{b}{3}x - \frac{4b}{3}$

Exercise 2G

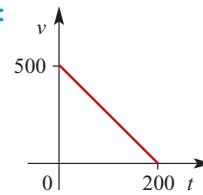
1 $w = 20n + 350$ for $n \in \mathbb{N} \cup \{0\}$

2 a $d_1 = 50t$ **b** $d_2 = 80 - 40t$
c Gradient = 50 Gradient = -40



3 a $V = 5t$ **b** $V = 10 + 5t$

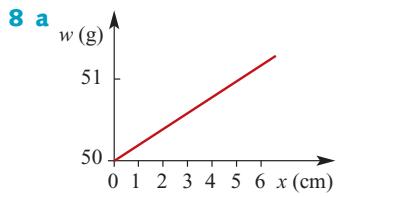
4 a $v = 500 - 2.5t$
b Domain $0 \leq t \leq 200$; Range $0 \leq v \leq 500$



5 $C = 1.5n + 2.6$

6 a $C = 0.24x + 85$ **b** \$145

7 $d = 200 - 5t$



b $w = 0.2x + 50$ **c** $x = 12.5$ cm

9 a $C = 0.06n - 1$ **b** \$59

10 a $C = 5n + 175$ **b** Yes **c** \$175

Exercise 2H

1 Both lines have gradient -1 , but their y -axis intercepts are 6 and $\frac{13}{2}$

2 $(t, 6-t)$ where t is a real number

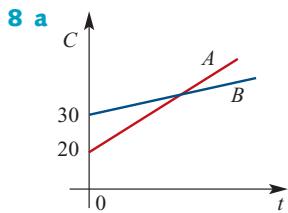
3 a $m = 4$ **b** $m \neq 4$ **c** $m = \frac{9}{5}$

4 $k = 2, m = 5$

5 $k = 24, m = 0$

6 $m = -3$

7 a $m = -5$ **b** $m = 3$

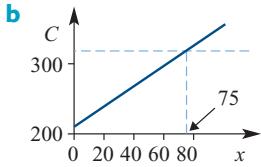


9 b = 0.28 and a = 0.3, $\frac{25}{7}$ m/s

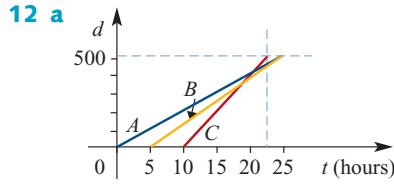
10 a

b 2 p.m.

11 a $C_1 = 210 + 1.6x$, $C_2 = 330$



c Fixed-charge method is cheaper for $x > 75$



b C wins the race

d C leaves 5 hours after B, and overtakes B $13\frac{1}{3}$ hours after B had started, then overtakes A 20 hours after A had started. C wins with a total time of $22\frac{1}{2}$ hours ($12\frac{1}{2}$ hours for journey + 10 hours handicap), with A and B deadheating for second place, each with a total time of 25 hours.

13 Both craft will pass over the point $(5\frac{1}{3}, -4)$

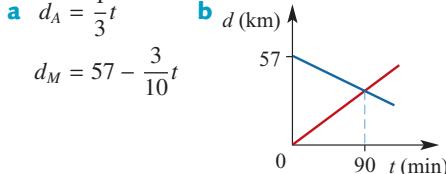
14 a $C_{PT} = 2.8x$, $C_B = 54 + x$

b \$C

c More than 30

15 a $d_A = \frac{1}{3}t$

$d_M = 57 - \frac{3}{10}t$



c 10:30 a.m. d Anne 30 km, Maureen 27 km

Chapter 2 review

Short-answer questions

1 a Midpoint = (3, 2); Length = 4

b Midpoint = $(-\frac{1}{2}, -\frac{9}{2})$; Length = $\sqrt{74}$

c Midpoint = $(5, \frac{5}{2})$; Length = 5

2 a $\frac{9}{4}$ b $-\frac{10}{11}$ c Undefined

d -1 e $\frac{b}{a}$ f $\frac{-b}{a}$

3 a $y = 4x$ b $y = 4x + 5$
c $y = 4x + 2$ d $y = 4x - 5$

4 a $a = -2$ b $b = \frac{20}{3}$

5 $4y + 3x = -7$

6 $3y + 2x = -5$

7 a $y = 11$ b $y = 6x - 10$ c $3y + 2x = -3$

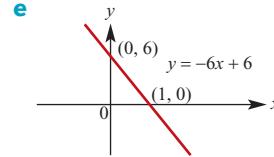
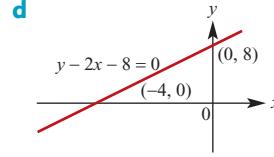
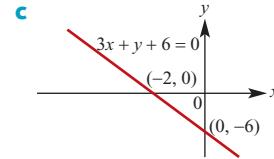
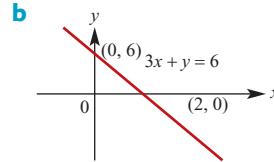
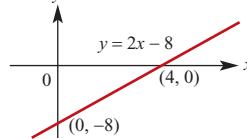
8 $y = x + 1$

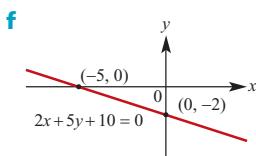
9 $y + x = 1$

10 $y = \frac{1}{3}x + \frac{20}{3}$

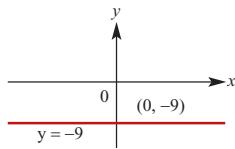
11 a $a = 1$, $b = -\frac{1}{2}$, $d = 5$, $e = 3$

12 a

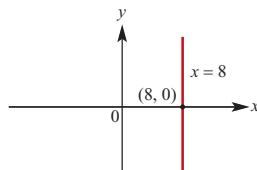




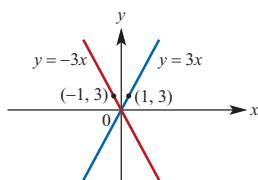
13 a $y = -9$



b $x = 8$



c i $y = 3x$ **ii** $y = -3x$



14 a $d = 60t$ **b** $m = 60$

15 $S = 800 + 500n$

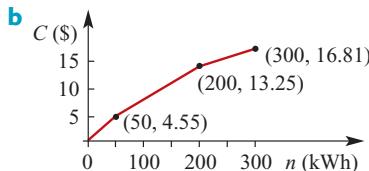
16 a $y = 2x + 2$ **b i** $\frac{-2}{a}$ **ii** $-2 < a < 0$
c $\left(\frac{1}{a-1}, \frac{1}{a-1} + 3\right)$

Multiple-choice questions

- 1 D** **2 E** **3 A** **4 E** **5 C** **6 D**
7 B **8 E** **9 C** **10 E** **11 C**

Extended-response questions

- 1 a** $C = 550 + 190n$ **b** 12 days
c Fewer than 5 days
- 2 a** Cost of the plug
b Cost per metre of cable **c** 1.8 **d** $11\frac{1}{9}$ m
- 3 a** The maximum profit (when $x = 0$)
b 43 seats
c Profit reduces by \$24 for each empty seat
- 4 a i** $C = 0.091n$
ii $C = 1.65 + 0.058n$
iii $C = 6.13 + 0.0356n$



- i** For 30 kWh, $C = 2.73$
ii For 90 kWh, $C = 6.87$
iii For 300 kWh, $C = 16.81$

c 389.61 kWh

5 a $y = -\frac{7}{3}x + 14\frac{2}{3}$ **b** $20\frac{1}{3}$ km south

6 a $s = 100 - 7x$

b

$s (\%)$

$x (\%)$

100

0

$\frac{100}{7} \approx 14.3$

c $\frac{5}{7}\%$

d $14\frac{2}{7}\%$

e Probably not a realistic model when $s = 0$

f $0 \leq x \leq 14\frac{2}{7}$

7 a $AB, y = x + 2$; $CD, y = 2x - 6$

b Intersection is at $(8, 10)$, on the near bank

8 a $\frac{128}{19}$

b $y = -\frac{199}{190}x + \frac{128}{19}$

c No, since gradient of AB is $\frac{20}{19} \approx 1.053$, whereas the gradient of VC is -1.047

9 a No **b** $1\frac{41}{71}$ km to the east of H

10 a $y = x - 38$ **b** $B(56, 18)$

c $y = -2x + 166$

d $(78, 10)$

11 a $y = 3x + 2$

b $(0, 2)$

c $y = 3x - 8$

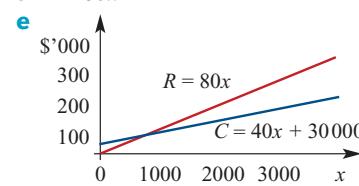
d $(2, -2)$

e Area = 10 square units

f Area = 40 square units

12 a $C = 40x + 30\ 000$ **b** \$45 **c** 5000

d $R = 80x$



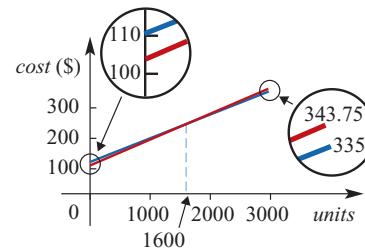
f 751 **g** $P = 40x - 30\ 000$

13 a Cost with method 1 is \$226.75; cost with method 2 is \$227; so method 1 is cheaper

b

	0	1000	2000	3000
Method 1	100	181.25	262.50	343.75
Method 2	110	185	260	335

c Cost the same for approx. 1600 units



d $C_1 = 0.08125x + 100$, $C_2 = 0.075x + 110$, $x = 1600$

- 14 a** (17, 12) **b** $3y = 2x + 2$
15 a $PD: y = \frac{2}{3}x + 120$; $DC: y = \frac{2}{5}x + 136$;
 $CB: y = -\frac{5}{2}x + 600$; $AB: y = \frac{2}{5}x + 20$;
 $AP: y = -\frac{3}{5}x + 120$
b At B and C , since product of gradients is -1
E.g. $m_{DC} = \frac{2}{5}$, $m_{CB} = -\frac{5}{2}$, $m_{DC} \times m_{CB} = -1$

Chapter 3

Exercise 3A

- 1 a** $2x - 8$ **b** $-2x + 8$ **c** $6x - 12$
d $-12 + 6x$ **e** $x^2 - x$ **f** $2x^2 - 10x$
2 a $6x + 1$ **b** $3x - 6$ **c** $x + 1$ **d** $5x - 3$
3 a $14x - 32$ **b** $2x^2 - 11x$
c $32 - 16x$ **d** $6x - 11$
4 a $2x^2 - 11x$ **b** $3x^2 - 15x$
c $-20x - 6x^2$ **d** $6x - 9x^2 + 6x^3$
e $2x^2 - x$ **f** $6x - 6$
5 a $6x^2 - 2x - 28$ **b** $x^2 - 22x + 120$
c $36x^2 - 4$ **d** $8x^2 - 22x + 15$
e $x^2 - (\sqrt{3} + 2)x + 2\sqrt{3}$
f $2x^2 + \sqrt{5}x - 5$ **g** $3x^2 + \sqrt{7}x - 14$
h $5x^2 + (10\sqrt{2} - 3)x - 6\sqrt{2}$
i $5x^2 - (3\sqrt{5} + 32\sqrt{10})x + 96\sqrt{2}$
6 a $6x^3 - 5x^2 - 14x + 12$ **b** $x^3 - 1$
c $24 - 20x - 8x^2 + 6x^3$ **d** $3x^2 + 4x + 3$
e $-10x^2 + 5x - 2$
7 a $x^2 - 8x + 16$ **b** $4x^2 - 12x + 9$
c $36 - 24x + 4x^2$ **d** $x^2 - x + \frac{1}{4}$
e $x^2 - 2\sqrt{5}x + 5$ **f** $x^2 - 4\sqrt{3}x + 12$
8 a $x^2 - 9$ **b** $4x^2 - 16$ **c** $81x^2 - 121$
d $4x^2 - 9$ **e** $4x^2 - 25$ **f** $x^2 - 5$
g $4x^2 - 27$ **h** $3x^2 - 7$
9 a $x^2 + y^2 - z^2 - 2xy$ **b** $4a^2 - 4ab + b^2 - c^2$
c $9w^2 + 8uz - 16z^2 - u^2$
d $4a^2 - 5b^2 + 4ac + c^2$
10 a **i** $x^2 + 2x + 1$ **ii** $(x + 1)^2$
b **i** $(x - 1)^2 + 2(x - 1) + 1$ **ii** x^2

Exercise 3B

- 1 a** $2(x + 2)$ **b** $4(a - 2)$ **c** $3(2 - x)$
d $2(x - 5)$ **e** $6(3x + 2)$ **f** $8(3 - 2x)$
2 a $2x(2x - y)$ **b** $8x(a + 4y)$ **c** $6b(a - 2)$
d $2xy(3 + 7x)$ **e** $x(x + 2)$ **f** $5x(x - 3)$
g $-4x(x + 4)$ **h** $7x(1 + 7x)$ **i** $x(2 - x)$
3 a $6x^2y^2(x + 2)$ **b** $xy(7x - 6y)$
c $2xy^2(4x + 3)$
4 a $(x^2 + 1)(x + 5)$ **b** $(x + 3)(y + 2)$

- c** $(x - 1)(x + 1)(y - 1)(y + 1)$
d $(a + b)(x + y)$ **e** $(a^2 + 1)(a - 3)$
f $(2a - 5)(b - 6)$ **g** $(2x + 5)(x - 1)$
h $(x + 2)(x - 2)(x + 2)$
i $(x - a)(x + a)(x - b)$
5 a $(x - 6)(x + 6)$ **b** $(x - 9)(x + 9)$
c $(x - a)(x + a)$ **d** $(2x - 9)(2x + 9)$
e $(3x - 4)(3x + 4)$ **f** $(5x - y)(5x + y)$
g $3(x - 4)(x + 4)$ **h** $2(x - 7)(x + 7)$
i $3a(x - 3)(x + 3)$ **j** $(a - \sqrt{7})(a + \sqrt{7})$
k $(\sqrt{2}a - \sqrt{5})(\sqrt{2}a + \sqrt{5})$
l $(x - 2\sqrt{3})(x + 2\sqrt{3})$

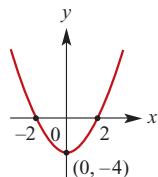
- 6 a** $(x - 6)(x + 2)$ **b** $(7 + x)(3 - x)$
c $3(x - 1)(x + 3)$ **d** $-5(2x + 1)$
e $-24x$
7 a $(x - 9)(x + 2)$ **b** $(y - 16)(y - 3)$
c $(a - 2)(a - 12)$ **d** $(a + 9)^2$
e $(x - 8)(x + 3)$
8 a $(3x - 1)(x - 2)$ **b** $(2x + 1)(3x + 2)$
c $(5x + 3)(x + 4)$ **d** $(2x + 1)(x + 4)$
e $(3x - 2)(2x - 5)$ **f** $(3x + 1)(2x - 3)$
g $(3x - 2)(4x - 3)$ **h** $(x - 2)(5x + 6)$
i $x(5x - 6)(x - 2)$
9 a $3(y - 6)(y + 2)$ **b** $2(x - 7)(x - 2)$
c $4(x - 3)(x - 6)$ **d** $3(x + 2)(x + 3)$
e $a(x + 3)(x + 4)$
10 a $x(x + 2)$ **b** $(2x - 3)(x + 2)$
c $2(2x + 5)(x + 2)$

Exercise 3C

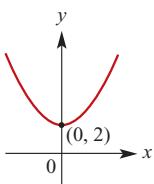
- 1 a** 2 or 3 **b** 0 or 2 **c** 4 or 3 **d** 4 or 3
e 3 or -4 **f** 0 or 1 **g** $\frac{5}{2}$ or 6 **h** -4 or 4
2 a -0.65, 4.65 **b** -0.58, 2.58 **c** -2.58, 0.58
3 a 9, -8 **b** 4, 2 **c** 11, -3 **d** 4, -16
e 2, -7 **f** -3, 8
4 a $-\frac{3}{2}, -1$ **b** $\frac{1}{2}, \frac{3}{2}$ **c** $-\frac{2}{3}, -\frac{3}{2}$ **d** $-\frac{3}{2}, 2$
e $\frac{5}{6}, 3$ **f** $-\frac{3}{2}, 3$ **g** $\frac{1}{2}, \frac{3}{5}$ **h** $-\frac{3}{4}, \frac{2}{3}$
i $\frac{1}{2}$ **j** -5, 1 **k** 0, 3 **l** -5, -3
m $\frac{1}{5}, 2$
5 3 **6** 4 or 9 **7** $2, 2\frac{3}{8}$
8 13 **9** 50 **10** 6 cm, 2 cm
11 5 **12** \$90, \$60 **13** 42

Exercise 3D

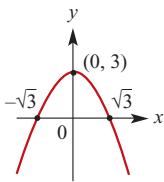
- 1 a** **i** $(0, -4)$
ii $x = 0$
iii $(-2, 0), (2, 0)$



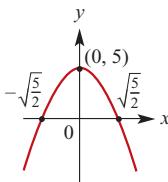
- b** i $(0, 2)$
ii $x = 0$
iii None



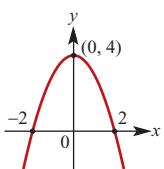
- c** i $(0, 3)$
ii $x = 0$
iii $(-\sqrt{3}, 0), (\sqrt{3}, 0)$



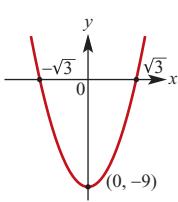
- d** i $(0, 5)$
ii $x = 0$
iii $\left(-\sqrt{\frac{5}{2}}, 0\right), \left(\sqrt{\frac{5}{2}}, 0\right)$



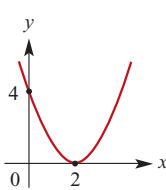
- e** i $(0, 4)$
ii $x = 0$
iii $(-2, 0), (2, 0)$



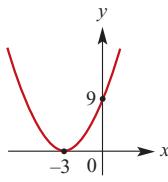
- f** i $(0, -9)$
ii $x = 0$
iii $(-\sqrt{3}, 0), (\sqrt{3}, 0)$



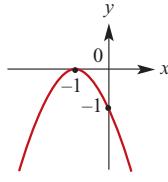
- 2 a** i $(2, 0)$
ii $x = 2$
iii $(2, 0)$



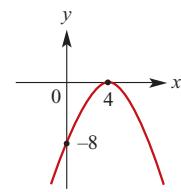
- b** i $(-3, 0)$
ii $x = -3$
iii $(-3, 0)$



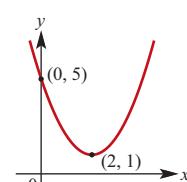
- c** i $(-1, 0)$
ii $x = -1$
iii $(-1, 0)$



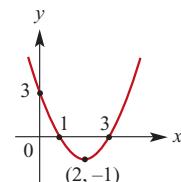
- d** i $(4, 0)$
ii $x = 4$
iii $(4, 0)$



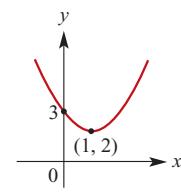
- 3 a** i $(2, 1)$
ii $x = 2$
iii None



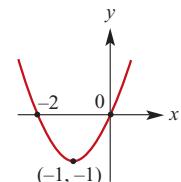
- b** i $(2, -1)$
ii $x = 2$
iii $(1, 0), (3, 0)$



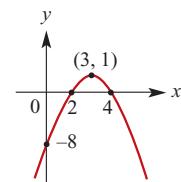
- c** i $(1, 2)$
ii $x = 1$
iii None



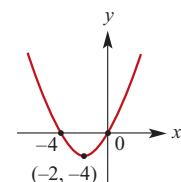
- d** i $(-1, -1)$
ii $x = -1$
iii $(-2, 0), (0, 0)$



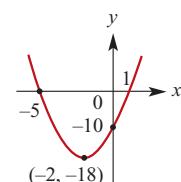
- e** i $(3, 1)$
ii $x = 3$
iii $(2, 0), (4, 0)$



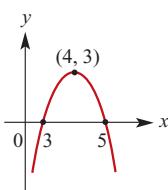
- f** i $(-2, -4)$
ii $x = -2$
iii $(-4, 0), (0, 0)$



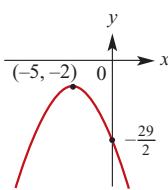
- g** i $(-2, -18)$
ii $x = -2$
iii $(-5, 0), (1, 0)$



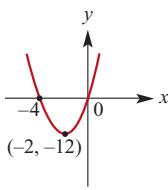
- h** **i** $(4, 3)$
ii $x = 4$
iii $(3, 0), (5, 0)$



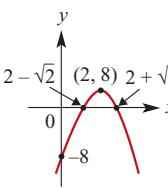
- i** **i** $(-5, -2)$
ii $x = -5$
iii None



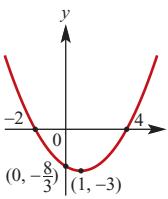
- j** **i** $(-2, -12)$
ii $x = -2$
iii $(0, 0), (-4, 0)$



- k** **i** $(2, 8)$
ii $x = 2$
iii $(2 - \sqrt{2}, 0), (2 + \sqrt{2}, 0)$



- l** **i** $(1, -3)$
ii $x = 1$
iii $(-2, 0), (4, 0)$



Exercise 3E

1 a $x^2 - 2x + 1$

b $x^2 + 4x + 4$

c $x^2 - 6x + 9$

d $x^2 - 6x + 9$

e $x^2 + 4x + 4$

f $x^2 - 10x + 25$

g $x^2 - x + \frac{1}{4}$

h $x^2 - 3x + \frac{9}{4}$

2 a $(x - 2)^2$

b $(x - 6)^2$

d $2(x - 2)^2$

e $-2(x - 3)^2$

g $\left(x - \frac{3}{2}\right)^2$

f $\left(x - \frac{1}{2}\right)^2$

3 a $1 \pm \sqrt{2}$

b $2 \pm \sqrt{6}$

d $\frac{5 \pm \sqrt{17}}{2}$

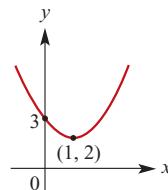
e $\frac{2 \pm \sqrt{2}}{2}$

g $-1 \pm \sqrt{1 - k}$

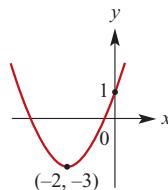
h $\frac{-1 \pm \sqrt{1 - k^2}}{k}$

i $\frac{3k \pm \sqrt{9k^2 - 4}}{2}$

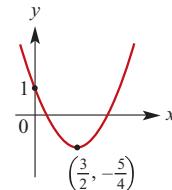
- 4 a** $y = (x - 1)^2 + 2$
t. pt $(1, 2)$



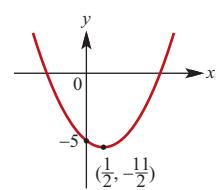
- b** $y = (x + 2)^2 - 3$
t. pt $(-2, -3)$



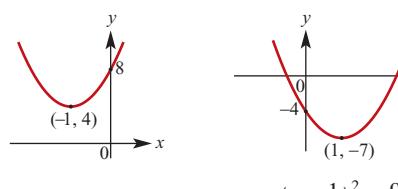
c $y = \left(x - \frac{3}{2}\right)^2 - \frac{5}{4}$
t. pt $\left(\frac{3}{2}, -\frac{5}{4}\right)$



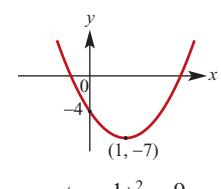
- 5 a** $y = 2\left(x - \frac{1}{2}\right)^2 - \frac{11}{2}$
t. pt $\left(\frac{1}{2}, -\frac{11}{2}\right)$



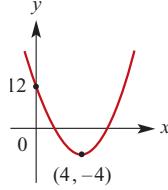
- b** $y = 4(x + 1)^2 + 4$
t. pt $(-1, 4)$



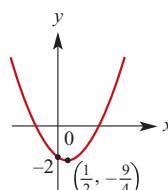
- c** $y = 3(x - 1)^2 - 7$
t. pt $(1, -7)$



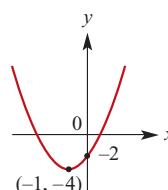
- 6 a** $y = (x - 4)^2 - 4$
t. pt $(4, -4)$



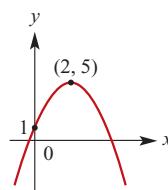
- b** $y = \left(x - \frac{1}{2}\right)^2 - \frac{9}{4}$
t. pt $\left(\frac{1}{2}, -\frac{9}{4}\right)$



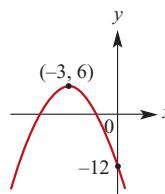
- c** $y = 2(x + 1)^2 - 4$
t. pt $(-1, -4)$



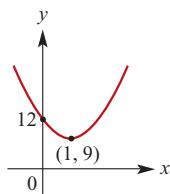
- d** $y = -(x - 2)^2 + 5$
t. pt $(2, 5)$



e $y = -2(x + 3)^2 + 6$
t. pt $(-3, 6)$



f $y = 3(x - 1)^2 + 9$
t. pt $(1, 9)$

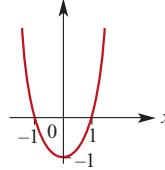


Exercise 3F

1 a 7 b 7

2 a -2 b 8

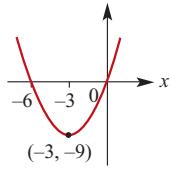
3 a



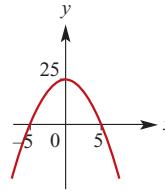
c 1

c 4

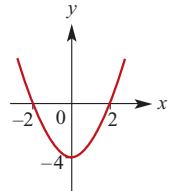
b



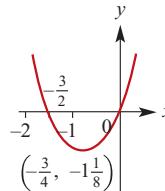
c



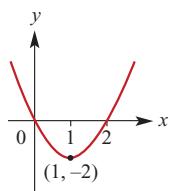
d



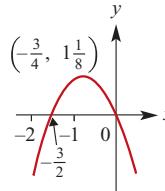
e



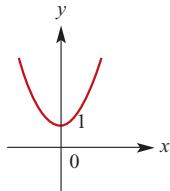
f



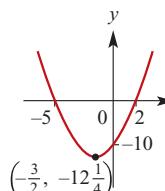
g



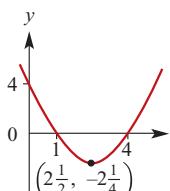
h



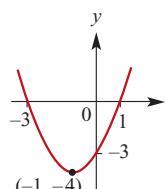
4 a



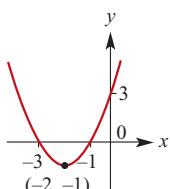
b



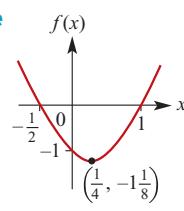
c



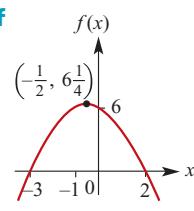
d



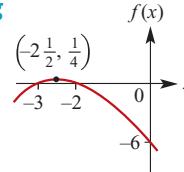
e



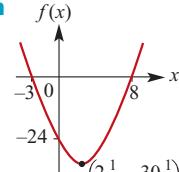
f



g

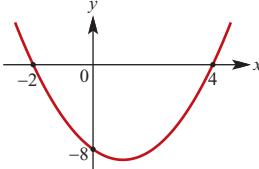


h



Exercise 3G

1 a -2, 4 b



c $-2 \leq x \leq 4$

2 a $x \leq -2$ or $x \geq 3$

d $x < 2$ or $x > 6$

e $-4 \leq x \leq \frac{1}{2}$

f $2 < x < 3$

g $\frac{3}{2} \leq x \leq \frac{7}{2}$

h $-2 \leq x \leq \frac{5}{2}$

i $-5 < x < \frac{5}{2}$

j $-2 \leq x \leq \frac{7}{2}$

k $x < \frac{2}{5}$ or $x > \frac{7}{2}$

l $x \leq \frac{5}{2}$ or $x \geq \frac{11}{2}$

3 a $x < -5$ or $x > 5$

b $-\frac{2}{3} \leq y \leq \frac{2}{3}$

c $y < -4$ or $y > 4$

d $-\frac{6}{5} \leq x \leq \frac{6}{5}$

e $y \leq -\frac{1}{4}$ or $y \geq \frac{1}{4}$

f $y < -\frac{5}{6}$ or $y > \frac{5}{6}$

4 a $x \geq 2$ or $x \leq -4$

b $-3 < x < 8$

c $-2 \leq x \leq 6$

d $x > 3$ or $x < -\frac{3}{2}$

e $-\frac{3}{2} < x < -\frac{2}{3}$

f $-3 \leq x \leq -2$

g $x > \frac{2}{3}$ or $x < -\frac{3}{4}$

h $\frac{1}{2} \leq x \leq \frac{3}{5}$

i $-4 \leq x \leq 5$

j $\frac{1}{2}(5 - \sqrt{41}) \leq p \leq \frac{1}{2}(5 + \sqrt{41})$

k $y < -1$ or $y > 3$

l $x \leq -2$ or $x \geq 1$

5 a $x \leq \frac{-3 - \sqrt{29}}{2}$ or $x \geq \frac{-3 + \sqrt{29}}{2}$

b $\frac{5 - \sqrt{17}}{2} < x < \frac{5 + \sqrt{17}}{2}$

c $\frac{3 - \sqrt{17}}{4} \leq x \leq \frac{3 + \sqrt{17}}{4}$

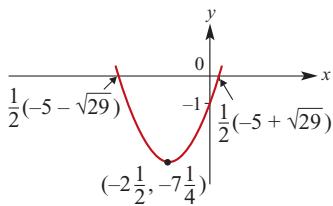
- d** $\frac{-3 - \sqrt{41}}{2} < x < \frac{-3 + \sqrt{41}}{2}$
e $\frac{-7 - \sqrt{41}}{4} < x < \frac{-7 + \sqrt{41}}{4}$
f $x \leq \frac{4 - \sqrt{6}}{2}$ or $x \geq \frac{4 + \sqrt{6}}{2}$

- 6** The square of any number is greater than or equal to zero.
7 The negative of the square of any number is less than or equal to zero.
8 $x^2 + 2x + 7 = (x + 1)^2 + 6$. For all x , we have $(x + 1)^2 \geq 0$ and so $(x + 1)^2 + 6 \geq 6$
9 $-x^2 - 2x - 7 = -(x + 1)^2 - 6$. For all x , we have $-(x + 1)^2 \leq 0$ and so $-(x + 1)^2 - 6 \leq -6$

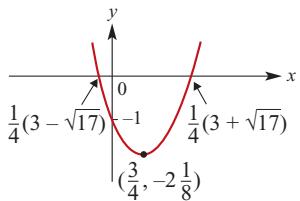
Exercise 3H

- 1 a** i 40 ii $2\sqrt{10}$
b i 28 ii $2\sqrt{7}$
c i 172 ii $2\sqrt{43}$
d i 96 ii $4\sqrt{6}$
e i 189 ii $3\sqrt{21}$
2 a $1 + \sqrt{5}$ **b** $\frac{3 - \sqrt{5}}{2}$ **c** $\frac{1 + \sqrt{5}}{2}$ **d** $1 + 2\sqrt{2}$
3 a $-3 \pm \sqrt{13}$ **b** $\frac{7 \pm \sqrt{61}}{2}$ **c** $\frac{1}{2}, 2$
d $-1 \pm \frac{3}{2}\sqrt{2}$ **e** $-2 \pm \frac{3}{2}\sqrt{2}$ **f** $1 \pm \frac{\sqrt{30}}{5}$
g $1 \pm \frac{\sqrt{2}}{2}$ **h** $1, \frac{-3}{2}$ **i** $\frac{-3 \pm \sqrt{6}}{5}$
j $\frac{-13 \pm \sqrt{145}}{12}$ **k** $\frac{2 \pm \sqrt{4 - 2k^2}}{2k}$
l $\frac{2k \pm \sqrt{6k^2 - 2k}}{2(1 - k)}$

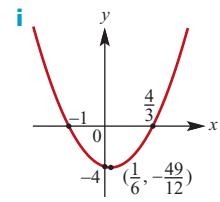
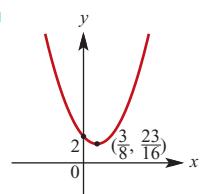
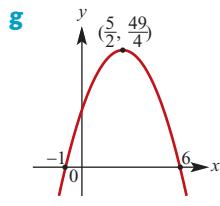
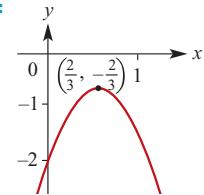
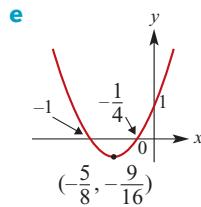
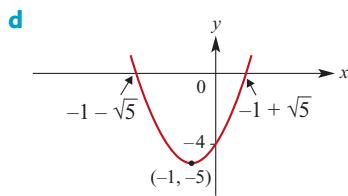
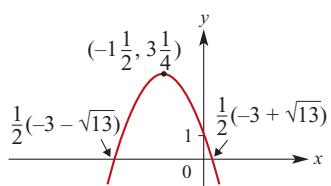
4 a



b



c



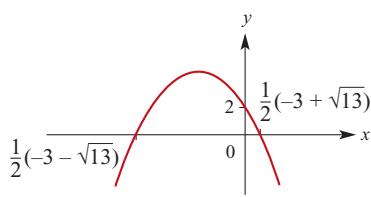
Exercise 3I

- 1 a** 20 **b** -12 **c** 25 **d** 41 **e** 41
2 a Crosses the x -axis **b** Does not cross
c Just touches the x -axis **d** Crosses the x -axis **e** Does not cross
f Does not cross
3 a Two real solutions **b** No real solutions
c Two real solutions **d** Two real solutions
e Two real solutions **f** No real solutions
4 a $\Delta = 0$, one rational solution
b $\Delta = 1$, two rational solutions
c $\Delta = 17$, two irrational solutions
d $\Delta = 0$, one rational solution
e $\Delta = 57$, two irrational solutions
f $\Delta = 1$, two rational solutions
5 a i $-\sqrt{5} < m < \sqrt{5}$ ii $m = \pm\sqrt{5}$
 iii $m > \sqrt{5}$ or $m < -\sqrt{5}$
b i $0 < m < \frac{4}{3}$ ii $m = \frac{4}{3}$
 iii $m > \frac{4}{3}$ or $m < 0$
c i $-\frac{4}{5} < m < 0$ ii $m = 0$ or $m = -\frac{4}{5}$
 iii $m < -\frac{4}{5}$ or $m > 0$
d i $-2 < m < 1$ ii $m = -2$ or $m = 1$
 iii $m > 1$ or $m < -2$

- 6** $\Delta = (2m - n)^2$, a perfect square **7** $p > \frac{4}{3}$
- 8** $p = \frac{-1}{2}$
- 9** **a** $p = \pm 3$ **b** $p > 1$ **c** $p > \frac{2}{3}$ **d** $p > 1$
- 10** $-2 < p < 8$
- 11** $\Delta = -4q^2 < 0$ for all values of q
- 12** **a** $\Delta = 16m^2 - 96m + 176 = 16(m - 3)^2 + 32$
b $\Delta \geq 32$; therefore two solutions
- 13** **a** $\Delta = 16$
b $\Delta > 0$; therefore two solutions
- 14** $\Delta = (m + 4)^2$, a perfect square; therefore rational solutions
- 15** $\Delta = (m - 2n)^2$, a perfect square; therefore rational solutions
- 16** The graph will cross the x -axis twice
- 17** The graph will cross the x -axis twice

Exercise 3J

- 1** **a** $(1 - \sqrt{5}, -1 - \sqrt{5}), (1 + \sqrt{5}, -1 + \sqrt{5})$
b $(-3, 9), (2, 4)$ **c** $(-3, 9), \left(\frac{7}{4}, \frac{49}{16}\right)$
d $(1, 3), (2, 5)$
- 2** **a** $(2, 0), (-5, 7)$ **b** $(1, -3), (4, 9)$
c $(1, -3), (-3, 1)$ **d** $(-1, 1), (-3, -3)$
e $\left(\frac{1 + \sqrt{33}}{2}, -3 - \sqrt{33}\right), \left(\frac{1 - \sqrt{33}}{2}, -3 + \sqrt{33}\right)$
f $\left(\frac{5 + \sqrt{33}}{2}, 23 + 3\sqrt{33}\right), \left(\frac{5 - \sqrt{33}}{2}, 23 - 3\sqrt{33}\right)$
- 3** **a** Touch at $(2, 0)$ **b** Touch at $(3, 9)$
c Touch at $(-2, -4)$ **d** Touch at $(-4, -8)$
- 4** **a** $x = 8, y = 16$ and $x = -1, y = 7$
b $x = -\frac{16}{3}, y = 37\frac{1}{3}$ and $x = 2, y = 30$
c $x = \frac{4}{5}, y = 10\frac{2}{5}$ and $x = -3, y = 18$
d $x = 10\frac{2}{3}, y = 0$ and $x = 1, y = 29$
e $x = 0, y = -12$ and $x = \frac{3}{2}, y = -7\frac{1}{2}$
f $x = 1.14, y = 14.19$ and $x = -1.68, y = 31.09$

5 **a** -13 **b** **i**

ii $m = -6 \pm \sqrt{32} = -6 \pm 4\sqrt{2}$

6 **a** $c = -\frac{1}{4}$ **b** $c > -\frac{1}{4}$

7 $a = 3$ or $a = -1$

8 $b = 1$

9 $y = (2 + 2\sqrt{3})x - 4 - 2\sqrt{3}$ and
 $y = (2 - 2\sqrt{3})x - 4 + 2\sqrt{3}$

Exercise 3K

- 1** $a = -4, c = 6$
- 2** **a** $\Delta = b^2 - 16a$ **b** $a = \frac{b^2}{16}$ **c** $a = \frac{1}{4}, b = 2$
- 3** **a** $y = 2(x + 2)(x - 6)$ **b** $y = -2(x + 2)^2 + 4$
c $y = -x^2 + 2x - 3$
- 4** **2** **5** $a = \frac{4}{7}, b = \frac{-24}{7}$
- 6** $a = -2, b = 1, c = 6$
- 7** **a** $y = -\frac{5}{16}x^2 + 5$ **b** $y = x^2$
c $y = \frac{1}{11}x^2 + \frac{7}{11}x$ **d** $y = x^2 - 4x + 3$
e $y = -\frac{5}{4}x^2 - \frac{5}{2}x + \frac{15}{4}$ **f** $y = x^2 - 4x + 6$
- 8** $y = \frac{5}{16}(x + 1)^2 + 3$ **9** $y = -\frac{1}{2}(x^2 - 3x - 18)$
- 10** $y = (x + 1)^2 + 3$ **11** $y = \frac{1}{180}x^2 - x + 75$
- 12** $y = 2x^2 - 4x$ **13** $y = x^2 - 2x - 1$
- 14** **a** C **b** B **c** D **d** A
- 15** **a** $y = a\left(x + \frac{1}{a}\right)^2 + a - \frac{1}{a}$ **b** $\left(-\frac{1}{a}, a - \frac{1}{a}\right)$
c $a = \pm 1$ **d** $-1 < a < 1$
- 16** $y = -2x^2 + 8x - 6$
- 17** **a** $y = ax(x - 10)$, $a > 0$
b $y = a(x + 4)(x - 10)$, $a < 0$
c $y = \frac{1}{18}(x - 6)^2 + 6$ **d** $y = a(x - 8)^2$, $a < 0$
- 18** **a** $y = -\frac{1}{4}x^2 + x + 2$ **b** $y = x^2 + x - 5$
- 19** $r = -\frac{1}{8}t^2 + 2\frac{1}{2}t - 6\frac{3}{8}$ **20** **a** B **b** D
- 21** **a** $y = -2x^2 - x + 5$ **b** $y = 2x^2 - x - 5$
c $y = 2x^2 + \frac{5}{2}x - \frac{11}{2}$

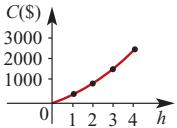
Exercise 3L

- 1** **a** $A = 60x - 2x^2$ **b**
- c** Maximum area = 450 m^2
- 2** $A = x(10 - x)$; Maximum area = 25 m^2
- 3** **a** $E = 100 - 20x - 20x^2$ **b** 0 and 1 **c** 0.5
- d** 0.23 and 0.77
- 4** **a** $A = 34x - x^2$ **b**
- c** 289 cm^2

5 a $4x + 10y = 80$

b $i A = 1.64x^2 - 25.6x + 256$
 ii 31.22 and 48.78

6 a

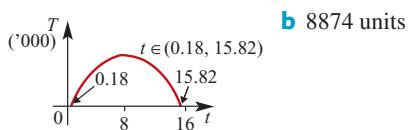


The domain depends on the height of the alpine area. In Australia, the highest mountain is approx. 2 km high and the minimum alpine height would be approx. 1 km. Thus, for Australia, domain = [1, 2].

b Theoretically, no. But of course there is a practical maximum.

c \$1225

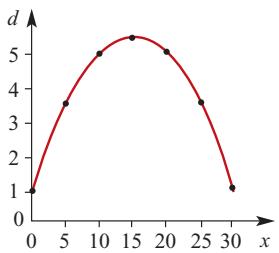
7 a



b 8874 units

8 a

x	0	5	10	15	20	25	30
d	1	3.5	5	5.5	5	3.5	1



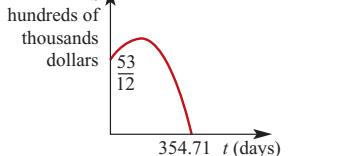
b i 5.5 m

ii $15 - 5\sqrt{7}$ m or $15 + 5\sqrt{7}$ m from the bat
 iii 1 m above the ground

9 $a = -\frac{16}{15}$, $b = \frac{8}{5}$, $c = 0$

10 a $a = -\frac{7}{21600}$, $b = \frac{41}{400}$, $c = \frac{53}{12}$

b



c i $S = \$1\,236\,666$ **ii** $S = \$59\,259$

Chapter 3 review

Short-answer questions

1 a $\left(x + \frac{9}{2}\right)^2$ **b** $(x + 9)^2$ **c** $\left(x - \frac{2}{5}\right)^2$

d $(x + b)^2$ **e** $(3x - 1)^2$ **f** $(5x + 2)^2$

2 a $-3x + 6$

c $49a^2 - b^2$ **d** $x^2 - x - 12$

e $2x^2 - 5x - 12$ **f** $x^2 - y^2$

g $a^3 - b^3$

i $3a^2 - 5a - 2$

k $2u + 2v - uv$

3 a $4(x - 2)$

c $3x(8a - 1)$

e $a(u + 2v + 3w)$

f $a^2(2b - 3a)(2b + 3a)$

g $(1 - 6ax)(1 + 6ax)$

i $(x + 2)(x - 1)$

k $(3x + 2)(2x + 1)$

m $(3x - 2)(x + 1)$

o $(3x - 2)(2x - 1)$

4 a $x = 5$ or $x = -3$

c $x = 2$ or $x = 3$

e $x = -3$ or $x = -2$

g $x = -\frac{1}{2}$ or $x = 3$

i $x = -\frac{12}{5}$ or $x = 1$

h $6x^2 + 8xy + 2y^2$

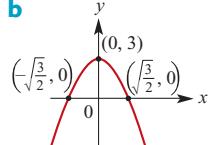
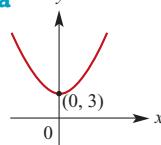
j $4xy$

l $-3x^2 + 15x - 12$

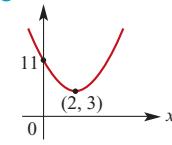
b $x(3x + 8)$

d $(2 - x)(2 + x)$

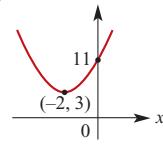
5 a y



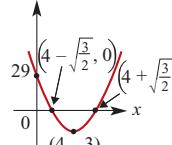
c y



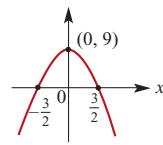
d y



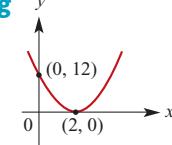
e y



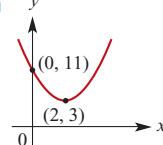
f y



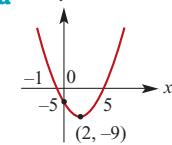
g y



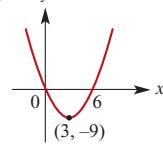
h y



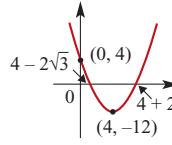
6 a y



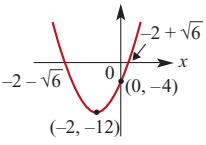
b y

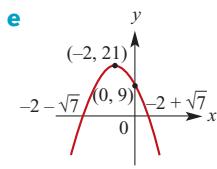


c y

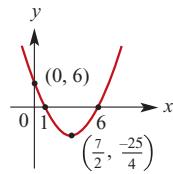


d y

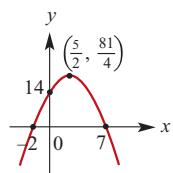




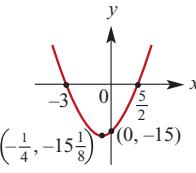
7 a $x = \frac{7}{2}$



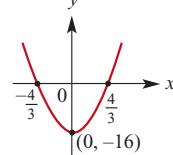
c $x = \frac{5}{2}$



e $x = -\frac{1}{4}$



g $x = 0$



8 $p = 1$ or $p = -\frac{3}{10}$

9 a $x < 0$ or $x > 1$

b $-2 - \sqrt{34} \leq x \leq -2 + \sqrt{34}$

c $-2 \leq x \leq \frac{1}{3}$

10 a $-3 \pm \sqrt{6}$

c $2 \pm \sqrt{2}$

e $\frac{-7 \pm \sqrt{17}}{4}$

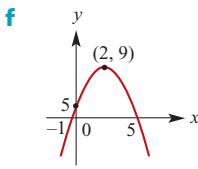
11 $y = \frac{5}{3}x(x - 5)$

12 $y = 3(x - 5)^2 + 2$

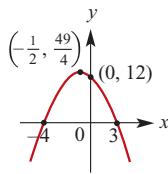
13 $m < -21 - 4\sqrt{29}$ or $m > -21 + 4\sqrt{29}$

14 225

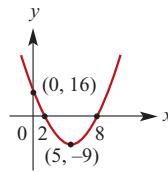
15 $y = 5(x - 1)^2 + 5$



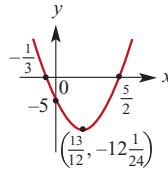
b $x = -\frac{1}{2}$



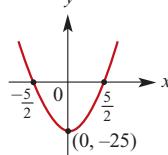
d $x = 5$



f $x = \frac{13}{12}$



h $x = 0$



16 a $(3, 9), (-1, 1)$

b $\left(\frac{4 - \sqrt{38}}{2}, 27 - 4\sqrt{38}\right),$

$\left(\frac{4 + \sqrt{38}}{2}, 27 + 4\sqrt{38}\right)$

c $\left(\frac{-7 - \sqrt{73}}{6}, 2\right), \left(\frac{-7 + \sqrt{73}}{6}, 2\right)$

d $(\frac{1}{2}, \frac{1}{2}), (-2, 8)$

17 a $y = 2(x + 4)(x - 1)$ b $y = -2(x + 1)^2 + 3$

c $y = 2x^2 - 2x - 3$

18 2.16 m

19 a $m = \pm \sqrt{8} = \pm 2\sqrt{2}$ b $m \leq -\sqrt{5}$ or $m \geq \sqrt{5}$

20 a $x = 0$ and $x = -b$ b $\left(-\frac{b}{2}, -\frac{b^2}{4}\right)$

c i $(0, 0), (1 - b, 1 - b)$ ii $b = 1$ iii $b \neq 1$

Multiple-choice questions

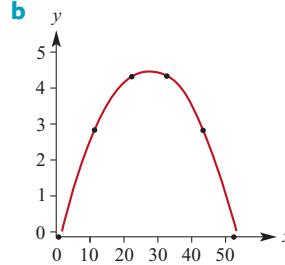
1 A 2 C 3 C 4 E 5 B

6 C 7 E 8 E 9 D 10 A

11 B 12 E 13 D

Extended-response questions

1 a $y = -0.0072x(x - 50)$



c $10.57 \text{ m and } 39.43 \text{ m } \left(25 \pm \frac{25\sqrt{3}}{3} \text{ m}\right)$

d 3.2832 m e 3.736 m (correct to 3 d.p.)

2 a Width = $\frac{12 - 4x}{6}$ cm; length = $\frac{12 - 4x}{3}$ cm

b $A = \frac{17}{9}x^2 - \frac{16}{3}x + 8$

c Length for square = $\frac{96}{17} \approx 5.65 \text{ cm}$ and length for rectangle = $\frac{108}{17} \approx 6.35 \text{ cm}$

3 a $V = 0.72x^2 - 1.2x$ b 22 hours

4 a $V = 10800x + 120x^2$

b $V = 46.6x^2 + 5000x$ c $\ell = 55.18 \text{ m}$

5 a $\ell = 50 - \frac{5x}{2}$ b $A = 50x - \frac{5}{2}x^2$



d Maximum area = 250 m^2 when $x = 10 \text{ m}$

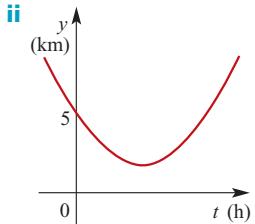
6 x = $\frac{-1 + \sqrt{5}}{2}$

7 a $\sqrt{25 + x^2}$

b i $16 - x$ **ii** $\sqrt{x^2 - 32x + 265}$

c 7.5 **d** 10.840 **e** 12.615

8 a i $y = \sqrt{64t^2 + 100(t - 0.5)^2}$
 $= \sqrt{164t^2 - 100t + 25}$



iii $t = \frac{1}{2}, 1:30$ p.m.; $t = \frac{9}{82}, 1:07$ p.m.

iv 0.305; 1:18 p.m.; distance 3.123 km

b i $0, \frac{25}{41}$ **ii** $\frac{25 \pm 2\sqrt{269}}{82}$

9 b $2x + 2y = b$

c $8x^2 - 4bx + b^2 - 16a^2 = 0$

e i $x = 6 \pm \sqrt{14}$, $y = 6 \mp \sqrt{14}$

ii $x = y = \sqrt{2}a$

f $x = \frac{(5 \pm \sqrt{7})a}{4}$, $y = \frac{(5 \mp \sqrt{7})a}{4}$

10 a $b = -2$, $c = 4$, $h = 1$

b i $(x, -6 + 4x - x^2)$ **ii** $(x, x - 1)$

iii $(0, -1), (1, 0), (2, 1), (3, 2), (4, 3)$

iv $y = x - 1$

c i $d = 2x^2 - 6x + 10$

ii

iii Min value of $d = 5.5$ when $x = 1.5$

11 a $45\sqrt{5}$

b i $y = \frac{1}{600}(7x^2 - 190x + 20\ 400)$

ii $\left(\frac{190}{14}, \frac{5351}{168}\right)$

c

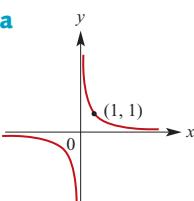
d i The distance (measured parallel to the y-axis) between path and pond

ii Minimum value = $\frac{473}{24}$ when $x = 35$

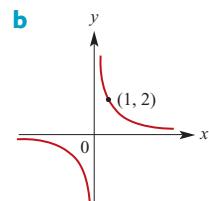
Chapter 4

Exercise 4A

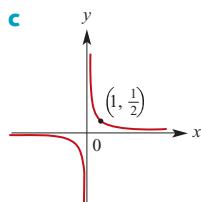
1 a



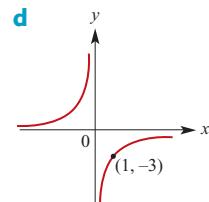
b



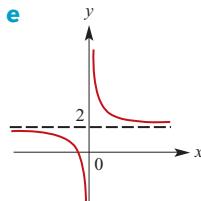
c



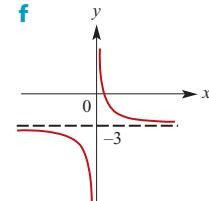
d



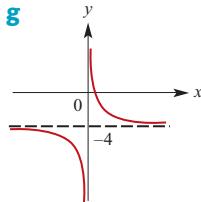
e



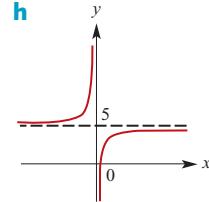
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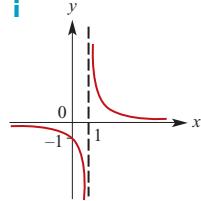
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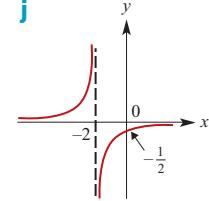
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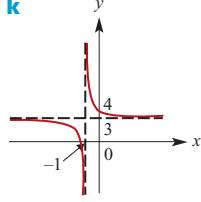
i



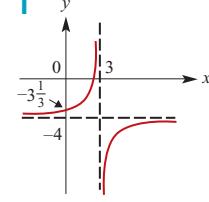
j



k



l



2 a $y = 0, x = 0$

c $y = 0, x = 0$

e $y = 2, x = 0$

g $y = -4, x = 0$

i $y = 0, x = 1$

k $y = 3, x = -1$

b $y = 0, x = 0$

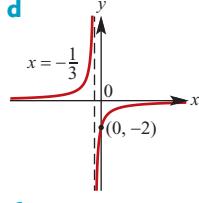
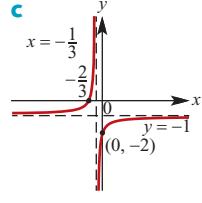
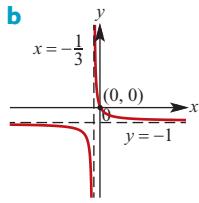
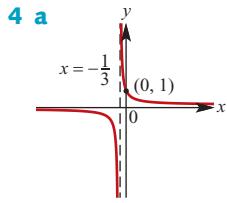
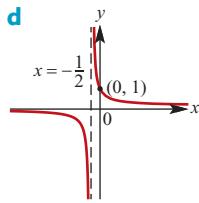
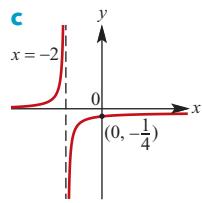
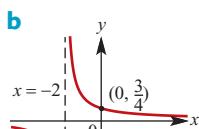
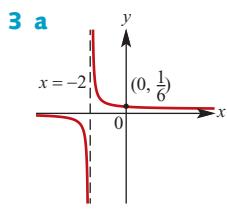
d $y = 0, x = 0$

f $y = -3, x = 0$

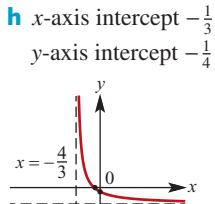
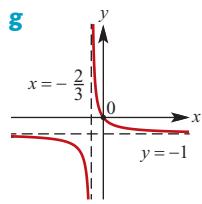
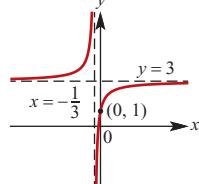
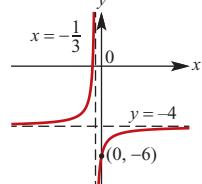
h $y = 5, x = 0$

j $y = 0, x = -2$

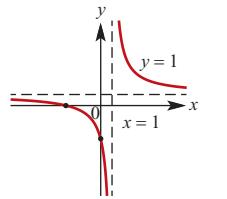
l $y = -4, x = 3$



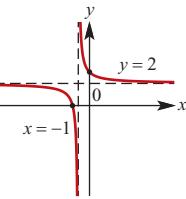
e x-axis intercept $-\frac{1}{2}$
y-axis intercept -6



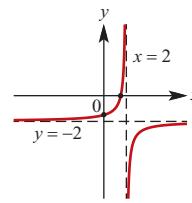
5 x-axis intercept -3
y-axis intercept -3



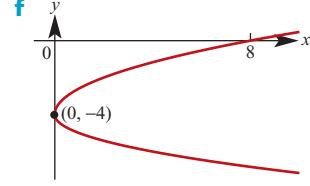
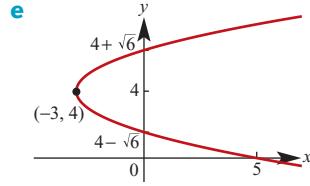
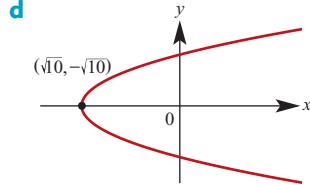
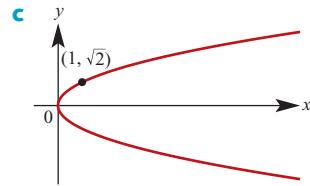
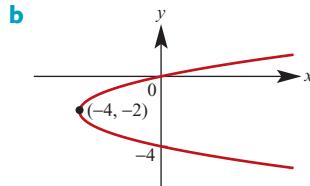
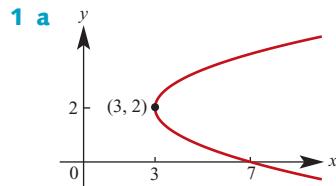
6 x-axis intercept $-\frac{3}{2}$
y-axis intercept 3

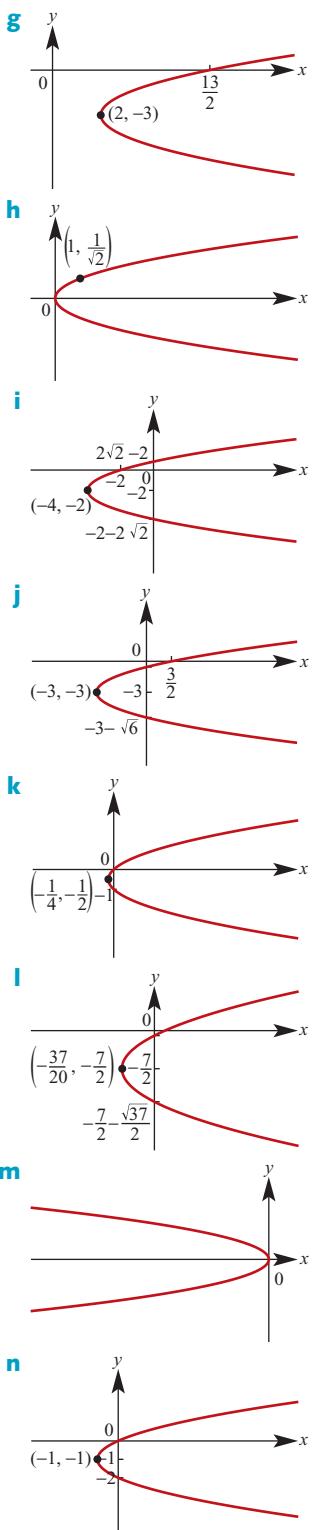


7 x-axis intercept $\frac{3}{2}$
y-axis intercept $-\frac{3}{2}$



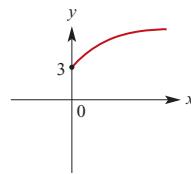
Exercise 4B



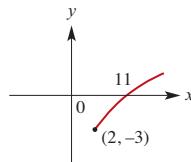


Exercise 4C

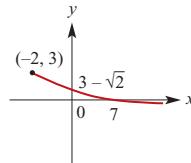
1 a $x \geq 0$ and $y \geq 3$



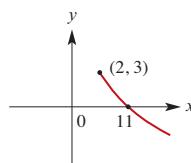
c $x \geq 2$ and $y \geq -3$



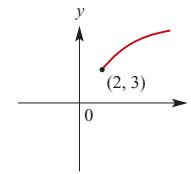
e $x \geq -2$ and $y \leq 3$



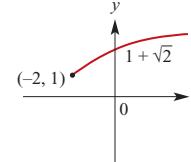
2 a $x \geq 2$ and $y \leq 3$



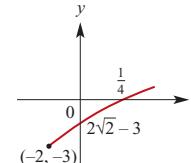
b $x \leq 2$ and $y \geq 3$



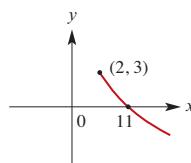
d $x \geq -2$ and $y \geq 1$



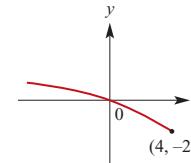
f $x \geq -2$ and $y \geq -3$



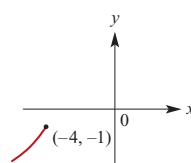
3 a $x \geq 0$ and $y \geq 0$



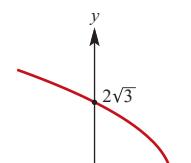
b $x \geq 1$ and $y \geq 0$



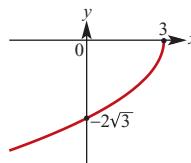
c $x \leq -4$ and $y \leq -1$



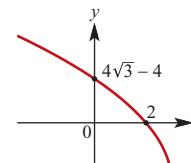
d $x \leq 3$ and $y \geq 0$



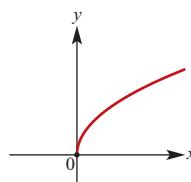
e $x \leq 3$ and $y \leq 0$



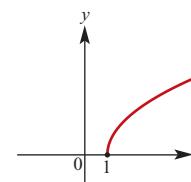
f $x \leq 3$ and $y \geq -4$



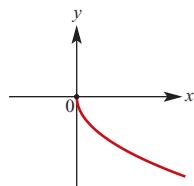
3 a $x \geq 0$ and $y \geq 0$



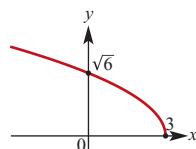
b $x \geq 1$ and $y \geq 0$



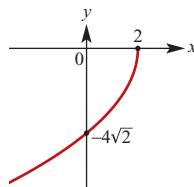
c $x \geq 0$ and $y \leq 0$



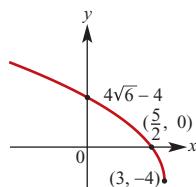
d $x \leq 3$ and $y \geq 0$



e $x \leq 2$ and $y \leq 0$



f $x \leq 3$ and $y \geq -4$



Exercise 4D

1 a $x^2 + y^2 = 9$

c $(x - 1)^2 + (y - 3)^2 = 25$

d $(x - 2)^2 + (y + 4)^2 = 9$

e $(x + 3)^2 + (y - 4)^2 = \frac{25}{4}$

f $(x + 5)^2 + (y + 6)^2 = (4.6)^2$

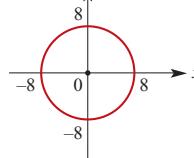
2 a $C(1, 3)$, $r = 2$

b $C(2, -4)$, $r = \sqrt{5}$

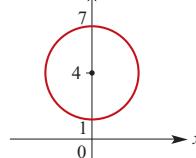
c $C(-3, 2)$, $r = 3$

d $C(-5, 4)$, $r = \sqrt{8}$

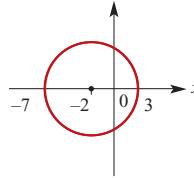
3 a



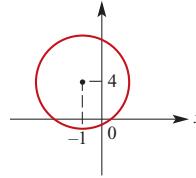
b



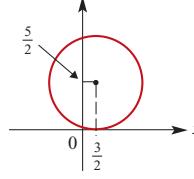
c



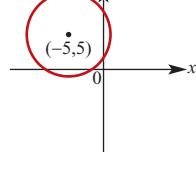
d



e



f



4 a $C(0, 3)$, $r = 5$

c $C(3, -2)$, $r = 2$

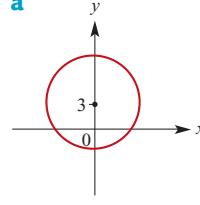
e $C(4, -2)$, $r = \sqrt{19}$

b $C(4, -6)$, $r = \sqrt{42}$

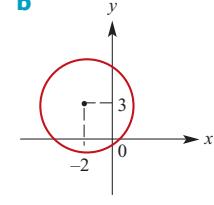
d $C(-2, 3)$, $r = 5$

f $C(\frac{1}{2}, -2)$, $r = \frac{3}{2}$

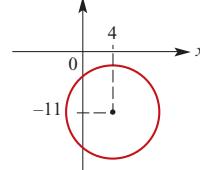
5 a



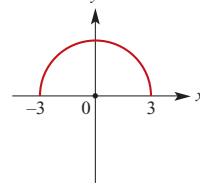
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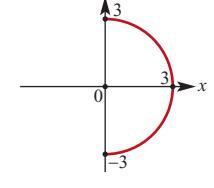
c



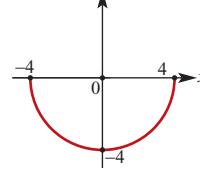
6 a



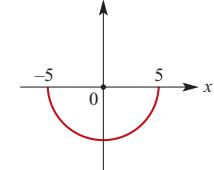
b



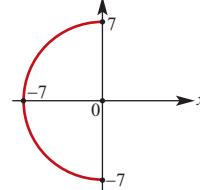
c



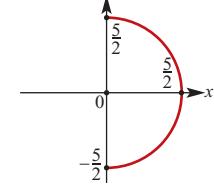
d



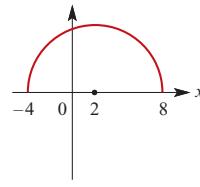
e



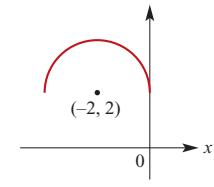
f



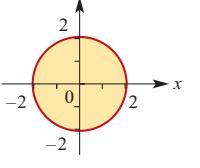
7 a



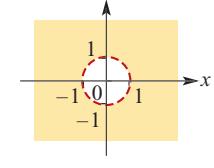
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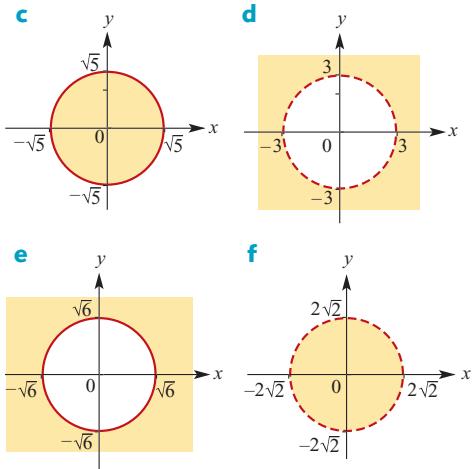


8 a



b



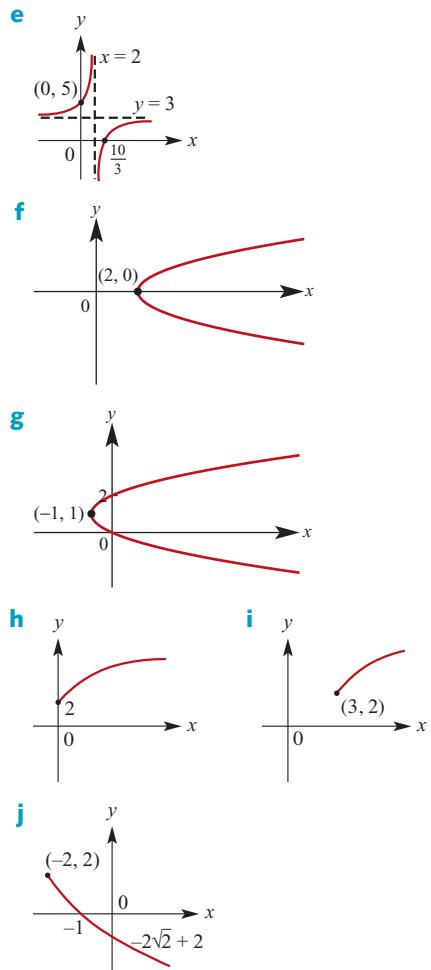
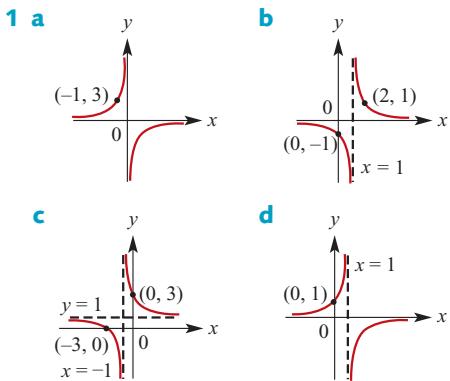


Exercise 4E

- 1** $a = 5$ **2** $a = -6, h = 3, k = 4$
3 $a = \frac{1}{2}, k = \frac{15}{2}$ **4** $a = -16, h = 2, k = -4$
5 $a = 4\sqrt{2}$ **6** $a = \frac{2\sqrt{3}}{3}, h = -2$
7 $(x - 2)^2 + (y - 1)^2 = 20$
8 $(x + 2)^2 + (y - 3)^2 = 1$
9 $(x + 2)^2 + (y - 3)^2 = 16$
10 $(x - 2)^2 + (y + 3)^2 = 9$
11 $(x - 4)^2 + (y - 4)^2 = 20$
12 $(x - 4)^2 + (y - 5)^2 = 25$ and
 $(x + 4)^2 + (y - 5)^2 = 25$
13 $(x + 1)^2 + (y + 1)^2 = 10$
14 **a** $(x - 2)^2 + (y + 2)^2 = 49$
b $y = 3\sqrt{x - 1} - 2$ **c** $y = \frac{1}{x - 2} + 2$
d $y = -\frac{2}{x - 1} - 2$ **e** $y = \sqrt{2 - x} + 1$
f $(y + 2)^2 = 2x + 9$

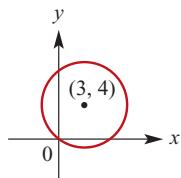
Chapter 4 review

Short-answer questions

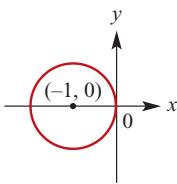


- 2** **a** $(x - 3)^2 + (y + 2)^2 = 25$
b $\left(x - \frac{3}{2}\right)^2 + \left(y + \frac{5}{2}\right)^2 = \frac{25}{2}$
c $\left(x - \frac{1}{4}\right)^2 + \left(y + \frac{1}{4}\right)^2 = \frac{17}{8}$
d $(x + 2)^2 + (y - 3)^2 = 13$
e $(x - 3)^2 + (y - 3)^2 = 18$
f $(x - 2)^2 + (y + 3)^2 = 13$

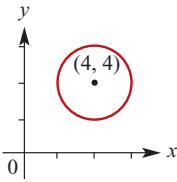
- 3** $2y + 3x = 0$
4 $2x + 2y = 1$ or $y = x - \frac{5}{2}$
5 **a** $(x - 3)^2 + (y - 4)^2 = 25$



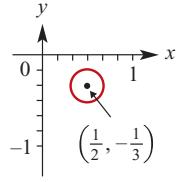
b $(x + 1)^2 + y^2 = 1$



c $(x - 4)^2 + (y - 4)^2 = 4$



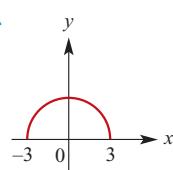
d $\left(x - \frac{1}{2}\right)^2 + \left(y + \frac{1}{3}\right)^2 = \frac{1}{36}$



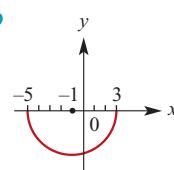
6 $C(-2, 3)$, $r = 6$

7 y-axis: $4\sqrt{6}$; x-axis: $2\sqrt{21}$

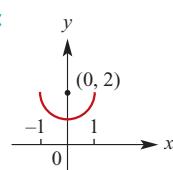
8 a



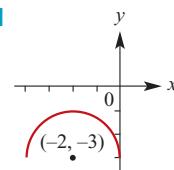
b



c



d



Multiple-choice questions

- | | | | | |
|-----|-----|-----|-----|------|
| 1 E | 2 B | 3 E | 4 A | 5 A |
| 6 D | 7 D | 8 C | 9 E | 10 B |

Extended-response questions

1 a $(x - 10)^2 + y^2 = 25$ c $m = \pm \frac{\sqrt{3}}{3}$

d $P\left(\frac{15}{2}, \frac{\pm 5\sqrt{3}}{2}\right)$ e $5\sqrt{3}$

2 a $x^2 + y^2 = 16$

b ii $m = \pm \frac{\sqrt{3}}{3}$; $y = \frac{\sqrt{3}}{3}x - \frac{8\sqrt{3}}{3}$
 $y = -\frac{\sqrt{3}}{3}x + \frac{8\sqrt{3}}{3}$

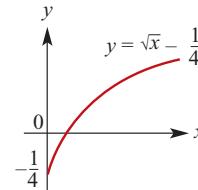
3 a $\frac{4}{3}$ b $-\frac{3}{4}$ c $4y + 3x = 25$ d $\frac{125}{12}$

4 a i $\frac{y_1}{x_1}$ ii $\frac{-x_1}{y_1}$

c $\sqrt{2}x + \sqrt{2}y = 8$ or $\sqrt{2}x + \sqrt{2}y = -8$

5 a $y = \frac{-\sqrt{3}}{3}x + \frac{2\sqrt{3}}{3}a$, $y = \frac{\sqrt{3}}{3}x - \frac{2\sqrt{3}}{3}a$

b $x^2 + y^2 = 4a^2$
 6 b ii $\left(\frac{1}{4}, \frac{1}{4}\right)$



c i $\frac{-1}{4} < k < 0$ ii $k = 0$ or $k < \frac{-1}{4}$
 iii $k > 0$

7 a $0 < k < \frac{1}{4}$ b $k = \frac{1}{4}$ or $k \leq 0$

Chapter 5

Exercise 5A

1 a $k = 2$

x	2	4	6	8
y	8	32	72	128

b $k = \frac{1}{3}$

x	$\frac{1}{2}$	1	$\frac{3}{2}$	2
y	$\frac{1}{6}$	$\frac{1}{3}$	$\frac{1}{2}$	$\frac{2}{3}$

c $k = 3$

x	4	9	49	900
y	6	9	21	90

d $k = \frac{2}{5}$

x	$\frac{1}{32}$	1	32	1024
y	$\frac{1}{5}$	$\frac{2}{5}$	$\frac{4}{5}$	$\frac{8}{5}$

2 a $V = 262.144$

b $r \approx 2.924$

3 a $a \approx 1.058$

b $b \approx 5.196$

4 a 72 cm^2

b 20 cm

5 a $\frac{648}{113} \text{ cm}$

b 1412.5 g

6 10.125 kg

7 62.035 cm

8 a 300%

b 800%

c 21%

9 52%

10 1.898 s

11 a 8.616 km

b 19.93 km

12 a i 300% increase

ii 41% increase

iii 700% increase

ii 29% decrease

b i 75% decrease

iii 87.5% decrease

c i 36% decrease

iii 48.8% decrease

d i 96% increase

ii 11% decrease

iii 174.4% increase

ii 18% increase

Exercise 5B

1 a $k = 2$

x	2	4	6	32
y	1	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{16}$

b $k = \frac{1}{2}$

x	$\frac{1}{4}$	1	4	9
y	1	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{6}$

c $k = 3$

x	1	2	3	6
y	3	$\frac{3}{4}$	$\frac{1}{3}$	$\frac{1}{12}$

d $k = \frac{1}{3}$

x	$\frac{1}{8}$	1	27	125
y	$\frac{2}{3}$	$\frac{1}{3}$	$\frac{1}{9}$	$\frac{1}{15}$

2 a $a = \frac{1}{2}$ **b** $b \approx 5.657$

3 a $a = 0.3125$ **b** $b = \sqrt{2}$

4 2.85 kg/cm²

5 a 2.4 amperes **b** 25%

6 64 candelas

7 5.15 cm

8 a i 75% decrease **ii** 29% decrease

iii 87.5% decrease

b i 300% increase **ii** 41% increase

iii 700% increase

c i 56.25% increase **ii** 12% increase

iii 95% increase

d i 49% decrease **ii** 15% decrease

iii 64% decrease

Exercise 5C

1 a direct

b direct square

c inverse

d direct square root

e inverse square

2 a $y \propto x^2$ (possibly)

b $y \propto x^3$

d $y \propto \sqrt{x}$ (possibly)

3 a, b, e

4 a $y = 3x$

b $y = \frac{3}{x}$

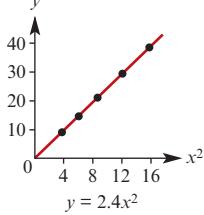
c $y = \frac{10}{3}x^2$

d $y = 2\sqrt{x}$

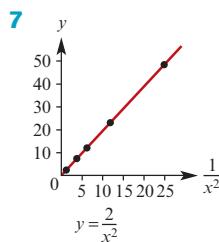
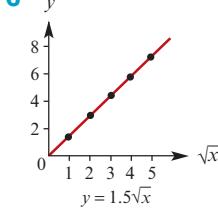
e $y = \frac{1}{3\sqrt{x}}$

f $y = 6x^3$

5



6



8 a $y = \frac{1}{4}\sqrt{x}$ **b** $y = 2x^{\frac{5}{4}}$

d $y = 10x^{\frac{2}{3}}$ **e** $y = 2x^{-\frac{5}{2}}$

9 a $a = 100$, $b = 0.2$ **b** 158.49

10 a $a = 1500$, $b = -0.5$ **b** 474.34

Exercise 5D

1 $k = 5$

x	2	4	6	10
z	10	2	60	12.5
y	1	10	0.5	4

2 $k = \frac{1}{2}$

x	2	4	1	10
z	10	8	50	3
y	10	16	25	15

3 $k = 3$

x	2	3	5	10
z	10	4	50	$\frac{400}{3}$
y	$\frac{15}{2}$	$\frac{4}{3}$	6	4

4 $a \approx 1.449$

5 $z \approx 0.397$

6 a 9.8 J/kg.m

b 5880 J

7 \$174

8 360 J

9 a 500% increase **b** 78% decrease

10 a 41% increase **b** 33% increase

11 a 183% increase **b** 466% increase

12 a Tensions are the same

b Work done by the second spring is 90% of the work done by the first

Exercise 5E

1 \$33.40

2 a Overhead charge \$1250; cost per guest \$237.50

b \$25 000

3 $p = 20.5$

4 \$55.11

5 a 330 m **b** 67.5 m

6 45 minutes

Chapter 5 review

Short-answer questions

- 1 a** When $b = 4$, $a = 6$; when $a = 8$, $b = \pm \frac{8}{\sqrt{3}}$
- b** When $x = 27$, $y = \frac{30}{2^{\frac{1}{3}}}$;
when $y = \frac{1}{8}$, $x = \frac{1}{256\ 000}$
- c** When $x = \frac{1}{2}$, $y = \frac{16}{3}$; when $y = \frac{4}{27}$, $x = \pm 3$
- d** $a = \frac{1}{6}$
- 2 a** $d = 4.9t^2$ **b** 491 m
c 2 s, correct to one decimal place
- 3 a** 14 m/s **b** 40 m **c** v and \sqrt{s}
- 4** 2.4 hours
- 5 a** y is halved **b** x is halved
c y is doubled **d** x is doubled
- 6** 4.05 cents
- 7** \$35
- 8** 18 amps
- 9** $I_2 = \frac{1}{4}I_1$
- 10** 34% increase

Multiple-choice questions

- | | | | | |
|------------|------------|------------|------------|-------------|
| 1 C | 2 A | 3 B | 4 C | 5 B |
| 6 D | 7 E | 8 D | 9 D | 10 B |

Extended-response questions

- 1 a** 0.24 kg **b** 11 cm
- 2 a** $h = 0.000\ 3375n^2$ **b** 17.1 m **c** 218 rpm

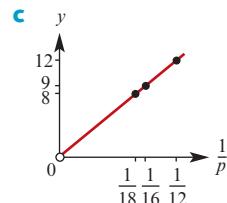
3 13 knots

- 4 a** $V = \frac{121.8}{P}$ **b** 9.6 kg/cm²

- 5 a** $w = \frac{3000}{d}$ **b** 600 kg **c** 333 kg

- 6 a** $v = \frac{144}{p}$

- b i** $v = 2$ **ii** $p = 48$



7 44.8 minutes

8 \$76

- 9** $S_n = \frac{1}{2}n(n + 1)$

- 10 a** $P = 3498.544 \times N^{0.5}$ **b** 25 956
c 51 023

- 11 a** $t = \frac{3600}{d^2}$ **b** $T = 0.14d^2$ **c** 23.9 mL
d 6.3 min **e** 9 min; 56 min

- 12 a** **i** $T = 0.000\ 539 \times R^{1.501}$
Mars 1.87; Jupiter 11.86; Saturn 29.45;
Uranus 84.09; Neptune 165.05
b 2.540×10^9 km

- 13 a** $a = 11.7$, $b = 0.41$ **b** 77
c $k = 163$, $p = -1.167$ **d** 7

Chapter 6

Exercise 6A

- 1 a** {7, 11} **b** {7, 11}

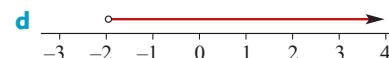
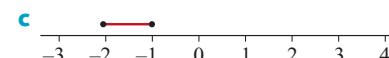
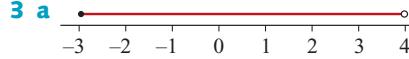
- c** {1, 2, 3, 5, 7, 11, 15, 25, 30}

- d** {1, 2, 3, 5, 7, 11, 15, 25, 30, 32}

- e** {1, 2, 3, 5, 7, 11, 15, 25, 30, 32}

- f** {1, 7, 11, 25, 30}

- 2 a** {1, 2, 3, 5, 15} **b** {25, 30, 32}
c {2, 3, 5, 15} **d** {25, 30}



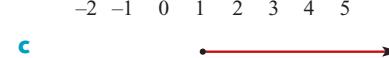
- 4 a** $(-2, 1]$ **b** $[-3, 3]$ **c** $[-3, 2)$ **d** $(-1, 2)$

- 5 a** $[-1, 2]$ **b** $(-4, 2]$ **c** $(0, \sqrt{2})$

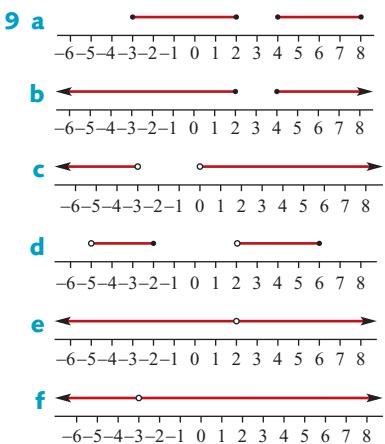
- d** $\left(-\frac{\sqrt{3}}{2}, \frac{1}{\sqrt{2}}\right]$ **e** $(-1, \infty)$ **f** $(-\infty, -2]$

- g** $(-\infty, \infty)$ **h** $[0, \infty)$ **i** $(-\infty, 0]$

- 6 a** {7} **b** B , i.e. {7, 11, 25, 30, 32}
c $(2, \infty)$ **d** {30, 32}



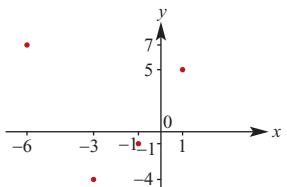
- 8 a** $(-\infty, -2) \cup (-2, \infty)$ **b** $(-\infty, 3) \cup (3, \infty)$
c $(-\infty, 4) \cup (4, \infty)$



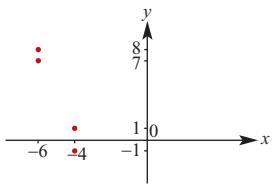
- 10 a** $(-6, -3)$ **b** \emptyset **c** $[-6, 0]$
d $[-1, 2]$ **e** $\{1\}$ **f** $(-10, -1)$

Exercise 6B

- 1 a** Domain = $\{-3, -1, -6, 1\}$;
Range = $\{-4, -1, 7, 5\}$

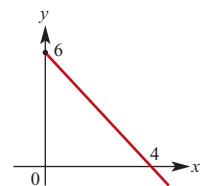
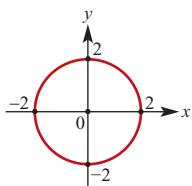


- b** Domain = $\{-4, -6\}$; Range = $\{-1, 1, 7, 8\}$



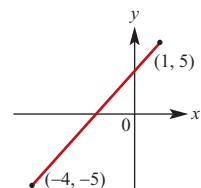
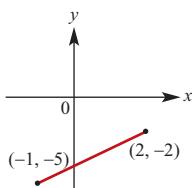
- c** Domain = $[-2, 2]$
Range = $[-2, 2]$

- d** Domain = $[0, \infty)$
Range = $(-\infty, 6]$



- e** Domain = $[-1, 2]$
Range = $[-5, -2]$

- f** Domain = $[-4, 1]$
Range = $[-5, 5]$



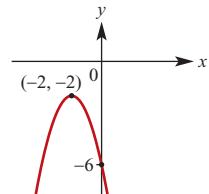
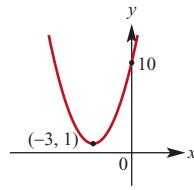
- 2 a** Domain = $[-2, 2]$; Range = $[-1, 2]$

- b** Domain = $[-2, 2]$; Range = $[-2, 2]$

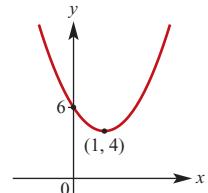
- c** Domain = \mathbb{R} ; Range = $[-1, \infty)$

- d** Domain = \mathbb{R} ; Range = $(-\infty, 4]$

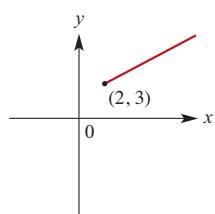
- 3 a** $y = (x + 3)^2 + 1$
Range = $[1, \infty)$ **b** $y = -(x + 2)^2 - 2$
Range = $(-\infty, -2]$



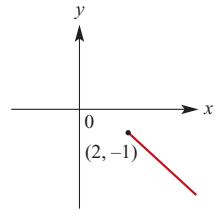
- c** $y = 2(x - 1)^2 + 4$
Range = $[4, \infty)$



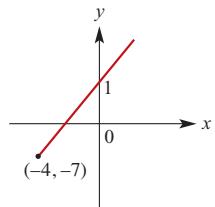
- 4 a** Range = $[3, \infty)$



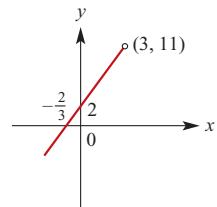
- b** Range = $(-\infty, -1]$



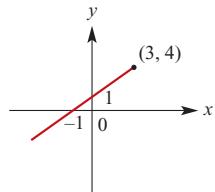
- c** Range = $[-7, \infty)$



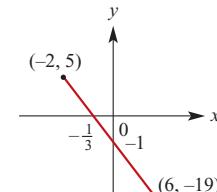
- d** Range = $(-\infty, 11)$



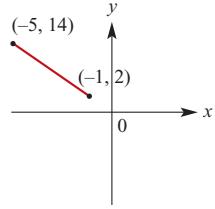
- e** Range = $(-\infty, 4]$



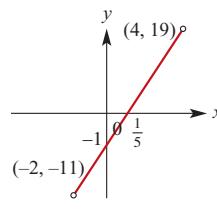
- f** Range = $[-19, 5]$



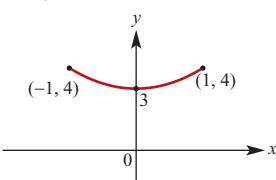
- g** Range = $[2, 14]$



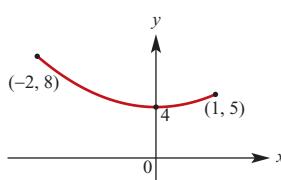
- h** Range = $(-11, 19)$



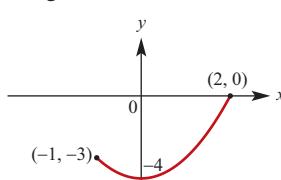
5 a Range = $[3, 4]$



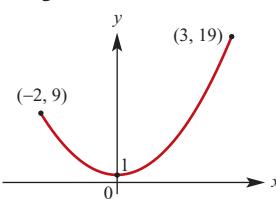
b Range = $[4, 8]$



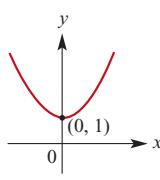
c Range = $[-4, 0]$



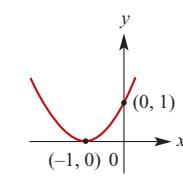
d Range = $[1, 19]$



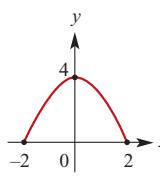
6 a Range = $[1, \infty)$



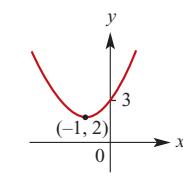
b Range = $[0, \infty)$



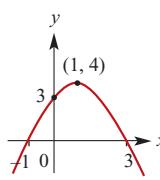
c Range = $[0, 4]$



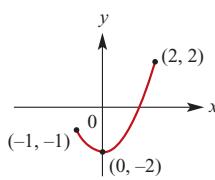
d Range = $[2, \infty)$



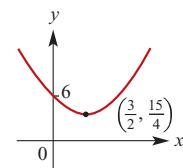
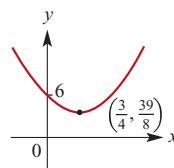
e Range = $(-\infty, 4]$



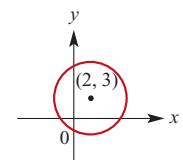
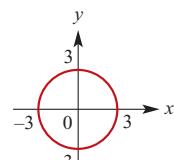
f Range = $[-2, 2]$



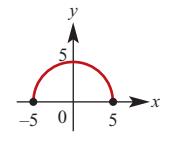
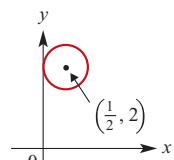
g Range = $\left[\frac{39}{8}, \infty\right)$ **h** Range = $\left[\frac{15}{4}, \infty\right)$



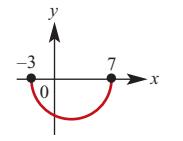
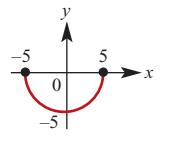
7 a Domain $-3 \leq x \leq 3$ Range $-3 \leq y \leq 3$



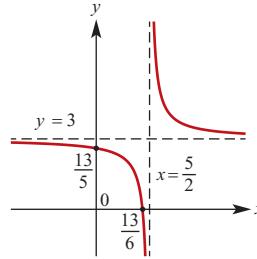
c Domain $0 \leq x \leq 1$ Range $1\frac{1}{2} \leq y \leq 2\frac{1}{2}$



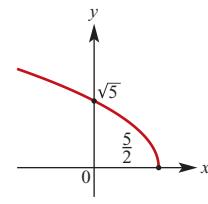
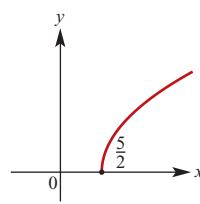
e Domain $-5 \leq x \leq 5$ Range $-5 \leq y \leq 0$



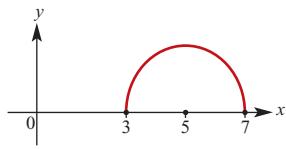
8 a Domain = $\mathbb{R} \setminus \left\{\frac{5}{2}\right\}$; Range = $\mathbb{R} \setminus \{3\}$



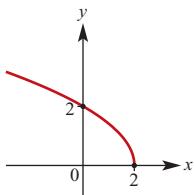
b Domain = $\left[\frac{5}{2}, \infty\right)$ **c** Domain = $(-\infty, \frac{5}{2}]$
Range = $\mathbb{R}^+ \cup \{0\}$ Range = $\mathbb{R}^+ \cup \{0\}$



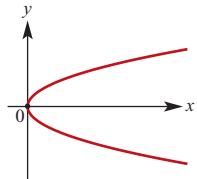
d Domain = [3, 7]; Range = [0, 2]



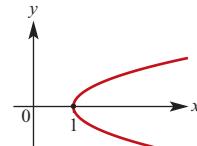
e Domain = (-∞, 2]
Range = $\mathbb{R}^+ \cup \{0\}$



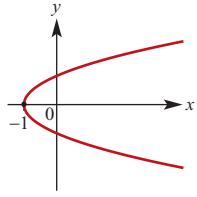
9 a Domain = $[0, \infty)$
Range = \mathbb{R}



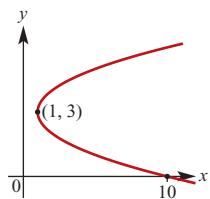
b Domain = $[1, \infty)$
Range = \mathbb{R}



c Domain = $[-1, \infty)$
Range = \mathbb{R}



d Domain = $[1, \infty)$
Range = \mathbb{R}



Exercise 6C

1 a Not a function; Domain = {0, 1, 2, 3};
Range = {1, 2, 3, 4}

b A function; Domain = {-2, -1, 0, 1, 2};
Range = {-5, -2, -1, 2, 4}

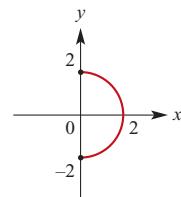
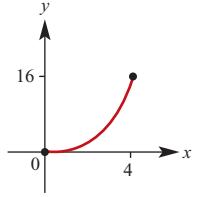
c Not a function; Domain = {-1, 0, 3, 5};
Range = {1, 2, 4, 6}

d A function; Domain = {1, 2, 4, 5, 6};
Range = {3}

2 Functions: a, b, c, e

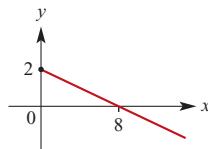
3 a A function
Domain = [0, 4]
Range = [0, 16]

b Not a function
Domain = [0, 2]
Range = [-2, 2]

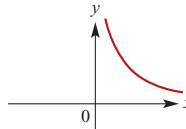


c A function

Domain = $[0, \infty)$
Range = $(-\infty, 2]$

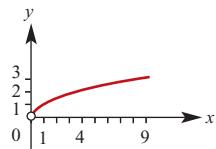


e A function
Domain = \mathbb{R}^+
Range = \mathbb{R}^+

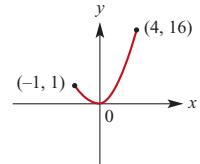


d A function

Domain = $(0, \infty)$
Range = $(0, \infty)$

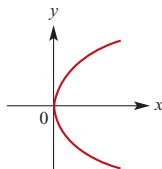


f A function
Domain = $[-1, 4]$
Range = $[0, 16]$



g Not a function

Domain = $[0, \infty)$
Range = \mathbb{R}



4 a $f: \mathbb{R} \rightarrow \mathbb{R}, f(x) = 3x + 2$

b $f: \mathbb{R} \rightarrow \mathbb{R}, f(x) = -\frac{3}{2}x + 6$

c $f: [0, \infty) \rightarrow \mathbb{R}, f(x) = 2x + 3$

d $f: [-1, 2] \rightarrow \mathbb{R}, f(x) = 5x + 6$

e $f: [-5, 5] \rightarrow \mathbb{R}, f(x) = -x^2 + 25$

f $f: [0, 1] \rightarrow \mathbb{R}, f(x) = 5x - 7$

5 a A function; Domain = \mathbb{R} ; Range = $\{-2\}$

b Not a function; Domain = {3}; Range = \mathbb{Z}

c A function; Domain = \mathbb{R} ; Range = \mathbb{R}

d A function; Domain = \mathbb{R} ; Range = $[5, \infty)$

e Not a function; Domain = $[-3, 3]$;
Range = $[-3, 3]$

6 a **i** -3 **ii** 5 **iii** -5 **iv** 9

v $2x - 5$ **vi** $\frac{2}{a} - 3$

b **i** 4 **ii** -4 **iii** $\frac{4}{3}$ **iv** 2

c **i** 4 **ii** 36 **iii** 36 **iv** $(a-2)^2$

d **i** 0 **ii** $\frac{a}{1+a}$ **iii** $\frac{-a}{1-a}$ **iv** $1-a$

7 a $5, 2t+1$ **b** $x = \frac{5}{2}$ **c** $x = -\frac{1}{2}$

d $t = -1$ **e** $x \geq -1$ **f** $x \geq 1$

8 a 1 **b** $\frac{1}{6}$ **c** ± 3 **d** -1, 4 **e** -1, 3 **f** -2, 3

9 a $g(-1) = -1, g(2) = 8, g(-2) = 0$

b $h(-1) = 3, h(2) = 18, h(-2) = -14$

c **i** $g(-3x) = 9x^2 - 6x$

ii $g(x-5) = x^2 - 8x + 15$

iii $h(-2x) = -16x^3 - 4x^2 + 6$

iv $g(x+2) = x^2 + 6x + 8$

v $h(x^2) = 2x^6 - x^4 + 6$

10 a $f(2) = 5, f(-4) = 29$

b Range = $[-3, \infty)$

11 a $f(2) = 7$

b $x = 2$

c $x = -1$

12 a 2

b ± 1

c $x = \pm\sqrt{3}$

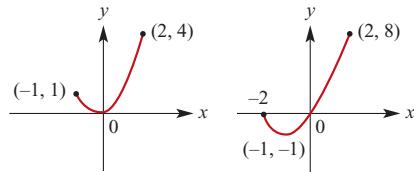
13 a $x = -1$

b $x > -1$

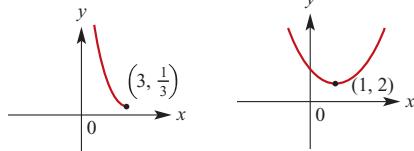
c $x = -\frac{6}{7}$

14 a Range = $[0, 4]$

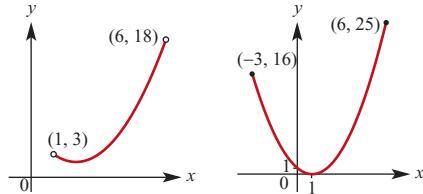
b Range = $[-1, 8]$



c Range = $\left[\frac{1}{3}, \infty\right)$



e Range = $[2, 18]$



15 a Domain = \mathbb{R} ; Range = \mathbb{R}

b Domain = $\mathbb{R}^+ \cup \{0\}$; Range = $\mathbb{R}^+ \cup \{0\}$

c Domain = \mathbb{R} ; Range = $[1, \infty)$

d Domain = $[-3, 3]$; Range = $[-3, 0]$

e Domain = \mathbb{R}^+ ; Range = \mathbb{R}^+

f Domain = \mathbb{R} ; Range = $(-\infty, 3]$

g Domain = $[2, \infty)$; Range = $\mathbb{R}^+ \cup \{0\}$

h Domain = $[\frac{1}{2}, \infty)$; Range = $[0, \infty)$

i Domain = $(-\infty, \frac{3}{2}]$; Range = $[0, \infty)$

j Domain = $\mathbb{R} \setminus \{\frac{1}{2}\}$; Range = $\mathbb{R} \setminus \{0\}$

k Domain = $\mathbb{R} \setminus \{\frac{1}{2}\}$; Range = $(0, \infty)$

l Domain = $\mathbb{R} \setminus \{\frac{1}{2}\}$; Range = $\mathbb{R} \setminus \{2\}$

16 a Domain = $[4, \infty)$; Range = $[0, \infty)$

b Domain = $(-\infty, 4]$; Range = $[0, \infty)$

c Domain = $[2, \infty)$; Range = $[3, \infty)$

d Domain = $\mathbb{R} \setminus \{4\}$; Range = $\mathbb{R} \setminus \{0\}$

e Domain = $\mathbb{R} \setminus \{4\}$; Range = $\mathbb{R} \setminus \{3\}$

f Domain = $\mathbb{R} \setminus \{-2\}$; Range = $\mathbb{R} \setminus \{-3\}$

17 a Domain = \mathbb{R} ; Range = \mathbb{R}

b Domain = \mathbb{R} ; Range = $[2, \infty)$

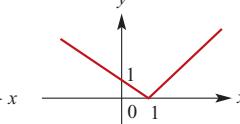
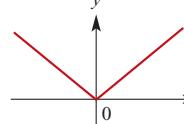
c Domain = $[-4, 4]$; Range = $[-4, 0]$

d Domain = $\mathbb{R} \setminus \{-2\}$; Range = $\mathbb{R} \setminus \{0\}$

Exercise 6D

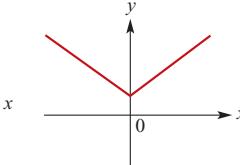
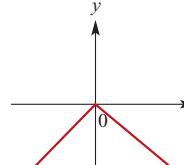
1 a Range = $[0, \infty)$

b Range = $[0, \infty)$

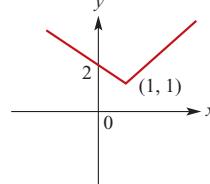


c Range = $(-\infty, 0]$

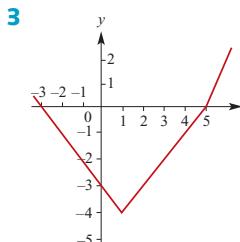
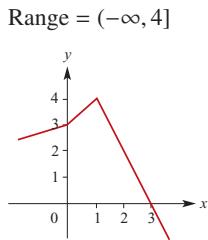
d Range = $[1, \infty)$



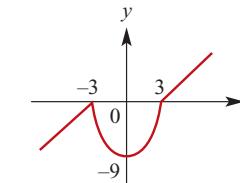
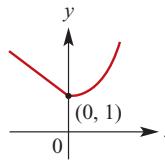
e Range = $[1, \infty)$



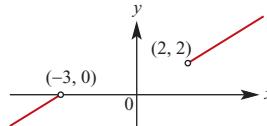
2 Range = $(-\infty, 4]$



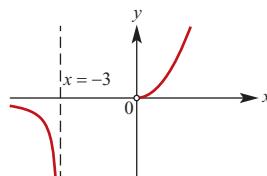
4 Range $[1, \infty)$

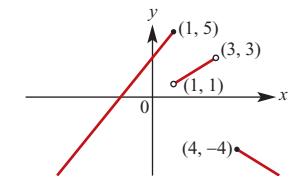
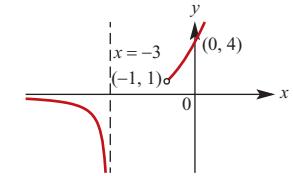
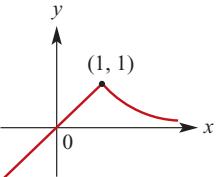


6 a Range = $(-\infty, 0) \cup (2, \infty)$



b Range = $\mathbb{R} \setminus \{0\}$



c Range = $(-\infty, 5]$ **d** Range = $\mathbb{R} \setminus [0, 1]$ **7** Range = $(-\infty, 1]$ 

$$\begin{aligned} \mathbf{8} \quad f(x) = & \begin{cases} x+3, & -3 \leq x \leq -1 \\ -x+1, & -1 < x \leq 2 \\ -\frac{1}{2}x, & 2 < x \leq 4 \end{cases} \end{aligned}$$

Exercise 6E

1 b i 25.06 **ii** 25.032 **iii** 25.2 **iv** 26

2 a $a = -3, b = \frac{1}{2}$ **b** 6

3 $f(x) = 7 - 5x$

4 a i $f(0) = -\frac{9}{2}$ **ii** $f(1) = -3$
b 3

5 $f(x) = -7(x-2)(x-4)$

6 $f(x) = (x-3)^2 + 7$, Range = $[7, \infty)$

7 $a = \frac{1}{10}, b = -\frac{9}{10}, c = 2$

8 $f(x) = -2(x-1)(x+5)$

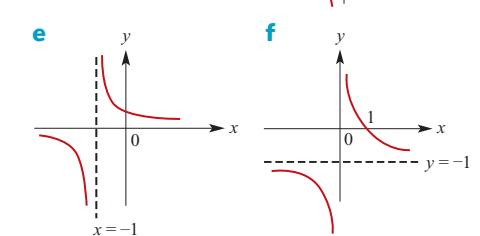
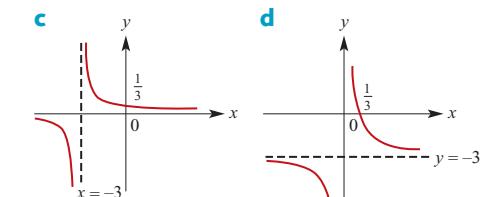
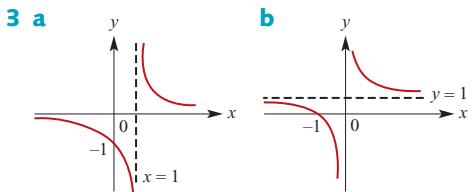
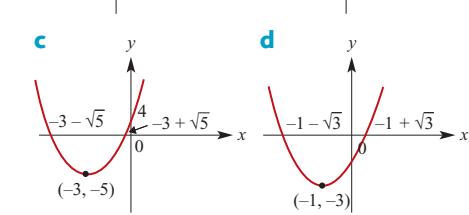
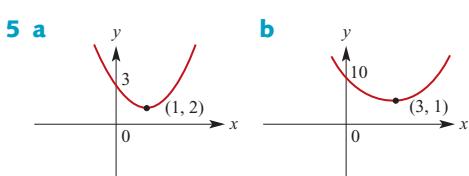
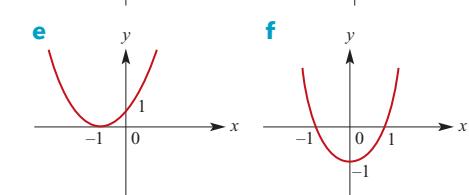
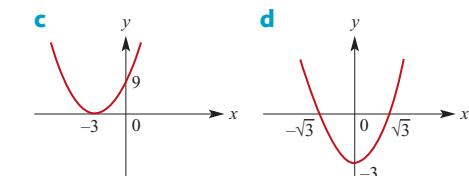
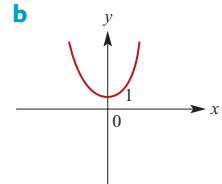
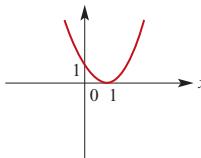
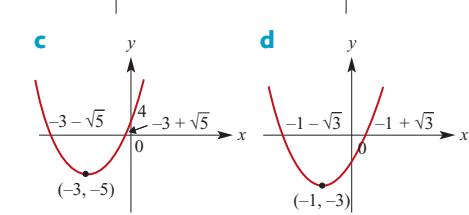
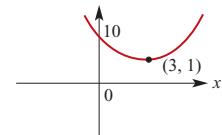
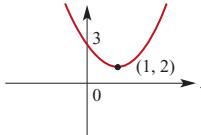
$$g(x) = -50(x-1)\left(x + \frac{1}{5}\right)$$

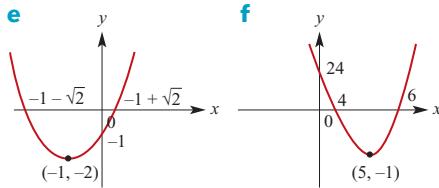
9 a $k < \frac{-37}{12}$ **b** $k = -\frac{25}{12}$

Exercise 6F

1 a $(-1, 1)$ **b** $(-5, 8)$
c $(-6, 2)$ **d** $(-7, 9)$
e $(-5, 3)$

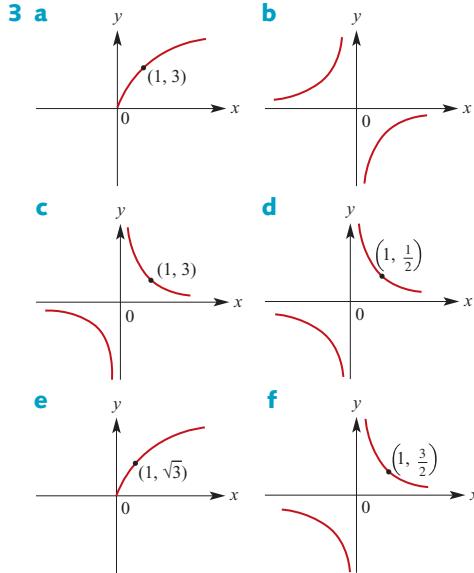
2 a $g(x) = \frac{1}{x-2} - 1$ **b** $g(x) = \frac{1}{x-4} + 3$
c $g(x) = (x+2)^2 - 3$ **d** $g(x) = (x-4)^2 - 2$
e $g(x) = \sqrt{x-2} - 1$

**4 a****5 a****d**



Exercise 6G

- 1 a** $(-2, 3)$ **b** $(2, -3)$ **c** $(-2, -12)$ **d** $(-8, -3)$
2 a i $y = 4x^2$ **ii** $y = \frac{x^2}{25}$ **iii** $y = \frac{2x^2}{3}$
iv $y = 4x^2$ **v** $y = -x^2$ **vi** $y = x^2$
b i $y = \frac{1}{2x}$ **ii** $y = \frac{5}{x}$ **iii** $y = \frac{2}{3x}$
iv $y = \frac{4}{x}$ **v** $y = \frac{-1}{x}$ **vi** $y = \frac{-1}{x}$
c i $y = \sqrt{2x}$ **ii** $y = \sqrt{\frac{x}{5}}$
iii $y = \frac{2\sqrt{x}}{3}$ **iv** $y = 4\sqrt{x}$
v $y = -\sqrt{x}$ **vi** $y = \sqrt{-x}, x \leq 0$



Exercise 6H

- 1 a** $y = 3\sqrt{x-2}$ **b** $y = -\sqrt{x+3}$
c $y = -3\sqrt{x}$ **d** $y = -\sqrt{\frac{x}{2}}$
e $y = 2\sqrt{x-2} - 3$ **f** $y = \sqrt{\frac{x+2}{2}} - 3$
2 a $y = \frac{3}{x-2}$ **b** $y = \frac{-1}{x+3}$
c $y = -\frac{3}{x}$ **d** $y = -\frac{2}{x}$
e $y = \frac{2}{x-2} - 3$ **f** $y = \frac{2}{x+2} - 3$

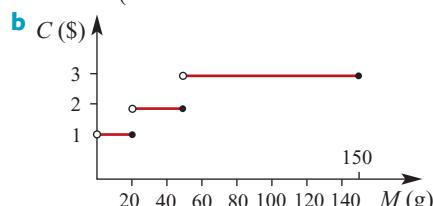
Exercise 6I

- 1 a i** A dilation of factor 2 from the x -axis, then a translation of 1 unit in the positive direction of the x -axis and 3 units in the positive direction of the y -axis
ii A reflection in the x -axis, then a translation of 1 unit in the negative direction of the x -axis and 2 units in the positive direction of the y -axis
iii A dilation of factor $\frac{1}{2}$ from the y -axis, then a translation of $\frac{1}{2}$ unit in the negative direction of the x -axis and 2 units in the negative direction of the y -axis
b i A dilation of factor 2 from the x -axis, then a translation of 3 units in the negative direction of the x -axis
ii A translation of 3 units in the negative direction of the x -axis and 2 units in the positive direction of the y -axis
iii A translation of 3 units in the positive direction of the x -axis and 2 units in the negative direction of the y -axis
c i A translation of 3 units in the negative direction of the x -axis and 2 units in the positive direction of the y -axis
ii A dilation of factor $\frac{1}{3}$ from the y -axis, then a dilation of factor 2 from the x -axis
iii A reflection in the x -axis, then a translation of 2 units in the positive direction of the y -axis

- 2 a** $(x, y) \rightarrow (3x + 2, y - 5)$
b $(x, y) \rightarrow \left(3x + 1, -\frac{y-7}{3}\right)$
c $(x, y) \rightarrow \left(-(x-4), \frac{y}{2}\right)$
d $(x, y) \rightarrow \left(-(x-4), \frac{15-y}{2}\right)$

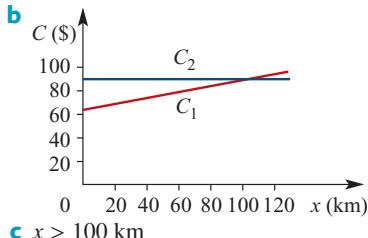
Exercise 6J

- 1** $C = 0.15n + 45$ where n is the number of calls
2 a $C(m) = \begin{cases} 1.20 & \text{for } 0 < m \leq 20 \\ 2.00 & \text{for } 20 < m \leq 50 \\ 3.00 & \text{for } 50 < m \leq 150 \end{cases}$



$$\text{Domain} = (0, 150] \\ \text{Range} = \{1.20, 2.00, 3.00\}$$

3 a $C_1 = 64 + 0.25x$, $C_2 = 89$



c $x > 100 \text{ km}$

4 a Length = $(50 - x)$ cm

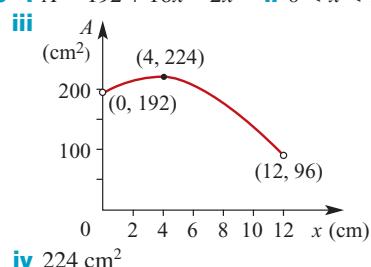
b $A(x) = x(50 - x)$ **c** $0 \leq x \leq 50$

d Maximum area = 625 cm^2 when $x = 25$

5 a i $A = (8 + x)y - x^2$

ii $P = 2x + 2y + 16$

b i $A = 192 + 16x - 2x^2$ **ii** $0 < x < 12$



iv 224 cm^2

Chapter 6 review

Short-answer questions

1 a $[-2, 4]$ **b** $[-2, 4]$ **c** $[1, 8]$ **d** $(-1, 6]$

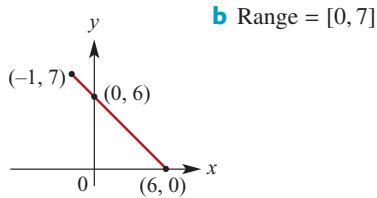
e $(-4, -2] \cup (1, 5]$ **f** $(-4, -2] \cup (2, \infty)$

g $(-\infty, -3] \cup (1, \infty)$

2 a -16 **b** 26

c $-\frac{2}{3}$

3 a



b Range = $[0, 7]$

4 a Range = \mathbb{R}

b Range = $[-5, 4]$

c Range = $[0, 4]$

d Range = $(-\infty, 9]$

e Range = $[2, \infty)$

f Range = $\{-6, 2, 4\}$

g Range = $[0, \infty)$

h Range = $\mathbb{R} \setminus \{2\}$

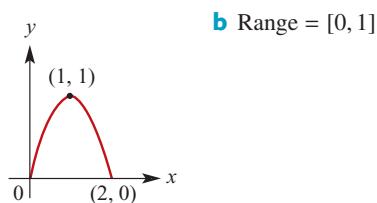
i Range = $[-5, 1]$

j Range = $[-1, 3]$

5 a $a = -15$, $b = \frac{33}{2}$

b Domain = $\mathbb{R} \setminus \{0\}$

6 a



b Range = $[0, 1]$

7 a $a = 3$, $b = -5$

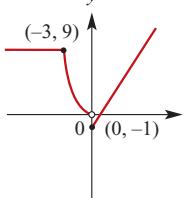
8 a $a = -\frac{1}{2}$, $b = 2$, $c = 0$

9 a $\mathbb{R} \setminus \{2\}$

c $[-5, 5]$

e $[-10, 10]$

10 a

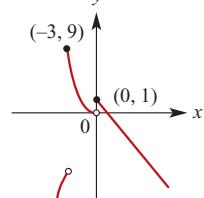


b $[2, \infty)$

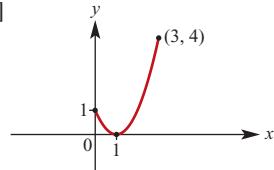
d $\mathbb{R} \setminus \{\frac{1}{2}\}$

f $(-\infty, 4]$

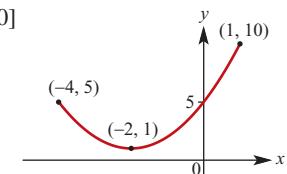
b



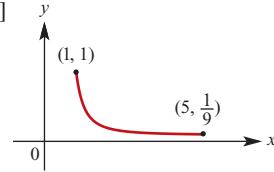
11 a Range = $[0, 4]$



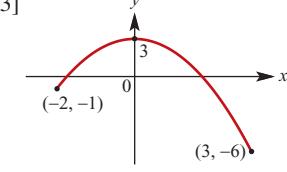
b Range = $[1, 10]$



c Range = $[\frac{1}{9}, 1]$



d Range = $[-6, 3]$



12 a Domain = $[1, \infty)$; Range = $[0, \infty)$

b Domain = $(-\infty, 1]$; Range = $[0, \infty)$

c Domain = $[0, \infty)$; Range = $(-\infty, 1]$

13 a Domain = $\mathbb{R} \setminus \{1\}$; Range = $\mathbb{R} \setminus \{0\}$

b Domain = $\mathbb{R} \setminus \{-1\}$; Range = $\mathbb{R} \setminus \{0\}$

c Domain = $\mathbb{R} \setminus \{1\}$; Range = $\mathbb{R} \setminus \{3\}$

14 a Domain = $[-1, 1]$; Range = $[0, 1]$

b Domain = $[-3, 3]$; Range = $[0, 3]$

c Domain = $[-1, 1]$; Range = $[3, 4]$

15 a $2p + 5$

b $2(p + h) + 5$

c $2h$

d 2

16 -2

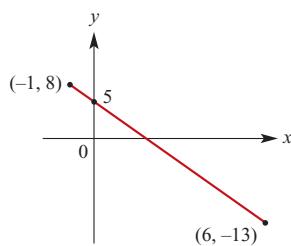
17 a $\left(-\infty, -\frac{15}{8}\right]$

b $[3\frac{7}{8}, \infty)$

c $(-\infty, 20]$

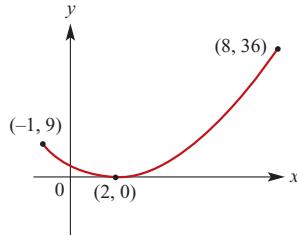
d $(-\infty, 3]$

18 a



b Range = $[-13, 8]$

19 a



b Range = $[0, 36]$

20 a Domain $-3 \leq x \leq 3$; Range $-3 \leq y \leq 3$

b Domain $1 \leq x \leq 3$; Range $-1 \leq y \leq 1$

c Domain $0 \leq x \leq 1$; Range $0 \leq y \leq 1$

d Domain $-1 \leq x \leq 9$; Range $-5 \leq y \leq 5$

e Domain $-4 \leq x \leq 4$; Range $-2 \leq y \leq 6$

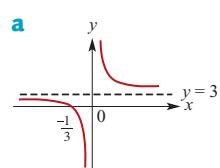
21 a $\{2, 4, 6, 8\}$

b $\{4, 3, 2, 1\}$

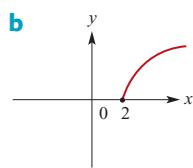
c $\{-3, 0, 5, 12\}$

d $\{1, \sqrt{2}, \sqrt{3}, 2\}$

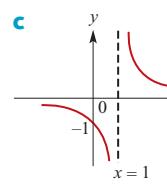
22 a



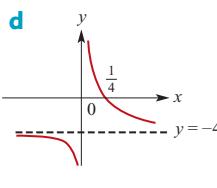
b



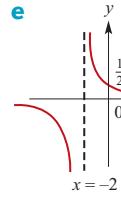
c



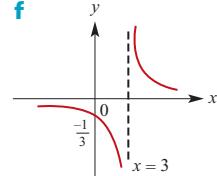
d



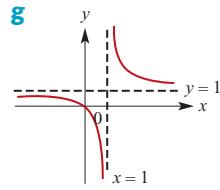
e



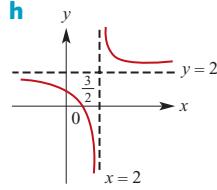
f



g



h



23 a i $(x, y) \rightarrow (x - 1, 3y + 2)$

ii $(x, y) \rightarrow (x - 2, -2y + 3)$

iii $(x, y) \rightarrow \left(\frac{x-1}{3}, y-1\right)$

b i $(x, y) \rightarrow (x - 2, 4y)$

ii $(x, y) \rightarrow (x - 6, y - 12)$

iii $(x, y) \rightarrow (x + 3, 4y - 5)$

c i $(x, y) \rightarrow (x + 4, y + 2)$

ii $(x, y) \rightarrow \left(\frac{x}{2}, 2y\right)$

iii $(x, y) \rightarrow (x, -2y + 3)$

Multiple-choice questions

1 B

2 E

3 D

4 B

5 E

6 E

7 D

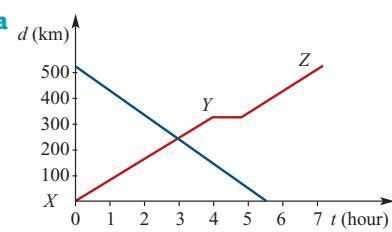
8 C

9 D

10 C

Extended-response questions

1 a



Coach starting from X :

$$d = \begin{cases} 80t & \text{for } 0 \leq t \leq 4 \\ 320 & \text{for } 4 < t \leq 4\frac{3}{4} \\ 80t - 60 & \text{for } 4\frac{3}{4} < t \leq 7\frac{1}{4} \end{cases}$$

Range = $[0, 520]$

Coach starting from Z :

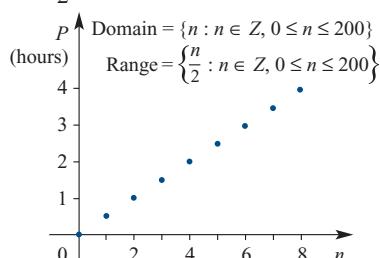
$$d = 520 - \frac{1040t}{11} \text{ for } 0 \leq t \leq 5\frac{1}{2}$$

Range = $[0, 520]$

b The coaches pass $238\frac{1}{3}$ km from X

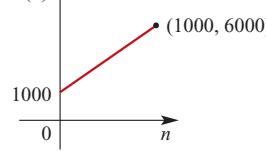
2 a $P = \frac{1}{2}n$

b

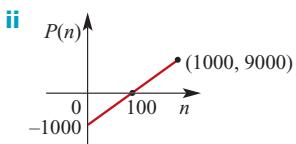


3 a i $C(n) = 1000 + 5n, n > 0$

ii $C(n) \uparrow$

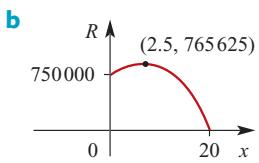


b i $P(n) = 15n - (1000 + 5n)$
 $= 10n - 1000$



4 $V = 8000(1 - 0.05n) = 8000 - 400n$

5 a $R = (50000 - 2500x)(15 + x)$
 $= 2500(x + 15)(20 - x)$



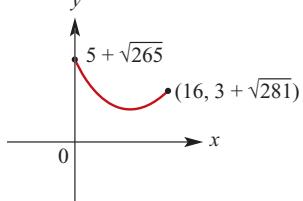
c Price for max revenue = \$17.50

6 a $A(x) = \frac{x}{4}(2a - (6 - \sqrt{3})x)$ **b** $0 < x < \frac{a}{\sqrt{3}}$

7 a i $d(x) = \sqrt{x^2 + 25} + \sqrt{(16 - x)^2 + 9}$

ii $0 \leq x \leq 16$

b i



ii 1.54

iii 3.40 or 15.04

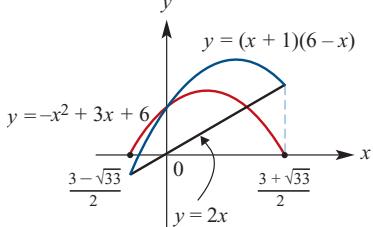
c i Minimum is $8\sqrt{5}$, occurs when $x = 10$

ii Range = $[8\sqrt{5}, 5 + \sqrt{265}]$

8 a $A\left(\frac{3 + \sqrt{33}}{2}, 3 + \sqrt{33}\right), B\left(\frac{3 - \sqrt{33}}{2}, 3 - \sqrt{33}\right)$

b i $d(x) = -x^2 + 3x + 6$

ii



c i Maximum value of $d(x)$ is 8.25

ii Range = $[0, 8.25]$

d $A(2.45, 12.25), B(-2.45, -12.25)$

$d(x) = -x^2 + 6$

Maximum value of $d(x)$ is 6; Range = $[0, 6]$

9 a $k = \frac{1}{4}$ **b** $h = -\frac{1}{4}$

10 a $h = -1 \pm 2\sqrt{2}$ **b** $a = \pm 2\sqrt{2}$

c $a = -8, b = 16$

11 a $k = 10$

b i $h > 2 + \sqrt{10}$ **ii** $h < 2 - \sqrt{10}$

iii $2 - \sqrt{10} < h < 2 + \sqrt{10}$

Chapter 7

Exercise 7A

1 a -3 **b** -1 **c** -7 **d** -15

2 a 0 **b** 0

3 a 6 **b** 9 **c** 26 **d** 11

e $a^3 + 4a^2 - 2a + 6$ **f** $8a^3 + 16a^2 - 4a + 6$

4 a $a = 4$ **b** $a = 4$ **c** $c = 6$

d $a = -33, b = -15$ **e** $a = -9, b = 23$

5 a $x^3 - 2x^2 - 2x + 2$ **b** $x^3 - x^2 + 2x$

c $x^3 - 2x^2 + 4x - 2$ **d** $3x^3 - 6x^2 + 3x$

e $-3x^4 + 8x^3 - 7x^2 + 2x$

f $-3x^3 - x^2 + 2x$ **g** $x^3 - x^2 - x + 2$

h $x^5 - x^4 - x^3 + x^2$

6 a $x^3 - 4x^2 + 7x - 6$ **b** $x^3 - 6x^2 + 11x - 12$

c $2x^3 - 5x^2 - x + 4$

d $x^3 + (b - 2)x^2 + (c - 2b)x - 2c$

e $2x^3 - 7x^2 - 10x - 3$

7 a $x^3 + (b + 1)x^2 + (c + b)x + c$

b $b = -8, c = 12$ **c** $(x + 1)(x - 6)(x - 2)$

8 $b = -3, c = -11$

9 a $a^5 + 5a^4b + 10a^3b^2 + 10a^2b^3 + 5ab^4 + b^5$

b $a^6 + 6a^5b + 15a^4b^2 + 20a^3b^3 + 15a^2b^4 + 6ab^5 + b^6$

10 a $(x - y)^4 = x^4 - 4x^3y + 6x^2y^2 - 4xy^3 + y^4$

b $(2x + y)^4 = 16x^4 + 32x^3y + 24x^2y^2 + 8xy^3 + y^4$

Exercise 7B

1 a $x^2 + 2x + \frac{3}{x - 1}$ **b** $2x^2 - x - 3 + \frac{6}{x + 1}$

c $3x^2 - 10x + 22 - \frac{43}{x + 2}$

d $2x^2 + 3x + 10 + \frac{28}{x - 3}$

2 a $x^2 - x + 4 - \frac{8}{x + 1}$

b $2x^2 - 8x + 49 - \frac{181}{x + 4}$

c $x^2 + x - 3 + \frac{11}{x + 3}$

d $x^2 - x + 4 + \frac{8}{x - 2}$

3 a $x^2 - 2x + 5$ **b** $2x^2 - 2x - 6$

c $x^2 - 2x - 6$ **d** $3x^2 - x - 6$

4 a Quotient $x^2 - 3$; Remainder 7

b Quotient $x^2 + 2x + 15$; Remainder 71

c Quotient $2x^2 - 3x$; Remainder -7

d Quotient $5x^2 + 20x + 77$; Remainder 315

5 a $\frac{1}{2}x^2 + \frac{7}{4}x - \frac{3}{8} + \frac{103}{8(2x + 5)}$

b $x^2 + 2x - 3 - \frac{2}{2x + 1}$ **c** $x^2 + 2x - 15$

d $\frac{1}{3}x^2 - \frac{8}{9}x - \frac{8}{27} + \frac{19}{27(3x - 1)}$

- 6 a** $x^2 + 3x + 8 + \frac{9}{x-1}$
b $x^2 - \frac{x}{2} + \frac{9}{4} + \frac{21}{4(2x-1)}$
- 7 a** Quotient $2x - 6$; Remainder 0
b Quotient $x - 6$; Remainder -2
c Quotient $2x - 6$; Remainder 42
d Quotient $x^2 - 4x + 2$; Remainder $-x + 7$
e Quotient $x^2 - 3x + 7$; Remainder $-10x + 9$
f Quotient $x^2 + x - \frac{3}{2}$; Remainder $\frac{15}{2}x + 16$

Exercise 7C

- 1 a** -2 **b** -29 **c** 15 **d** 4 **e** 7
f -12 **g** 0 **h** -5 **i** -8
- 2 a** $a = -3$ **b** $a = 2$ **c** $a = 4$ **d** $a = -10$
- 3 a** $P(1) = 0$ **b** $P(1) = 0$
c $P(-2) = 0$ **d** $P(\frac{3}{2}) = 0$
- 4 a** 6 **b** 28 **c** $-\frac{1}{3}$
- 5 a** $(x-1)(x+1)(2x+1)$ **b** $(x+1)^3$
c $(x-1)(6x^2 - 7x + 6)$
d $(x-1)(x+5)(x-4)$
e $(x+1)^2(2x-1)$ **f** $(x+1)(x-1)^2$
g $(x-2)(4x^2 + 8x + 19)$
h $(x+2)(2x+1)(2x-3)$

6 1

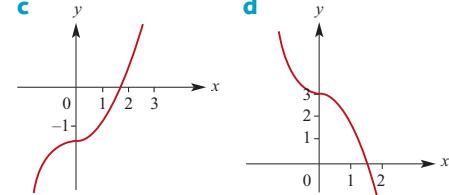
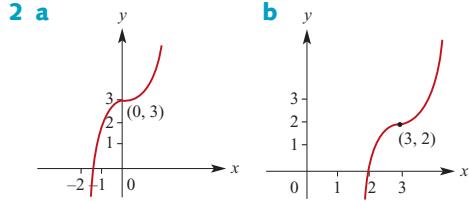
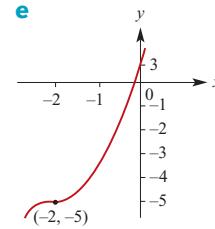
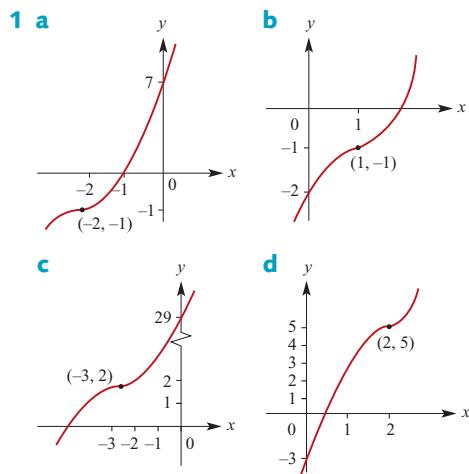
- 7 a** $(2x-3)(x^2 - 2x + 5)$
b $(2x+1)(x^2 - 2x + 5)$
c $(2x+1)(x-1 - \sqrt{6})(x-1 + \sqrt{6})$
d $(2x+3)(x-1 - \sqrt{2})(x-1 + \sqrt{2})$
- 8 a** $(x-1)(x^2 + x + 1)$
b $(x+4)(x^2 - 4x + 16)$
c $(3x-1)(9x^2 + 3x + 1)$
d $(4x-5)(16x^2 + 20x + 25)$
e $(1-5x)(1+5x+25x^2)$
f $(3x+2)(9x^2 - 6x + 4)$
g $(4m-3n)(16m^2 + 12mn + 9n^2)$
h $(3b+2a)(9b^2 - 6ab + 4a^2)$

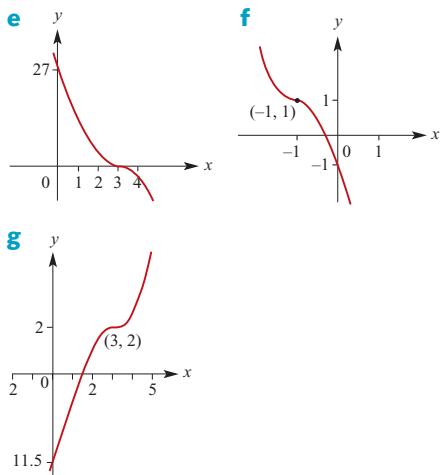
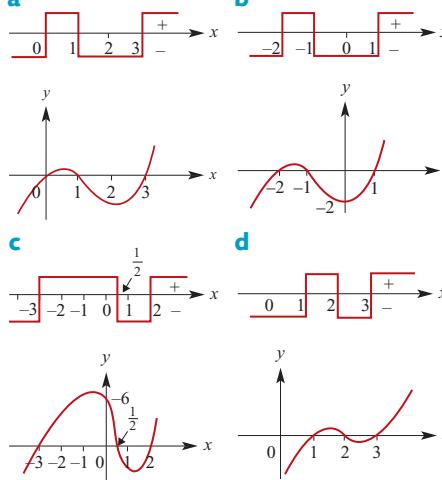
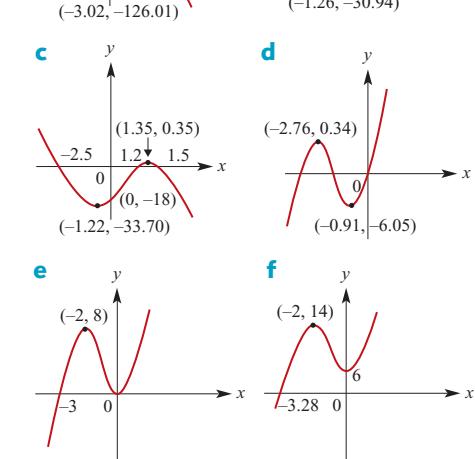
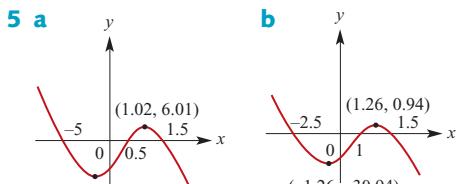
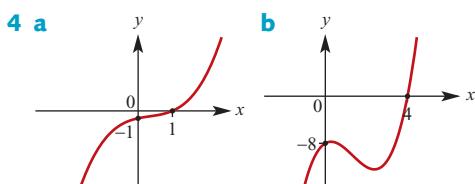
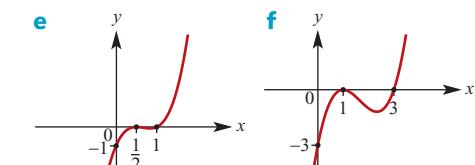
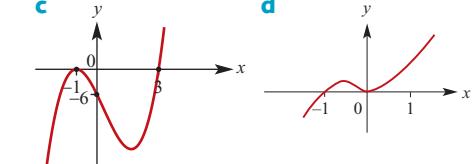
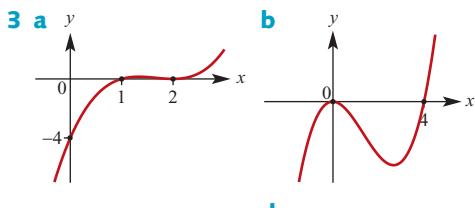
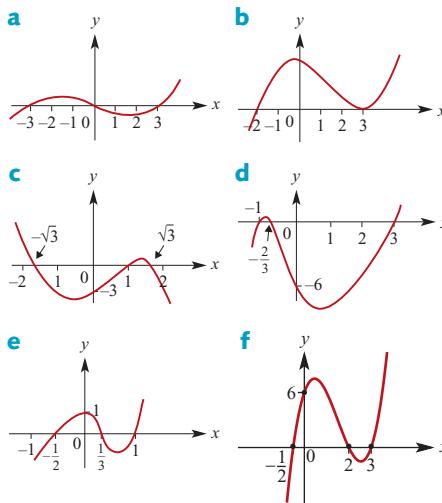
- 9 a** $(x+2)(x^2 - x + 1)$
b $(3x+2)(x-1)(x-2)$
c $(x-3)(x+1)(x-2)$
d $(3x+1)(x+3)(2x-1)$

10 a $a = 3$, $b = -3$, $P(x) = (x-1)(x+3)(x+1)$ **11 b i** n odd **ii** n even**12 a** $a = 1$, $b = 1$ **b i** $P(x) = x^3 - 2x^2 + 3$ **Exercise 7D**

- 1 a** 1, -2, 4 **b** 4, 6 **c** $\frac{1}{2}, 3, -\frac{2}{3}$ **d** 0, -3, $\frac{5}{2}$
- 2 a** -2, 0, 4 **b** 0, $-1 \pm 2\sqrt{3}$ **c** -5, 0, 8
d $0, -1 \pm \sqrt{17}$
- 3 a** 1 **b** -1 **c** 5, $\pm\sqrt{10}$ **d** $\pm 4, a$

- 4 a** 2, 3, -5 **b** $-1, -\frac{2}{3}, 3$ **c** 1, $-\sqrt{2}, \sqrt{2}$
d $-\frac{2}{5}, -4, 2$ **e** $-\frac{1}{2}, \frac{1}{3}, 1$ **f** $-2, -\frac{3}{2}, 5$
- 5 a** -6, 2, 3 **b** $-2, -\frac{2}{3}, \frac{1}{2}$ **c** 3
d -1 **e** -1, 3 **f** $3, -2 \pm \sqrt{3}$
- 6 a** 0, $\pm 2\sqrt{2}$ **b** $1 + 2\sqrt[3]{2}$ **c** -2
d -5 **e** $\frac{1}{10}$
- 7 a** $2(x-9)(x-13)(x+11)$
b $(x+11)(x+3)(2x-1)$
c $(x+11)(2x-9)(x-11)$
d $(2x-1)(x+11)(x+15)$

Exercise 7E


Exercise 7F
1 a

2 a


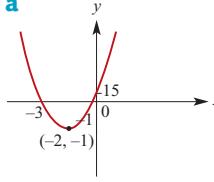
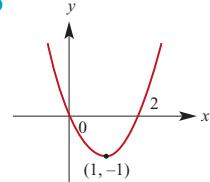
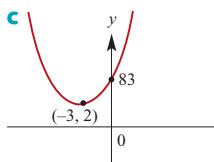
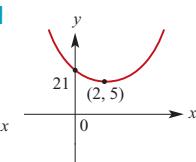
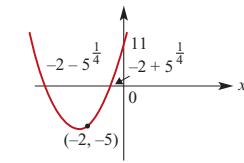
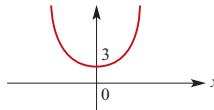
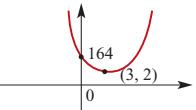
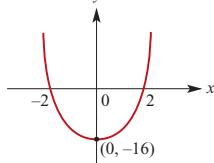
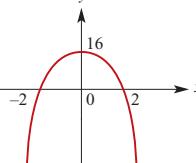
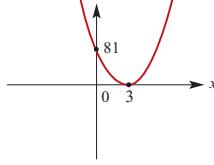
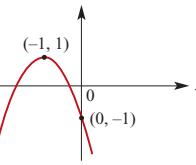
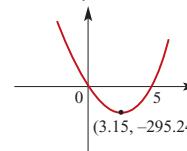
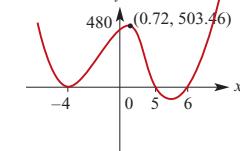
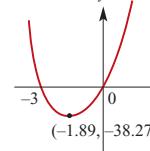
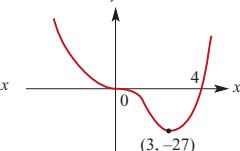
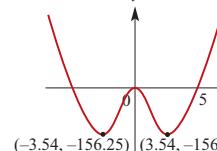
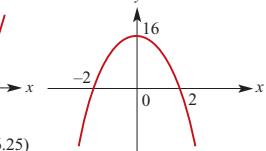
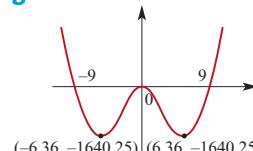
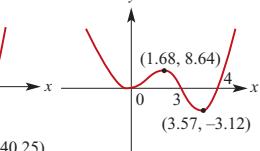
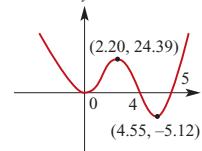
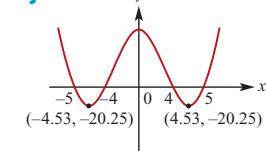
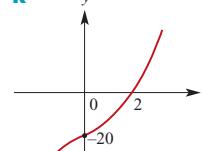
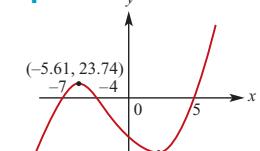
6 $f(x) = (x+1)^2(x-3)$, so graph just touches the x -axis at $x = -1$ and cuts it at $x = 3$

Exercise 7G

1 a $a = 11$ **b** $a = 2$ **c** $a = \frac{4}{3}, b = \frac{44}{3}$

2 a $y = -\frac{1}{8}(x+2)^3$ **b** $y-2 = -\frac{1}{4}(x-3)^3$

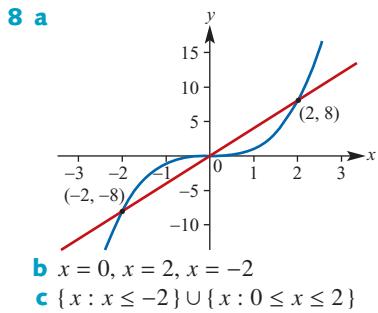
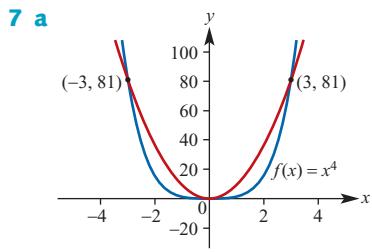
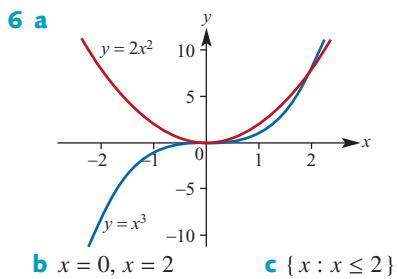
- 3** $y = 2x(x - 2)^2$ **4** $y = -2x(x + 4)^2$
5 $y = -2(x - 1)(x - 3)(x + 1)$ **6** $a = 36$
7 **a** $y = (x - 3)^3 + 2$ **b** $y = \frac{23}{18}x^3 + \frac{67}{18}x^2$
c $y = 5x^3$
8 **a** $y = -\frac{1}{3}x^3 + \frac{4}{3}x$ **b** $y = \frac{1}{4}x(x^2 + 2)$
9 **a** $y = -4x^3 - 50x^2 + 96x + 270$
b $y = 4x^3 - 60x^2 + 80x + 26$
c $y = x^3 - 2x^2 + 6x - 4$
d $y = 2x^3 - 3x$
e $y = 2x^3 - 3x^2 - 2x + 1$
f $y = x^3 - 3x^2 - 2x + 1$
g $y = -x^3 - 3x^2 - 2x + 1$

Exercise 7H
1 a

b

c

d

e

2 a

b

c

d

e

f

3 a $x = 0$ or $x = 3$
b $x = 2$ or $x = -1$ or $x = 5$ or $x = -3$
c $x = 0$ or $x = -2$ **d** $x = 0$ or $x = 6$
e $x = 0$ or $x = 3$ or $x = -3$
f $x = 3$ or $x = -3$
g $x = 0$ or $x = 4$ or $x = -4$
h $x = 0$ or $x = 4$ or $x = 3$
i $x = 0$ or $x = 4$ or $x = 5$
j $x = 2$ or $x = -2$ or $x = 3$ or $x = -3$
k $x = 4$
l $x = -4$ or $x = 2$
4 a

b

c

d

e

f

g

h

i

j

k

l

5 a Even

b Odd

c Even

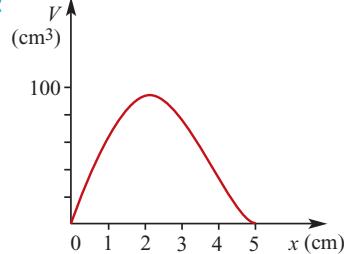
d Odd



Exercise 7I

- 1 a** Length of each edge = $20 - 2x$
b $V(x) = 4x(10 - x)^2$
c $V(5) = 500$; Volume of box = 500 cm^3
d $x = 5$ or $x = \frac{5}{2}(3 - \sqrt{5})$

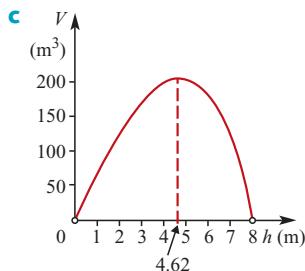
- 2 a** $\ell = 12 - 2x, w = 10 - 2x$
b $V = 4x(6 - x)(5 - x)$



- d** $V = 80$ **e** $x = 3.56$ or $x = 0.51$
f $V_{\max} = 96.8 \text{ cm}^3$ when $x = 1.81$
- 3 a** Surface area = $x^2 + 4xh$
b $h = \frac{75 - x^2}{4x}$ **c** $V = \frac{1}{4}(75x - x^3)$
- d i** $\frac{71}{2}$ **ii** $\frac{125}{2}$ **iii** 22
e $x = -2 + 3\sqrt{7}$

4 a $h = 60 - 20x$

b $V = 600x^2(3 - x)$
d $x = 1$ or $x = 1 + \sqrt{3}$
b $V = \frac{\pi h}{3}(64 - h^2)$



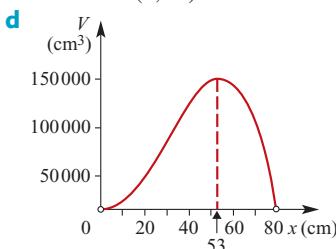
d Domain = $\{h : 0 < h < 8\}$

f $h = 2.48$ or $h = 6.47$

g $V_{\max} \approx 206.37 \text{ m}^3$ when $h = 4.62$

6 a $h = 160 - 2x$

c Domain = $(0, 80)$



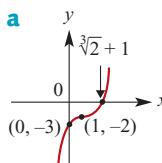
e $x = 20.498$ or $x = 75.63$

f $V_{\max} \approx 151\ 703.7 \text{ cm}^3$ when $x \approx 53$

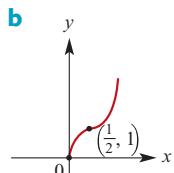
Chapter 7 review

Short-answer questions

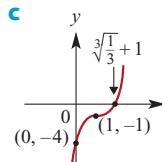
1 a



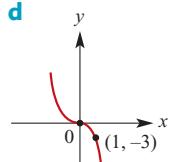
b



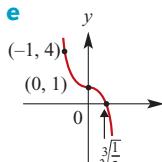
c



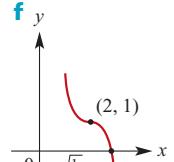
d

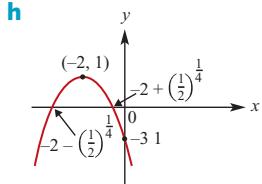
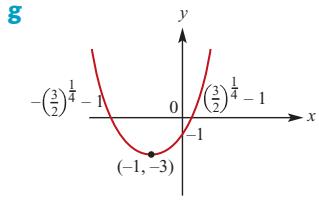
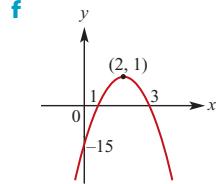
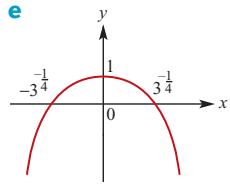
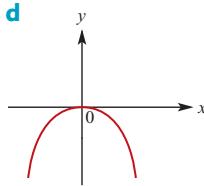
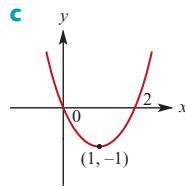
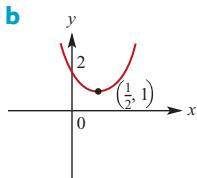
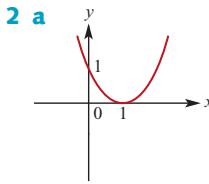
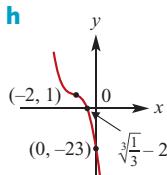
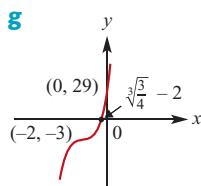


e



f





3 a $x = 2, x = -\frac{1}{2}, x = -3$

b $x = 2, x = \frac{\sqrt{17} + 1}{4}, x = \frac{1 - \sqrt{17}}{4}$

c $x = -1, x = 2, x = 6$

4 a $P\left(\frac{3}{2}\right) = 0$ and $P(-2) = 0$; $(3x+1)$

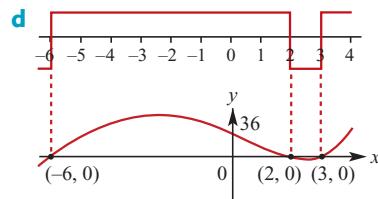
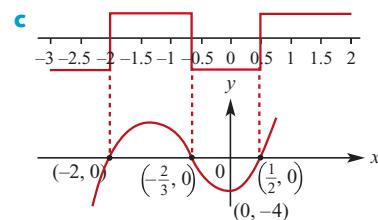
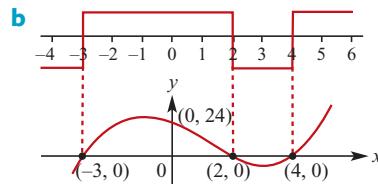
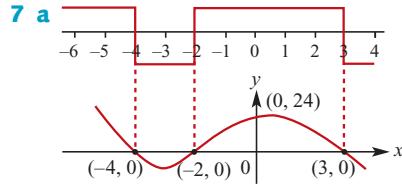
b $x = -2, \frac{1}{2}, 3$

c $x = -1, -\sqrt{11}, +\sqrt{11}$

d i $P\left(\frac{1}{3}\right) = 0$ **ii** $(3x-1)(x+3)(x-2)$

5 a $f(1) = 0$ **b** $(x-1)(x^2 + (1-k)x + k+1)$

6 $a = 3, b = -24$



8 a -41 **b** 12 **c** $\frac{43}{9}$

9 $y = -\frac{2}{5}(x+2)(x-1)(x-5)$

10 $y = \frac{2}{81}x(x+4)^2$

11 a $a = 3, b = 8$ **b** $(x+3)(2x-1)(x-1)$

12 a Dilation of factor 2 from the x -axis, then translation of 1 unit in the positive direction of the x -axis and 3 units in the positive direction of the y -axis

b Reflection in the x -axis, then translation of 1 unit in the negative direction of the x -axis and 2 units in the positive direction of the y -axis

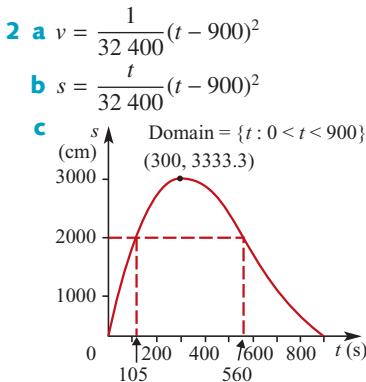
c Dilation of factor $\frac{1}{2}$ from the y -axis, then translation of $\frac{1}{2}$ unit in the negative direction of the x -axis and 2 units in the negative direction of the y -axis

Multiple-choice questions

- | | | | | |
|------------|------------|------------|------------|-------------|
| 1 B | 2 D | 3 A | 4 D | 5 A |
| 6 C | 7 B | 8 B | 9 D | 10 B |

Extended-response questions

- 1** **a** $V = \pi r^2(6 - r)$ **b** $0 \leq r \leq 6$
c $V(3) = 27\pi$ **d** $r = 3$ or $r = \frac{3}{2}(1 + \sqrt{5})$
e Maximum ≈ 100.53 (correct to 2 d.p.)



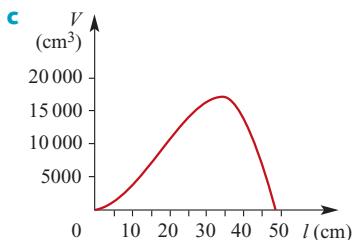
- d** No, it is not feasible as the maximum range of the taxi is less than 3.5 km (≈ 3.33 km)
e Maximum speed $\approx \frac{2000}{105} = 19$ m/s
 Minimum speed $\approx \frac{2000}{560} = 3.6$ m/s

3 **a** $R = a(x - 5)^3 + 10$ **b** $a = \frac{2}{25}$

c $R = \frac{12}{343}(x - 7)^3 + 12$

4 4730 cm^2

b $V = \ell^2(\sqrt{2365} - \ell)$



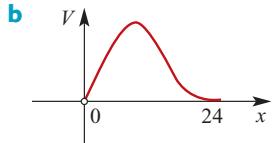
- d** **i** $\ell = 23.69$ or $\ell = 39.79$
ii $\ell = 18.1$ or $\ell = 43.3$

e $V_{\max} \approx 17039 \text{ cm}^3$ when $\ell \approx 32.42 \text{ cm}$

5 **a** $a = \frac{-43}{15000}, b = 0.095, c = \frac{-119}{150}, d = 15.8$

b **i** $(5.59, 13.83)$ **ii** $(0, 15.8)$

6 **a** $V = (96 - 4x)(48 - 2x)x = 8x(24 - x)^2$



- i** $0 < x < 24$
ii $V_{\max} = 16384 \text{ cm}^3$ when $x = 8.00$

c 15680 cm^3 **d** 14440 cm^3 **e** 9720 cm^3

Chapter 8

Short-answer questions

- 1** **a** $M\left(\frac{1}{2}, -\frac{3}{2}\right), N\left(\frac{3}{2}, 4\right)$ **b** $m_{BC} = m_{MN} = \frac{11}{2}$
2 **a** -6 **b** 69 **c** -15
3 **a** $12a^2 - 4$ **b** $3a^2 - 6a - 1$
c $12a$

- 4** **a** No **b** $x = -\frac{3}{7}$ **c** $x \leq -\frac{3}{7}$ **d** $k = -\frac{3}{16}$

5 $x = 2$ and $y = 3$, or $x = 3$ and $y = 2$

- 6** $AB = BC = CD = DA = 5\sqrt{2}$,
 $m_{BC} = m_{AD} = 1$ and $m_{AB} = m_{CD} = -7$

7 **a** $y = (x + 2)^2 - 13$ **b** $y = \left(x - \frac{3}{2}\right)^2 - \frac{53}{4}$
c $y = 2\left(x - \frac{3}{4}\right)^2 + \frac{79}{8}$

8 **a** $\left(\frac{1 - \sqrt{41}}{2}, 3 - 2\sqrt{41}\right), \left(\frac{\sqrt{41} + 1}{2}, 2\sqrt{41} + 3\right)$
b $(2, 6)$ **c** $(-4, 14)$

9 **a** $x < \frac{-3 - \sqrt{29}}{2}$ or $x > \frac{-3 + \sqrt{29}}{2}$
b $x \leq \frac{5 - \sqrt{65}}{4}$ or $x \geq \frac{5 + \sqrt{65}}{4}$

10 **a** $\mathbb{R} \setminus \{\frac{5}{2}\}$ **b** $(-\infty, 5]$ **c** \mathbb{R}

11 $p = -38, (x - 3)(x + 4)(3x - 2)$

12 $a = -5, R = -35$

13 **a** $[1, 4]$ **b** $[0, 3]$ **c** $(-4, \infty)$
d $[3, \infty)$ **e** \mathbb{R}

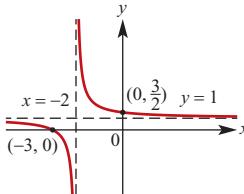
14 **a** $3b + 2f = 18.20$ **b** \$2.80

15 **a** $k = 1$ **b** $k = -16$

16 **a** $\frac{2}{5}$ **b** $2y + 5x - 17 = 0$

17 4 cm; 49 hours

18 **a** $a\left(x + \frac{1}{a}\right)^2 + \frac{a^2 - 1}{a}$ **b** $\left(-\frac{1}{a}, \frac{a^2 - 1}{a}\right)$
c $a = \pm 1$ **d** $a \in (-1, 1)$

19 **a** 

b $A\left(0, \frac{3}{2}\right), B(-3, 0)$ **c** $y = \frac{1}{2}x + \frac{3}{2}$

d $\left(-\frac{3}{2}, \frac{3}{4}\right)$ **e** $y = -2x - \frac{9}{4}$

20 $\sqrt{2}$ cm

21 192 g

Multiple-choice questions

- | | | | | |
|-------------|-------------|-------------|-------------|-------------|
| 1 B | 2 D | 3 C | 4 A | 5 D |
| 6 A | 7 D | 8 D | 9 C | 10 C |
| 11 C | 12 A | 13 E | 14 B | 15 A |
| 16 E | 17 B | 18 D | 19 D | 20 E |
| 21 B | 22 D | 23 E | 24 D | 25 B |
| 26 D | 27 D | 28 A | 29 B | 30 D |
| 31 D | 32 B | 33 C | 34 A | 35 C |
| 36 D | 37 A | 38 A | 39 B | 40 C |
| 41 D | 42 E | 43 E | 44 C | 45 C |
| 46 C | 47 A | 48 C | 49 E | |

Extended-response questions

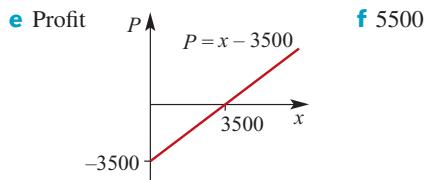
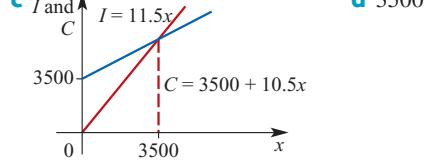
- 1 a** $4b - 5c - d = 41$, $2b - 7c - d = 53$,
 $-4b + 3c - d = 25$

b $x^2 + y^2 - 2x - 4y - 29 = 0$

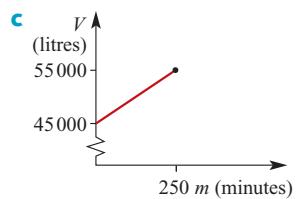
- 2 a** $c = -b - 8$ **b** $x = 0$ or $x = -b$
c $y = 0$ or $y = b + 8$ **d** $b = -8$

- 3 a** $x \leq a$ **b** $\left(\frac{\sqrt{4a+1}-1}{2}, \frac{\sqrt{4a+1}-1}{2}\right)$
c $a = 2$ **d** $a = 6$ **e** $a = c^2 + c$

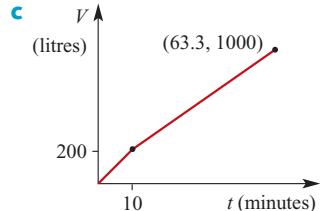
- 4 a** $C = 3500 + 10.5x$ **b** $I = 11.5x$
c I and C **d** 3500



- 5 a** $V = 45000 + 40m$ **b** 4 hours 10 minutes

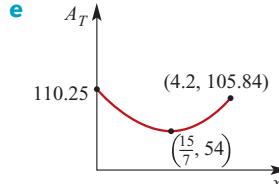


- 6 a** 200 L **b** $V = \begin{cases} 20t & 0 \leq t \leq 10 \\ 15t + 50 & 10 < t \leq \frac{190}{3} \end{cases}$



- 7 a** $A_R = 6x^2$
b $A_S = (10.5 - 2.5x)^2$
c $0 \leq x \leq 4.2$

d $A_T = 12.25x^2 - 52.5x + 110.25$



f 110.25 cm² (when area of rectangle = 0)

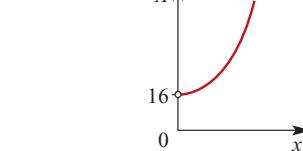
g Rectangle 9 × 6 and square 3 × 3,
 or rectangle $\frac{27}{7} \times \frac{18}{7}$ and square $\frac{51}{7} \times \frac{51}{7}$

- 8 a** 20 m **b** 20 m **c** 22.5 m

- 9 a** $A = 10x^2 + 28x + 16$

b i 54 cm² **ii** 112 cm²

c 3 cm

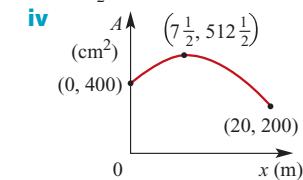


e $V = 2x^3 + 8x^2 + 8x$ **f** $x = 3$ **g** $x = 6.66$

- 10 a i** $A = (10 + x)y - x^2$ **ii** $P = 2(y + x + 10)$

- b i** $A = 400 + 30x - 2x^2$

ii $512\frac{1}{2}$ m² **iii** $0 \leq x \leq 20$

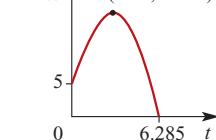


- 11 a** $A = 6x^2 + 7xy + 2y^2$

- c i** $x = 0.5$ m **ii** $y = 0.25$ m

- 12 a** 50.9 m **b** $t = 6.12$ seconds

- c** $h(t)$ **d** 6.285 seconds

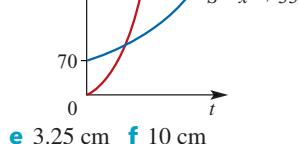


- 13 a** $x + 5$ **b** $V = 35x + 7x^2$

c $S = x^2 + 33x + 70$

- d** $V = 35x + 7x^2$

$S = x^2 + 33x + 70$



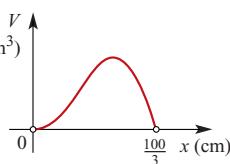
14 a $2y + 3x = 22$

- b i** $B(0, 11)$ **ii** $D(8, -1)$
c 52 units²
d 6.45 units

15 a 25 km/h **b** Tap A 60 min; Tap B 75 min
c 4 cm

16 a $h = 100 - 3x$ **b** $V = 2x^2(100 - 3x)$

c $0 < x < \frac{100}{3}$



- e i** $x = 18.142$ or $x = 25.852$
ii $x = 12.715$ or $x = 29.504$

f $V_{\text{max}} = 32921.811 \text{ cm}^3$ when $x = 22.222$

g i $S = 600x - 14x^2$

ii $S_{\text{max}} = \frac{45000}{7} \text{ cm}^2$ when $x = \frac{150}{7}$

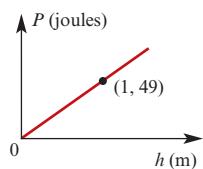
h $x = 3.068$ or $x = 32.599$

17 a $y = (7.6 \times 10^{-5})x^3 - 0.0276x^2 + 2.33x$
b $y = (7.6 \times 10^{-5})x^3 - 0.0276x^2 + 2.33x + 5$
c 57.31 m

18 a $y = \frac{3}{4}x - 4$ **b** $y = -\frac{4}{3}x + \frac{38}{3}$

c $D(8, 2)$ **d** 5 units **e** 50 units²

19 a i $P = 49h$ **ii**



iii 1136.8

b i $P = 9.8mh$ **ii** 100% increase

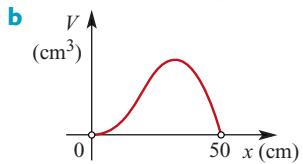
iii 50% decrease

c i 14 **ii** 42

d 4

20 a i $y = 250 - 5x$

ii $V = x^2(250 - 5x) = 5x^2(50 - x)$



c $(0, 50)$

d $x = 11.378$ or $x = 47.813$

e $V_{\text{max}} = 92592.59 \text{ cm}^3$ when $x = 33.33$ and $y = 83.33$

21 a i $A = \frac{a^3}{6}$ **ii** 4.5 **iii** 30

b i $A_1 = \frac{a^3}{12}$ **ii** 486 **iii** 36

c i $A_2 = \frac{1}{a} - \frac{1}{b}$ **ii** $\frac{5}{6}$ **iii** $\frac{11}{3}$

iv 99.99 **v** 999.999

Chapter 9

Exercise 9A

1 $\{H, T\}$

2 $\{1, 2, 3, 4, 5, 6\}$

3 a 52 **b** 4

c clubs ♣, hearts ♥, spades ♠, diamonds ♦

d clubs and spades are black;
diamonds and hearts are red **e** 13

f ace, king, queen, jack **g** 4

h 16

4 a $\{0, 1, 2, 3, 4, 5\}$ **b** $\{0, 1, 2, 3, 4, 5, 6\}$

c $\{0, 1, 2, 3\}$

5 a $\{0, 1, 2, 3, \dots\}$ **b** $\{0, 1, 2, 3, \dots, 41\}$

c $\{1, 2, 3, \dots\}$

6 a $\{2, 4, 6\}$ **b** $\{FFF\}$ **c** \emptyset

7 a $\frac{1}{2}$ **b** $\frac{3}{10}$ **c** $\frac{3}{20}$

8 a $\frac{4}{15}$ **b** $\frac{2}{3}$ **c** $\frac{4}{15}$

9 a $\frac{1}{4}$ **b** $\frac{1}{2}$ **c** $\frac{4}{13}$ **d** $\frac{2}{13}$

10 a $\frac{9}{13}$ **b** $\frac{10}{13}$ **c** $\frac{5}{13}$ **d** $\frac{1}{13}$

11 a $\frac{1}{365}$ **b** $\frac{30}{365}$ **c** $\frac{30}{365}$ **d** $\frac{90}{365}$

12 a $\frac{1}{9}$ **b** $\frac{1}{3}$ **c** $\frac{5}{9}$ **d** $\frac{4}{9}$

13 $\frac{1}{3}$

14 0.4

15 a $\frac{1}{3}$ **b** $\frac{1}{8}$ **c** $\frac{1}{4}$

16 a $\frac{1}{7}$ **b** $\frac{5}{7}$

17 a $\frac{3}{4}$ **b** $\frac{1}{2}$ **c** $\frac{10}{13}$ **d** $\frac{23}{26}$

18 $\frac{1}{5}, \frac{1}{5}, \frac{1}{5}, \frac{2}{5}$

19 a $\frac{1}{13}, \frac{2}{13}, \frac{2}{13}, \frac{2}{13}, \frac{2}{13}, \frac{4}{13}$ **b** $\frac{9}{13}$

Exercise 9B

1 a $\frac{17}{50}$ **b** $\frac{1}{10}$ **c** $\frac{4}{15}$ **d** $\frac{1}{200}$

2 a No **b** Answers will vary
c Answers will vary **d** Yes

e As the number of trials approaches infinity,
the relative frequency approaches the value
of the probability

3 $\Pr(\text{a } 6 \text{ from first die}) \approx \frac{78}{500} = 0.156$

$\Pr(\text{a } 6 \text{ from second die}) \approx \frac{102}{700} \approx 0.146$

Choose first die, as higher probability of a 6

4 a $\frac{17}{20}$ b $\frac{4}{5}$ c $\frac{9}{10}$ d 51

5 0.445

6 a $\frac{\pi}{4}$ b $\frac{\pi}{4} \approx 0.7855$

7 $\frac{3}{4}$

8 a $\frac{1}{3}$ b $\frac{1}{6}$ c $\frac{5}{6}$

9 a $\frac{4\pi}{25}$ b $1 - \frac{4\pi}{25} \approx 0.4973$

10 a i x^2 ii $\frac{1}{4}\pi x^2$ iii $\frac{1}{16}\pi x^2$
b i $\frac{\pi}{16}$ ii $\frac{3\pi}{16}$ iii $1 - \frac{\pi}{4}$

Exercise 9C

1 a $\frac{1}{4}$ b $\frac{1}{4}$

2 a $\frac{1}{2}$ b $\frac{1}{2}$ c $\frac{1}{4}$

3 a $\frac{1}{2}$ b $\frac{1}{18}$ c $\frac{5}{18}$

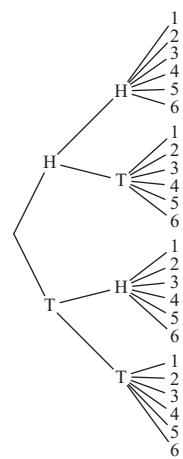
4 a $\frac{1}{12}$ b $\frac{1}{2}$ c $\frac{7}{12}$

5 a $\frac{3}{8}$ b $\frac{3}{8}$ c $\frac{1}{8}$ d $\frac{1}{8}$

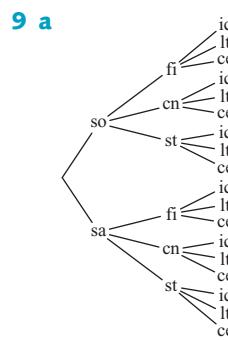
6 a $\frac{1}{2}$ b $\frac{1}{4}$ c $\frac{3}{4}$

7 $\frac{1}{4}$

8 a



b i $\frac{1}{24}$ ii $\frac{1}{4}$ iii $\frac{1}{8}$ iv $\frac{1}{2}$



b i $\frac{1}{18}$ ii $\frac{1}{3}$ iii $\frac{1}{6}$ iv $\frac{2}{3}$
c i $\frac{1}{36}$ ii $\frac{1}{2}$ iii $\frac{5}{12}$ iv $\frac{1}{12}$

10 a 2nd ball

	1	2	3	4	5
1st ball	(1, 1)	(1, 2)	(1, 3)	(1, 4)	(1, 5)
2	(2, 1)	(2, 2)	(2, 3)	(2, 4)	(2, 5)
3	(3, 1)	(3, 2)	(3, 3)	(3, 4)	(3, 5)
4	(4, 1)	(4, 2)	(4, 3)	(4, 4)	(4, 5)
5	(5, 1)	(5, 2)	(5, 3)	(5, 4)	(5, 5)

b i $\frac{4}{25}$ ii $\frac{4}{5}$ iii $\frac{3}{25}$

Exercise 9D

1 a {1, 2, 3, 4, 6} b {2, 4}

c {5, 6, 7, 8, 9, 10} d {1, 3}

e {1, 3, 5, 6, 7, 8, 9, 10} f {5, 7, 8, 9, 10}

2 a {1, 2, 3, 5, 6, 7, 9, 10, 11}

b {1, 3, 5, 7, 9, 11} c {2, 4, 6, 8, 10, 12}

d {1, 3, 5, 7, 9, 11} e {1, 3, 5, 7, 9, 11}

3 a {E, H, M, S} b {C, H, I, M}

c {A, C, E, I, S, T} d {H, M}

e {C, E, H, I, M, S} f {H, M}

4 a 20 b 45

5 a $\frac{2}{3}$ b 0 c $\frac{1}{2}$ d $\frac{5}{6}$

6 a $\frac{1}{2}$ b $\frac{1}{3}$ c $\frac{1}{6}, \frac{2}{3}$

7 a $\frac{7}{18}$ b $\frac{4}{18} = \frac{2}{9}$ c $\frac{2}{18} = \frac{1}{9}$ d $\frac{1}{2}$

8 a $\frac{3}{10}$ b $\frac{1}{5}$ c $\frac{1}{10}$ d $\frac{2}{5}$

9 $\Pr(A \cup B) = 0.7$

10 $\Pr(A \cup B) = 0.47$

11 a $\Pr(A \cap B) = 0.28$ b $\Pr(A \cup B) = 0.45$

12 a $\Pr(A \cap B) = 0.45$ b $\Pr(A \cup B) = 0.58$

13 a $\Pr(A \cap B) = 0$ b $\Pr(A \cup B) = 0.7$

14 a $\Pr(A \cap B) = 0$ b $\Pr(A \cup B) = 0.23$

15 $\Pr(A \cap B) = 0.2$

16 $\Pr(A \cap B) = 0.05$

17 $\Pr(A \cup B') = 0.7$

18 0.32

19 a 0.43 b 0.29

Exercise 9E

1 a 0.2 b 0.5 c 0.3 d 0.7

2 a 0.75 b 0.4 c 0.87 d 0.48

3 a 0.63 b 0.23 c 0.22 d 0.77

4 a 0.45 b 0.40 c 0.25 d 0.70

5 a 0.9 b 0.6 c 0.1 d 0.9

6 a 95% b 5%

7 a $A = \{J\heartsuit, Q\heartsuit, K\heartsuit, A\heartsuit, J\spadesuit, Q\spadesuit, K\spadesuit, A\spadesuit, J\clubsuit, Q\clubsuit, K\clubsuit, A\clubsuit\}$
 $C = \{2\heartsuit, 3\heartsuit, 4\heartsuit, 5\heartsuit, 6\heartsuit, 7\heartsuit, 8\heartsuit, 9\heartsuit, 10\heartsuit, J\spadesuit, Q\spadesuit, K\spadesuit, A\spadesuit\}$

b i $\Pr(\text{a picture card}) = \frac{4}{13}$

ii $\Pr(\text{a heart}) = \frac{1}{4}$

iii $\Pr(\text{a heart picture card}) = \frac{1}{13}$

iv $\Pr(\text{a picture card or a heart}) = \frac{25}{52}$

v $\Pr(\text{a picture card or a club, diamond or spade}) = \frac{43}{52}$

8 a $\frac{8}{15}$ b $\frac{7}{10}$ c $\frac{2}{15}$ d $\frac{1}{3}$

9 a 0.8 b 0.57 c 0.28 d 0.08

10 a 0.81 b 0.69 c 0.74 d 0.86

11 a 0 b 1 c $\frac{1}{5}$ d $\frac{1}{3}$

12 a 0.88 b 0.58 c 0.30 d 0.12

Exercise 9F

1 $\frac{1}{4}$ 2 $\frac{1}{3}$ 3 $\frac{1}{13}$ 4 $\frac{7}{19}$ 5 $\frac{1}{6}$

6 a $\frac{4}{17}$ b $\frac{4}{7}$

7 $\frac{7}{12}$

8 a $\frac{375}{500} = \frac{3}{4}$ b $\frac{225}{300} = \frac{3}{4}$

9 a $\frac{65}{284}$ b $\frac{137}{568}$ c $\frac{21}{65}$ d $\frac{61}{246}$

10 a 0.06 b 0.2

11 a $\frac{4}{7}$ b 0.3 c $\frac{15}{22}$

12 a 0.2 b 0.5 c 0.4

13 a 0.2 b $\frac{10}{27}$ c $\frac{1}{3}$

14 a 0.3 b 0.75

15 16%

16 a $\frac{1}{5}$

17 a $\frac{1}{16}$ b $\frac{1}{169}$ c $\frac{1}{4}$ d $\frac{16}{169}$

18 a $\frac{1}{17}$ b $\frac{1}{221}$ c $\frac{13}{51}$ d $\frac{20}{221}$

19 0.230 808 ≈ 0.231

20 a $\frac{15}{28}$ b $\frac{1}{2}$ c $\frac{1}{2}$ d $\frac{2}{5}$
e $\frac{3}{7}$ f $\frac{8}{13}$ g $\frac{5}{28}$ h $\frac{3}{14}$

21 a 0.85 b 0.6 c 0.51 d 0.51

22 0.4, 68%

23 a i 0.444 ii 0.4 iii 0.35 iv 0.178 v 0.194
b 0.372
c i 0.478 ii 0.425

24 a i 0.564 ii 0.05 iii 0.12 iv 0.0282 v 0.052
b 0.081
c 0.35

25 a $\frac{1}{6}$ b $\frac{53}{90}$ c $\frac{15}{53}$

26 a $B \subseteq A$ b $A \cap B = \emptyset$ c $A \subseteq B$

Exercise 9G

1 $\Pr(\text{male and support guns}) = 0.35$;
 $\Pr(\text{male}) \times \Pr(\text{support guns}) = 0.6 \times 0.65 = 0.39 \neq 0.35$; therefore not independent

2 $\Pr(\text{male and prefer sport}) = 0.45$;
 $\Pr(\text{male}) \times \Pr(\text{prefer sport}) = 0.45$;
therefore independent

3 $\Pr(\text{speeding and serious}) = \frac{42}{376} \approx 0.112$;

$\Pr(\text{speeding}) \times \Pr(\text{serious}) = \frac{130}{376} \times \frac{103}{376} \approx 0.095 \neq 0.112$; therefore not independent

4 a Yes b Yes c No

5 $\Pr(A) \times \Pr(B) = \frac{3}{6} \times \frac{2}{6} = \frac{1}{6} = \Pr(A \cap B)$

6 No

7 a 0.6 b 0.42 c 0.88

8 0.6

9 a 0.35 b 0.035 c 0.1225 d 0.025

10 a $\frac{4}{15}$ b $\frac{1}{15}$ c $\frac{133}{165}$ d $\frac{6}{11}$ e $\frac{4}{15}$
No, as $\Pr(L|F) \neq \Pr(L)$

11 $\Pr(A) \times \Pr(B) = \frac{20}{36} \times \frac{9}{36} = \frac{5}{36} = \Pr(A \cap B)$

12 a 0.35 b 0.875

13 a $\frac{18}{65}$ b $\frac{12}{65}$ c $\frac{23}{65}$ d $\frac{21}{65}$ e $\frac{4}{65}$
f $\frac{8}{65}$ g $\frac{2}{15}$ h $\frac{8}{21}$; No

14 a i 0.75 ii 0.32 iii 0.59 b No c No

Exercise 9H

1 Approx. 0.125

2 Approx. 0.5

3 Approx. 0.033

4 Approx. 29.29

5 a Approx. 1.75 b Approx. 2.19

Chapter 9 review

Short-answer questions

- 1** a $\frac{1}{6}$ b $\frac{5}{6}$
- 2** 0.007
- 3** a $\frac{1}{3}$ b $\frac{1}{4}$ c $\frac{1}{2}$
- 4** a 0.36 b $\frac{87}{245}$
- 5** $\frac{4}{15}$
- 6** a {156, 165, 516, 561, 615, 651} b $\frac{2}{3}$ c $\frac{1}{3}$
- 7** a $\frac{5}{12}$ b $\frac{1}{4}$
- 8** a 0.036 b 0.027 c 0.189 d 0.729
- 9** a $\frac{1}{27}$ b $\frac{4}{27}$ c $\frac{4}{9}$ d $\frac{20}{27}$
- 10** No
- 11** a 0.5 b 0 c 1
- 12** a $\frac{7}{18}$ b $\frac{1}{2}$
- 13** a $\frac{2}{7}$ b $\frac{32}{63}$ c $\frac{9}{16}$
- 14** a 0.2 b 0.4
- 15** a 0.7 b 0.3 c $\frac{1}{3}$ d $\frac{2}{3}$
- 16** a $B \subseteq A$ b $A \cap B = \emptyset$
c A and B are independent

Multiple-choice questions

- 1** B **2** C **3** A **4** C **5** D **6** A
- 7** D **8** E **9** A **10** B **11** B **12** B
- 13** A **14** E **15** C **16** A **17** B **18** D

Extended-response questions

- 1** a 0.15 b 0.148
- 2** a A: $\frac{3}{28}$; B: $\frac{3}{4}$ b A: $\frac{9}{64}$; B: $\frac{49}{64}$
c $\frac{1}{8}$ d $\frac{9}{58}$
- 3** a $\frac{4}{5}$ b 0.69 c 0.208
- 4** a 1.6 b 2.9
- 5** A and B: $\frac{3}{8}$; C and D: $\frac{1}{8}$

Chapter 10

Exercise 10A

- 1** a 11 b 12 c 37 d 29
- 2** a 60 b 500 c 350 d 512
- 3** a 128 b 160
- 4** 20 **5** 63 **6** 26
- 7** 240 **8** 260 000
- 9** 17 576 000 **10** 30

Exercise 10B

- 1** a 6 b 120 c 5040 d 2 e 1 f 1
- 2** a 20 b 72 c 6 d 56 e 120 f 720
- 3** 120 **4** 5040 **5** 24
- 6** 720 **7** 720 **8** 336
- 9** a 5040 b 210
- 10** a 120 b 120
- 11** a 840 b 2401
- 12** a 480 b 1512
- 13** a 60 b 24 c 252
- 14** a 150 b 360 c 1560
- 15** a 720 b 48

Exercise 10C

- 1** a 3 b 3 c 6 d 4
- 2** a 10 b 10 c 35 d 35
- 3** a 190 b 100 c 4950 d 31 125
- 4** a 20 b 7 c 28 d 1225
- 5** 1716 **6** 2300
- 7** 133 784 560 **8** 8 145 060 **9** 18
- 10** a 5 852 925 b 1 744 200
- 11** 100 386
- 12** a 792 b 336
- 13** a 150 b 75 c 6 d 462 e 81
- 14** a 8 436 285 b 3003 c 66 d 2 378 376
- 15** 186 **16** 32 **17** 256 **18** 31 **19** 57
- 20** a 10 b 21

Exercise 10D

- 1** a 0.5 b 0.5
- 2** 0.375
- 3** a 0.2 b 0.6 c 0.3
- 4** 0.2 **5** $\frac{329}{858}$
- 6** a $\frac{2^7}{2^{8-1}} \approx 0.502$ b $\frac{56}{255}$ c $\frac{73}{85}$
- 7** a $\frac{5}{204}$ b $\frac{35}{136}$
- 8** a $\frac{1}{6}$ b $\frac{5}{6}$ c $\frac{17}{21}$ d $\frac{34}{35}$
- 9** a $\frac{25}{49}$ b $\frac{24}{49}$ c $\frac{3}{7}$ d $\frac{1}{5}$
- 10** a 0.659 b 0.341 c 0.096 d 0.282
- 11** a $\frac{5}{42}$ b $\frac{20}{21}$ c $\frac{15}{37}$

Exercise 10E

- 1** a $x^4 + 8x^3 + 24x^2 + 32x + 16$
- 2** $16x^4 + 32x^3 + 24x^2 + 8x + 1$
- 3** $16x^4 - 96x^3 + 216x^2 - 216x + 81$
- 4** $27x^3 - 27x^2 + 9x - 1$
- 5** $16x^4 - 32x^3 + 24x^2 - 8x + 1$

- f** $-32x^5 + 80x^4 - 80x^3 + 40x^2 - 10x + 1$
g $-243x^5 + 405x^4 - 270x^3 + 90x^2 - 15x + 1$
h $16x^4 - 96x^3 + 216x^2 - 216x + 81$

Chapter 10 review

Short-answer questions

- 1** a 499 500 b 1 000 000 c 1 000 000
2 648 **3** 120 **4** $8n$
5 5416 **6** 36 750 **7** 50 400
8 a 10 **b** 32
9 1200
10 a $\frac{1}{8}$ **b** $\frac{3}{8}$ **c** $\frac{3}{28}$
11 $x^6 - 6x^5 + 15x^4 - 20x^3 + 15x^2 - 6x + 1$

Multiple-choice questions

- 1** E **2** D **3** A **4** D **5** C
6 B **7** C **8** A **9** E **10** E

Extended-response questions

- 1** a 2880 b 80 640
2 a 720 b 48 c 336
3 a 60 b 45
4 a 210 b 100 c 80
5 a 1365 b 210 c 1155
6 a 3060 b 330 c 1155
7 Div. 1: 1.228×10^{-7} Div. 2: 1.473×10^{-6}
Div. 3: 2.726×10^{-5} Div. 4: 1.365×10^{-3}
Div. 5: 3.362×10^{-3}
8 a 1.290×10^{-4} b 6.449×10^{-4}

Chapter 11

Short-answer questions

- 1** a $\frac{1}{9}$ b $\frac{8}{9}$
2 a $\{348, 384, 438, 483, 834, 843\}$, $n(\varepsilon) = 6$
b $\frac{2}{3}$ c $\frac{2}{3}$
3 a $\frac{1}{2}$ b $\frac{12}{13}$
4 a $\frac{1}{4}$ b $\frac{3}{8}$
5 a $\Pr(1) = \Pr(2) = \Pr(3) = \Pr(5) = \frac{2}{17}$,
 $\Pr(4) = \frac{8}{17}$, $\Pr(6) = \frac{1}{17}$
b $\frac{9}{17}$
6 $\frac{1}{4}$
7 a 0.6 b $\frac{1}{3}$
8 a $\frac{1}{2}$ b $\frac{3}{4}$ c $\frac{1}{2}$ d $\frac{1}{4}$

- 9** a 0.48 b 0.56
10 a $\Pr(A \cap B) = 0.05$ b $\Pr(A | B) = 0.25$
11 a 0.4 b 0.2 c 0.7

12 720

13 $\frac{52!}{7!45!}$

- 14** a $\frac{7}{22}$ b $\frac{21}{44}$

Multiple-choice questions

- 1** E **2** C **3** E **4** B **5** E **6** C
7 C **8** B **9** D **10** D **11** D **12** E
13 A **14** E **15** E **16** B **17** C **18** C
19 A **20** E **21** D **22** E

Extended-response questions

- 1** a i $\frac{15}{28}$ ii $\frac{37}{56}$ iii $\frac{43}{49}$
b i $\frac{9}{14}$ ii $\frac{135}{392}$
2 a $\frac{1}{2}$ b $\frac{13}{36}$
3 a $\frac{3}{8}$ b $\frac{1}{56}$ c $\frac{3}{28}$ d $\frac{6}{7}$
4 a $\frac{59}{120}$ b $\frac{45}{59}$
5 a i $m = 30$, $q = 35$, $s = 25$
ii $m + q = 65$
b $\frac{3}{10}$
c $\frac{7}{12}$
6 a $\frac{167}{360}$
b i $\frac{108}{193}$ ii $\frac{45}{193}$
7 a i $\frac{1}{9}$ ii $\frac{5}{18}$
b i $\frac{1}{81}$ ii $\frac{13}{324}$
8 a 0.084 b 0.52 c 0.68
9 a 60 b 8 c 0.1
10 a $\frac{1}{60}$ b $\frac{1}{5}$ c $\frac{3}{5}$ d $\frac{6}{13}$
11 a i $10\ 000 \text{ cm}^2$ ii 400 cm^2 iii 6400 cm^2
b i 0.04 ii 0.12 iii 0.64
c i 0.0016 ii 0.000 64
12 a $\frac{7}{18}$ b $\frac{13}{36}$ c $\frac{23}{108}$

Chapter 12

Exercise 12A

- 1** a $\frac{\pi}{3}$ b $\frac{4\pi}{5}$ c $\frac{4\pi}{3}$ d $\frac{11\pi}{6}$ e $\frac{7\pi}{3}$ f $\frac{8\pi}{3}$
2 a 120° b 150° c 210° d 162°
e 100° f 324° g 220° h 324°

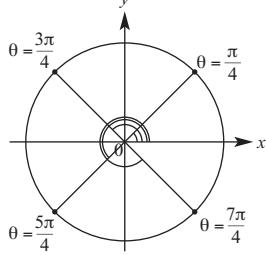
- 3 a** 34.38° **b** 108.29° **c** 166.16° **d** 246.94°
e 213.14° **f** 296.79° **g** 271.01° **h** 343.78°

- 4 a** 0.66 **b** 1.27 **c** 1.87 **d** 2.81
e 1.47 **f** 3.98 **g** 2.38 **h** 5.74

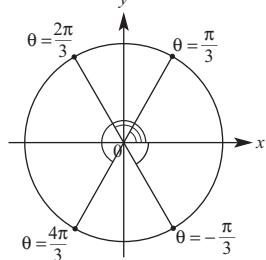
- 5 a** -60° **b** -720° **c** -540° **d** -180°
e 300° **f** -330° **g** 690° **h** -690°

- 6 a** -2π **b** -3π **c** $-\frac{4\pi}{3}$ **d** -4π
e $-\frac{11\pi}{6}$ **f** $-\frac{7\pi}{6}$

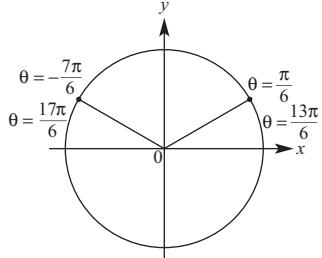
7 a



b



c



Exercise 12B

- 1 a** 0, 1 **b** $-1, 0$ **c** $1, 0$ **d** $1, 0$
e $0, -1$ **f** $1, 0$ **g** $-1, 0$ **h** $0, 1$
2 a 0.95 **b** 0.75 **c** -0.82 **d** 0.96
e -0.5 **f** -0.03 **g** -0.86 **h** 0.61
3 a $0, -1$ **b** $-1, 0$ **c** $-1, 0$ **d** $-1, 0$
e $-1, 0$ **f** $0, -1$ **g** $0, -1$ **h** $0, -1$

Exercise 12C

- 1 a** 0 **b** 0 **c** Undefined **d** 0
e Undefined **f** Undefined
2 a -34.23 **b** -2.57 **c** -0.97 **d** -1.38
e 0.95 **f** 0.75 **g** 1.66
3 a 0 **b** 0 **c** 0 **d** 0 **e** 0 **f** 0

Exercise 12D

- 1 a** 67.98° **b** 4.5315 **c** 2.5357
d 6.4279 **e** 50.19° **f** 3.4202
g 2.3315 **h** 6.5778 **i** 6.5270

Exercise 12E

- 1 a** -0.42 **b** -0.7 **c** -0.42 **d** -0.38
e 0.42 **f** -0.38 **g** -0.7 **h** 0.7
2 a $\frac{5\pi}{6}$ **b** $\frac{7\pi}{6}$ **c** $\frac{11\pi}{6}$
3 a $-\frac{1}{2}$ **b** $\frac{\sqrt{3}}{2}$ **c** $\frac{1}{2}$ **d** $-\frac{\sqrt{3}}{2}$
e $-\sqrt{3}$ **f** $-\sqrt{3}$

- 4 a** $-\frac{\sqrt{3}}{2}$ **b** $\frac{1}{2}$ **c** $-\sqrt{3}$ **d** $-\frac{\sqrt{3}}{2}$ **e** $-\frac{1}{2}$

- 5 a** $a = 0.7660, b = 0.6428$
b $c = -0.7660, d = 0.6428$
c **i** $\cos 140^\circ = -0.7660, \sin 140^\circ = 0.6428$
ii $\cos 140^\circ = -\cos 40^\circ$

- 6 a** -0.7 **b** -0.6 **c** -0.4 **d** -0.6
e -0.7 **f** -0.7 **g** 0.4 **h** 0.6
7 a 120° **b** 240° **c** -60° **d** 120°
e 240° **f** 300°

Exercise 12F

- 1 a** $\sin = \frac{\sqrt{3}}{2}, \cos = -\frac{1}{2}, \tan = -\sqrt{3}$

- b** $\sin = \frac{1}{\sqrt{2}}, \cos = -\frac{1}{\sqrt{2}}, \tan = -1$

- c** $\sin = -\frac{1}{2}, \cos = -\frac{\sqrt{3}}{2}, \tan = \frac{1}{\sqrt{3}}$

- d** $\sin = -\frac{\sqrt{3}}{2}, \cos = -\frac{1}{2}, \tan = \sqrt{3}$

- e** $\sin = -\frac{1}{\sqrt{2}}, \cos = \frac{1}{\sqrt{2}}, \tan = -1$

- f** $\sin = \frac{1}{2}, \cos = \frac{\sqrt{3}}{2}, \tan = \frac{1}{\sqrt{3}}$

- g** $\sin = \frac{\sqrt{3}}{2}, \cos = \frac{1}{2}, \tan = \sqrt{3}$

- h** $\sin = -\frac{1}{\sqrt{2}}, \cos = -\frac{1}{\sqrt{2}}, \tan = 1$

- i** $\sin = \frac{\sqrt{3}}{2}, \cos = \frac{1}{2}, \tan = \sqrt{3}$

- j** $\sin = -\frac{\sqrt{3}}{2}, \cos = \frac{1}{2}, \tan = -\sqrt{3}$

- 2 a** $\frac{\sqrt{3}}{2}$ **b** $-\frac{1}{\sqrt{2}}$ **c** $-\frac{1}{\sqrt{3}}$

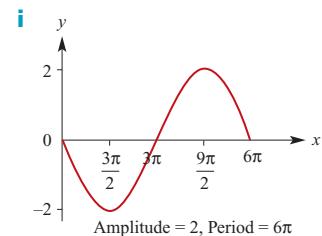
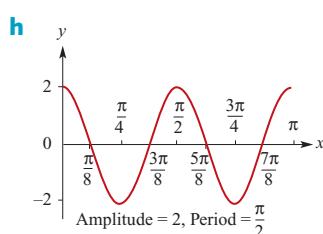
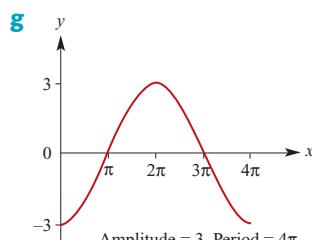
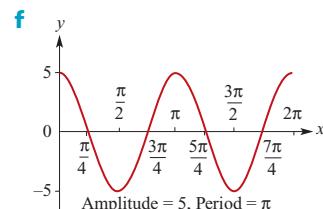
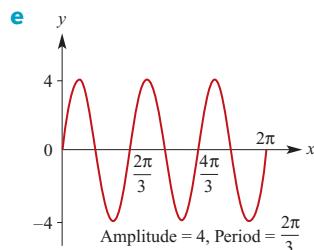
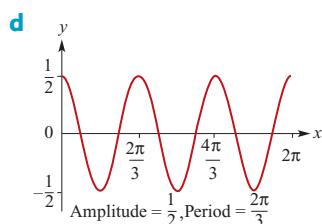
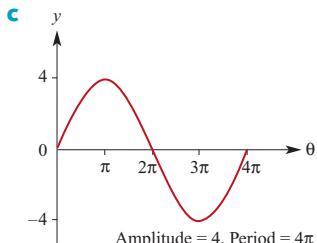
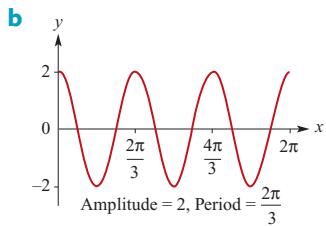
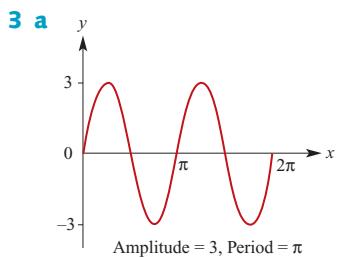
- d** $-\frac{1}{2}$ **e** $-\frac{1}{\sqrt{2}}$ **f** $\sqrt{3}$

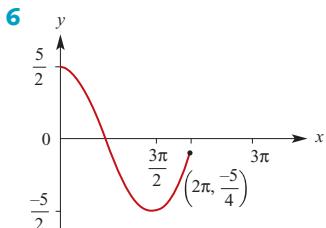
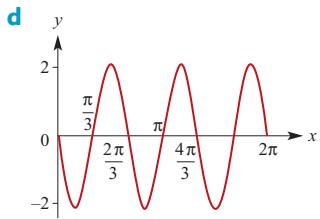
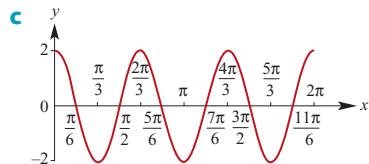
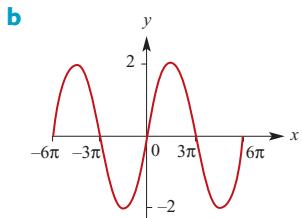
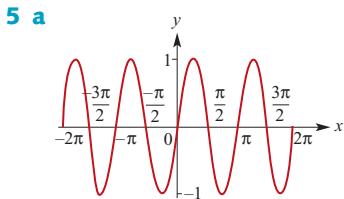
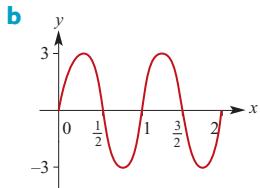
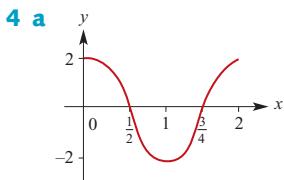
- g** $-\frac{\sqrt{3}}{2}$ **h** $\frac{1}{\sqrt{2}}$ **i** $-\frac{1}{\sqrt{3}}$

- 3** a $-\frac{\sqrt{3}}{2}$ b $-\frac{1}{\sqrt{2}}$ c $\frac{1}{\sqrt{3}}$
 d Undefined e 0 f $-\frac{1}{\sqrt{2}}$
 g $\frac{1}{\sqrt{2}}$ h -1

Exercise 12G

- 1** a i 2π ii 2 b i π ii 3 c i $\frac{2\pi}{3}$ ii $\frac{1}{2}$
 d i 4π ii 3 e i $\frac{2\pi}{3}$ ii 4 f i $\frac{\pi}{2}$ ii $\frac{1}{2}$
 g i 4π ii 2 h i 2 ii 2 i i 4 ii 3
- 2** a Dilation of factor 3 from the x -axis;
 Amplitude = 3; Period = 2π
 b Dilation of factor $\frac{1}{5}$ from the y -axis;
 Amplitude = 1; Period $\frac{2\pi}{5}$
 c Dilation of factor 3 from the y -axis;
 Amplitude = 1; Period = 6π
 d Dilation of factor 2 from the x -axis and
 dilation of factor $\frac{1}{5}$ from the y -axis;
 Amplitude = 2; Period = $\frac{2\pi}{5}$





- 7 a** Dilation of factor $\frac{1}{5}$ from the y -axis and reflection in the x -axis;
Amplitude = 1; Period = $\frac{2\pi}{5}$

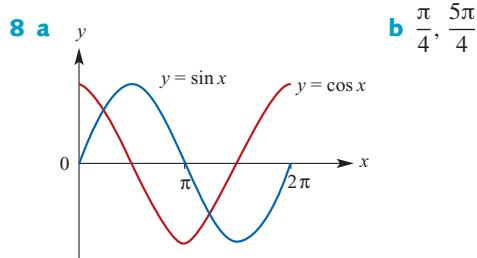
b Reflection in the y -axis;

Amplitude = 1; Period = 2π

c Dilation of factor 3 from the y -axis and dilation of factor 2 from the x -axis;
Amplitude = 2; Period = 6π

d Dilation of factor 2 from the y -axis, dilation of factor 4 from the x -axis and reflection in the x -axis; Amplitude = 4; Period = 4π

e Dilation of factor 3 from the y -axis, dilation of factor 2 from the x -axis and reflection in the y -axis; Amplitude = 2; Period = 6π



Exercise 12H

1 a $\frac{\pi}{3}, \frac{5\pi}{3}, \frac{7\pi}{3}, \frac{11\pi}{3}$ **b** $\frac{\pi}{4}, \frac{3\pi}{4}, \frac{9\pi}{4}, \frac{11\pi}{4}$

c $\frac{\pi}{3}, \frac{2\pi}{3}, \frac{7\pi}{3}, \frac{8\pi}{3}$

2 a 0.93, 2.21 **b** 4.30, 1.98 **c** 3.50, 5.93
d 0.41, 2.73 **e** 2.35, 3.94 **f** 1.77, 4.51

3 a 150, 210 **b** 30, 150 **c** 120, 240
d 120, 240 **e** 60, 120 **f** 45, 135

4 a $\frac{\pi}{6}, \frac{11\pi}{6}$ **b** $\frac{5\pi}{4}, \frac{7\pi}{4}$ **c** $\frac{\pi}{4}, \frac{7\pi}{4}$

5 a $\frac{3\pi}{4}, -\frac{3\pi}{4}$ **b** $\frac{\pi}{3}, \frac{2\pi}{3}$ **c** $\frac{2\pi}{3}, -\frac{2\pi}{3}$

6

7 a $\frac{7\pi}{12}, \frac{11\pi}{12}, \frac{19\pi}{12}, \frac{23\pi}{12}$

b $\frac{\pi}{12}, \frac{11\pi}{12}, \frac{13\pi}{12}, \frac{23\pi}{12}$

c $\frac{\pi}{12}, \frac{5\pi}{12}, \frac{13\pi}{12}, \frac{17\pi}{12}$

d $\frac{5\pi}{12}, \frac{7\pi}{12}, \frac{13\pi}{12}, \frac{15\pi}{12}, \frac{21\pi}{12}, \frac{23\pi}{12}$

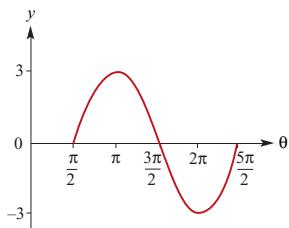
e $\frac{5\pi}{12}, \frac{7\pi}{12}, \frac{17\pi}{12}, \frac{19\pi}{12}$

f $\frac{5\pi}{8}, \frac{7\pi}{8}, \frac{13\pi}{8}, \frac{15\pi}{8}$

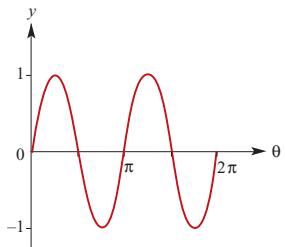
- 8 a** 2.034, 2.678, 5.176, 5.820
b 1.892, 2.820, 5.034, 5.961
c 0.580, 2.562, 3.721, 5.704
d 0.309, 1.785, 2.403, 3.880, 4.498, 5.974

Exercise 12I

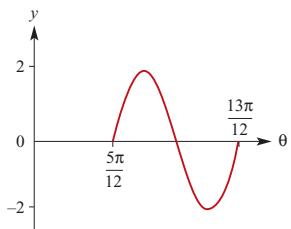
- 1 a** Period = 2π , Amplitude = 3, $y = \pm 3$



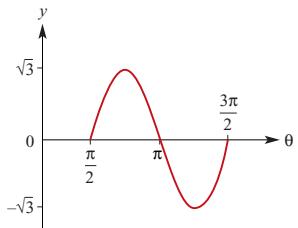
- b** Period = π , Amplitude = 1, $y = \pm 1$



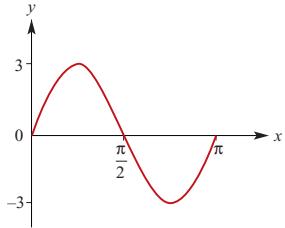
- c** Period = $\frac{2\pi}{3}$, Amplitude = 2, $y = \pm 2$



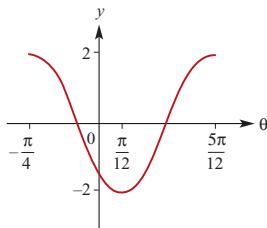
- d** Period = π , Amplitude = $\sqrt{3}$, $y = \pm \sqrt{3}$



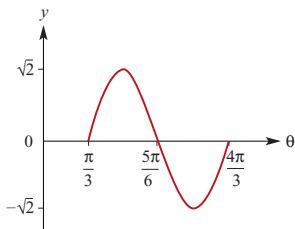
- e** Period = π , Amplitude = 3, $y = \pm 3$



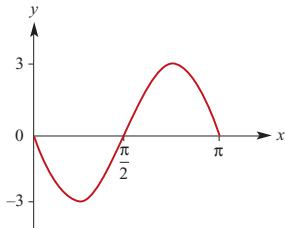
- f** Period = $\frac{2\pi}{3}$, Amplitude = 2, $y = \pm 2$



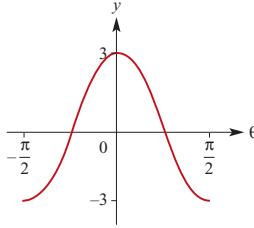
- g** Period = π , Amplitude = $\sqrt{2}$, $y = \pm \sqrt{2}$



- h** Period = π , Amplitude = 3, $y = \pm 3$

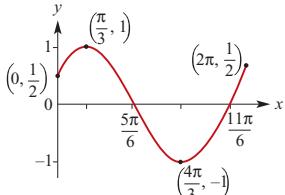


- i** Period = π , Amplitude = 3, $y = \pm 3$



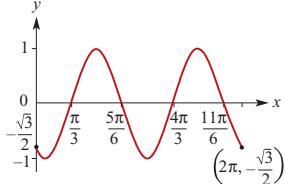
- 2 a** $f(0) = \frac{1}{2}$, $f(2\pi) = \frac{1}{2}$

b



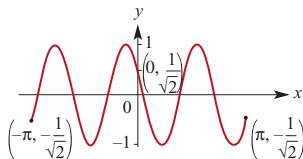
- 3 a** $f(0) = -\frac{\sqrt{3}}{2}$, $f(2\pi) = -\frac{\sqrt{3}}{2}$

b



4 a $f(-\pi) = -\frac{1}{\sqrt{2}}$, $f(\pi) = -\frac{1}{\sqrt{2}}$

b



5 a $y = 3 \sin\left(\frac{x}{2}\right)$

c $y = 2 \sin\left(\frac{x}{3}\right)$

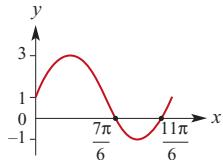
e $y = \sin\frac{1}{2}(x + \frac{\pi}{3})$

b $y = 3 \sin(2x)$

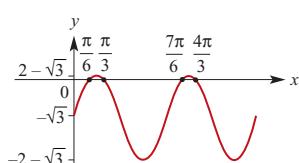
d $y = \sin 2\left(x - \frac{\pi}{3}\right)$

Exercise 12J

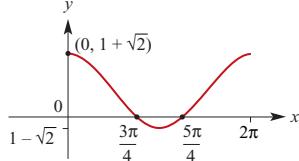
1 a



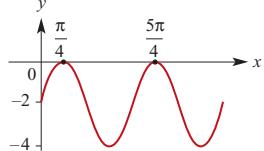
b



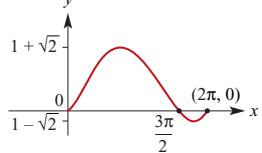
c



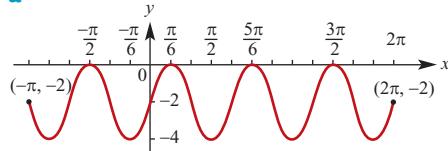
d



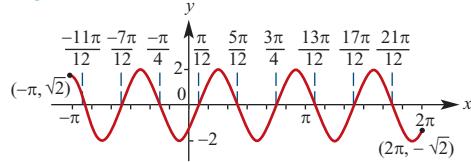
e



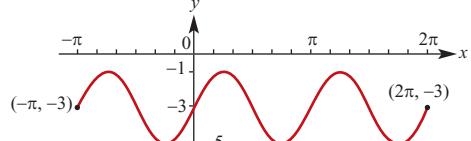
2 a



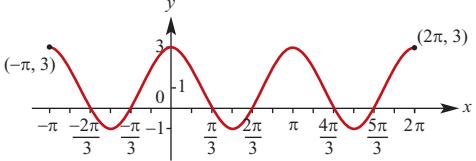
b



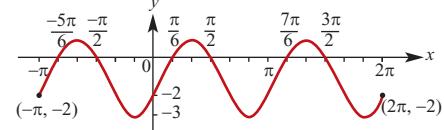
c



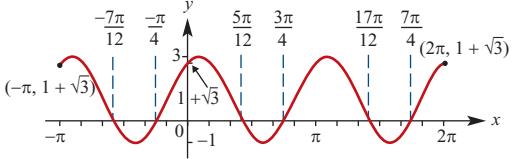
d



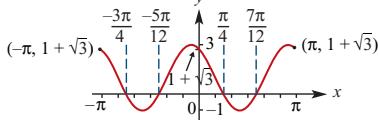
e



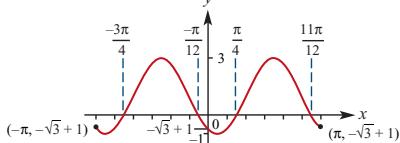
f



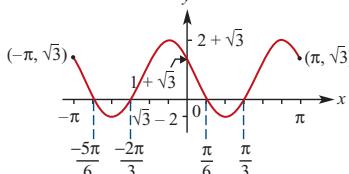
3 a



b

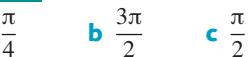


c



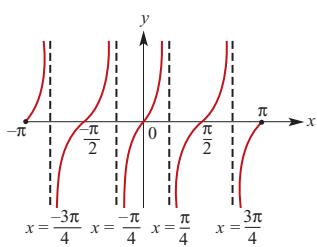
Exercise 12K

1 a $\frac{\pi}{4}$

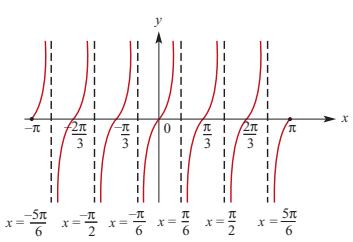


c $\frac{\pi}{2}$

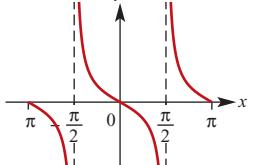
2 a



b



c



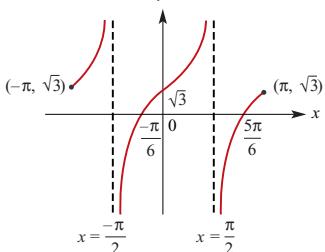
3 a $-\frac{7\pi}{8}, -\frac{3\pi}{8}, \frac{\pi}{8}, \frac{5\pi}{8}$

b $-\frac{17\pi}{18}, -\frac{11\pi}{18}, -\frac{5\pi}{18}, \frac{\pi}{18}, \frac{7\pi}{18}, \frac{13\pi}{18}$

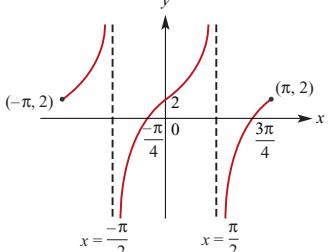
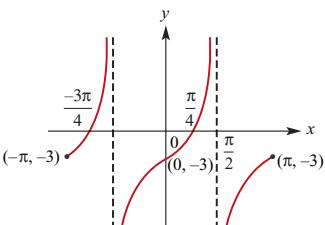
c $-\frac{5\pi}{6}, -\frac{\pi}{3}, \frac{\pi}{6}, \frac{2\pi}{3}$

d $-\frac{13\pi}{18}, -\frac{7\pi}{18}, -\frac{\pi}{18}, \frac{5\pi}{18}, \frac{11\pi}{18}, \frac{17\pi}{18}$

4 a



b


c

Exercise 12L

1 a 0.6

b 0.6

c -0.7

d 0.3

e -0.3

f $\frac{10}{7}$

g -0.3

h 0.6

i -0.6

j -0.3

2 a $\frac{\pi}{3}$

b $\frac{\pi}{3}$

c $\frac{5\pi}{12}$

d $\frac{\pi}{14}$

3 $\sin x = \frac{-4}{5}, \tan x = \frac{-4}{3}$

4 $\cos x = \frac{-12}{13}, \tan x = \frac{-5}{12}$

5 $\sin x = \frac{-2\sqrt{6}}{5}, \tan x = -2\sqrt{6}$

Exercise 12M

1 a $\frac{1 + \sqrt{3}}{2\sqrt{2}} = \frac{\sqrt{2} + \sqrt{6}}{4}$

b $\frac{1 - \sqrt{3}}{2\sqrt{2}} = \frac{\sqrt{2} - \sqrt{6}}{4}$

2 a $\frac{\sqrt{3} - 1}{2\sqrt{2}} = \frac{\sqrt{6} - \sqrt{2}}{4}$

b $\frac{\sqrt{3} + 1}{2\sqrt{2}} = \frac{\sqrt{6} + \sqrt{2}}{4}$

3 a $\frac{\sqrt{3} - 1}{2\sqrt{2}} = \frac{\sqrt{6} - \sqrt{2}}{4}$

b $\frac{\sqrt{3} + 1}{2\sqrt{2}} = \frac{\sqrt{6} + \sqrt{2}}{4}$

c $\frac{1 - \sqrt{3}}{1 + \sqrt{3}} = -2 + \sqrt{3}$

4 $\sin(u + v) = \frac{63}{65}$

5 a $\frac{\sqrt{3}}{2} \sin \theta + \frac{1}{2} \cos \theta$

b $\frac{1}{\sqrt{2}}(\cos \varphi + \sin \varphi)$

c $\frac{\tan \theta + \sqrt{3}}{1 - \sqrt{3} \tan \theta}$

d $\frac{1}{\sqrt{2}}(\sin \theta - \cos \theta)$

6 a $\sin u$

b $\cos u$

7 a $-\frac{119}{169}$

b $\frac{24}{25}$

c $\frac{24}{7}$

d $-\frac{33}{65}$

e $-\frac{16}{65}$

8 a $\frac{63}{16}$

b $-\frac{24}{7}$

c $\frac{56}{65}$

d $\frac{24}{25}$

9 a $\frac{7}{25}$

b $\frac{3}{5}$

c $\frac{117}{44}$

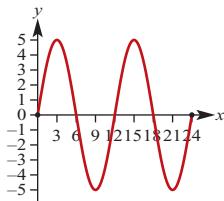
d $\frac{-336}{625}$

10 a $-\frac{\sqrt{3}}{2}$

b $-\frac{1}{2}$

11 a $1 - \sin(2\theta)$

b $\cos(2\theta)$

Exercise 12N
1 a


- b** $t = 3$ and $t = 15$
c 5 m above mean sea level
d $\frac{5\sqrt{3}}{2}$ m above mean sea level
e $\frac{5\sqrt{3}}{2}$ m above mean sea level
f $t \in [1, 5] \cup [13, 17]$
- 2 a** 5 metres **b** 1 metres
c $t = 0.524, 2.618$ or 4.712 seconds
d $t = 0, 1.047$ or 2.094 seconds
e Particle oscillates between $x = 1$ and $x = 5$

3 a 7 m **b** 3 m

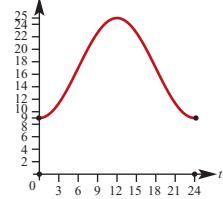
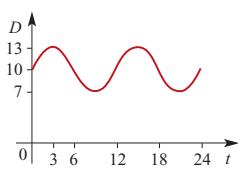
- c** $t = \frac{1}{4}, \frac{5}{4}, \frac{9}{4}, \frac{13}{4}$ or $\frac{17}{4}$
d $t = \frac{1}{12}, \frac{5}{12}, \frac{13}{12}, \frac{17}{12}, \frac{25}{12}$ or $\frac{29}{12}$

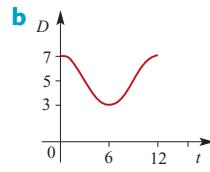
e Particle oscillates between $x = 3$ and $x = 7$
4 a i 10 **ii** $10 + 5\sqrt{3}$ **iii** $10 + 5\sqrt{3}$
iv $10 - 5\sqrt{3}$ **v** $10 - 5\sqrt{3}$

- b** 6 seconds **c** 20 metres
d $\frac{1}{2}, \frac{5}{2}, \frac{13}{2}, \frac{17}{2}$ s **e** $\frac{7}{2}, \frac{11}{2}, \frac{19}{2}, \frac{23}{2}$ s

5 a 9°C **b** Maximum = 25°C; Minimum = 9°C

c Between 7:28 and 16:32

d

6 a

b $\{t : D(t) \geq 8.5\} = [0, 7] \cup [11, 19] \cup [23, 24]$
c 12.9 m

7 a $p = 5, q = 2$

c A ship can enter 2 hours after low tide

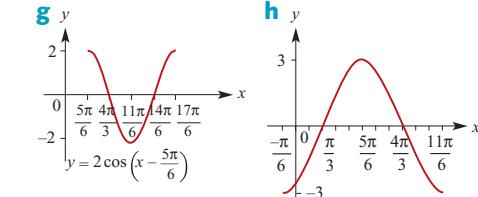
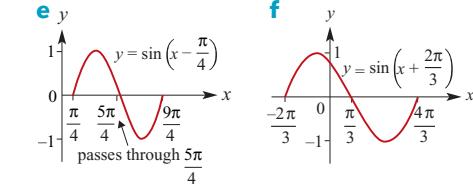
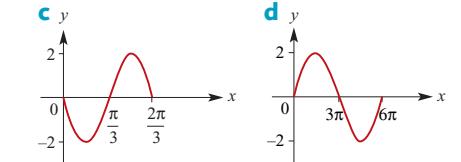
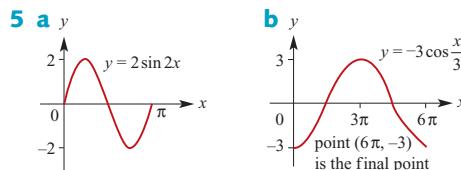
Chapter 12 review
Short-answer questions

- 1 a** $\frac{11\pi}{6}$ **b** $\frac{9\pi}{2}$ **c** 6π **d** $\frac{23\pi}{4}$ **e** $\frac{3\pi}{4}$
f $\frac{9\pi}{4}$ **g** $\frac{13\pi}{6}$ **h** $\frac{7\pi}{3}$ **i** $\frac{4\pi}{9}$

- 2 a** 150° **b** 315° **c** 495° **d** 45°
e 1350° **f** -135° **g** -45° **h** -495°
i -1035°

- 3 a** $\frac{1}{\sqrt{2}}$ **b** $\frac{1}{\sqrt{2}}$ **c** $-\frac{1}{2}$ **d** $-\frac{\sqrt{3}}{2}$
e $\frac{\sqrt{3}}{2}$ **f** $-\frac{1}{2}$ **g** $\frac{1}{2}$ **h** $-\frac{1}{\sqrt{2}}$

- 4 a** $2, 4\pi$ **b** $3, \frac{\pi}{2}$ **c** $\frac{1}{2}, \frac{2\pi}{3}$ **d** $3, \pi$
e $4, 6\pi$ **f** $\frac{2}{3}, 3\pi$



- 6 a** $-\frac{2\pi}{3}, -\frac{\pi}{3}$ **b** $-\frac{\pi}{3}, -\frac{\pi}{6}, \frac{2\pi}{3}, \frac{5\pi}{6}$

- c** $\frac{\pi}{6}, \frac{3\pi}{2}$ **d** $\frac{7\pi}{6}$

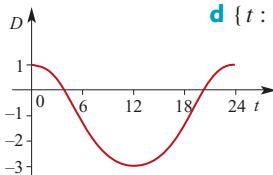
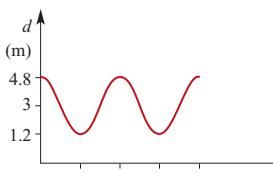
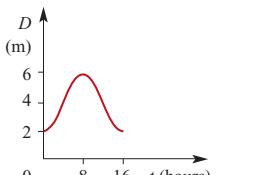
- 7 a** $\frac{140}{221}$ **b** $-\frac{21}{221}$ **c** $\frac{171}{140}$

- 8** $\frac{2}{9}$

Multiple-choice questions

- 1 C** **2 D** **3 E** **4 C** **5 E** **6 D**
7 E **8 E** **9 C** **10 B** **11 A**

Extended-response questions

- 1 a** i 1.83×10^{-3} hours ii 11.79 hours
b 26 April ($t = 3.86$), 14 August ($t = 7.48$)
- 2 a** 19.5°C **b** $D = -1 + 2 \cos\left(\frac{\pi t}{12}\right)$
- c** 
- 3 a** 
- b** 3 a.m., 3 p.m., 3 a.m.
c 9 a.m., 9 p.m. **d** 10:03 a.m.
e i 6:12 p.m. ii 5 trips
- 4 b** 
- c** $t = 16$ (8 p.m.)
d $t = 4$ and $t = 12$ (8 a.m. and 4 p.m.)
e i 1.5 m ii 2.086 m
f 9 hours 17 minutes

Chapter 13

Exercise 13A

- 1 a** A and C (SAS) **b** All of them (AAS)
c A and B (SSS)
- 2 a** 4.10 **b** 0.87 **c** 2.94
d 4.08 **e** 33.69° **f** 11.92
- 3** $\frac{40}{\sqrt{3}} = \frac{40\sqrt{3}}{3}$ cm
- 4** $66.42^\circ, 66.42^\circ, 47.16^\circ$
- 5** 23 m
- 6 a** 9.59° **b** $\sqrt{35}$ m
- 7 a** 60° **b** $10\sqrt{3}$ m
- 8 a** 6.84 m **b** 6.15 m
- 9** 12.51° **10** 182.7 m **11** 1451 m
- 12 a** $5\sqrt{2}$ cm **b** 90°
- 13** 3.07 cm **14** 37.8 cm **15** 31.24 m
- 16** 4.38 m **17** 57.74 m
- 18** $\frac{2\sqrt{3}}{2 - \sqrt{3}} \approx 12.93$ m **19** $\frac{10}{1 + \sqrt{3}} \approx 3.66$

Exercise 13B

- 1 a** 8.15 **b** 3.98 **c** 11.75 **d** 9.46
- 2 a** 56.32° **b** 36.22° **c** 49.54°
d 98.16° or 5.84°
- 3 a** $A = 48^\circ, b = 13.84, c = 15.44$
b $a = 7.26, C = 56.45^\circ, c = 6.26$
c $B = 19.8^\circ, b = 4.66, c = 8.27$
d $C = 117^\circ, b = 24.68, c = 34.21$
e $C = 30^\circ, a = 5.40, c = 15.56$
- 4 a** $B = 59.12^\circ, A = 72.63^\circ, a = 19.57$ or
 $B = 120.88^\circ, A = 10.87^\circ, a = 3.87$
b $C = 26.69^\circ, A = 24.31^\circ, a = 4.18$
c $B = 55.77^\circ, C = 95.88^\circ, c = 17.81$ or
 $B = 124.23^\circ, C = 27.42^\circ, c = 8.24$
- 5** 554.26 m
- 6** 35.64 m
- 7** 1659.86 m
- 8 a** 26.60 m **b** 75.12 m

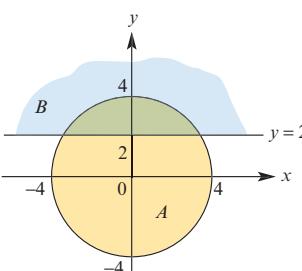
Exercise 13C

- 1** 5.93 cm
- 2** $\angle ABC = 97.90^\circ, \angle ACB = 52.41^\circ$
- 3 a** 26 **b** 11.74 **c** 49.29° **d** 73
e 68.70 **f** 47.22° **g** 7.59 **h** 38.05°
- 4** 2.626 km **5** 3.23 km **6** 55.93 cm
- 7 a** 8.23 cm **b** 3.77 cm
- 8 a** 7.326 cm **b** 5.53 cm
- 9 a** 87.61 m **b** 67.7 m

Exercise 13D

- 1 a** 11.28 cm^2 **b** 15.10 cm^2
c 10.99 cm^2 **d** 9.58 cm^2
- 2 a** 6.267 cm^2 **b** 15.754 cm^2
c 19.015 cm^2 **d** 13.274 cm^2
e 24.105 cm^2 or 29.401 cm^2
f 2.069 cm^2

Exercise 13E

- 1** 45.81 cm
- 2 a** 95.5° **b** 112.88°
- 3 a** 6.20 cm **b** 2.73 cm^2
- 4** 

Area of $A \cap B = 9.83$ square units

- 5** 61.42 cm^2

- 6 a** 125.66 m **b** 41.96%
7 a 10.47 m **b** 20.94 m^2
8 6.64 cm^2
9 $r = 7 \text{ cm}$, $\theta = \left(\frac{18}{7}\right)^\circ$ or $r = 9 \text{ cm}$, $\theta = \left(\frac{14}{9}\right)^\circ$
10 247.33 cm

Exercise 13F

- 1** 400.10 m **2** 34.77 m **3** 575.18 m
4 109.90 m **5** 16.51 m **6** 056°
7 a 034° **b** 214°
8 a 3583.04 m **b** 353°
9 027° **10** 113° **11** 22.01°
12 a $\angle BAC = 49^\circ$ **b** 264.24 km
13 10.63 km

Exercise 13G

- 1 a** 13 cm **b** 15.26 cm
c 31.61° **d** 38.17°
2 a 4 cm **b** 71.57° **c** 12.65 cm
d 13.27 cm **e** 72.45° **f** 266.39 cm^2
3 10.31° at *B*; 14.43° at *A* and *C*
4 a 85 m **b** 45.04 m
5 17.58°
6 1702.55 m
7 a 24.78° **b** 65.22° **c** 20.44°
8 42.40 m
9 1945.54 m
10 a 6.96 cm **b** 16.25 cm^2
11 a 5 km **b** 215.65° **c** 6.55°

Chapter 13 review**Short-answer questions**

- 1** $\frac{1}{8}$
2 $\frac{2}{5}$
3 a 2 **b** 0.7°
4 $10\sqrt{3}$ cm
5 a $5\sqrt{3}$ cm **b** $\frac{25\sqrt{3}}{4} \text{ cm}^2$ **c** $\frac{105}{4} \text{ cm}^2$
d $\frac{5(21 + 5\sqrt{3})}{4} \text{ cm}^2$
6 143° **7** $\frac{17}{28}$ **8** $\frac{3\sqrt{93}}{31}$ **9** $\left(\frac{11}{6}\right)^\circ$
10 $\sqrt{181}$ km
11 $AC = \frac{12\sqrt{3}}{5}$ km, $BC = 2.4$ km
12 180 cm^2
13 a $\frac{2\sqrt{3}\pi}{3} \text{ cm}$ **b** $2\pi \text{ cm}^2$
14 $16 \sin\left(\frac{5}{4}\right) - 10 \approx 5.18 \text{ cm}^2$

Multiple-choice questions

- 1 D** **2 C** **3 C** **4 B** **5 A**
6 A **7 D** **8 B** **9 C** **10 A**

Extended-response questions

- 1 a** $\angle ACB = 12^\circ$, $\angle CBO = 53^\circ$, $\angle CBA = 127^\circ$
b 189.33 m **c** 113.94 m
2 a 4.77 cm **b** 180 cm^2 **c** 9.55 cm
3 a $\angle TAB = 3^\circ$, $\angle ABT = 97^\circ$, $\angle ATB = 80^\circ$
b 2069.87 m **c** 252.25 m
4 a 184.78 m **b** 199.71 m **c** 14.93 m
5 a 370.17 m **b** 287.94 m **c** 185.08 m
6 a $8\sqrt{2}$ cm **b** 10 cm **c** 10 cm **d** 68.90°

Chapter 14**Exercise 14A**

- 1 a** x^5 **b** $8x^7$ **c** x^2 **d** $2x^3$ **e** a^6
f 2^6 **g** x^2y^2 **h** x^4y^6 **i** $\frac{x^3}{y^3}$ **j** $\frac{x^6}{y^4}$
2 a 3^{17} **b** x^7y^5 **c** 3^{4x+3} **d** $30a^5b^6$
3 a x^2y **b** b^{4x+1} **c** $4a^5b$
4 a $\frac{1}{49}$ **b** 64 **c** $\frac{8}{125}$
5 a b^{10} **b** 729 **c** b^4
6 a $\frac{27a^8b}{16}$ **b** $\frac{125b^6}{c^9}$
7 a 64 **b** $-27a^3$ **c** $-96a^3$
8 a 2^{-2n} **b** 2^4 **c** $\frac{5^{2n}}{2^{2n}}$
9 a x^9 **b** 2^{16} **c** 3^{17} **d** q^8p^9 **e** $a^{11}b^3$
f 2^8x^{18} **g** $m^{11}n^{12}p^{-2}$ **h** $2a^5b^{-2}$
10 a x^2y^3 **b** $8a^8b^3$ **c** x^5y^2 **d** $\frac{9}{2}x^2y^3$
11 a $\frac{1}{n^4p^5}$ **b** $\frac{2x^8z}{y^4}$ **c** $\frac{b^5}{a^5}$ **d** $\frac{a^3b}{c}$
e $a^{n+2}b^{n+1}c^{n-1}$
12 a 3^{17n} **b** 2^{3-n} **c** $\frac{3^{4n-11}}{2^2}$
d $2^{n+1}3^{3n-1}$ **e** 5^{3n-2} **f** $2^{3x-3} \times 3^{-4}$
g $3^{6-n} \times 2^{-5n}$ **h** $3^3 = 27$ **i** 6
13 a $2^{12} = 4096$ **b** $5^5 = 3125$ **c** $3^3 = 27$

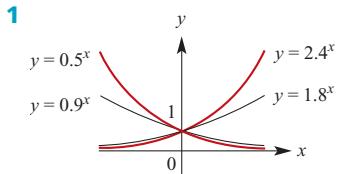
Exercise 14B

- 1 a** 25 **b** 27 **c** $\frac{1}{9}$ **d** 16
e $\frac{1}{2}$ **f** $\frac{1}{4}$ **g** $\frac{1}{25}$ **h** 16
i $\frac{1}{10\ 000}$ **j** 1000 **k** 27 **l** $\frac{3}{5}$
m -2 **n** $\frac{1}{625}$ **o** 16 **p** 343

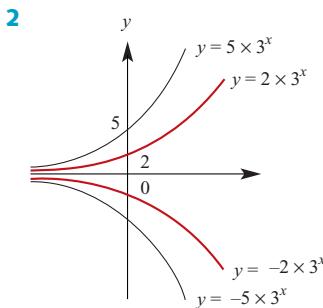
- 2** a $a^{\frac{1}{6}}b^{-\frac{7}{6}}$ b $a^{-6}b^{\frac{9}{2}}$ c $3^{-\frac{7}{3}} \times 5^{-\frac{7}{6}}$
 d $\frac{1}{4}$ e x^6y^{-8} f $a^{\frac{14}{15}}$
- 3** a $(2x-1)^{\frac{3}{2}}$ b $(x-1)^{\frac{5}{2}}$ c $(x^2+1)^{\frac{3}{2}}$
 d $(x-1)^{\frac{7}{2}}$ e $x(x-1)^{-\frac{1}{2}}$ f $(5x^2+1)^{\frac{4}{3}}$

Exercise 14C

- 1** a 4.78×10 b 6.728×10^3
 c 7.923×10 d 4.358×10^4
 e 2.3×10^{-3} f 5.6×10^{-7}
 g $1.200\,034 \times 10$ h 5.0×10^7
 i 2.3×10^{10} j 1.3×10^{-9}
 k 1.65×10^5 l 1.4567×10^{-5}
- 2** a 1.0×10^{-8} b 1.67×10^{-24}
 c 5×10^{-5} d $1.853\,18 \times 10^3$
 e 9.461×10^{12} f 2.998×10^{10}
- 3** a 81 280 000 000 000 b 270 000 000
 c 0.000 000 000 028
- 4** a 4.569×10^2 b 3.5×10^4
 c 5.6791×10^3 d 4.5×10^{-2}
 e 9.0×10^{-2} f 4.5682×10^3
- 5** a 0.000 0567 b $\frac{262}{2625}$
- 6** a 11.8 b 4.76×10^7

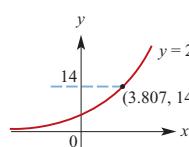
Exercise 14D


- All pass through $(0, 1)$
- Horizontal asymptote $y = 0$
- Increasing for base > 1
- Decreasing for base < 1

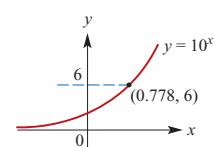


- $y = a \times b^x$ has y -axis intercept at $(0, a)$
- Horizontal asymptote $y = 0$
- Graphs c and d are reflections in the x -axis of graphs a and b

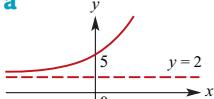
3 $x = 3.807$



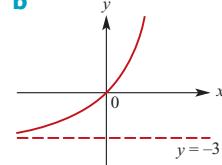
4 $x = 0.778$



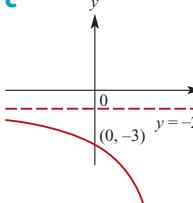
5 a



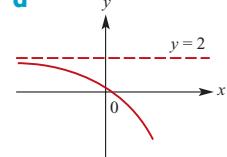
b



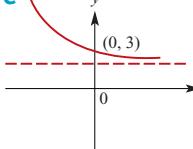
c



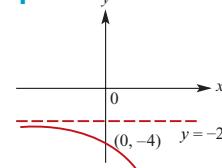
d



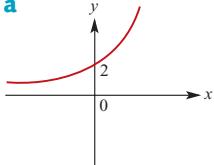
e



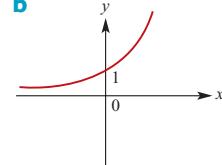
f



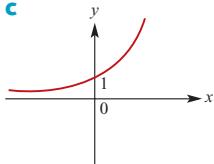
6 a



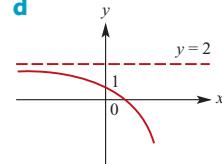
b



c



d


Exercise 14E

- 1** a 3 b 3 c $\frac{1}{2}$ d $\frac{3}{4}$ e $\frac{1}{3}$
 f 4 g 2 h 3 i 3
- 2** a 1 b 2 c $-\frac{3}{2}$ d $\frac{4}{3}$ e -1
 f 8 g 3 h -4 i 8 j 4
 k $3\frac{1}{2}$ l 6 m $7\frac{1}{2}$
- 3** a $\frac{4}{5}$ b $\frac{3}{2}$ c $5\frac{1}{2}$
- 4** a 0 b $0, -2$ c 1, 2 d 0, 1
- 5** a 2.32 b 1.29 c 1.26 d 1.75

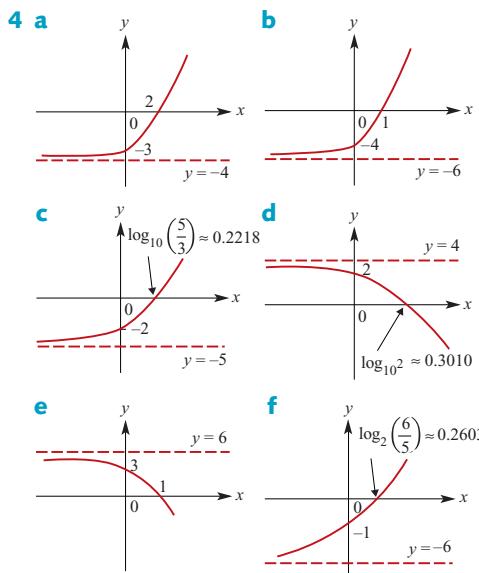
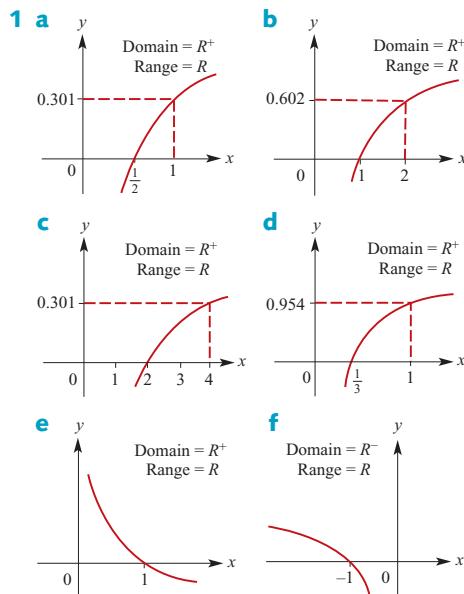
- 6** a $x > 2$ b $x > \frac{1}{3}$ c $x \leq \frac{1}{2}$ d $x < 3$
 e $x < \frac{3}{4}$ f $x > 1$ g $x \leq 3$

Exercise 14F

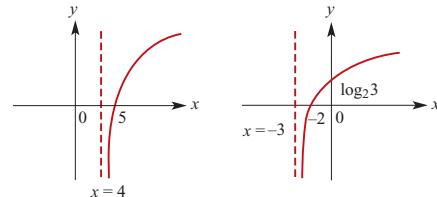
- 1** a 7 b 4 c 3 d -1
 2 a $\log_2(10a)$ b 1 c $\log_2\left(\frac{9}{4}\right)$ d 1
 e $3\log_2 a$ f 9 g $-\log_5 6$ h -2
 3 a 3 b 4 c -7 d -3
 e 4 f -3 g 4 h -6
 i -9 j -1 k 4 l -2
 4 a 2 b 7 c 9 d 1
 e $\frac{5}{2}$ f $\log_x(a^5)$ g 3 h 1
 5 a 2 b 27 c $\frac{1}{125}$ d 8
 e 30 f $\frac{2}{3}$ g 8 h 64
 i 4 j 10
 6 a 5 b 32.5 c 22 d 20
 e $\frac{3 \pm \sqrt{17}}{2}$ f 3 or 0
 7 $2 + 3a - \frac{5c}{2}$ g 10
 10 a 4 b $\frac{6}{5}$ c 3 d 10
 e 9 f 2

Exercise 14G

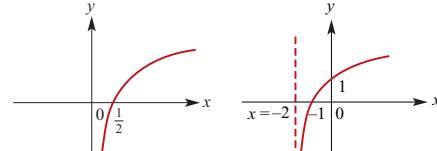
- 1** a 2.81 b -1.32 c 2.40 d 0.79
 e -2.58 f -0.58
2 a 1.90 b 3.10 c -0.68
3 a $x > 3$ b $x < 1.46$ c $x < -1.15$
 d $x \leq 2.77$ e $x \geq 1.31$

**Exercise 14H**

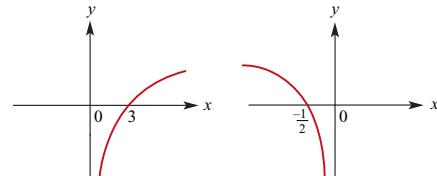
- 2** a Domain = $(4, \infty)$ b Domain = $(-3, \infty)$



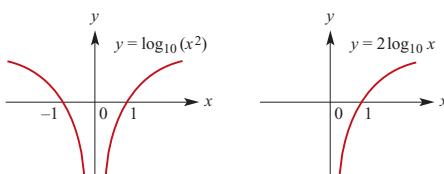
- c:** Domain = $(0, \infty)$ d Domain = $(-2, \infty)$

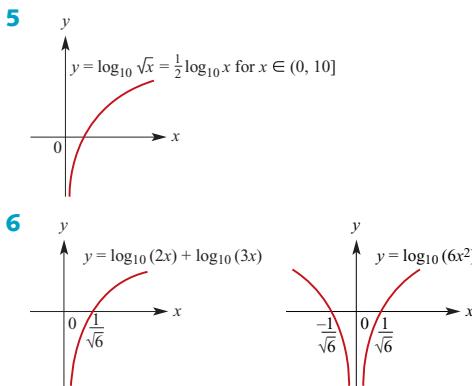


- e:** Domain = $(0, \infty)$ f Domain = $(-\infty, 0)$



- 3** a 0.64 b 0.40




Exercise 14I

1 a $N = 1000 \times 2^{\frac{t}{15}}$ **b** 50 minutes

2 79 726 years

3 7575 years

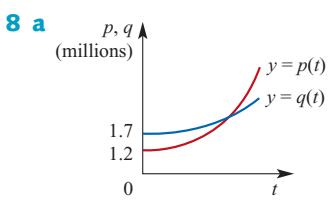
4 a 535 millibars

b 7331 metres

5 22 hours

6 6.4°C

7 $t > 18.668\dots$



- b i** $t = 12.56\dots$ (mid 1962)
ii $t = 37.56\dots$ (mid 1987)

9 a $y = 3 \times 5^x$ **b** $y = 4 \times (\frac{1}{2})^x$ **c** $y = 5 \times (\frac{3}{2})^x$

10 a $k = \log_{10}\left(\frac{5}{4}\right)$ **b** 7.212 hours

11 a $N = 1000 \times 10^{\frac{t}{5}}$ **b** 210 minutes
c 15 hours **d** 251 189 bacteria

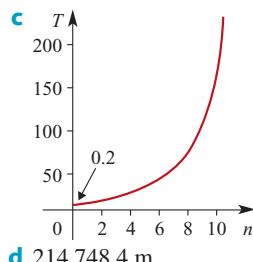
12 $a = 6 \times \left(\frac{10}{3}\right)^{-\frac{2}{3}}$ and $k = \frac{1}{3} \log_{10}\left(\frac{10}{3}\right)$

13 $y = 1.5 \times 0.575^x$

14 $p = 2.5 \times 1.35^t$

Cuts, n	Sheets	Thickness, T (mm)
0	1	0.2
1	2	0.4
2	4	0.8
3	8	1.6
4	16	3.2
5	32	6.4
6	64	12.8
7	128	25.6
8	256	51.2
9	512	102.4
10	1024	204.8

b $T = 0.2 \times 2^n$



d 214 748.4 m

16 $d_0 = 41.92$, $m = 0.094$

Chapter 14 review
Short-answer questions

1 a a^4 **b** $\frac{1}{b^2}$ **c** $\frac{1}{m^2 n^2}$ **d** $\frac{1}{ab^6}$

e $\frac{3a^6}{2}$ **f** $\frac{5}{3a^2}$ **g** a^3 **h** $\frac{n^8}{m^4}$

i $\frac{1}{p^2 q^4}$ **j** $\frac{8}{5a^{11}}$ **k** $2a$ **l** $a^2 + a^6$

2 3.84×10^8

3 10^6 seconds or $11\frac{31}{34}$ days

4 50

5 a $\log_2 7$ **b** $\frac{1}{2} \log_2 7$ **c** $\log_{10} 2$

d $\log_{10}\left(\frac{18}{5}\right)$ **e** $1 + \log_{10} 11$ **f** $1 + \log_{10} 101$

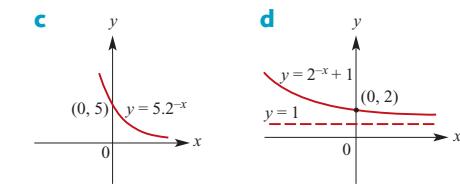
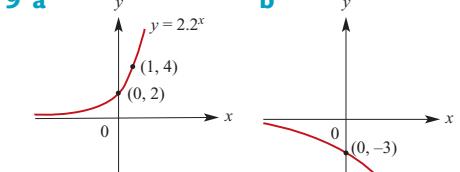
g $\frac{1}{5} \log_2 100$ **h** $-\log_2 10$

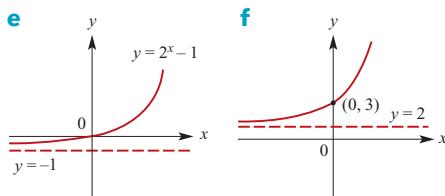
6 a 6 **b** 7 **c** 2 **d** 0
e 3 **f** -2 **g** -3 **h** 4

7 a $\log_{10} 6$ **b** $\log_{10} 6$ **c** $\log_{10}\left(\frac{a^2}{b}\right)$

d $\log_{10}\left(\frac{a^2}{25000}\right)$ **e** $\log_{10} y$ **f** $\log_{10}\left(\frac{a^2 b^3}{c}\right)$

8 a $x = 3$ **b** $x = 3$ or $x = 0$
c $x = 1$ **d** $x = 2$ or $x = 3$





10 $x = 1$

11 a $a = \frac{1}{2}$ b $y = -4$ or $y = 20$

Multiple-choice questions

- 1 C 2 A 3 C 4 A 5 B
6 A 7 A 8 A 9 A

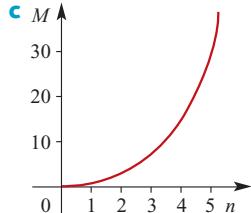
Extended-response questions

1 a

n	1	2	3	4
M	1	3	7	15

b $M = 2^n - 1$

n	5	6	7
M	31	63	127



d

Three discs	1	2	3
Times moved	4	2	1

Four discs	1	2	3	4
Times moved	8	4	2	1

2 $n = 2$

3 a $1.9 \times 10^{-8} \text{ N}$ b $m_1 = \frac{Fr^2 10^{11}}{6.67m_2}$

c $9.8 \times 10^{24} \text{ kg}$

4 a $(\frac{1}{2})^{3n}$ b $(\frac{1}{2})^{5n-2}$ c $n = 3$

5 a $729(\frac{1}{4})^n$ b $128(\frac{1}{2})^n$ c 4 times

6 a Batch 1: $15(0.95)^n$; Batch 2: $20(0.94)^n$
b 32 years

7 a 13.81 years b 7.38 years

8 a Temperature = 87.065×0.94^t

b i 87.1°C ii 18.56°C

c Temperature = 85.724×0.94^t

d i 85.72°C ii 40.82°C

e 28.19 minutes

9 a $a = 0.2$ and $b = 5$

b i $z = x \log_{10} b$ ii $a = 0.2$ and $k = \log_{10} 5$

10 a $y = 2 \times 1.585^x$ b $y = 2 \times 10^{0.2x}$
c $x = 5 \log_{10} \left(\frac{y}{2} \right)$

Chapter 15**Exercise 15A**

- 1 a 3, 7, 11, 15, 19 b 5, 19, 61, 187, 565
c 1, 5, 25, 125, 625 d $-1, 1, 3, 5, 7$
e 1, 3, 7, 17, 41

- 2 a $t_n = t_{n-1} + 3$, $t_1 = 3$ b $t_n = 2t_{n-1}$, $t_1 = 1$
c $t_n = -2t_{n-1}$, $t_1 = 3$ d $t_n = t_{n-1} + 3$, $t_1 = 4$
e $t_n = t_{n-1} + 5$, $t_1 = 4$

- 3 a $1, \frac{1}{2}, \frac{1}{3}, \frac{1}{4}$ b 2, 5, 10, 17

- c 2, 4, 6, 8 d 2, 4, 8, 16
e 5, 8, 11, 14 f $-1, 8, -27, 64$
g 3, 5, 7, 9 h 2, 6, 18, 54

- 4 a $t_n = 3n$ b $t_n = 2^{n-1}$
c $t_n = \frac{1}{n^2}$ d $t_n = 3(-2)^{n-1}$
e $t_n = 3n + 1$ f $t_n = 5n - 1$

5 $t_{n+1} = 3n + 4$, $t_{2n} = 6n + 1$

6 a $t_1 = 15$, $t_n = t_{n-1} + 3$ b $t_n = 12 + 3n$ c $t_{13} = 51$

7 a $t_1 = 94.3$, $t_n = 0.96t_{n-1}$ b $t_n = 94.3(0.96)^{n-1}$ c $t_9 = 68.03$

8 a $t_0 = 100$, $t_n = 1.8t_{n-1} + 20$ b $t_1 = 200$, $t_2 = 380$, $t_3 = 704$, $t_4 = 1287$, $t_5 = 2336$

9 a 1st year \$2120; 2nd year \$2671.20;
3rd year \$3255.47

b $t_n = 1.06(t_{n-1} + 400)$, $t_1 = 2120$ c \$8454.02

10 a 1, 4, 7, 10, 13, 16 b 3, 1, -1, -3, -5, -7
c $\frac{1}{2}, 1, 2, 4, 8, 16$ d 32, 16, 8, 4, 2, 1

11 a 1.1, 1.21, 1.4641, 2.144, 4.595, 21.114
b $27, 18, 12, 8, \frac{16}{3}, \frac{32}{9}$
c $-1, 3, 11, 27, 59, 123$
d $-3, 7, -3, 7, -3, 7$

12 a $t_1 = 1$, $t_2 = 2$, $t_3 = 4$ b $u_1 = 1$, $u_2 = 2$, $u_3 = 4$
c $t_1 = u_1$, $t_2 = u_2$, $t_3 = u_3$ d $t_4 = 8$, $u_4 = 7$

13 $S_1 = a + b$, $S_2 = 4a + 2b$, $S_3 = 9a + 3b$,
 $S_{n+1} - S_n = 2an + a + b$

14 $t_2 = \frac{3}{2}$, $t_3 = \frac{17}{12}$, $t_4 = \frac{577}{408}$; the number is $\sqrt{2}$

15 $t_3 = 2$, $t_4 = 3$, $t_5 = 5$

Exercise 15B

- 1 a 0, 2, 4, 6 b $-3, 2, 7, 12$
c $-\sqrt{5}, -2\sqrt{5}, -3\sqrt{5}, -4\sqrt{5}$ d 11, 9, 7, 5

- 2 a -31 b 24 c 5 d $6\sqrt{3}$

- 3** a $a = 3$, $d = 4$, $t_n = 4n - 1$
 b $a = 3$, $d = -4$, $t_n = 7 - 4n$
 c $a = -\frac{1}{2}$, $d = 2$, $t_n = 2n - \frac{5}{2}$
 d $a = 5 - \sqrt{5}$, $d = \sqrt{5}$, $t_n = \sqrt{5}n + 5 - 2\sqrt{5}$
- 4** a 13 b 8 c 20 d 56
- 5** a $a = -2$, $d = 3$, $t_7 = 16$
6 $t_n = 156n - 450$ 7 -2
8 54 9 19
- 10** a 672 b 91st week
- 11** a 70 b 94 c Row F
- 12** 117
- 13** $\frac{218}{9}$
- 14** 7, 9, 11, 13
- 15** $t_n = a - \frac{a(n-1)}{m-1}$
- 16** a 11.5 b 50
- 17** 16
- 18** 5
- 20** 3

Exercise 15C

- 1** a 426 b 55 c $60\sqrt{2}$ d 108
- 2** 112
- 3** 680
- 4** 2450
- 5** a 14 b 322
- 6** a 20 b -280
- 7** a 12 b 105
- 8** a 180 b {9}
- 9** 11
- 10** 20
- 11** 0
- 12** a 16.5 km b 45 km c 7 walks d 189 km
- 13** a 10 days b 25 per day
- 14** a 86 b 2600 c 224 d 2376
 e 5 extra rows
- 15** \$176 400
- 16** $a = -15$, $d = 3$, $t_6 = 0$, $S_6 = -45$
- 17** 2160
- 18** 266
- 19** a $t_n = \frac{5}{4}n + \frac{11}{4}$ b $t_n = 3n - 1$
- 20** a b b $\frac{n}{2}(b + bn)$
- 21** $t_5 = -10$, $S_{25} = -1250$
- 22** 1575d
- 23** a $S_{n-1} = 23n - 3n^2 - 20$
 b $t_n = 20 - 6n$ c $a = 14$, $d = -6$
- 24** 7, 12, 17

Exercise 15D

- 1** a 3, 6, 12, 24 b 3, -6, 12, -24
 c 10 000, 1000, 100, 10
 d 3, 9, 27, 81
- 2** a $\frac{5}{567}$ b $\frac{1}{256}$ c 32 d a^{x+5}
- 3** a $t_n = 3\left(\frac{2}{3}\right)^{n-1}$ b $t_n = 2(-2)^{n-1}$
 c $t_n = 2(\sqrt{5})^{n-1}$
- 4** a 3 b $\pm\frac{2}{5}$
- 5** t_9
- 6** a 6 b 9 c 9 d 6 e 8
- 7** $\frac{2}{3^5}$
- 8** $16\sqrt{2}$
- 9** a 24 b 12 288
- 10** a 21 870 m² b 9th day
- 11** 47.46 cm
- 12** a \$5397.31 b 48th year
- 13** a 57.4 km b 14th day
- 14** \$5 369 000
- 15** a \$7092.60 b 12 years
- 16** \$3005.61 b 11.6% p.a.
- 18** $t_{10} = 2048$ b $t_6 = 729$
- 20** 5 weeks
- 21** a 60 b 2.5 c 1 d x^4y^7
- 22** 3 or 1
- 23** $a = \frac{1 \pm \sqrt{5}}{2}$
- 24** a 168.07 mL b 20 times
- 25** a side lengths $\frac{a+b}{2}$ b side lengths \sqrt{ab}

Exercise 15E

- 1** a 5115 b -182 c $-\frac{57}{64}$
- 2** a 1094 b -684 c 7812
- 3** 10
- 4** 7
- 5** a 1062.9 mL b 5692.27 mL c 11 days
- 6** a 49 minutes (to nearest minute)
 b 164 minutes c Friday
- 7** $\frac{481\ 835}{6561} \approx 73.44$ m
- 8** a \$18 232.59 b \$82 884.47
- 9** Bianca \$3247.32; Andrew \$3000
- 10** a 155 b $\frac{15\sqrt{2}}{2} + 15$
- 11** a 8 b { $n : n > 19$ }
- 12** $\frac{x^{2m+2} + 1}{x^2 + 1}$

- 13 a** 54 976 km **b** 43 times
14 Option 1: \$52 million;
 Option 2: \$45 040 000 million

Exercise 15F

- 1 a** $\frac{5}{4}$ **b** $\frac{3}{5}$
2 Perimeter $p\left(\frac{1}{2}\right)^{n-1}$; Area $\frac{p^2\sqrt{3}}{9 \times 4^n}$;
 Sum of perimeters $2p$; Sum of areas $\frac{p^2\sqrt{3}}{27}$
3 $3333\frac{1}{3}$ **4** Yes
5 Yes, as the number of hours approaches infinity, but the problem becomes unrealistic after 4 to 5 hours
6 $S_\infty = 8$ **7** $\frac{1}{2}$
8 12 m **9** 75 m
10 a $\frac{4}{9}$ **b** $\frac{1}{30}$ **c** $\frac{31}{3}$ **d** $\frac{7}{198}$ **e** 1 **f** $\frac{37}{9}$
11 $r = \frac{1}{2}$, $t_1 = 16$, $t_2 = 8$;
 $r = -\frac{1}{2}$, $t_1 = 48$, $t_2 = -24$
12 $\frac{5}{8}$ **13** $\frac{2}{3}$

Chapter 15 review
Short-answer questions

- 1 a** 3, -1, -5, -9, -13, -17
b 5, 12, 26, 54, 110, 222
2 a 2, 4, 6, 8, 10, 12
b -1, -4, -7, -10, -13, -16
3 a \$5250, \$6037.50
b $t_1 = 5250$, $t_n = 1.05(t_{n-1} + 500)$
4 147 **5** -0.1
6 -258.75 **7** {12}
8 1 **9** 1000×1.035^n
10 $t_2 = 6$, $t_4 = \frac{8}{3}$ or $t_2 = -6$, $t_4 = -\frac{8}{3}$
11 96 **12** -9840
13 $\frac{3}{4}$ **14** $x = 8$ or $x = -2$

Multiple-choice questions

- 1 D** **2 B** **3 A** **4 A** **5 B**
6 D **7 E** **8 C** **9 E** **10 D**

Extended-response questions

- 1 a** 0.8, 1.5, 2.2, ... **b** Yes **c** 8.5 m
2 a Yes **b** $t_n = 25n + 25$ **c** 650
3 $22\frac{1}{7}$ km from town A; $9\frac{6}{7}$ km from town B
4 a 20, 36, 52, 68, 84, 100, 116, 132
b $T_n = 16n + 4$ **c** Yes, size 12

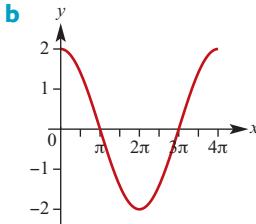
- 5 a** $D_n = 7n - 5$ **b** 27
6 472 mm **7** 520
8 a 99.9999 mg **b** 100 mg
9 a $\frac{1}{729}$ m **b** 1.499 m
 No, maximum height of water is 1.5 m
10 a 27.49 **b** 1680.8
11 a $7\frac{1}{9}$ m **b** 405 m
12 $2^{64} - 1 = 1.845 \times 10^{19}$
13 a **i** $t_n = 3750 + 250n$
ii $S_n = 3875n + 125n^2$
iii $n = 22$
iv $m = \frac{T - 4000}{250} + 1$
v $p = 51$
b **i** $S_n = 37500(1.08^n - 1)$
ii $Q_B - Q_A = 37500(1.08^n - 1) - 3875n - 125n^2$; $n = 18$
14 a 3^{n-1} **b** $\left(\frac{1}{2}\right)^{n-1}$ **c** $\left(\frac{3}{4}\right)^{n-1}$
d Area of white region approaches zero
15 a 8^{n-1} **b** $\left(\frac{1}{3}\right)^{n-1}$ **c** $\left(\frac{8}{9}\right)^{n-1}$
d Area of white region approaches zero

Chapter 16

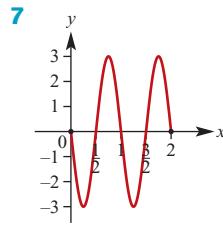
Short-answer questions

- 1 a** $\frac{\pi}{3}$ **b** $\frac{3\pi}{2}$ **c** $\frac{7\pi}{9}$
2 a -1 **b** 0 **c** 0 **d** Undefined
3 a 21.80° **b** 3.06 **c** 9.97
4 a -0.3 **b** -0.5 **c** 1.6 **d** -0.6 **e** 0.1 **f** $\frac{4}{5}$
5 a $\frac{\sqrt{3}}{2}$ **b** $-\frac{\sqrt{3}}{2}$ **c** -1 **d** $\frac{1}{2}$ **e** $\frac{1}{\sqrt{2}}$ **f** $-\sqrt{3}$

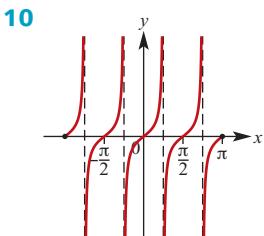
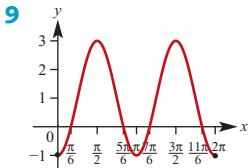
6 a Period = 4π ; Amplitude = 2



c Dilation of factor 2 from the x-axis and dilation of factor 2 from the y-axis



- 8** a $\frac{-7\pi}{6}, \frac{-5\pi}{6}, \frac{5\pi}{6}, \frac{7\pi}{6}$
 b $\frac{-7\pi}{4}, \frac{-5\pi}{4}, \frac{\pi}{4}, \frac{3\pi}{4}$
 c $\frac{-17\pi}{12}, \frac{-13\pi}{12}, \frac{-5\pi}{12}, \frac{-\pi}{12}, \frac{7\pi}{12}, \frac{11\pi}{12}, \frac{19\pi}{12}, \frac{23\pi}{12}$
 d $\frac{-4\pi}{3}, \frac{-\pi}{3}, \frac{2\pi}{3}, \frac{5\pi}{3}$



11 $\sin(A - B) = \frac{1}{5\sqrt{2}} = \frac{\sqrt{2}}{10}$

12
$$\frac{1 - \cos(2A)}{1 + \cos(2A)} = \frac{1 - (1 - 2\sin^2 A)}{1 + (2\cos^2 A - 1)} = \frac{2\sin^2 A}{2\cos^2 A} = \tan^2 A$$

13 a $\sqrt{21}$ cm b $\frac{2}{\sqrt{7}}$ c $\sqrt{3}$ cm²

14 15 cm²

15 12 cm

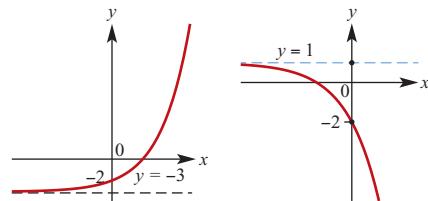
16 a $-24a^{10}$ b $\frac{a^3}{2b^2}$ c $\frac{3}{4x^5}$ d 8

e $\frac{y^{\frac{2}{3}}}{x^{\frac{1}{6}}}$ f $\frac{1}{(2x-1)^{\frac{1}{2}}}$

17 a $\frac{25}{9}$ b 16 c 81 d $-\frac{1}{3}$

18 a $2^{6n} \times 3^{3n}$ b 12 c $\log_{10} 36$ d -3

19 a Range $(-3, \infty)$ b Range $(-\infty, 1)$



20 a $x = 3$ b $x = 0, 2$ c $x > 4$ d $x = 7$ e $x = 1$

21 a $x = \log_2 5$ b $x = \frac{1}{3}(\log_5(10) - 1)$

c $x > \frac{\log_{10} 0.2}{\log_{10} 0.6}$

22 6

23 -141

24 a $S_{n-1} = 2n^2 - n - 1$ b $t_n = 4n + 1$
 c $t_1 = 5$ d $d = 4$

25 6

26 8 m

27 16 cm

28 a 2550 b 3367

Multiple-choice questions

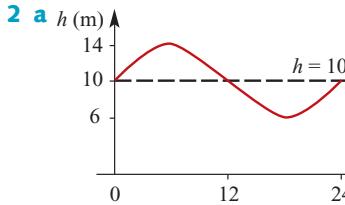
- | | | | | | |
|-------------|-------------|-------------|-------------|-------------|-------------|
| 1 D | 2 A | 3 D | 4 D | 5 D | 6 A |
| 7 E | 8 D | 9 D | 10 E | 11 E | 12 B |
| 13 D | 14 A | 15 B | 16 E | 17 C | 18 B |
| 19 E | 20 B | 21 B | 22 B | 23 E | 24 D |
| 25 A | 26 D | 27 C | 28 B | 29 A | 30 D |
| 31 B | 32 A | 33 A | 34 D | 35 C | 36 C |
| 37 A | 38 D | 39 B | 40 D | 41 E | 42 B |
| 43 B | 44 A | 45 E | 46 B | 47 B | 48 C |
| 49 A | 50 A | 51 C | | | |

Extended-response questions

1 a 78 m to C, 49 m to D

b 60 m

c 279°

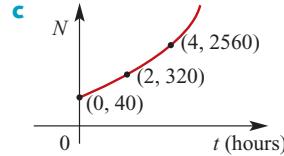


b $t = 3.2393$ and $t = 8.7606$

c $t \in [0.9652, 11.0348]$

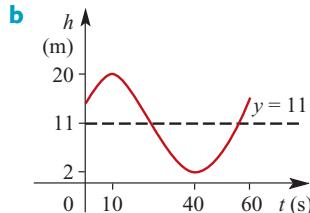
3 a 40 bacteria

b i 320 ii 2560 iii 10 485 760



d 40 minutes ($= \frac{2}{3}$ hours)

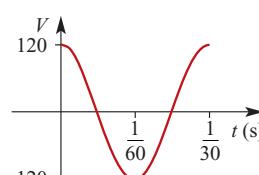
4 a 60 seconds



c $[2, 20]$

d First at height 2 metres after 40 seconds; then every 60 seconds after this first time

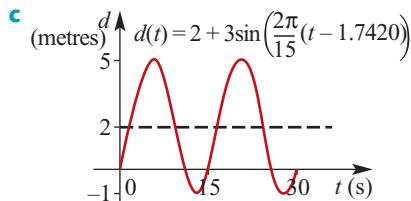
e At $t = 0$, $t = 20$ and $t = 60$, for $t \in [0, 60]$

5 a  **b** $t = \frac{1}{180}$ s

c $t = \frac{k}{30}$ s, for $k = 0, 1, 2, \dots$

6 a i Period = 15 seconds
ii Amplitude = 3 **iii** $c = \frac{2\pi}{15}$

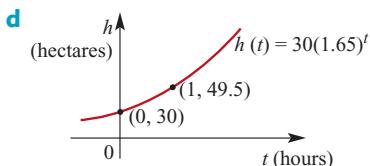
b $h = 1.74202$



7 a i 30 **ii** 49.5 **iii** 81.675

b $k = 1.65$

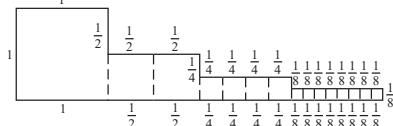
c 6.792 hours



8 a 4 **b** 6 **c** 8 **d** 2

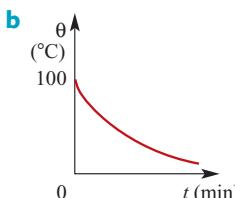
e i $P_n = P_{n-1} + 2$ **iii** $P_n = 2n + 2$

iv



9 a

t	0	1	2	3	4	5
0	100	60	40	30	25	22.5



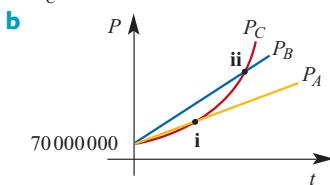
c 1 minute

d 27.071

10 a $P_A = 70\ 000\ 000 + 3\ 000\ 000t$

$P_B = 70\ 000\ 000 + 5\ 000\ 000t$

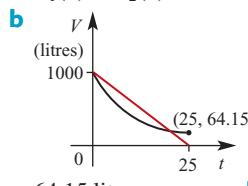
$P_C = 70\ 000\ 000 \times 1.3^{\frac{t}{10}}$



c i 35 years **ii** 67 years

11 a i 4 billion **ii** 5.944 billion **iii** 7.25 billion
b 2032

12 a $V_1(0) = V_2(0) = 1000$



c 64.15 litres **d** $t = 0$ and $t = 23.00$

13 a i $OC_1 = R - r_1$ **ii** $r_1 = \frac{R}{3}$

b i $OC_2 = \frac{R}{3} - r_2$ **ii** $r_2 = \frac{R}{9}$

c i $r = \frac{1}{3}$ **ii** $r_n = \frac{R}{3^n}$

iii $S_\infty = \frac{R}{2}$ **iv** $S_\infty = \frac{\pi R^2}{8}$

14 a i $80n + 920$

ii A: 2840 tonnes; B: 2465 tonnes

iii $40n(n + 24)$

iv A: 46 080 tonnes; B: 39 083 tonnes

b April 2016

15 a 14 m **b** $t_n = 1.5n - 1$ **c** 53 **d** 330 m

16 a i 15.4 million tonnes

ii 21.7 million tonnes

b $t_n = 0.9n + 9.1$ **c** 371 million tonnes

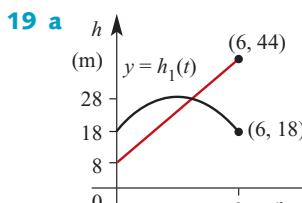
d 12 years **e** $P_n = 12.5(1.05)^{n-1}$

f 15 years

17 a 12:05 p.m. **b** 2752 km **c** 26.1°

18 b i 51.48 cm **ii** 4764.95 cm²

iii 94.80%



b 3:19 a.m. to nearest minute ($t = 3.31$)

c i 9 a.m. **ii** $8 + 6t$ metres

Chapter 17

Exercise 17A

1 3.2 m/s

2 a 2

b 7

c $\frac{-1}{2}$

d $\frac{1 - \sqrt{5}}{4}$

3 a $\frac{-25}{7}$

b $\frac{-18}{7}$

c 4

d $\frac{4b}{3a}$

4 a 4 m/s

b 32 m/s

5 a \$2450.09

b \$150.03 per year

6 3.125 cm/min

7 C

Exercise 17B

1 7.19

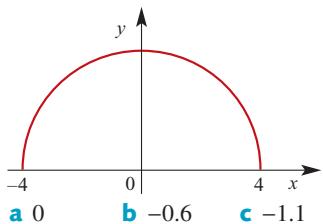
2 a 0.015 b $\frac{1}{60} \approx 0.0167$

3 a i 9 ii 4.3246 iii 2.5893
 b 2.30

 4 a 25°C at 16:00 b $\approx 3^\circ\text{C/h}$ c -2.5°C/h

5 -0.5952

6



a 0

b -0.6

c -1.1

7 4

8 a $16 \text{ m}^3/\text{min}$

b $10 \text{ m}^3/\text{min}$

9 a 18 million/min

b 8.3 million/min

10 a 620 m³/min flowing out

b 4440 m³/min flowing out

c 284 000 m³/min flowing out

11 a 7 b 9 c 2 d 35

12 a 28 b 12

13 a i $\frac{2}{\pi} \approx 0.637$
 ii $\frac{2\sqrt{2}}{\pi} \approx 0.9003$
 iii 0.959
 iv 0.998

b 1

Exercise 17C

1 a $-2 - h$ b -2

2 a $5 + h$ b 5

3 $2x - 2$

4 32

5 $10 \text{ m}^3/\text{min}$

6 7 per day

7 a 1 b $3x^2 + 1$ c 20
 d $30x^2 + 1$ e 5 f $30x^3 + 4$

8 a $2x + 2$ b 13 c $3x^2 + 4x$

9 a $5 + 3h$ b 5.3

c 5

10 a $\frac{-1}{2+h}$ b -0.48 c $\frac{-1}{2}$

11 a $6 + h$ b 6.1

c 6

12 a $6x$ b 4 c 0 d $6x + 4$

e $6x^2$

f $8x - 5$ g $-2 + 2x$

13 $4x^3$

Exercise 17D

1 a $2x + 4$ b 2 c $3x^2 - 1$ d $x - 3$

e $15x^2 + 6x$

f $-3x^2 + 4x$

2 a $12x^{11}$ b $21x^6$ c 5 d 5

e 0 f $10x - 3$

g $50x^4 + 12x^3$

h $8x^3 - x^2 - \frac{1}{2}x$

3 a 6 b 20 c 5 d 10 e 0

f 7 g 31 h 7 i -34

4 a 60 b -16 c 57 d 168

5 a 7 b 2 c -16 d 11

6 a -1 b 0 c $12x^2 - 3$

d $x^2 - 1$ e $2x + 3$ f $18x^2 - 8$

g $15x^2 + 3x$

7 a $2(x + 4)$ b $48t^2 + 16t - 7$ c $2x$

8 a i 3 ii $3a^2$ b $3x^2$

9 a $\frac{dy}{dx} = 3(x - 1)^2 \geq 0$ for all x ;
 therefore gradient of graph ≥ 0 for all x

b $\frac{dy}{dx} = 1$ for $x \neq 0$
 c $18x + 6$

10 a 1, Gradient = 2 b 1, Gradient = 1
 c 3, Gradient = -4 d -5 , Gradient = 4
 e 28, Gradient = -36 f 9, Gradient = -24

11 a i $4x - 1$, $(3, (\frac{1}{2}, 0))$

ii $\frac{1}{2} + \frac{2}{3}x$, $(\frac{7}{6}, (\frac{3}{4}, \frac{25}{16}))$

iii $3x^2 + 1$, $(4, (0, 0))$

iv $4x^3 - 31$, $(-27, (2, -46))$

b Coordinates of the point where gradient is 1

12 a $6t - 4$ b $-2x + 3x^2$ c $-4z - 4z^3$
 d $6y - 3y^2$ e $6x^2 - 8x$ f $19.6t - 2$

13 a $(4, 16)$ b $(2, 8), (-2, -8)$ c $(0, 0)$

d $(\frac{3}{2}, -\frac{5}{4})$ e $(2, -12)$ f $(-\frac{1}{3}, \frac{4}{27}), (1, 0)$

Exercise 17E

1 a $-\frac{1}{(x-3)^2}$ b $-\frac{1}{(x+2)^2}$

2 a $-\frac{2}{x^3}$ b $-\frac{4}{x^5}$

3 a $-6x^{-3} - 5x^{-2}$ b $-6x^{-3} + 10x$

c $-15x^{-4} - 8x^{-3}$ d $6x - \frac{20}{3}x^{-5}$

e $-12x^{-3} + 3$ f $3 - 2x^{-2}$

4 a $-2z^{-2} - 8z^{-3}$, $z \neq 0$ b $-9z^{-4} - 2z^{-3}$, $z \neq 0$

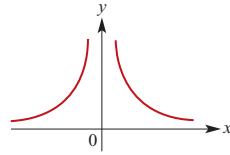
c $\frac{1}{2}$, $z \neq 0$ d $18z + 4 - 18z^{-4}$, $z \neq 0$

e $2z^{-3}$, $z \neq 0$ f $-\frac{3}{5}$, $z \neq 0$

5 a $f'(x) = 12x^3 + 18x^{-4} - x^{-2}$

b $f'(x) = 20x^3 - 8x^{-3} - x^{-2}$

6



a Gradient of $PQ = \frac{-2-h}{(1+h)^2}$

7 a $11\frac{3}{4}$ b $\frac{1}{8}$ c -1 d 5

8 a $-\frac{1}{2}$ **b** $\frac{1}{2}$

9 $f'(x) = -\frac{1}{x^2} < 0$ for all $x \neq 0$

Exercise 17F

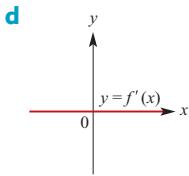
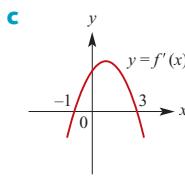
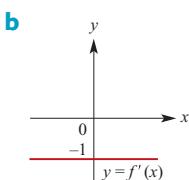
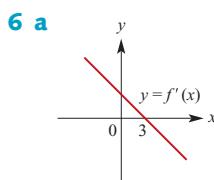
1 Graphs b and d

2 Graphs a, b and e

3 a $x = 1$ **b** $x = 1$ **c** $x > 1$ **d** $x < 1$
e $x = \frac{1}{2}$

4 a $(-\infty, -3) \cup (\frac{1}{2}, 4)$ **b** $(-3, \frac{1}{2}) \cup (4, \infty)$
c $\{-3, \frac{1}{2}, 4\}$

5 a B **b** C **c** D **d** A **e** F **f** E

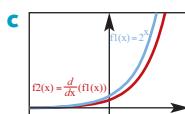
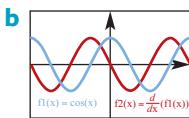
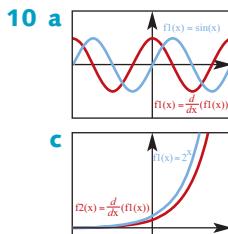


7 a $(-1, 1.5)$ **b** $(-\infty, -1) \cup (1.5, \infty)$

c $\{-1, 1.5\}$

8 a $(3, 0)$ **b** $(4, 2)$

9 a $(\frac{1}{2}, -6\frac{1}{4})$ **b** $(0, -6)$



11 a i 66.80° **ii** 42.51°

b $(0.5352, 0.2420)$

c No

12 a $a = 2, b = -5$ **b** $\left(\frac{5}{4}, -\frac{25}{8}\right)$

Exercise 17G

1 a $\frac{x^4}{8} + c$ **b** $x^3 - 2x + c$ **c** $\frac{5x^4}{4} - x^2 + c$

d $\frac{x^4}{5} - \frac{2x^3}{3} + c$ **e** $\frac{x^3}{3} - x^2 + x + c$

f $\frac{x^3}{3} + x + c$ **g** $\frac{z^4}{2} - \frac{2z^3}{3} + c$

h $\frac{4t^3}{3} - 6t^2 + 9t + c$ **i** $\frac{t^4}{4} - t^3 + \frac{3t^2}{2} - t + c$

2 $f(x) = x^4 + 2x^3 + 2x$

3 $y = 2x^3 + 12$

4 a $y = x^2 - x$

b $y = 3x - \frac{x^2}{2} + 1$

c $y = \frac{x^3}{3} + x^2 + 2$

d $y = 3x - \frac{x^3}{3} + 2$

e $y = \frac{2x^5}{5} + \frac{x^2}{2}$

5 a $V = \frac{t^3}{3} - \frac{t^2}{2} + \frac{9}{2}$ **b** $\frac{1727}{6} \approx 287.83$

6 $f(x) = x^3 - x + 2$

7 a B **b** $w = 2000t - 10t^2 + 100\,000$

8 $f(x) = 5x - \frac{x^2}{2} + 4$

9 $f(x) = \frac{x^4}{4} - x^3 - 2$

10 a $k = 8$ **b** $(0, 7)$

11 $8\frac{2}{3}$

12 a $k = -4$ **b** $y = x^2 - 4x + 9$

13 a $k = -32$ **b** $f(7) = 201$

14 $y = \frac{1}{3}(x^3 - 5)$

Exercise 17H

1 a 15

b 1

c $-3\frac{1}{2}$

d $-2\frac{1}{2}$

e 0

f 4

g 2

h $2\sqrt{3}$

i -2

j 12

k $\frac{11}{9}$

l $\frac{1}{4}$

2 a 3, 4

b 7

c Discontinuity at 0, as $f(0) = 0$,

$\lim_{x \rightarrow 0^+} f(x) = 0$ but $\lim_{x \rightarrow 0^-} f(x) = 2$

b Discontinuity at 1, as $f(1) = 3$,

$\lim_{x \rightarrow 1^+} f(x) = 3$ but $\lim_{x \rightarrow 1^-} f(x) = -1$

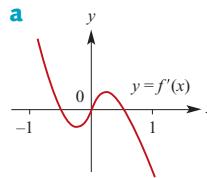
c Discontinuity at 0, as $f(0) = 1$,

$\lim_{x \rightarrow 0^+} f(x) = 1$ but $\lim_{x \rightarrow 0^-} f(x) = 0$

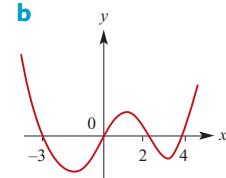
4 $x = 1$

Exercise 17I

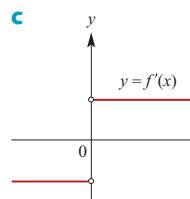
1 a



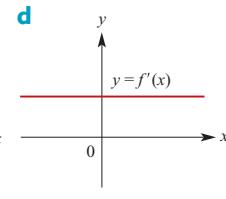
b

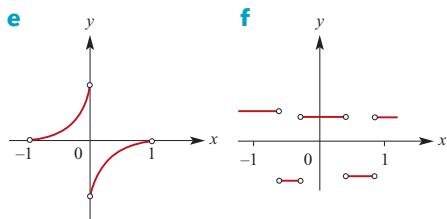


c

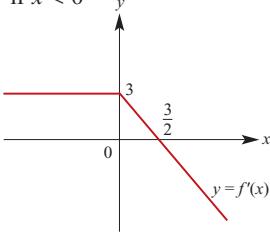


d

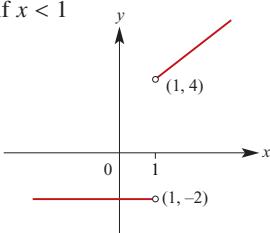




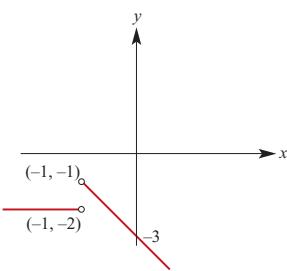
2 $f'(x) = \begin{cases} -2x + 3 & \text{if } x \geq 0 \\ 3 & \text{if } x < 0 \end{cases}$



3 $f'(x) = \begin{cases} 2x + 2 & \text{if } x > 1 \\ -2 & \text{if } x < 1 \end{cases}$



4 $f'(x) = \begin{cases} -2x - 3 & \text{if } x > -1 \\ -2 & \text{if } x < -1 \end{cases}$



Chapter 17 review

Short-answer questions

- 1 a** 1 **b** 13
2 a 3 **b** $-2x$ **c** $2x + 5$
d $3x^2 + 1$ **e** $2x + 2$ **f** $6x - 1$
3 a $6x - 2$ **b** 0 **c** $4 - 4x$
d $4(20x - 1)$ **e** $6x + 1$ **f** $-6x - 1$
4 a -1 **b** 0 **c** $\frac{4x + 7}{4}$ **d** $\frac{4x - 1}{3}$
e x
5 a 1; 2 **b** 3; -4 **c** -5; 4 **d** 28; -36
6 a $\left(\frac{3}{2}, -\frac{5}{4}\right)$ **b** (2, -12) **c** (0, 1), $\left(\frac{3}{2}, -\frac{11}{16}\right)$
d (3, 0), (1, 4)

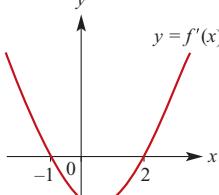
- 7 a** $x = \frac{1}{2}$ **b** $x = \frac{1}{2}$ **c** $x > \frac{1}{2}$ **d** $x < \frac{1}{2}$
e $x \in \mathbb{R} \setminus \left\{\frac{1}{2}\right\}$ **f** $x = \frac{5}{8}$

- 8 a** $-4x^{-5}$ **b** $-6x^{-4}$ **c** $\frac{2}{3x^3}$ **d** $\frac{4}{x^5}$
e $-\frac{15}{x^6}$ **f** $-\frac{2}{x^3} - \frac{1}{x^2} = -\frac{2+x}{x^3}$
g $-\frac{2}{x^2}$ **h** $10x + \frac{2}{x^2}$
9 a $a = 2, b = -1$ **b** $\left(\frac{1}{4}, -\frac{1}{8}\right)$
10 a $\frac{x}{2} + c$ **b** $\frac{x^3}{6} + c$ **c** $\frac{x^3}{3} + \frac{3x^2}{2} + c$
d $\frac{4x^3}{3} + 6x^2 + 9x + c$ **e** $\frac{at^2}{2} + c$ **f** $\frac{t^4}{12} + c$
g $\frac{t^3}{3} - \frac{t^2}{2} - 2t + c$ **h** $\frac{-t^3}{3} + \frac{t^2}{2} + 2t + c$

11 $f(x) = x^2 + 5x - 25$

12 a $f(x) = x^3 - 4x^2 + 3x$
b 0, 1, 3

13



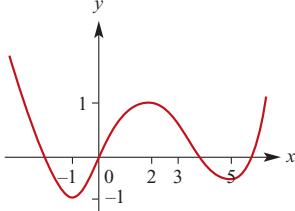
14 a $(-1, 4)$ **b** $(-\infty, -1) \cup (4, \infty)$ **c** $\{-1, 4\}$

Multiple-choice questions

- 1 E** **2 D** **3 B** **4 E** **5 B** **6 C**
7 C **8 A** **9 E** **10 A** **11 D**

Extended-response questions

1



2 $y = \frac{7}{36}x^3 + \frac{1}{36}x^2 - \frac{20}{9}x$

3 a i 71.57° **ii** 89.58°

b 2 km

4 a 0.12, -0.15

b $x = 2, y = 2.16$; Height 2.16 km

5 a At $x = 0$, gradient is -2; at $x = 2$, gradient is 2. Angles of inclination to the positive direction of the x -axis are supplementary.

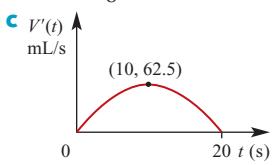
6 a m **b** cm **c** $-m$

Chapter 18

Exercise 18A

- 1** **a** $y = 4x - 4$, $4y + x = 18$
b $y = 12x - 15$, $12y + x = 110$
c $y = -x + 4$, $y = x$
d $y = 6x + 2$, $6y + x = 49$
- 2** $y = 2x - 10$
- 3** $y = 2x - 1$, $y = 2x - \frac{8}{3}$;
Both have gradient 2; Distance apart = $\frac{\sqrt{5}}{3}$
- 4** $y = 3x + 2$, $y = 3x + 6$
- 5** **a** Tangents both have gradient 2 **b** $(0, -3)$
- 6** $(3, 12), (1, 4)$
- 7** **a** $y = 10x - 16$ **b** $(-4, -56)$
- 8** **a** $y = 5x - 1$ **b** $(2, 4), (4, -8)$

Exercise 18B

- 1** **a** 36; $\frac{36}{1} = 36$ **b** $48 - 12h$ **c** 48
- 2** **a** $1200t - 200t^2$ **b** \$1800 per month
c At $t = 0$ and $t = 6$
- 3** **a** $30 - 4P$
b 10, -10
c For $P < 7.5$ revenue increases as P increases
- 4** **a** 50 people per year **b** 0 people per year
c Decreasing by 50 people per year
- 5** **a** **i** 0 mL **ii** $833\frac{1}{3}$ mL
b $V'(t) = \frac{5}{8}(20t - t^2)$
c 
- 6** **a** 0.6 km^2 **b** $0.7 \text{ km}^2/\text{h}$

Exercise 18C

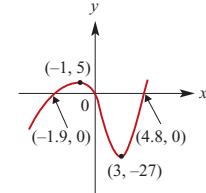
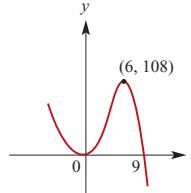
- 1** **a** $(3, -6)$ **b** $(3, 2)$ **c** $(2, 2)$ **d** $(4, 48)$
e $(0, 0), (2, -8)$ **f** $(0, -10), (2, 6)$
- 2** $a = 2, b = -8, c = -1$
- 3** $a = -\frac{1}{2}, b = 1, c = 1\frac{1}{2}$
- 4** **a** $a = 2, b = -5$ **b** $\left(\frac{5}{4}, -\frac{25}{8}\right)$
- 5** $a = -8$
- 6** $a = 6$
- 7** **a** $(2.5, -12.25)$ **b** $\left(\frac{7}{48}, -\frac{625}{96}\right)$
c $(0, 27), (3, 0)$ **d** $(-2, 48), (4, -60)$
e $(-3, 4), (-1, 0)$ **f** $(-1.5, 0.5)$

8 $a = -1, b = 2$

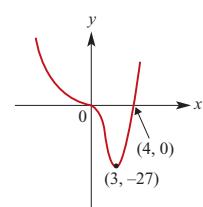
9 $a = -\frac{2}{9}, b = \frac{3}{2}, c = -3, d = 7\frac{1}{2}$

Exercise 18D

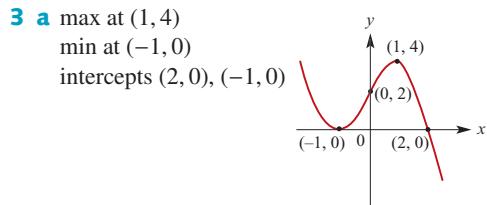
- 1** **a** min $(0, 0)$
max $(6, 108)$
- b** min $(3, -27)$
max $(-1, 5)$



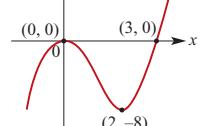
- c** inflection $(0, 0)$
min $(3, -27)$



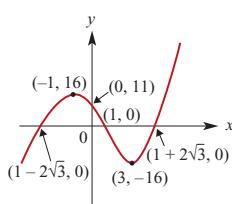
- 2** **a** $(0, 0)$ max; $\left(\frac{8}{3}, -\frac{256}{27}\right)$ min
b $(0, 0)$ min; $(2, 4)$ max **c** $(0, 0)$ min
 $\left(\frac{10}{3}, \frac{-200\ 000}{729}\right)$ min; $(0, 0)$ inflection
d $(3, -7)$ min; $\left(\frac{1}{3}, \frac{67}{27}\right)$ max
e $(6, -36)$ min; $\left(\frac{4}{3}, \frac{400}{27}\right)$ max



- b** min at $(2, -8)$
max at $(0, 0)$
intercepts $(3, 0), (0, 0)$

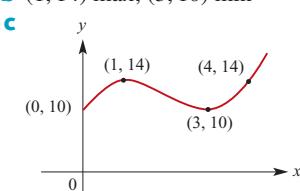


- c** min at $(3, -16)$
max at $(-1, 16)$
intercepts $(0, 11), (1 \pm 2\sqrt{3}, 0), (1, 0)$



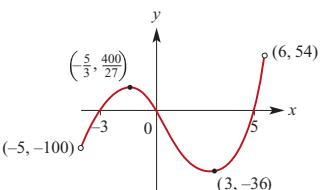
- 4** **a** Local maximum
b Stationary point of inflection

- 5 a** $(-\infty, 1) \cup (3, \infty)$
b (1, 14) max; (3, 10) min



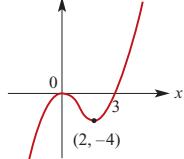
- 6** $\{x : -2 < x < 2\}$
7 a $x \in (-1, 1)$ **b** $x \in (-\infty, -1) \cup (1, \infty)$

- 8 a** $x = -\frac{5}{3}, x = 3$
b max at $(-\frac{5}{3}, \frac{400}{27})$, min at $(3, -36)$
 intercepts $(5, 0), (0, 0), (-3, 0)$

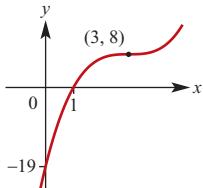


- 9**
-
- 10**
-

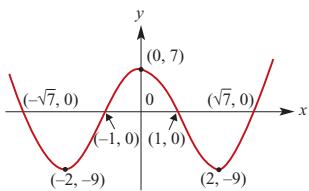
- 11 a i** $(0, 2)$ **ii** $(-\infty, 0) \cup (2, \infty)$ **iii** $\{0, 2\}$
b



- 12** Stationary point of inflection at $(3, 8)$



- 13** min at $(-2, -9)$ and $(2, -9)$; max at $(0, 7)$
 intercepts $(\pm\sqrt{7}, 0), (\pm 1, 0), (0, 7)$



Exercise 18E

- 1** 2500 cm^2 **2** 25 **3** 2
4 a $V(x) = (6 - 2x)^2 x$
b $V_{\max} = 16 \text{ m}^3$ when $x = 1$
5 a i 0.9375 m **ii** 2.5 m **iii** 2.8125 m
b $x = \frac{40}{3}, y = \frac{80}{27}$
c i $x = 11.937, x = 1.396$ **ii** $x = 14.484$
6 b $V = \frac{75x - x^3}{2}$ **c** 125 cm^3 **d** 118 cm^3

- 7** 256π
8 $x = \frac{5}{3}(9 - \sqrt{21})$
9 Absolute max = 2; Absolute min = -30
10 Absolute max = 6; Absolute min = -9
11 Absolute max = 32; Absolute min = -8
12 Absolute max = 1050; Absolute min = -8
13 b $\frac{dV}{dx} = 30x - 36x^2$ **c** $\frac{125}{36}$ **d** $\frac{432}{125}$
e $\frac{125}{36}$ when $x = \frac{5}{6}$
14 a $15 \leq y \leq 18$ **b** Max 75, min 36
15 a $\frac{125000}{27}$ **b** 3000 **c** $\frac{125000}{27}$
16 b $\frac{dA}{dx} = \frac{1}{8}(2x - 10)$ **c** $x = 5$ **d** $\frac{25}{8} \text{ m}^2$

Exercise 18F

- 1 a** $t = 2, t = 3$ and $t = 8$
b $0 \leq t < 2.5$ and $t > 6$
c $t = 2.5$ and $t = 6$
2 a -12 cm/s **b** $t = 6, x = -25$
c -9 cm/s **d** 9 cm/s
3 a $t = 2$ **b** $0 \leq t < 2$ **c** 8 m
d 4 s **e** $p = -2, q = 8, r = 0$
f -4 m/s
4 a -3 cm/s **b** $2\sqrt{3} \text{ s}$
5 a $x = 5 \text{ cm}, v = 0 \text{ cm/s}, a = -12 \text{ cm/s}^2$
b $t = 0, x = 5, a = -12;$ $t = 1, x = 3, a = 12$
6 a 2 m/s^2 **b** 50 m/s^2
7 a $(15 - 9.8t) \text{ m/s}$ **b** -9.8 m/s^2
8 a 3.5 s **b** 2 m/s^2 **c** 14.5 m
d When $t = 2.5 \text{ s}$; the particle is 1.25 m to the left of O
9 a 0 s, 1 s, 2 s
b $2 \text{ m/s}, -1 \text{ m/s}, 2 \text{ m/s}; -6 \text{ m/s}^2, 0 \text{ m/s}^2, 6 \text{ m/s}^2$
c 0 m/s
10 a 12 cm to the right of O
b 2 cm to the right of O
c Moving to the left at 7 cm/s
d $t = 3.5 \text{ s}$; particle is 0.25 cm to the left of O
e -2 cm/s **f** 2.9 cm/s

- 11 a** 18 m/s^2 , 54 m/s^2 , 114 m/s^2 , **b** 58 m/s^2
12 a 3 cm to the left of O , moving to the right at
24 cm/s
b $v = 3t^2 - 22t + 24$
c At $\frac{4}{3}$ s and 6 s
d $11\frac{22}{27}$ cm to the right of O and 39 cm to the
left of O
e $4\frac{2}{3}$ s
f $a = 6t - 22$
g When $t = \frac{11}{3}$ s and the particle is $13\frac{16}{27}$ cm
left of O moving to the left at $16\frac{1}{3}$ cm/s
13 a When $t = \frac{2}{3}$ s and $a = -2 \text{ cm/s}^2$, and when
 $t = 1$ and $a = 2 \text{ cm/s}^2$
b When $t = \frac{5}{6}$ and the particle is moving
to the left at $\frac{1}{6}$ cm/s
14 When $t = 2$ s, $v = 6 \text{ cm/s}$, $a = -14 \text{ cm/s}^2$
When $t = 3$ s, $v = -5 \text{ cm/s}$, $a = -8 \text{ cm/s}^2$
When $t = 8$ s, $v = 30 \text{ cm/s}$, $a = 22 \text{ cm/s}^2$
15 a $t = 4$ s and $t = -1$ s **b** $t = \frac{3}{2}$ s

Exercise 18G

- 1 a** $x = 2t^2 - 6t$ **b** At the origin O
c 9 cm **d** 0 cm/s **e** 3 cm/s
2 a $x = t^3 - 4t^2 + 5t + 4$, $a = 6t - 8$
b When $t = 1$, $x = 6$; when $t = \frac{5}{3}$, $x = 5\frac{23}{27}$
c When $t = 1$, $a = -2 \text{ cm/s}^2$;
when $t = \frac{5}{3}$, $a = 2 \text{ cm/s}^2$
3 $x = 215\frac{1}{3}$, $v = 73$
4 a $v = -10t + 25$ **b** $x = -5t^2 + 25t$
c 2.5 s **d** $31\frac{1}{4}$ m **e** 5 s
5 The 29th floor

Exercise 18H

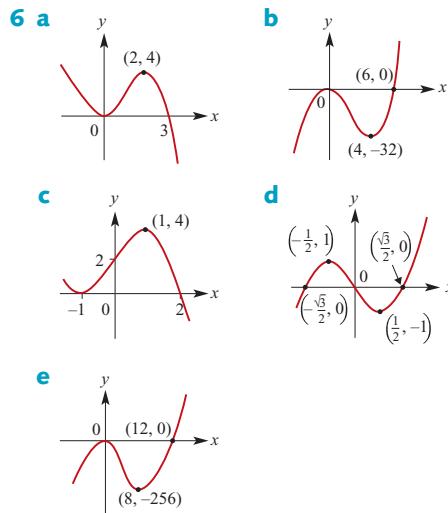
- 1 a** $(x - 2)(3x - 2(b + 1))$
b $(2, 0)$, $\left(\frac{2(b+1)}{3}, \frac{-4(b-2)^3}{27}\right)$ **d** $b = 5$
2 a $(0, 0)$ and $(9, -2187)$
b (a, b) and $(9 + a, -2187 + b)$
3 a i $(-\infty, \frac{1}{2a})$ **ii** $\left(\frac{1}{2a}, \infty\right)$
b $y = -x + \frac{1}{a}$ **c** $y = x - \frac{1}{a}$ **d** $\left(-\infty, \frac{1}{4a}\right]$
4 a $(a, 0)$ and $\left(\frac{a+2}{3}, \frac{4(a-1)^3}{27}\right)$
b Local minimum at $(a, 0)$
Local maximum at $\left(\frac{a+2}{3}, \frac{4(a-1)^3}{27}\right)$
c i $y = (a-1)^2(x-1)$ **ii** $y = 0$
iii $y = \frac{-(a-1)^2}{4}(x-a)$
5 a i $2(a-2)$ **ii** $m = 2(a-2)$
b $(a, (a-2)^2)$
c $y = 2(a-2)x - a^2 + 4$ **d** $\frac{a+2}{2}$

- 6 a** $h = 2$ **b** $a = 3$ **c** $a = -16, b = -24$
7 a $(0, 0)$ **b** (a, b)
8 a $2(x-1)(x-b)(2x-b-1)$
b $(1, 0), (b, 0), \left(\frac{b+1}{2}, \frac{(b-1)^4}{16}\right)$ **c** $b = 3$

Chapter 18 review

Short-answer questions

- 1 a** $\frac{dy}{dx} = 4 - 2x$ **b** 2 **c** $y = 2x + 1$
2 a $3x^2 - 8x$ **b** -4 **c** $y = -4x$ **d** $(0, 0)$
3 a $3x^2 - 12$; $x = \pm 2$
b Local minimum when $x = 2$
Local maximum when $x = -2$
c $x = 2, y = -14$; $x = -2, y = 18$
4 a Stationary point of inflection at $x = 0$
b Maximum at $x = 0$
c Min at $x = 3$, max at $x = 2$
d Min at $x = 2$, max at $x = -2$
e Max at $x = 2$, min at $x = -2$
f Max at $x = 3$, min at $x = 1$
g Max at $x = 4$, min at $x = -3$
h Max at $x = 3$, min at $x = -5$
5 a $\left(-\frac{2}{3}, -\frac{16}{9}\right)$ minimum, $\left(\frac{2}{3}, \frac{16}{9}\right)$ maximum
b $(-1, 0)$ maximum, $(2, -27)$ minimum
c $\left(\frac{2}{3}, \frac{100}{27}\right)$ maximum, $(3, -9)$ minimum



- 6 a** C **b** A **c** B
8 a 20 m **b** 6 s **c** 40 m/s
9 72
10 a $\frac{15}{2} \text{ m/s}$ **b** $\frac{128}{3} \text{ m}$ **c** 0 m **d** $\frac{64}{9} \text{ m/s}$

Multiple-choice questions

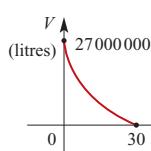
- 1 D** **2 E** **3 E** **4 A** **5 C** **6 D**
7 D **8 A** **9 A** **10 C** **11 A** **12 A**

Extended-response questions

1 a -14 m/s

b -8 m/s^2

2 a



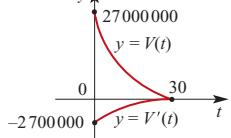
b i 17.4 minutes **ii** 2.9 minutes

c $\frac{dV}{dt} = -3000(30-t)^2$

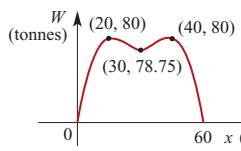
d 30 minutes

e 28.36 minutes

f



3 a



b From 5.71 days until 54.29 days

c When $x = 20$ and when $x = 40$, $\frac{dW}{dx} = 0$;

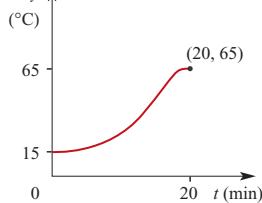
When $x = 60$, $\frac{dW}{dx} = -12$ tonnes per day

d When $x = 30$, $W = 78.75$

4 a 15°C

b $0^\circ\text{C}/\text{min}$, $\frac{45}{16}^\circ\text{C}/\text{min}$, $\frac{15}{4}^\circ\text{C}/\text{min}$,
 $\frac{45}{16}^\circ\text{C}/\text{min}$, $0^\circ\text{C}/\text{min}$

c

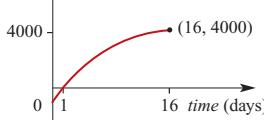


5 a 768 units/day

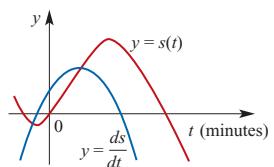
b 432, 192, 48, 0

c $t = 16$

d sweetness (units)



6 a



b 11:59 a.m., 12:03 p.m.

c $\frac{5}{27} \text{ km}, 1 \text{ km}$

d $\frac{8}{27} \text{ km/min} = 17\frac{7}{9} \text{ km/h}$

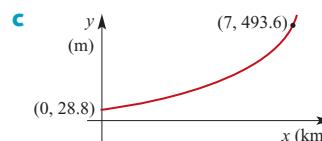
e $\frac{1}{3} \text{ km/min} = 20 \text{ km/h}$

7 a $0 \leq t \leq 12$

b i 27 L/h **ii** 192 L/h

8 a 28.8 m

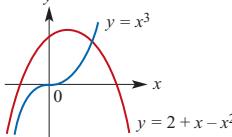
b 374.4



d Path gets too steep after 7 km

e i 0.0384 **ii** 0.0504 **iii** 0.1336

9 a



b For $x \leq 0$, the minimum vertical distance occurs when $x = -1$; Min distance = 1 unit

10 8 mm for maximum and $\frac{4}{3}$ mm for minimum

11 a $y = 5 - x$ **b** $P = x(5-x)$

c Max value is 6.25 when $x = 2.5$ and $y = 2.5$

12 a $y = 10 - 2x$ **b** $A = x^2(10 - 2x)$

c $A = \frac{1000}{27}$, $x = \frac{10}{3}$, $y = \frac{10}{3}$

13 $20\sqrt{10}$

14 a $y = 8 - x$ **b** $s = x^2 + (8-x)^2$ **c** 32

15 $\frac{4}{3}, \frac{8}{3}$

16 Maximum area is 625 m^2 for $25 \text{ m} \times 25 \text{ m}$

17 $x = 12$ **18** 32

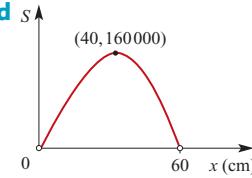
19 Maximum value of P is 2500

20 Maximum area is 2 km^2 for $2 \text{ km} \times 1 \text{ km}$

21 $p = \frac{3}{2}$, $q = \frac{8}{3}$

22 a $y = 60 - x$ **b** $S = 5x^2(60 - x)$

c $0 < x < 60$



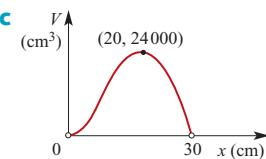
e $x = 40, y = 20$

f 74 005

23 12°C

24 b $0 < x < 30$

c



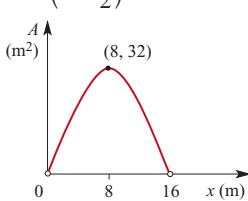
d 20 cm, 40 cm, 30 cm

e $x = 14.82$ or $x = 24.4$

- 25 b** Maximum when $x = 3$ and $y = 18$
26 a Use 44 cm for circle and 56 cm for square
b Use all the wire for the circle
27 Length 7.2 metres, width 4.5 metres

28 a $A = xy$ **b** $A = \left(8 - \frac{x}{2}\right)x$

c $0 < x < 16$

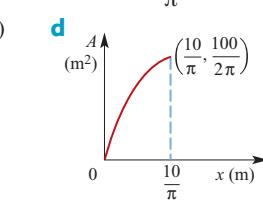


e 32 m^2

29 $h = 1188$, $a = 937$

30 a $y = 10 - \pi x$ **b** $0 \leq x \leq \frac{10}{\pi}$

c $A = \frac{x}{2}(20 - \pi x)$



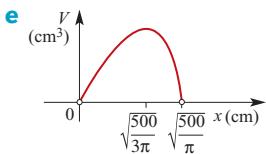
e Maximum at $x = \frac{10}{\pi}$

f A semicircle

31 a $h = \frac{500}{\pi x} - x$ **b** $V = 500x - \pi x^3$

c $\frac{dV}{dx} = 500 - 3\pi x^2$ **d** $x = 10\sqrt{\frac{5}{3\pi}} \approx 7.28$

e $V = \frac{500}{\pi}x - \frac{1}{3}\pi x^4$ **f** 2427.89 cm^3



g $x = 2.05$, $h = 75.41$ or $x = 11.46$, $h = 2.42$

32 a $r = 4.3 \text{ cm}$, $h = 8.6 \text{ cm}$

b $r = 4.3 \text{ cm}$, $h = 8.6 \text{ cm}$

Chapter 19

Short-answer questions

1 $36 \text{ cm}^2/\text{cm}$

2 a 1 cm/s **b** 41 cm/s

3 a i -4 **ii** -3 **b** $-2 - h$ **c** -2

4 $x - 1$

5 a $6x^2 - 1$ **b** $2x + 1$ **c** 1

6 a 13 **b** 10

7 a $x = 0$ or $x = \frac{1}{2}$ **b** $x = \frac{1}{4}$ **c** $x < \frac{1}{4}$

d $x > \frac{1}{4}$ **e** $x = \frac{11}{4}$

8 a $-6x^{-4} + x^{-2}$ **b** $\frac{2z - 9}{z^4}$

9 Tangent $y = -3x - 1$; Normal $y = \frac{1}{3}x - \frac{13}{3}$

10 a $t = 0$ and $t = 2$

b $t = 0$, $a = -1 \text{ cm/s}^2$; $t = 2$, $a = 1 \text{ cm/s}^2$

c $-\frac{1}{2} \text{ cm/s}$

11 Local minimum $\left(\frac{2}{\sqrt{3}}, -\frac{32}{3\sqrt{3}}\right)$

Local maximum $\left(-\frac{2}{\sqrt{3}}, \frac{32}{3\sqrt{3}}\right)$

Multiple-choice questions

1 C **2** A **3** B **4** A **5** B **6** A

7 D **8** B **9** C **10** A **11** C **12** B

13 A **14** C **15** C **16** A **17** D **18** E

19 C **20** B **21** E **22** D **23** A **24** A

25 C **26** D **27** B **28** B **29** B **30** C

31 D **32** E **33** A **34** A **35** C **36** C

37 D **38** D **39** D

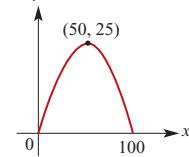
Extended-response questions

1 a 100

c $x = 50$, $y = 25$

b $\frac{dy}{dx} = 1 - 0.02x$

d y



e i $(25, 18.75)$ **ii** $(75, 18.75)$

2 a $\left(66\frac{2}{3}, 14\frac{22}{27}\right)$

b i 0.28 **ii** -0.32 **iii** -1

c A gradual rise to the turning point and a descent which becomes increasingly steep (in fact, alarmingly steep)

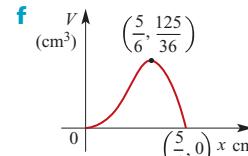
d Smooth out the end of the trip

3 a $h = 5 - 4x$

c $0 < x < \frac{5}{4}$

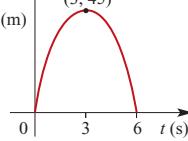
d $\frac{dV}{dx} = 30x - 36x^2$

e $\left\{0, \frac{5}{6}\right\}$; Maximum volume = $3\frac{17}{36} \text{ cm}^3$

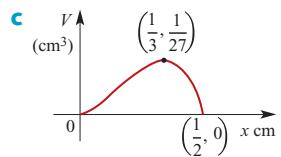


4 a $\frac{dh}{dt} = 30 - 10t$ **b** 45 m

c h



5 a $A = 4x - 6x^2$ **b** $V = x^2 - 2x^3$

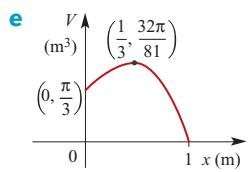


d $\frac{1}{3}$ cm \times $\frac{1}{3}$ cm \times $\frac{1}{3}$ cm; Volume = $\frac{1}{27}$ cm³

6 a i $r = \sqrt{1 - x^2}$ **ii** $h = 1 + x$

c $0 < x < 1$

d i $\frac{dV}{dx} = \frac{\pi}{3}(1 - 2x - 3x^2)$ **ii** $\{\frac{1}{3}\}$ **iii** $\frac{32\pi}{81}$ m³



7 a 1000 insects **b** 1366 insects

c i $t = 40$ **ii** $t = 51.70$

d 63.64

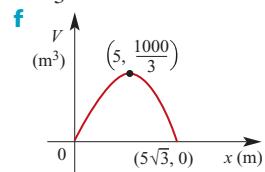
e i $\frac{1000 \times 2^{\frac{3}{4}}}{h} (2^{\frac{h}{20}} - 1)$

ii Consider h decreasing and approaching zero; instantaneous rate of change
= 58.286 insects/day

8 a $h = \frac{150 - 2x^2}{3x}$ **b** $V = \frac{2}{3}(150x - 2x^3)$

c $\frac{dV}{dx} = 2(50 - 2x^2)$ **d** $0 < x < 5\sqrt{3}$

e $\frac{1000}{3}$ m³ when $x = 5$



9 a 10

c i $h = 2.5x$

d $V = 40(420x - 135x^2)$

e i $x = \frac{14}{9}$, $y = \frac{140}{9}$ **ii** $13,066\frac{2}{3}$ m³

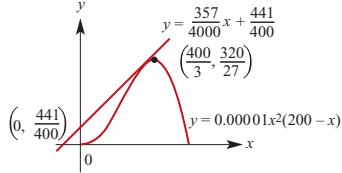
10 a $a = 200$, $k = 0.00001$

b i $\frac{400}{3}$ **ii** $\frac{320}{27}$ **c i** $\frac{8379}{800}$ **ii** $\frac{357}{4000}$

d i $y = \frac{357}{4000}x + \frac{441}{400}$ **ii** $\frac{441}{400}$

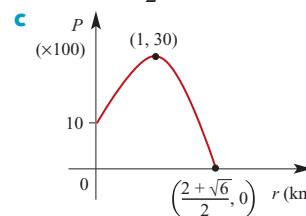
e 0.09975

f

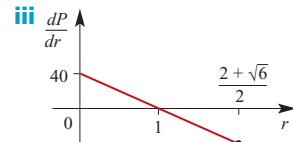


11 a 10 000 people/km²

b $0 \leq r \leq \frac{2 + \sqrt{6}}{2}$



d i $\frac{dP}{dr} = 40 - 40r$ **ii** 20, 0, -40



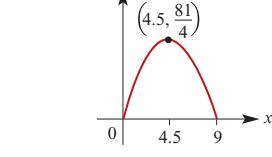
e At $r = 1$

12 a $y = ax - x^2$ **b** $0 < x < a$ **c** $\frac{a^2}{4}, \frac{a}{2}$

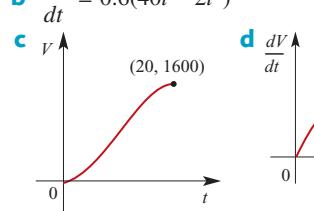
d Negative coefficient of x^2 for quadratic function

e i

Graph of y vs x . The curve is a downward-opening parabola segment. Key points marked: $(0, 0)$, $(\frac{a}{2}, \frac{a^2}{4})$, and $(a, 0)$.



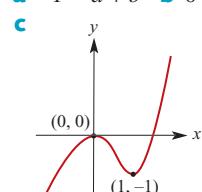
b $\frac{dV}{dt} = 0.6(40t - 2t^2)$



d $\frac{dV}{dt}$

Graph of $\frac{dV}{dt}$ vs t . The curve is a straight line starting at $(0, 0)$ and passing through $(10, 120)$, continuing downwards.

14 a $-1 = a + b$ **b** $0 = 3a + 2b$, $a = 2$, $b = -3$



15 a i $80 - 2x$ **ii** $h = \frac{\sqrt{3}}{2}x$

b $A = \frac{\sqrt{3}}{4}x(160 - 3x)$

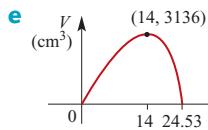
c $x = \frac{80}{3}$

16 a $y = \frac{1400 - 2x^2 - 8x}{4x}$

b $V = -\frac{x^3}{2} - 2x^2 + 350x$

c $\frac{dV}{dx} = -\frac{3}{2}x^2 - 4x + 350$

d $x = 14$



f Maximum volume is 3136 cm^3

g $x = 22.83$ and $y = 1.92$, or
 $x = 2.94$ and $y = 115.45$

Chapter 20

Short-answer questions

1 $x = 4$

2 $t = \frac{2d-b}{a-2c}$

3 $x \geq -\frac{3}{2}$

4 **a** -12 **b** 3 **c** 100

5 15

6 $x \leq \frac{37}{5}$

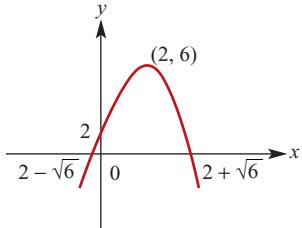
7 $a = 7.9$

8 **a** $\left(\frac{a+8}{2}, \frac{b+14}{2}\right)$ **b** $a = 2, b = 6$

9 **a** $4y - 3x = 30$ **b** $\frac{25}{2}$

10 **a** $(2, \frac{1}{2})$ **b** $\sqrt{445}$ **c** $11x + 18y = 31$
d $22y - 36x + 61 = 0$

11



12 $f(x) = \frac{9}{8}(x-2)^2 - 6$

13 $a = -2$

14 **a** $w = 1500 - 9x$ **b** $V = 20x^2(1500 - 9x)$
c $0 \leq x \leq \frac{500}{3}$ **d** $120\,000\,000 \text{ cm}^3$

15 400 tiles

16 **a** $\frac{16}{81}$ **b** $\frac{28}{153}$

17 $\frac{1}{3}$

18 **a** $\frac{1}{2}$ **b** $\frac{1}{3}$

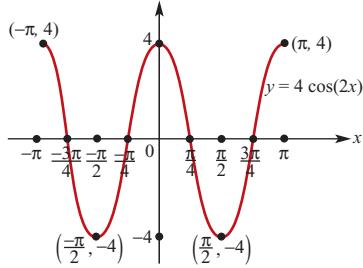
19 0.42

20 $-\frac{\pi}{9}, \frac{\pi}{9}$

21 **a** $c = 6$ **b** $0 = -8a - 2b + 6, 0 = 3a + b$
c $a = 3, b = -9$

22 $a = -48$

23 **a** Amplitude = 4; Period = π
b



24 **a** 0.3 **b** $400(2 - \sqrt{2})$

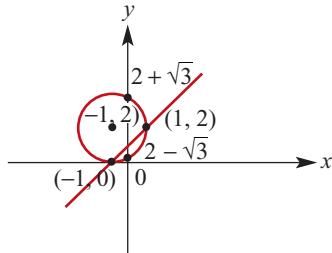
25 **a** $\left(\frac{2}{3}\right)^c$

b Area = 15 cm^2 ; Perimeter = 16 cm

26 **a** $\frac{1}{4}$ **b** $\frac{1}{3}$ **c** $\frac{1}{4}$

27 **a** $(0, 1)$

b



28 $4\sqrt{19} \text{ km}$

29 **a** $x = 3$ **b** $x = -\frac{5}{2}$ or $x = 1$

30 403

31 $x = \frac{1}{3}$ or $x = -\frac{1}{2}$

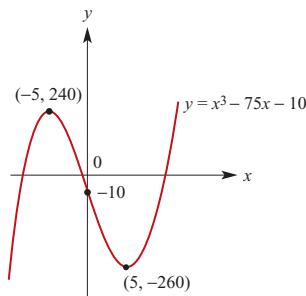
32 $k = 4$ and $y = -2x^2 + 4x + 3$

33 $a = \frac{1}{3}$

34 $b = -\frac{1}{3}$

35 Intersect at $(-3, -27)$; both curves have gradient 27 at this point

36 **a** $(5, -260)$ and $(-5, 240)$



b $-260 \leq p \leq 240$

37 **a** $\mathbb{R} \setminus \{3\}$ **b** $\mathbb{R} \setminus \{2\}$
c $(-\infty, 2]$
d $[4, \infty)$ **e** $(-\infty, 5)$

Multiple-choice questions

- | | | | | |
|-------------|-------------|-------------|-------------|-------------|
| 1 B | 2 A | 3 D | 4 D | 5 D |
| 6 C | 7 C | 8 A | 9 B | 10 A |
| 11 B | 12 A | 13 E | 14 A | 15 E |
| 16 A | 17 B | 18 A | 19 B | 20 A |
| 21 B | 22 C | 23 C | 24 D | 25 D |
| 26 C | 27 B | 28 A | 29 B | 30 B |
| 31 B | 32 E | 33 E | 34 D | 35 D |
| 36 B | 37 D | 38 A | 39 C | 40 A |
| 41 C | 42 D | 43 D | | |

Extended-response questions

1 a i $-b$ ii $x = \frac{b}{2}$

b i $S(b) = \frac{b}{2}(32 - b^2)$ ii $b = 2$

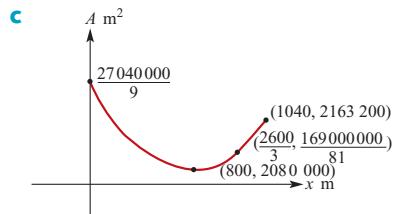
2 a $a = 4$ b $\left(\frac{1}{4}, 4\right)$ c $\frac{34}{15}$

3 a $2t^2 - 6t$ b O c 0 cm/s d 9 cm e 3 cm/s

4 a $y = 13 - 9x$ b $A = 156x - 60x^2$

c $x = \frac{13}{10}$ and $y = \frac{13}{10}$

5 b $2\ 080\ 000 \text{ m}^2$ when $x = 800$ and $y = 1200$



6 a i $(-\infty, 0) \cup \left(\frac{2a}{3}, \infty\right)$ ii $\left(0, \frac{2a}{3}\right)$

b $y = -a^2(x - a)$ c $y = \frac{x}{a^2} - \frac{1}{a}$

- 7 a** $\{(0, 1), (0, 3), (0, 5), (0, 7), (0, 9), (0, 11), (2, 1), (2, 3), (2, 5), (2, 7), (2, 9), (2, 11), (4, 1), (4, 3), (4, 5), (4, 7), (4, 9), (4, 11), (6, 1), (6, 3), (6, 5), (6, 7), (6, 9), (6, 11), (8, 1), (8, 3), (8, 5), (8, 7), (8, 9), (8, 11), (10, 1), (10, 3), (10, 5), (10, 7), (10, 9), (10, 11)\}$

b i $\frac{1}{36}$ ii $\frac{5}{36}$ iii $\frac{5}{36}$ c $\frac{2}{13}$

8 a i $a = 50\ 000$, $d = 5000$

ii 11th month iii $4\ 950\ 000 \text{ litres}$

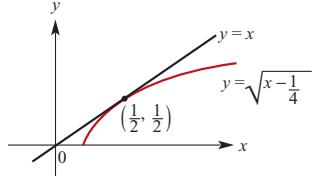
b i $q_n = 12\ 000(1.1)^{n-1}$

ii 256 611 litres

c 31st month

9 a $x \geq 2a$ b $x = \frac{1 \pm \sqrt{1 - 8a}}{2}$ c $a = \frac{1}{8}$

d



10 a 0.343 b 0.399

11 a 0.4219 b 0.2156 c 0.6125

12 a 155 m

b i 16.00 m ii 29.04 m iii 17°

c 32.7 cm^2

13 a $[-mb + 3, -ma + 3]$

b $\left(\frac{a+b}{2}, \frac{-m(a+b)+6}{2}\right)$

c $2ym - 2x = -m^2(a+b) + 6m - (a+b)$

d $y = -mx - 3m + 8$

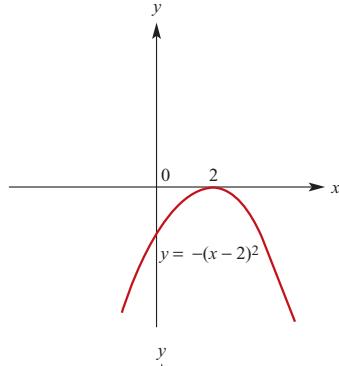
$A'(a - 3, -ma + 8)$, $B'(b - 3, -mb + 8)$

e $y = mx + 3$

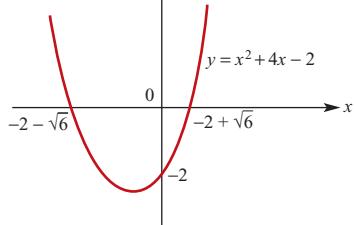
$A'(-a, -ma + 3)$, $B'(-b, -mb + 3)$

f $b = 12$, $m = \frac{7}{6}$

14 a i



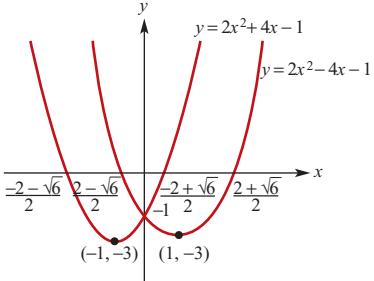
ii



b $\left(\frac{2}{1-p}, \frac{p^2 - 5p}{p-1}\right)$ c $p = 0$ or $p = 5$

d $0 < p < 5$ and $p \neq 1$

e $y = 2x^2 - 4x - 1$



15 a $\frac{\pi}{6}$ b $115\sqrt{2} \text{ cm}$ c $115\sqrt{3} \text{ cm}$