

Answers

1 Indices

1.1 Multiplication and Division

- (a) 20 (b) 21 (c) 36 (d) 42 (e) 45 (f) 18
(g) 28 (h) 49 (i) 40 (j) 8 (k) 9 (l) 4
(m) 7 (n) 7 (o) 9 (p) 0 (q) 0 (r) 0
- (a) 3 (b) 7 (c) 4 (d) 8 (e) 3 (f) 4 (g) 9
(h) 7 (i) 3 (j) 7 (k) 4 (l) 5 (m) 2 (n) 4
(o) 7 (p) 0 (q) 0 (r) 0
- 24
- 27
- (a) 16 (b) 28 (c) 32
- (a) 6 (b) 3 (c) 4
- 8
- (a) 35 (b) 14 (c) 42
- (a) Daniel 70p, Joel 56p (b) Daniel has 14p more than Joel
- (a) 80 (b) 64 (c) 40
- £6
- (a) 9 (b) 7, with 1 left over
- Team A: 7, Team B: 21, Team C: 14, Team D: 14
- (a) 7 (b) 5

1.2 Squares, Cubes, Square Roots and Cube Roots

- (a) 25 (b) 36 (c) 1 (d) 49 (e) 6 (f) 1 (g) 7
(h) 5
- (a) 27 (b) 64 (c) 216 (d) 1000 (e) 3 (f) 10
(g) 6 (h) 4
- (a) 100 (b) 4 (c) 16 (d) 49 (e) 64 (f) 81
(g) 1 (h) 343 (i) 512 (j) 0 (k) 0 (l) 8
- (a) 10 (b) 2 (c) 9 (d) 8 (e) 4 (f) 3
- (a) 144 (b) 121 (c) 3375 (d) 2197 (e) 169 (f) 225
(g) 400 (h) 1331 (i) 11 (j) 20 (k) 13 (l) 15
(m) 15 (n) 13 (o) 12 (p) 11
- (a) 52 (b) 5 (c) 116 (d) 25 (e) 16 (f) 72
(g) 1001 (h) 100

1.3 Index Notation

1. (a) 4^5 (b) 3^3 (c) 6^7 (d) 7^4 (e) 18^3 (f) 19^2
 (g) 4^6 (h) 7^5 (i) 10^6 (j) 100^5
2. (a) 81 (b) 625 (c) 2401 (d) 10 000 (e) 1 (f) 729
 (g) 128 (h) 2 (i) 4096 (j) 4 (k) 1 (l) 25
3. (a) 2^{11} (b) 3^9 (c) 3^{13} (d) 4^5 (e) 5^4 (f) 5^5
 (g) 4^2 (h) 5^3 (i) 3^2 (j) 7^4 (k) 17^2 (l) 9^4
 (m) 4^5 (n) 4^{16} (o) 3^6 (p) $3^0 = 1$ (q) $3^1 = 3$
 (r) 3^5 (s) 3^7 (t) 4^7 (u) 5^0
4. (a) 2^2 (b) 2^3 (c) 2^4 (d) 2^6 (e) 3^3 (f) 5^2
 (g) 4^3 (h) 3^4 (i) 5^3
5. (a) 3^{13} (b) 2^8 (c) 4^{11} (d) 3^{10} (e) 2^9 (f) 2^{10}
 (g) 3^5 (h) 3^7 (i) 3^5 (j) 8^{10} (k) 7^3 (l) 9^2
 (m) 2^4 or 4^2 (n) 2^3 (o) 2^3
6. (a) 2^3 (b) 10^3 (c) 2^4 (d) 3^3 (e) 3^4 (f) 10^4
 (g) 5^4 (h) 4^3 (i) 6^4 (j) 2^0 (k) 6^2 (l) 5^0
7. (a) 2^6 (b) 3^4 (c) 6^6 (d) 5^6 (e) 2^8 (f) 4^6
 (g) 3^8 (h) 5^8 (i) 3^6
8. (a) 2^8 (b) 2^4 (c) 3^{10} (d) 5^3 (e) $(10^5)^3$ (f) $(7^5)^4$
9. (a) 3^6 (b) 2^{14} (c) 5^{12} (d) 7^3 (e) 7^4 (f) 2^7
 (g) $3^0 = 1$ (h) $4^1 = 4$ (i) $2^1 = 2$
10. (a) a^5 (b) a^{10} (c) x^9 (d) x^2 (e) y^3 (f) p^3
 (g) q^3 (h) x^8 (i) b^3 (j) b^6 (k) c^3 (l) x^5
 (m) y^2 (n) $x^0 = 1$ (o) x^8 (p) p^4 (q) x^3 (r) y^4
 (s) $x^0 = 1$ (t) $x^1 = x$ (u) x^{12} (v) x^8 (w) x^{15}
 (x) x^{54}
11. (a) $p = 3$ (b) $q = 0$
12. $2x^4$

1.4 Factors

- (a) 1, 2, 7, 14 (b) 1, 3, 9, 27 (c) 1, 2, 3, 6 (d) 1, 3, 5, 15
 (e) 1, 2, 3, 6, 9, 18 (f) 1, 5, 25 (g) 1, 2, 4, 5, 8, 10, 20, 40
 (h) 1, 2, 4, 5, 10, 20, 25, 50, 100 (i) 1, 3, 5, 9, 15, 45
 (j) 1, 2, 5, 10, 25, 50 (k) 1, 2, 3, 4, 6, 9, 12, 18, 36 (l) 1, 2, 4, 7, 14, 28
- (a) 1×10 , 2×5 , 5×2 , 10×1 (b) 1×8 , 2×4 , 4×2 , 8×1
 (c) 1×7 , 7×1 (d) 1×9 , 3×3 , 9×1
 (e) 1×16 , 2×8 , 4×4 , 8×2 , 16×1 (f) 1×22 , 2×11 , 11×2 , 22×1
 (g) 1×11 , 11×1
 (h) 1×24 , 2×12 , 3×8 , 4×6 , 6×4 , 8×3 , 12×2 , 24×1
- (a) 4 (b) 3 (c) 3 (d) 4 (e) 5 (f) 4 (g) 11
 (h) 1
- (a) 6, 10, 20, 8, 2, 24, 4 (b) 10, 20, 15, 55
- (a) (i) 20, 22, 24, 26 (ii) 21, 24, 27 (iii) 20, 25
 (b) prime numbers
- (a) (i) 16 (ii) 18 (b) (i) 25 (ii) 27

1.5 Prime Factors

- 2, 3, 5, 7, 13, 19, 23
- 53, 59
- (a) 2×5 (b) $2 \times 3 \times 7$ (c) $2^2 \times 17$ (d) $2^3 \times 3 \times 7$
 (e) 2×5^3 (f) $2 \times 3^3 \times 5$ (g) $3 \times 11 \times 13$ (h) $3 \times 5^2 \times 11$
 (i) $7 \times 11 \times 13$
- (a) $32 = 2^5$ and $56 = 2^3 \times 7$ (b) $2^3 (= 8)$
- (a) $2 \times 3 = 6$ (b) $2 \times 3 = 6$ (c) $3 \times 5 = 15$ (d) 2
 (e) $2 \times 5 = 10$ (f) $5 \times 7 = 35$ (g) $2^3 \times 3 = 24$
 (h) $2 \times 3 \times 13 = 78$ (i) $3 \times 7^2 = 147$
- (a) $45 = 3^2 \times 5$, $99 = 3^2 \times 11$, $135 = 3^3 \times 5$
 (b) (i) $3^2 = 9$ (ii) $3^2 = 9$ (iii) $3^2 \times 5 = 45$ (c) $3^2 = 9$
- (a) 5 (b) $3^2 \times 5 = 45$ (c) $2^3 = 8$ (d) $2 \times 5 = 10$
 (e) $2^3 \times 3 = 24$ (f) $2 \times 3 \times 5 = 30$ (g) $2^2 \times 3^3 = 108$
 (h) $2^2 \times 11 = 44$ (i) $2^2 \times 3^2 \times 7 = 252$

1.6 Further Index Notation

1. (a) $\frac{1}{16}$ (b) $\frac{1}{8}$ (c) $\frac{1}{6}$ (d) $\frac{1}{7}$ (e) 3 (f) 8 (g) 2
 (h) 3 (i) 1 (j) $\frac{1}{25}$ (k) 8 (l) 32 (m) 2187
 (n) 125 (o) $\frac{1}{2}$
2. (a) -4 (b) -1 (c) -3 (d) $\frac{1}{2}$ (e) $-\frac{1}{2}$ (f) 2
 (g) 3 (h) -1 (i) $\frac{1}{3}$ (j) -1 (k) -2 (l) -2
 (m) -3 (n) $\frac{1}{2}$ (o) -2 (p) $\frac{1}{3}$ (q) $\frac{2}{3}$ (r) $\frac{2}{5}$
3. (a) 0.125 (b) 0.05 (c) 2 (d) 4 (e) $\frac{1}{225} = 0.004444\dots$
 (f) 0.000125 (g) 729 (h) 27 (i) $\frac{1}{2}$ (j) 1728
 (k) 62748517 (l) 1331
4. (a) $\frac{1}{a}$ (b) a^{10} (c) a^4 (d) $\frac{1}{a^6}$ (e) $\frac{1}{a^2}$ (f) $\frac{1}{a^6}$
 (g) a^8 (h) $a^{\frac{5}{2}}$ (i) $\frac{1}{a^{\frac{3}{2}}}$ (j) a^2 (k) $\frac{1}{a^3}$ (l) a^3
 (m) $\frac{a^2}{b^2}$ (n) $\frac{a^6}{b^{12}}$ (o) $a^{12}b^2$ (p) $\frac{b^4}{a^4}$ (q) $\frac{a^8}{b^{12}}$
 (r) $\frac{m^2}{n^6}$ (s) $\frac{a^3}{b^5}$ (t) $\frac{m^2}{a}$ (u) $\frac{c^3}{a^4b}$ (v) $\frac{x}{m^2}$
 (w) $\frac{z^{12}}{x^8y^4}$ (x) $\frac{b^{\frac{16}{3}}}{a^2}$
5. (a) $\frac{1}{9}$ (b) a^4 (c) $y = \frac{5}{2}$

1.7 Standard Form

1. (a) 4.7×10^4 (b) 5.21×10^4 (c) 3.2×10^7 (d) 3.241×10^5
 (e) 4.2×10^2 (f) 8.1×10^4 (g) 5×10^3 (h) 4.7×10^{10}
 (i) 3.2×10^9 (j) 6.2×10^{-4} (k) 5.71×10^{-2} (l) 2.0×10^{-7}
 (m) 1.24×10^{-1} (n) 3.71×10^{-2} (o) 2.1×10^{-4} (p) 7×10^{-5}
 (q) 4.71×10^{-1} (r) 3×10^{-4}
2. (a) 1×10^6 (b) 1.5×10^4 (c) 6.4×10^6 (d) 3.04×10^7
 (e) 4×10^6 (f) 4×10^5
3. (a) 600 000 (b) 431 (c) 58 600 000 (d) 0.00083 (e) 4172
 (f) 0.0000642 (g) 47 (h) 0.32 (i) 0.000847
 (j) 334 000 000 (k) 0.0003471 (l) 842.1 (m) 16.75
 (n) 0.0000084 (o) 0.000712
4. (a) Yes (b) No: 4.32×10^3 (c) No: 1.56×10^{-7}
 (d) No: 4×10^2 (e) Yes (f) No: 7×10^{-5} (g) Yes
 (h) No: 5.471×10^4 (i) Yes
5. (a) 6×10^4 (b) 1.6×10^7 (c) 1.25×10^5 (d) 4×10^{-3}
 (e) 2×10^{-3} (f) 1.6×10^{-3} (g) 2.8×10^{-3} (h) 8.8×10^3
 (i) 9×10^{-4} (j) 9×10^2 (k) 4×10^{-4} (l) 1×10^4
6. (a) 5×10^4 (b) 6.2×10^5 (c) 1.456×10^6
7. (a) $365 \times 24 = 8.76 \times 10^3$ (b) $7 \times 24 \times 60 = 1.008 \times 10^4$
 (c) $24 \times 60^2 = 8.64 \times 10^4$
8. (a) 6370 km (b) $6370000 = 6.37 \times 10^6$
 (c) $2 \times \pi \times 6.37 \times 10^6 = 4.0024... \times 10^7$
9. 5 900 000 000 000 000 000 000 000 000 10. 3×10^{-2} mm
11. 4.82×10^8 kg
12. (a) 153 000 000 km and 147 000 000 km
 (b) 1.53×10^{11} m and 1.47×10^{11} m
13. (a) 4.444355556×10^9 (b) 3.68785269×10^8 (c) 8×10^9
 (d) 1.536×10^{11} (e) 1.6544×10^{10} (f) 2.24×10^9

1.8 Calculations with Standard Form

1. (a) 6×10^{12} (b) 8×10^8 (c) 9×10^{16} (d) 2×10^{12}
 (e) 2.4×10^{15} (f) 1.2×10^7 (g) 2.88×10^{11} (h) 2.2×10^2
 (i) 5.832×10^7 (j) 6.76×10^{-4} (k) 1.302×10^{-8}
 (l) 4.5×10^{-13}
2. (a) 4×10^4 (b) 3×10^3 (c) 2×10^2 (d) 8×10^2
 (e) 1.2×10^6 (f) 1.2×10^9 (g) 2.7×10^{-1} (h) 5×10^7
 (i) 4.1×10^{19} (j) 1.1×10^8 (k) 3×10^9 (l) 1.1×10^{-10}
3. (a) 1.764×10^{13} (b) 1.369×10^{-3} (c) 1.728×10^{-15}
 (d) $2.846... \times 10^4$ (e) 7.44×10^{22} (f) 1.558×10^{-7}
 (g) $9.5833... \times 10^{-2}$ (h) 1.46875×10^3 (i) 5.0625×10^{-10}
 (j) $2.449... \times 10^2$ (k) 5.12×10^{11} (l) 6.753×10^{12}
4. (a) 8.64×10^5 (b) 6.048×10^5 (c) 3.1536×10^7
5. (a) 2.73×10^{-12} kg (b) 3.64×10^2 kg (c) 6.37×10^{-22} kg
6. 1.26×10^{12} mm²
7. (a) (i) 3.32×10^3 m (ii) 9.96×10^5 m (iii) 1.328×10^1 m
 (b) (i) $3.012... \times 10^{-2}$ s (ii) $6.024... s$ (iii) $6.024... \times 10^{-5}$ s
8. (a) 3×10^{10} m (b) 5×10^2 s (8 min 20 s)
9. (a) 3.84×10^8 m (b) 9.6×10^5 s (266 hours 40 min)
10. (a) 1×10^6 cm³ (b) 1.3 kg (c) $2.30769... \times 10^3$ cm³
 (d) 9×10^{-2} kg, $3.333... \times 10^4$ cm³
11. $4.5 \times 10^9 \times (1.03)^{10} = 6.0476... \times 10^9$
12. (a) 52 000 000 (b) 1.2×10^{-1} cm 13. 8.54×10^8
14. 1.845×10^{11} tonnes (2 $\times 10^{11}$ to 1 s.f.)
15. (a) 4.29981696 (b) 3×10^{-2}
16. (a) 1.496×10^8 (b) $2.5752... \times 10^6$
17. (a) 5×10^{101} (b) 5×10^{-8}

2 Formulae

2.1 Using Formulae

- (a) $A = 8, P = 12$ (b) $A = 30, P = 26$ (c) $A = 22, P = 26$
 (d) $A = 20, P = 18$
- (a) 16 (b) 12 (c) 15 (d) 20
- (a) 30 (b) 400
- (a) 30 (b) 12 (c) 17
- (a) 60 (b) 105 (c) 144
- (a) 26 (b) 14 (c) 19 (d) 46 (e) 18 (f) 12
 (g) 4 (h) 2 (i) 26 (j) 50 (k) 30 (l) 40 (m) 6
 (n) 10
- £130 8. 17.4 cm

2.2 Construct and Use Simple Formulae

- (a) $P = 2a + b, P = 16$ (b) $P = 4a, P = 20$ (c) $P = 5a + b, P = 40$
 (d) $P = a + 2b + c, P = 27$ (e) $P = 6a, P = 60$
 (f) $P = 2a + 2b + 2c, P = 36$ (g) $P = 2a + 2b + c, P = 520$
 (h) $P = 3a + b, P = 21$
- (a) $A = ab, A = 60 \text{ cm}^2$ (b) $A = a^2, A = 9 \text{ cm}^2$
 (c) $A = a^2 + ab, A = 20 \text{ cm}^2$ (d) $A = ab + bc, A = 48 \text{ cm}^2$
 (e) $A = \frac{1}{2}ab, A = 10 \text{ cm}^2$ (f) $A = \frac{1}{2}ab + b^2, A = 45000 \text{ cm}^2$
- (a) $(x + 1)$ and $(x + 2)$ (b) $T = 3x + 3$
- (a) $M = \frac{x + y}{2}$ (b) $M = \frac{p + q + r + s + t}{5}$
- (a) $T = 3p + 2q$ (b) £190
- (a) $P = 2x + 2(x + 3) = 4x + 6$ (b) $A = x(x + 3)$
- (a) $x + 1$ (b) $x - 3$ (c) $S = 3x - 2$
- (a) $C = 3 + 2n$ (b) £19
- (a) $C = 1 + 2m$ (b) £7

2.2

10. (a) $2n$ (b) $2n + 6$
11. (a) $100 - 8x$ (b) $(20 - 2x)(30 - 2x)$
12. $C = 27n$
13. (a) $C = 45l$ (b) $C = xl$
14. (a) $S = P + Q$ (b) (i) $S = X + 3250$ (ii) $S = X + 650n$

2.3 Revision of Negative Numbers

1. (a) -2 (b) 4 (c) -3 (d) -8 (e) 24 (f) 54
(g) 8 (h) -8 (i) 27 (j) 8 (k) -13 (l) -35
(m) -24 (n) -11 (o) -5 (p) 3 (q) 11 (r) 3
(s) -8 (t) -6 (u) -1
2. (a) 1 (b) 16 (c) 25 3. $-3\text{ }^\circ\text{C}$ 4. $24\text{ }^\circ\text{C}$

2.4 Substitution into Formulae

1. (a) 50 (b) 68 (c) 14 (d) 23 (e) -4 (f) 59
2. (a) 10 (b) 40 (c) 11.25 (d) 4 (e) -10 (f) 7.04
3. (a) 19.6 (b) 18.4 (c) 18.08 (d) 18.8
4. (a) -280 (b) -40 (c) 80 (d) 800 ; 4
5. (a) 80 (b) 51 (c) ± 4 (d) ± 3 (e) -3 (f) ± 5
(g) 0 (h) $\frac{3}{4}$ (i) 1 (j) 10 (k) -2 (l) -10
(m) ± 10 (n) 0.18 (o) 0.38 (p) ± 5 (q) ± 8 (r) ± 15
6. (a) 3.8 (b) 0.225 (c) 2.6 (d) 7.5 (e) 9.7 (f) 2.4
(g) 0.5 (h) 7.12 (i) 3.7
7. -21.67 (2 d.p.)
8. -13
9. (a) $-\frac{13}{8}$ (b) $-\frac{5}{8}$

2.5 More Complex Formulae

- (a) $\frac{12}{7}$ (b) -30 (c) $-\frac{21}{4}$ (d) $-\frac{20}{3}$
- (a) ± 1.3 (b) ± 8 (c) ± 3.4
- (a) $-\frac{3}{2}$ (b) $\frac{12}{25}$ (c) -10 (d) $\frac{10}{4} \left(= \frac{5}{2} \right)$ (e) -4
 (f) $-\frac{1}{3}$ (g) $-\frac{17}{7}$ (h) $\frac{7}{9}$ (i) 1
- (a) ± 5 (b) ± 12 (c) ± 7 (d) ± 11 (e) ± 2 (f) ± 13
- (a) $\frac{60}{11}$ (b) 588.24 (2 d.p.) (c) 572.67 (2 d.p.)
- 33.5
- (a) -32.3 (3 s.f.) (b) -30
- (a) i) 0.2kg ii) kg per cm^3 , kgcm^{-3} or $\frac{\text{kg}}{\text{cm}^3}$ (b) 2.29kg (2dp)

2.6 Changing the Subject

- (a) $x = \frac{y}{4}$ (b) $x = \frac{y-3}{2}$ (c) $x = \frac{y+8}{4}$ (d) $x = 4y - 2$
 (e) $x = 5y + 2$ (f) $x = y - a$ (g) $x = ya + b$ (h) $x = \frac{y-c}{a}$
 (i) $x = \frac{yc-b}{a}$ (j) $x = \frac{yb+c}{a}$ (k) $x = y - a - b$ (l) $x = yc + a - b$
 (m) $x = \frac{y}{ab}$ (n) $x = \frac{y-c}{ab}$ (o) $x = \frac{3cy+b}{4a}$ (p) $x = \frac{pd+bc}{a}$
 (q) $x = \frac{y}{b} - a$ (r) $x = \frac{4y}{a} - 3$ (s) $x = \frac{2q}{3} + 4$ (t) $x = \frac{4v}{5} - y$
 (u) $x = 4(z - a) + 3$
- $I = \frac{V}{R}$; $R = \frac{V}{I}$
- $m = \frac{F}{a}$; $a = \frac{F}{m}$
- $r = \frac{C}{2\pi}$
- (a) $t = \frac{v-u}{a}$ (b) $a = \frac{v-u}{t}$

6. $z = 3m - x - y$

7. (a) $a = \frac{v^2 - u^2}{2s}$ (b) $a = \frac{s}{(t + \frac{1}{2}t^2)}$

8. $z = \frac{v}{xy}$

9. (a) $r = +\sqrt{\frac{V}{\pi h}}$ (only a positive value because r is radius) (b) 2.82

10. (a) $h = \frac{V}{x^2}$; $h = \frac{A - 2x^2}{4x}$ (b) 2 (c) 2.5

11. (a) $a = \frac{2A}{h} - b$ (b) $A = \frac{1}{2} \times 3a \times h = \frac{3ah}{2}$; $a = \frac{2A}{3h}$

2.7 Further Change of Subject

1. (a) $x = \frac{5-y}{3}$ (b) $x = \frac{8-y}{6}$ (c) $x = \frac{a-y}{2}$ (d) $x = \frac{6-5y}{2}$

(e) $x = \frac{8-2y}{7}$ (f) $x = \frac{3y+5}{7}$ (g) $x = a - b - 2p$ (h) $x = 10 - aq$

(i) $x = \frac{q - rb}{5}$

2. (a) $a = 4q^2$ (b) $a = bz^2$ (c) $a = \frac{c}{z^2}$ (d) $a = \frac{3y^2}{8}$

(e) $a = 32bv^2$ (f) $a = \frac{\pi r^2}{25}$ (g) $a = 4p^2 - b$

(h) $a = b - 12r^2$ (i) $a = \frac{18}{c^2} - b$

3. (a) $\frac{2}{2a-1}$ (b) $\frac{1}{b+2}$ (c) $\frac{1}{2-x}$ (d) $\frac{3x}{3-x}$ (e) $\frac{5p}{5+p}$

(f) $\frac{6x}{3-x}$ (g) $\frac{4rv}{v-2r}$ (h) $\frac{7q}{q-7}$ (i) $\frac{ap}{p-a}$

4. (a) $g = \frac{4\pi^2 l}{T^2}$ (b) 10.07 (2 d.p.)

5. (a) $v = \frac{uf}{u-f}$ (b) -24

6. (a) $h = \frac{v^2}{2g}$ (b) 1.8 (c) $g = \frac{v^2}{2h}$ (d) 0.8

7. (a) $R = \frac{u^2}{g}$ (b) 14.4

$$8. \quad (a) \quad X = \frac{RYZ}{YZ - RZ - RY} \quad (b) \quad 24$$

$$9. \quad (a) \quad r = \sqrt[3]{\frac{3V}{4\pi}} \quad (b) \quad 2.62 \text{ (2 d.p.)}$$

2.8 Expansion of Brackets

$$1. \quad (a) \quad 3x + 3 \quad (b) \quad 4a + 8 \quad (c) \quad 3x - 18 \quad (d) \quad 15 - 5b \\ (e) \quad 16 - 2x \quad (f) \quad 3x + 12 \quad (g) \quad 10x - 24 \quad (h) \quad 12x - 30 \\ (i) \quad 6x + 21$$

$$2. \quad (a) \quad -2x - 12 \quad (b) \quad -3x - 6 \quad (c) \quad -6x + 18 \quad (d) \quad -7x + 14 \\ (e) \quad -8x - 4 \quad (f) \quad -15 + 10x \quad (g) \quad -6x + 16 \quad (h) \quad 12 + 3x \\ (i) \quad -16 + 32x$$

$$3. \quad (a) \quad x^2 + x \quad (b) \quad x - x^2 \quad (c) \quad x^2 - 6x \quad (d) \quad -3x^2 + 2x \\ (e) \quad -4x^2 + 6x \quad (f) \quad 4a^2 + 5a \quad (g) \quad 6a^2 - 15a \quad (h) \quad 12y^2 - 63y \\ (i) \quad 30y - 12y^2$$

$$4. \quad (a) \quad 2x - 13 \quad (b) \quad x^2 - 2x \quad (c) \quad 5x + 23 \quad (d) \quad 6x + 6 \\ (e) \quad 11x - 28 \quad (f) \quad n^2 + 10n - 8 \quad (g) \quad 2a + 28 \\ (h) \quad 3x^2 - 10x + 24 \quad (i) \quad 3x^2 - 5x$$

$$5. \quad (a) \quad x^3 + x^2 \quad (b) \quad 2x^3 - 10x^2 \quad (c) \quad 2x + 6 \quad (d) \quad 8x - 4 \\ (e) \quad 6x^3 - 12x \quad (f) \quad 4x^3 + 2x^2 + 4x \quad (g) \quad 2ap + aq + bp \\ (h) \quad 3ny + 4xy - 5nx \quad (i) \quad 2xp$$

$$6. \quad (a) \quad x^2 + 4x \quad (b) \quad a^2 - a \quad (c) \quad x^2 - 2x$$

$$7. \quad (a) \quad 2(x + 1) \quad (b) \quad 2x + 2 \quad (c) \quad \text{Double then add 2} \\ (d) \quad x(x + 1) = x^2 + x \quad \text{Think of a number, multiply it by itself then add the original number.}$$

$$8. \quad (a) \quad b \quad (b) \quad c - a \quad (c) \quad b(c - a) \quad (d) \quad bc - ba$$

2.9 Factorisation

- (a) 5 (b) 2 (c) 5 (d) $(3x + 2)$ (e) $(3 - n)$
 (f) $(2x - 7)$ (g) $(2a + 3)$ (h) $(11x - 3)$
- (a) $6(x + 4)$ (b) $5(x - 4)$ (c) $8(2 - x)$ (d) $4(2n + 3)$
 (e) $2(6x - 7)$ (f) $3(a - 8)$ (g) $11(x - 6)$ (h) $5(2 + 5x)$
 (i) $20(5x - 2)$ (j) $10(5 - 4x)$ (k) $6(x - 5)$ (l) $5(y - 9)$
 (m) $12(1 + 3x)$ (n) $16(x + 2)$ (o) $3(9x - 11)$
- (a) x (b) x (c) a (d) $(4x + 1)$ (e) $(x + 4)$
 (f) $(2x + 1)$ (g) $(a + b)$ (h) $(2x - a)$
- (a) $x(5x + 1)$ (b) $a(a + 3)$ (c) $n(5n + 2)$ (d) $3n(2n + 1)$
 (e) $5n(n - 2)$ (f) $3x(x + 2)$ (g) $15x(x - 2)$ (h) $7x(2x + 3)$
 (i) $8x(2x + 3)$ (j) $6x(5x - 3)$ (k) $5(1 + n^2)$ (l) $5(2n^2 - 3)$
 (m) $3n(n^2 + 3)$ (n) $9x(x - 3)$ (o) $5x^2(2x - 1)$
- (a) $ax(1 + x)$ (b) $x(b + cx)$ (c) $2q(p - 2r)$ (d) $5y(3x - y)$
 (e) $8p(2q + 3p)$ (f) $6x(x + 3y)$ (g) $3p(p - 3x)$
 (h) $8x(3p + 7x)$ (i) $2xy(8x - 9y)$
- (a) $2x(3x + 2)$ (b) $8x^2(2x + 1)$ (c) No (d) $3xy(x - 6y)$
- (a) $6x(6 + x)$ (b) $x = \frac{y-3}{5}$

2.10 Algebraic Manipulation

- (a) $-a - b$ (b) $\frac{b-d}{a-c}$ (c) $\frac{-1}{a-b}$ (d) $4a + 6$ (e) $\frac{c-b}{3}$
 (f) $\frac{a-c}{b-d}$ (g) $\frac{a-2}{3}$ (h) a (i) $\frac{p+q}{q-p}$ (j) $3a + 2b$
 (k) $\frac{-5-a}{3}$ (l) $\frac{ab}{4-a}$
- (a) $\frac{P}{1-P}$ (b) $\frac{b}{P-a}$ (c) $\frac{Qa+b}{Q-1}$ (d) $\frac{q^2y+y}{q^2-1}$
 (e) $\frac{-2-3a}{a-1}$ (f) $\frac{4c-b}{3}$ (g) $\frac{p^2}{1-p^2}$ (h) $\frac{-2}{w^2-1}$ or $\frac{2}{1-w^2}$
 (i) $\frac{w^2+2}{1-w^2}$ (j) $\pm \sqrt{\frac{2}{p-1}}$ (k) $\pm \sqrt{\frac{3p-2}{p-1}}$ (l) $\pm \sqrt{\frac{gy+y}{1-g}}$

2.11 Algebraic Fractions

1. (a) $\frac{9x}{20}$ (b) $\frac{11x}{28}$ (c) $\frac{8x}{15}$ (d) $\frac{41y}{21}$ (e) $\frac{23y}{20}$ (f) $\frac{13y}{7}$
 (g) $\frac{19x}{70}$ (h) $\frac{x}{6}$ (i) $\frac{9x}{8}$ (j) $\frac{27x}{24}$ (k) $\frac{5a+4b}{20}$
 (l) $\frac{8x+3y}{24}$ (m) $\frac{5a-3b}{15}$ (n) $\frac{10a+12b}{15}$ (o) $\frac{32a-27b}{36}$
2. (a) $\frac{4y+2x}{xy}$ (b) $\frac{6y-x}{xy}$ (c) $\frac{y+3x}{xy}$ (d) $\frac{5}{a}$ (e) $\frac{8b+3a}{2ab}$
 (f) $\frac{10b-3a}{6ab}$ (g) $\frac{25b+12a}{15ab}$ (h) $\frac{23}{15a}$ (i) $\frac{17}{28a}$
 (j) $\frac{21b-16a}{24ab}$ (k) $\frac{1}{12a}$ (l) $\frac{11}{8a}$
3. (a) $\frac{2x+1}{x(x+1)}$ (b) $\frac{3x+4}{x(x+2)}$ (c) $\frac{7x+3}{x(x+1)}$ (d) $\frac{4x+10}{x(x+2)}$
 (e) $\frac{4x+2}{x(x+2)}$ (f) $\frac{14x-12}{3x(x+3)}$ (g) $\frac{-6}{x(x+1)}$ (h) $\frac{6x-10}{x(x-5)}$
 (i) $\frac{27x+42}{5x(x+6)}$ (j) $\frac{17x-49}{2x(x-7)}$ (k) $\frac{23x-50}{3x(x-10)}$ (l) $\frac{7x-8}{3x(x-8)}$
4. (a) $\frac{2x+3}{(x+1)(x+2)}$ (b) $\frac{2x}{(x+1)(x+1)}$ (c) $\frac{7}{(x+2)}$
 (d) $\frac{6x-28}{(x-2)(x-6)}$ (e) $\frac{-x-2}{(x+3)(x+4)}$ (f) $\frac{x+35}{(x+7)(x-7)}$
 (g) $\frac{8x+28}{(x-4)(8+x)}$ (h) $\frac{-2x+30}{(x-4)(x+7)}$ (i) $\frac{8x+27}{(x+6)(x-1)}$
 (j) $\frac{5x-2}{(2x+6)(3x-8)}$ (k) $\frac{-6x}{(2x+5)(5-4x)}$ (l) $\frac{17x-7}{(2x-1)(3x-1)}$
 (m) $\frac{37x+13}{(2x+3)(5x-1)}$ (n) $\frac{18x+4}{(3x-7)(2x+3)}$ (o) $\frac{29x+9}{(5x-4)(2x+3)}$
5. (a) $\frac{3x^2}{(x+1)(x-2)}$ (b) $\frac{15x}{(x-7)(2x+1)}$ (c) $\frac{5x^2-3x}{(x-1)(3x-1)}$
 (d) $\frac{x^2+3x+12}{(x+3)(x-1)}$ (e) $\frac{8x^2+11x}{(x-3)(x+4)}$ (f) $\frac{5x}{(2-x)(4x-3)}$
 (g) $\frac{5x^2-13x}{(5-x)(x+1)}$ (h) $\frac{-4x^2-14x}{(4+x)(x+6)}$ (i) $\frac{x^2-4x-18}{(x+6)(x-1)}$

3 Angle Geometry

3.1 Measuring Angles

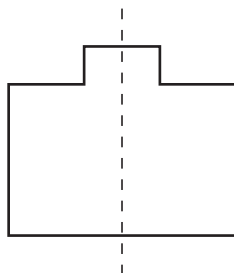
Note that measured angles are approximate answers

- (a) 78° (b) 120° (c) 60° (d) 130° (e) 125° (f) 60°
- (a) 315° (b) 195° (c) 240° (d) 325° (e) 264°
(f) 350°
- (a) $a = 62^\circ, b = 118^\circ$ (b) $a = 58^\circ, b = 76^\circ, c = 46^\circ$
(c) $a = 104^\circ, b = 76^\circ$ (d) $a = 42^\circ, b = 74^\circ, c = 64^\circ$
The angles add up to 180°
- (a) $50^\circ, 60^\circ, 70^\circ$ (b) $31^\circ, 59^\circ, 90^\circ$ (c) $15^\circ, 19^\circ, 147^\circ$
(d) $33^\circ, 40^\circ, 107^\circ$ The three angles add up to 180°
- (a) $a = 150^\circ, b = 90^\circ, c = 120^\circ$ (b) $a = 152^\circ, b = 116^\circ, c = 63^\circ, d = 29^\circ$
(c) $a = 48^\circ, b = 154^\circ, c = 35^\circ, d = 123^\circ$ (d) $a = 45^\circ, b = 45^\circ, c = 270^\circ$
In each case the angles add up to 360°
- (c) 7.7 cm and 6.4 cm, 90°
- (b) 11.5 cm, $34^\circ, 66^\circ$
- (a) $34^\circ, 34^\circ, 51^\circ, 241^\circ$ (b) $25^\circ, 29^\circ, 98^\circ, 208^\circ$
In both cases the angles add up to 360°
- The interior angles will always add up to 540°

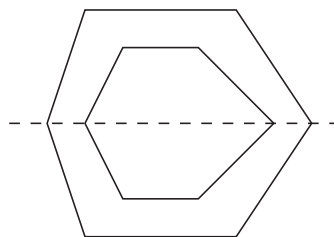
3.2 Line and Rotational Symmetry

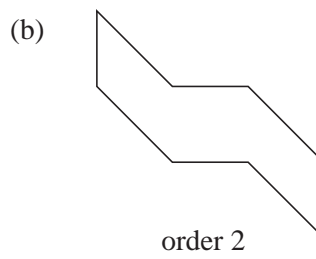
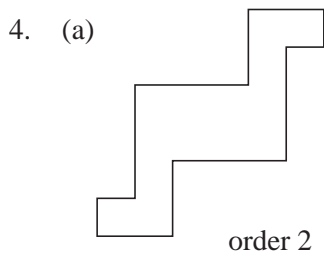
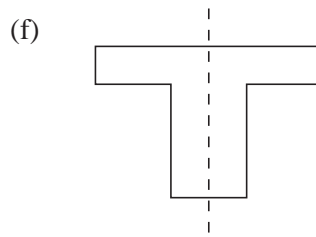
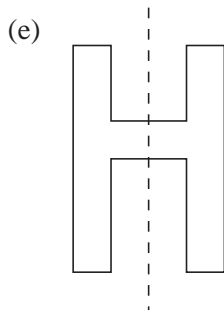
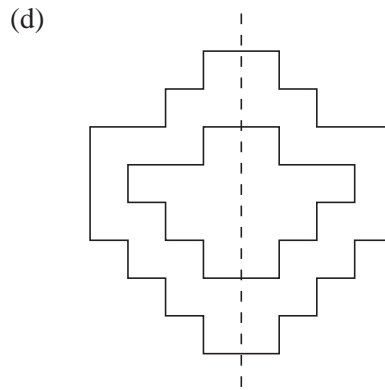
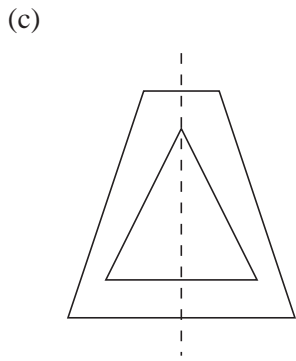
- (a) B - 2 lines, D - 2 lines, E - 1 line, F - 1 line, G - 4 lines, I - 1 line
(b) A - order 4, B - order 2, D - order 2, G - order 4, H - order 3
- A - has symmetry, no lines, order 3
C - has symmetry, 1 line, no order
E - has symmetry, 1 line, no order
G - has symmetry, 1 line, no order
I - no symmetry, no lines, no order
B - has symmetry, 1 line, no order
D - has symmetry, 1 line, no order
F - has symmetry, 4 lines, order 8
H - has symmetry, no lines, order 4

- (a)

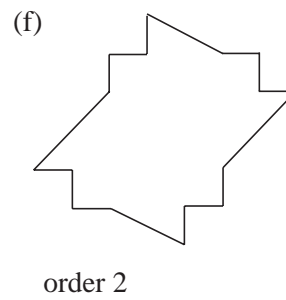
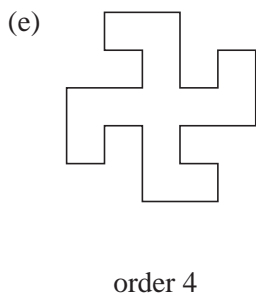
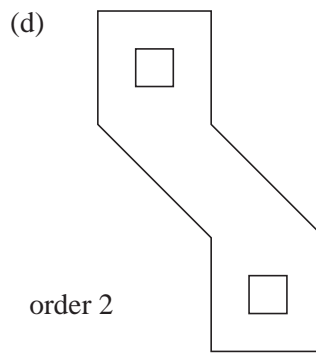


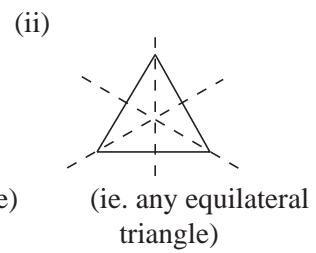
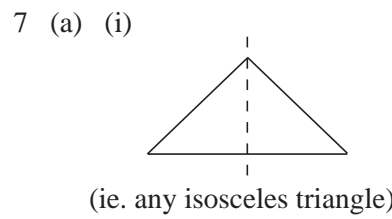
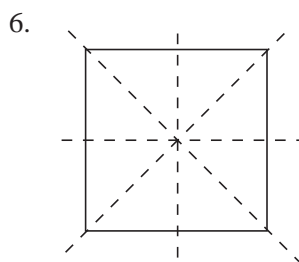
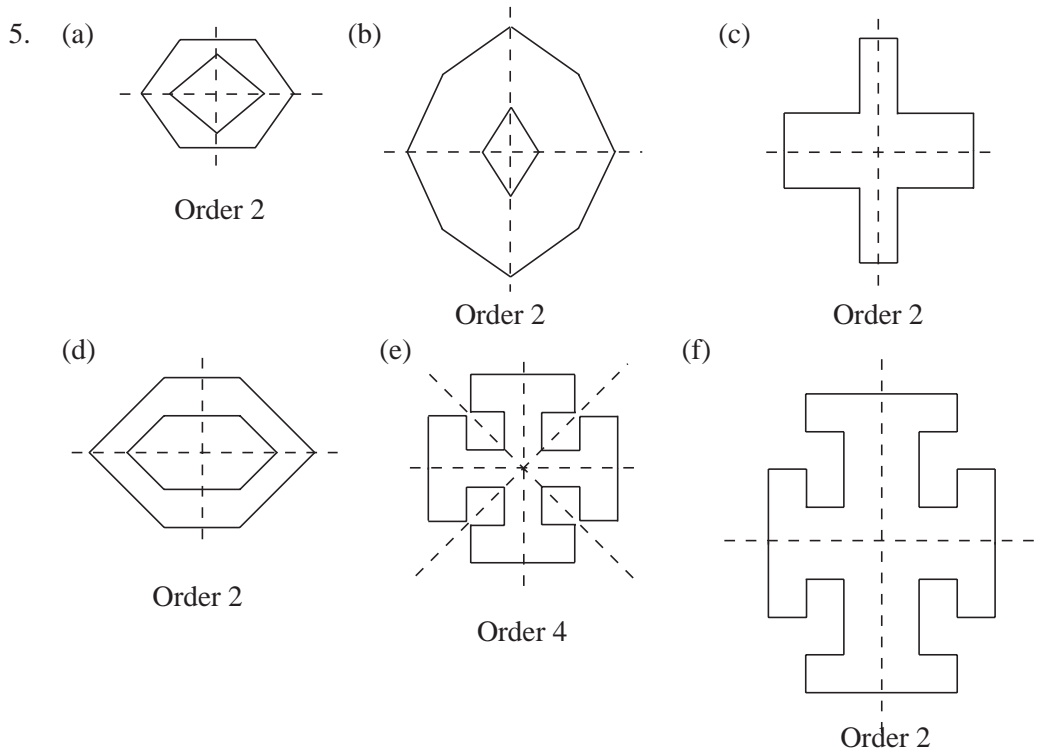
- (b)



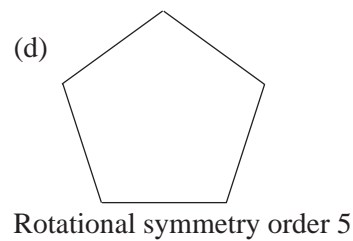
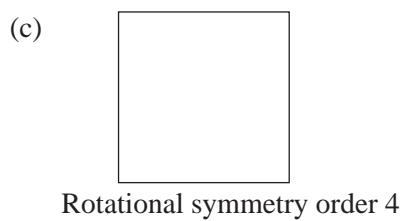
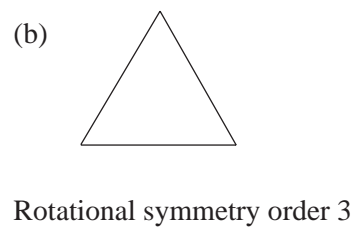
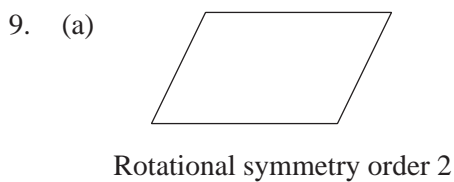
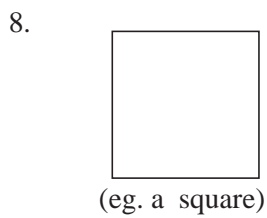


(c) Not possible



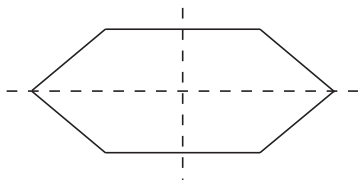


(b) No.



10. (a) No

(b)

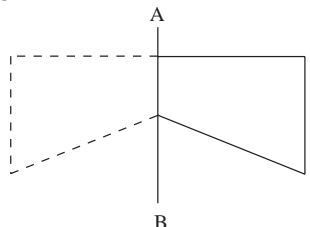


(c) No

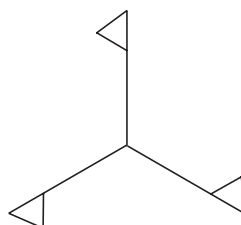
11. Letter I has rotational symmetry.

12. Designs (a), (b) and (d) have line symmetry.

13. (a)



(b)



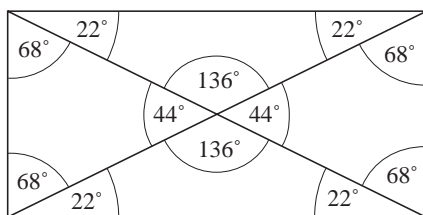
(c) Rotational symmetry of order 2.

3.3 Angle Geometry

1. (a) $a = 50^\circ$ (b) $x = 130^\circ$ (c) $b = 92^\circ$ (d) $a = 80^\circ$
 (e) $a = 111^\circ$ (f) $x = 82^\circ$ (g) $x = 110^\circ$ (h) $a = 45^\circ$
 (i) $x = 55^\circ$ (j) $a = b = 70^\circ$ (k) $a = b = c = 60^\circ$
 (l) $a = 50^\circ, b = 80^\circ$ (m) $a = 109^\circ$ (n) $x = 114^\circ$ (o) $x = 87^\circ$

2. (a) (i) $a = 70^\circ, b = 110^\circ$ (ii) $a = 53^\circ, b = 127^\circ$ (iii) $a = 48^\circ, b = 132^\circ$
 (b) b is equal to the sum of the two opposite angles in the triangle.
 (c) (i) $b = 105^\circ$ (ii) $b = 106^\circ$ (iii) $b = 135^\circ$

3.



4. (a) $a = 75^\circ, b = 75^\circ, c = 30^\circ, d = 75^\circ$
 (b) $a = 60^\circ, b = 60^\circ, c = 30^\circ, d = 60^\circ, e = 60^\circ, f = 60^\circ, g = 30^\circ$
 (c) $a = 80^\circ, b = 45^\circ, c = 45^\circ, d = 55^\circ, e = 80^\circ$
 (d) $a = 30^\circ, b = 20^\circ, c = 10^\circ, d = 80^\circ, e = 80^\circ, f = 60^\circ$
5. (a) $a = 65^\circ, b = 80^\circ$ (b) $a = 40^\circ,$
 (c) $a = 60^\circ, b = 60^\circ, c = 60^\circ, d = 120^\circ, e = 30^\circ$
 (d) $a = 65^\circ, b = 65^\circ, c = 58^\circ, d = 90^\circ, e = 35^\circ$
 (e) $a = 90^\circ, b = 97^\circ, c = 41.5^\circ, d = 41.5^\circ, e = 69^\circ, f = 69^\circ, g = 104^\circ,$
 $h = 38^\circ$
 (f) $a = 60^\circ, b = 60^\circ, c = 60^\circ, d = 80^\circ, e = 100^\circ, f = 40^\circ, g = 40^\circ,$
 $h = 120^\circ, i = 38^\circ$

6. $a = 44^\circ, b = 68^\circ, c = 68^\circ, d = 112^\circ, e = 112^\circ, f = 68^\circ$
7. $a = 50^\circ, b = 40^\circ, c = 70^\circ, d = 20^\circ, e = 65^\circ, f = 50^\circ$
8. $a = 25^\circ, b = 110^\circ, c = 45^\circ, d = 65^\circ, e = 70^\circ, f = 25^\circ, g = 25^\circ$
9. (a) $9x = 180^\circ, x = 20^\circ$ (b) $3x - 30 = 180^\circ, x = 70^\circ$
 (c) $3x + 30 = 180^\circ, x = 50^\circ$ (d) $5x = 360^\circ, x = 72^\circ$
 (e) $4x + 20 = 180^\circ, x = 40^\circ$ (f) $4x = 360^\circ, x = 90^\circ$
 (g) $17x + 20 = 360^\circ, x = 20^\circ$ (h) $2x = 30^\circ, x = 15^\circ$
 (i) $5x + 90 = 360^\circ, x = 54^\circ$ (j) $10x + 80 = 180^\circ, x = 10^\circ$
 (k) $6x = 150^\circ, x = 25^\circ$ (l) $13x + 22 = 360^\circ, x = 26^\circ$
10. (a) order = 6 (b) (i) $\text{AOB} = 60^\circ$ (ii) Equilateral triangle
11. $\text{BCD} = 134^\circ$ $\text{ABC} = 77^\circ$

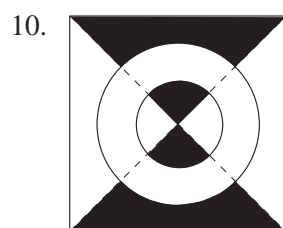
3.4 Angles with Parallel and Intersecting Lines

1. (a) $a = 38^\circ$, Opposite angles
 (b) $a = 57^\circ$, Opposite angles, $b = 123^\circ$, Straight line
 (c) $a = 60^\circ$, Straight line, $b = 120^\circ$, Opposite angles, $c = 60^\circ$, Opposite angles
 (d) $a = 100^\circ$, Straight line, $b = 100^\circ$, Opposite angles
 (e) $a = 145^\circ$, Straight line, $b = 35^\circ$, Opposite angles, $c = 145^\circ$, Opposite angles
 (f) $a = 50^\circ$, Corresponding angles
 (g) $a = 40^\circ$, Corresponding angles, $b = 140^\circ$, Straight line
 (h) $a = 60^\circ$, Straight line, $b = 60^\circ$, Corresponding angles, $c = 120^\circ$, Straight line
 (i) $a = 42^\circ$, Opposite angles, $b = 138^\circ$, Supplementary angles,
 $c = 42^\circ$, Corresponding angles
 (j) $a = 100^\circ$, Straight line, $b = 80^\circ$, Opposite angles, $c = 100^\circ$, Opposite angles
 $d = 80^\circ$, Corresponding angles
 (k) $a = 25^\circ$, Opposite angles, $b = 155^\circ$, Straight line,
 $c = 25^\circ$, Corresponding angles
 (l) $a = 124^\circ$, Alternate angles, $b = 56^\circ$, Straight line
 (m) $a = 37^\circ$, Corresponding angles, $b = 143^\circ$, Straight line,
 $c = 37^\circ$, Opposite angles
 (n) $a = 56^\circ$, Corresponding then Opposite angles, $b = 124^\circ$, Straight line,
 $c = 124^\circ$, Corresponding then Opposite angles,
 (o) $a = 160^\circ$, Straight line, $b = 160^\circ$, Corresponding angles,
 $c = 20^\circ$, Alternate angles
2. (a) $a = 70^\circ, b = 140^\circ$
 (b) $a = 60^\circ, b = 110^\circ, c = 70^\circ, d = 120^\circ$
 (c) $a = 52^\circ, b = 128^\circ, c = 52^\circ, d = 128^\circ$
 (d) $a = 75^\circ, b = 105^\circ, c = 75^\circ, d = 105^\circ$

- (e) $a = 60^\circ, b = 80^\circ, c = 80^\circ$
 (f) $a = 70^\circ, b = 50^\circ, c = 60^\circ, d = 70^\circ, e = 70^\circ$
 (g) $a = 74^\circ, b = 100^\circ, c = 41^\circ, d = 115^\circ$
 (h) $a = 48^\circ, b = 48^\circ, c = 132^\circ, d = 138^\circ, e = 42^\circ, f = 48^\circ$
 (i) $a = 64^\circ, b = 52^\circ, c = 64^\circ$
 (j) $a = 38^\circ, b = 52^\circ, c = 52^\circ$
3. (a) $4x = 180^\circ, x = 45^\circ$ (b) $10x = 360^\circ, x = 36^\circ$
 (c) $8x = 180^\circ, x = 22.5^\circ$ (d) $9x = 180^\circ, x = 20^\circ$
 (e) $6x = 180^\circ, x = 30^\circ$ (f) $8x = 180^\circ, x = 22.5^\circ$
4. AB is parallel to EF, GH is parallel to IJ
5. $a = 80^\circ, b = 50^\circ, c = 80^\circ, d = 50^\circ$
6. (a) AC and BD are parallel (b) $\angle BAC = 50^\circ$ because AEC is isosceles
7. (a) Square, Rectangle, Rhombus and Parallelogram
 (b) Rectangle, Parallelogram, Kite, Rhombus and Square
8. (a) 36° ; alternate angles (b) 54° ; angle POQ is 90°
9. (a) $p = 48^\circ$ (b) $q = 84^\circ$ (c) Alternate angles

3.5 Angle Symmetry in Polygons

1. (a) 108° (b) 120° (c) 135° (d) 144°
2. (a) 1260° (b) 1620°
3. (a) Square (b) Hexagon (c) Pentagon (d) Nonagon
 (e) Triangle (f) Decagon
4. Many possible solutions
6. (a) (i) No (ii) No (iii) No (b) (i) Yes (ii) No (iii) No
7. (a) 1260° (b) $180^\circ, 360^\circ, 540^\circ, 720^\circ, 900^\circ, 1080^\circ$
 (c) $180n - 360$ (d) 2160° (e) 9
8. (a) $\frac{360}{n}$ (b) $180 - \frac{360}{n}$ (c) 162°
9. (a) 2 (c) (i) 5 (ii) 72°



3.5

11. (a) 45° (b) 135°
12. (b) (ii) 120° (c) (i) 2 (ii) 6 (d) Cube

3.6 Symmetry Properties of 3D Shapes

2. (a) 4 (b) 2 (c) 4 (d) 4
3. (d) Not possible
5. 8 planes of symmetry along solid, 1 plane of symmetry through cross section
5 axes of symmetry

3.7 Compass Bearings

1. (a) Katie (b) James (c) Hester (d) Robin (e) Tom
(f) Simon (g) NE
2. (a) 100° (b) 155° (c) 177° (d) 355° (e) 207°
(f) 180°
3. (a) (i) 150° (ii) 090° (iii) 055° (b) 230 m
4. (a) 128° (b) 267° (c) 257° (d) 317° (e) 100°
5. (a) 535 m, 450 m (b) 38 m (c) 348° , 67 km (d) 293°
(e) 073° , 465 m
6. (a) 315° , 169 m (b) 203° , 400 km (c) 015° , 545 km
(d) 043° , 10 km (e) 348° , 8.5 km (f) 015° , 15.5 km
(g) 175° , 1430 m
7. 188° , 7000 km
8. (a) Kendal (b) Taunton
9. (5 km, 50°)
10. (a) (i) 20° (ii) alternate angles (iii) 48°
(b) (i) 052° (ii) 212° (iii) 312°
12. (a) 103°

3.8 Angles and Circles 1

1. (a) $a = 90^\circ$, $b = 65^\circ$
(b) $a = 72^\circ$, $b = 90^\circ$
(c) $a = 90^\circ$, $b = 76^\circ$, $c = 90^\circ$, $d = 74^\circ$
(d) $a = 90^\circ$, $b = 58^\circ$, $c = 90^\circ$, $d = 32^\circ$
(e) $a = 90^\circ$, $b = 49^\circ$, $c = 60^\circ$, $d = 60^\circ$, $e = 30^\circ$, $f = 30^\circ$, $g = 120^\circ$
(f) $a = 40^\circ$, $b = 100^\circ$, $c = 50^\circ$, $d = 50^\circ$, $e = 80^\circ$
(g) $a = 44^\circ$, $b = 44^\circ$, $c = 46^\circ$, $d = 46^\circ$, $e = 88^\circ$, $f = 44^\circ$
(h) $a = 70^\circ$, $b = 40^\circ$, $c = 140^\circ$, $d = 20^\circ$, $e = 20^\circ$

3. (a) $a = 90^\circ, b = 65^\circ$ (b) $a = 74^\circ$ (c) $a = 90^\circ, b = 90^\circ, c = 50^\circ, d = 75^\circ$
 (d) $a = 10^\circ, b = 170^\circ$
4. (a) $a = 20^\circ, b = 140^\circ$ (b) $a = 25^\circ, b = 25^\circ$ (c) $a = 30^\circ, b = 120^\circ$
 (d) $a = 100^\circ, b = 40^\circ, c = 40^\circ$
 (e) $a = 48^\circ, b = 84^\circ, c = 42^\circ, d = 42^\circ, e = 96^\circ$
 (f) $a = 75^\circ, b = 75^\circ, c = 15^\circ, d = 15^\circ, e = 150^\circ$
 (g) $a = 69^\circ, b = 69^\circ, c = 42^\circ, d = 69^\circ, e = 69^\circ$
 (h) $a = 28^\circ, b = 124^\circ, c = 70^\circ, d = 40^\circ, e = 16^\circ$
5. (a) $a = 30^\circ, b = 70^\circ, c = 70^\circ, d = 80^\circ$ (b) $a = 110^\circ, b = 140^\circ$
 (c) $a = 110^\circ, b = 140^\circ, c = 40^\circ, d = e = f = g = 70^\circ$
 (d) $a = b = 65^\circ, c = 60^\circ, d = 115^\circ$
6. (a) 5 (b) 7.8 (c) 12 (d) 10

3.9 Angles and Circles 2

1. (a) 30° (b) 120° (c) $c = d = 35^\circ$ (d) 146°
 (e) $f = 90^\circ, g = 55^\circ$ (f) $x = y = 43^\circ$
 (g) $a = 65^\circ, b = 25^\circ, c = 25^\circ, d = 65^\circ$ (h) $a = 27^\circ, b = 126^\circ, c = 63^\circ$
2. (a) $\text{OAB} = \text{OBA}, \text{BAC} = \text{BFC}, \text{OGA} = \text{OAG}, \text{OFC} = \text{OCF},$
 $\text{OCB} = \text{OBC}, \text{FCB} = \text{ACD} = \text{GAC}$
 (b) angles $\text{GAC}, \text{ACD}, \text{BCF}$
3. (a) $a = 120^\circ, b = 75^\circ$ (b) $c = 149^\circ, d = 123^\circ$
 (c) $a = 55^\circ, b = 125^\circ$ (d) $c = 140^\circ$ (e) $a = 48^\circ, b = 75^\circ$
 (f) $a = 75^\circ, b = 100^\circ$ (g) $a = 85^\circ, b = 30^\circ$ (h) $x = 160^\circ$
4. ABCD and PQR
5. (a) $a = 37^\circ, b = 108^\circ, c = 37^\circ$ (b) $a = 30^\circ, b = c = 75^\circ, d = 60^\circ, e = 30^\circ$
 (c) $a = 32.5^\circ, b = 147.5^\circ$ (d) 34°
6. (a) 50° (b) 22.5° (c) 40°
9. $x = 94^\circ, y = 28^\circ, z = 19^\circ$
10. (a) x (b) $90 - x$ (c) x (d) $2x$

3.10 Circles and Tangents

1. (a) 40° (b) $b = 55^\circ, c = 35^\circ$ (c) $a = b = c = 70^\circ$
 (d) $a = 11^\circ, b = 79^\circ, c = 79^\circ, d = 22^\circ$ (e) $a = 52^\circ, b = 104^\circ$
 (f) $a = b = c = 24^\circ, d = 62^\circ$
2. (a) 4.8 (b) $\frac{8}{3}$ (c) $x = 3.9, y = 4$ (d) $x = 7, y = 3.5$
 (e) $x = 4, y = 6$ (f) $x = 3, y = 2$
3. (c) 6
4. (b) 30°
5. $a = 74^\circ, b = 36^\circ, c = 32^\circ$
6. (a) $x = 65,$ (b) $y = 130,$ (c) $z = 50$

4 Trigonometry

4.1 Squares and Triangles

- (a) Isosceles (b) Scalene (c) Equilateral (d) Isosceles
(e) Scalene (f) Equilateral (g) Isosceles (h) Isosceles
- (a) Isosceles (b) Scalene
- (a) 25 cm^2 (b) 49 cm^2 (c) 100 m^2 (d) 1 cm^2
- (a) 4 m^2 (b) $10\,000 \text{ m}^2$ (c) 225 cm^2 (d) 289 cm^2
- (a) 3 cm (b) 5 m (c) 10 m (d) 8 cm (e) 1 cm (f) 20m
- 32 cm^2
- 72 cm^2
- 9 cm^2

4.2 Pythagoras' Theorem

- (a) 5 m (b) 13 m (c) 9 cm (d) 24 m (e) 10 m (f) 8 cm
(g) 15 m (h) 39 cm
- (a) 13.04 cm (b) 20.52 cm (c) 8.94 cm (d) 8.60 m (e) 7.14 cm
(f) 8.94 cm (g) 7.81 m (h) 11.83 m (i) 14.97 cm (j) 6.40 m
(k) 10.47 m (l) 7.07 m (m) 7.22 cm (n) 4.89 m
- (a) 320 m (b) 233.2 m (c) 86.8 m
- 2.5 m
- 2.44 m
- 9.54 m
- 10.77 m
- 4.24 m
- 2.06 m
- (a) 10.44 km (b) 14.32 km
- 6.71 m
- (a) 295 m (b) X

4.3 Further Work with Pythagoras' Theorem

- (a) 7.14 (b) 7.07 (c) 5.39 (d) 7.75 (e) 10.95
(f) 14.28
- (a) 14.14 (b) 1.94 (c) 1.29 (d) 3.12
- (a) Yes (b) No (c) Yes (d) No
- (a) 3.46 m (b) 1.73 m (c) 5.69 m
- 122.47 cm
- 332.75 cm
- (a) 26.93 km (b) 26.93 km
- 28.21 cm
- 11.18 m, 11.18 m, 19.02 m
- 41.22 m, 48.21 m
- 7.75 cm; 15.49 cm²
- (a) 27.71 cm² (b) 173.21 cm² (c) 1.73 cm²

4.4 Sine, Cosine and Tangent

- | | | | |
|-----|------------|------------|----------|
| (a) | hyp : BC ; | adj : AC ; | opp : AB |
| (b) | hyp : DF ; | adj : DE ; | opp : EF |
| (c) | hyp : GI ; | adj : GH ; | opp : HI |
| (d) | hyp : LK ; | adj : LJ ; | opp : JK |
| (e) | hyp : MO ; | adj : MN ; | opp : NO |
| (f) | hyp : PQ ; | adj : RQ ; | opp : PR |
- | | | | |
|-----|---|---|---|
| (a) | $\sin \theta = \frac{3}{5}$ | $\cos \theta = \frac{4}{5}$ | $\tan \theta = \frac{3}{4}$ |
| (b) | $\sin \theta = \frac{5}{13}$ | $\cos \theta = \frac{12}{13}$ | $\tan \theta = \frac{5}{12}$ |
| (c) | $\sin \theta = \frac{15}{17}$ | $\cos \theta = \frac{8}{17}$ | $\tan \theta = \frac{15}{8}$ |
| (d) | $\sin \theta = \frac{2}{2.5} = \frac{4}{5}$ | $\cos \theta = \frac{1.5}{2.5} = \frac{3}{5}$ | $\tan \theta = \frac{2}{1.5} = \frac{4}{3}$ |
| (e) | $\sin \theta = \frac{48}{50}$ | $\cos \theta = \frac{14}{50}$ | $\tan \theta = \frac{48}{14}$ |
| (f) | $\sin \theta = \frac{3.5}{12.5} = \frac{7}{25}$ | $\cos \theta = \frac{12}{12.5} = \frac{24}{25}$ | $\tan \theta = \frac{3.5}{12} = \frac{7}{24}$ |

3. (a) 0.500 (b) 3.732 (c) 1.308 (d) 0.407 (e) 0.649
 (f) 1.000 (g) 0.754 (h) 1.000 (i) 0.707 (j) 0.669
 (k) 0.686 (l) 0.707
4. (a) 60° (b) 90° (c) 24.2° (d) 55.2° (e) 48.6° (f) 23.1°
 (g) 45° (h) 30° (i) 63.4° (j) 82.0° (h) 15.1° (i) 79.2°
6. (a) $\cos \theta = \frac{z}{x}$ (b) $\sin \alpha = \frac{z}{x}$ (c) $\tan \theta = \frac{y}{z}$ (d) $\cos \alpha = \frac{y}{x}$
 (e) $\sin \theta = \frac{y}{x}$ (f) $\tan \alpha = \frac{z}{y}$

4.5 Finding Lengths in Right Angled Triangles

1. (a) 5.14 cm (b) 11.82 cm (c) 5.13 cm (d) 6.06 cm (e) 9 cm
 (f) 8.21 cm (g) 10.63 cm (h) 18.38 cm (i) 15.59 cm (j) 6.68m
 (k) 10.28 m (l) 20 m (m) 11.30 m (n) 4.16 m (o) 7.43 m
2. (a) 3.71 m (b) 1.50 m
3. (a) 1.73 m (b) 1.21 m (c) 1 m
4. 0.60 m
5. 143.4 m
6. (a) 386.4 km (b) 103.5 km
7. (a) 103.9 km (b) 60 km
8. 20.5 m to 35.3 m
9. (a) 12.11 cm (b) 13.46 cm (c) 6.55 cm (d) 7 cm
 (e) 26.86 m (f) 38.83 m (g) 13.68 cm (h) 30.66 cm
 (i) 1.51m
10. (a) 1.88 m (b) 2.92 m
11. 124.5 cm
12. (a) 3.83 cm, 22.98 cm² (b) $a \tan \theta$; $\frac{1}{2} a^2 \tan \theta$
13. 10.34 m
14. (a) 4.44 cm (b) 7.56 cm

4.6 Finding Angles in Right Angled Triangles

- (a) 53.1° (b) 71.6° (c) 75.5° (d) 47.0° (e) 33.1°
(f) 18.6° (g) 29.1° (h) 14.5° (i) 45.6° (j) 14.5°
(k) 45.5° (l) 23.8°
- 60°
- 11.5°
- (a) 21.8° (b) 68.2°
- (a) 48.2° (b) 11.18 m
- 040°
- 306°
- (a) $\alpha = 33.7^\circ$, $\beta = 19.4^\circ$ (b) 7.21 m, 10 m
- 5.74°
- (a) 12.37 cm (b) 72.08°
- (a) 7.62 m (b) 30.96°

4.7 Mixed Problems with Trigonometry

- 8.82 m
- 12.50 m
- 7.13°
- 1.03°
- (a) 381.6 m (b) 1.91°
- 7.85 m
- 7.20 m
- (a) 8.76 m (b) 6.02 m (c) 6.56 m (d) 5.09 m
- (a) 57.15 m (b) 12.02 m 10. 23.58° ; 938.6 m
- (a) 8.96 m (b) 38.5° (c) 6.72 m
- (a) (i) 373.4 m (ii) 20.4° (b) 200.2 m

4.8 Sine and Cosine Rules

- (a) 51.6° (b) 52.3° (c) 48.8° (d) 69.4° (e) 34.2° (f) 56.0°
- (a) 5.43 (b) 9.05 (c) 6.01 (d) 30.13 (e) 9.84 (f) 4.77
- (a) $A = 52.8^\circ$ $B = 42.2^\circ$ $a = 3.68$
 (b) $A = 19.9^\circ$ $B = 50.1^\circ$ $b = 12.16$
 (c) $B = 73^\circ$ $b = 4.45$ $c = 3.56$
 (d) $A = 44.2^\circ$ $B = 56.8^\circ$ $a = 4.33$
- (a) Yes (b) No, only one (c) No, impossible even for one (d) Yes
- $B = 65.6^\circ$, $C = 47.4^\circ$, $b = 123.6$
- $A = 34.1^\circ$, $C = 64.9^\circ$, $a = 6.25$
- (a) $B = 52.4^\circ$, $C = 67.6^\circ$, $a = 3.28$ (b) $B = 25.1^\circ$, $C = 4.9^\circ$, $a = 17.66$
 (c) $A = 45.5^\circ$, $B = 106.6^\circ$, $C = 27.9^\circ$
 (d) $A = 120.5^\circ$, $B = 36.9^\circ$, $C = 22.6^\circ$
 (e) $b = 8.41$, $A = 64.92^\circ$, $C = 60.08^\circ$
 (f) $c = 9.81$, $A = 28.45^\circ$, $B = 21.55^\circ$
- (a) 263.7 m (b) 192.9 m
- 2.65 miles
- (a) 117.3° (b) 10.2 m
- 47.96°
- (a) 23.35 cm (b) 62.66°
- 303.1°
- 45.98 (if no allowance made for inaccurate measurements) or 46.87
- 26.8 m
- (a) 80° (b) 6.99 cm

4.9 Angles Larger than 90°

- (a) $\frac{\sqrt{3}}{2}$ (b) $-\frac{1}{2}$ (c) $-\frac{1}{\sqrt{2}}$ (d) $-\frac{1}{2}$ (e) $-\frac{1}{\sqrt{2}}$ (f) -1
 (g) $\frac{1}{2}$ (h) $\frac{\sqrt{3}}{2}$ (i) $\frac{1}{\sqrt{2}}$ (j) $-\frac{\sqrt{3}}{2}$ (k) -1 (l) $-\frac{1}{2}$
- (a) 0.766 (b) -0.819 (c) -0.766 (d) 0.643 (e) 0.940
 (f) -0.766 (g) -0.985 (h) -0.985 (i) -0.259 (j) 0.985
 (k) 0.707 (l) -0.766

4. 6 ; -135° , -45° , 225° , 315° , 585° , 675°
5. 6 ; -300° , -60° , 60° , 300° , 420° , 660°
6. (a) -315.6° , -224.4° , 44.4° , 135.6°
(b) -156.4° , -23.6° , 203.6° , 336.4° (c) -90° , 270°
(d) -306.9° , -53.1° , 53.1° , 306.9°
(e) -246.4° , -113.6° , 113.6° , 246.4° (f) -180° , 180°
7. (a) 14.0° , 194.0° , 374.0° , 554.0° (b) 45° , 225° , 405° , 585°
(c) 153.4° , 333.4° , 513.4° , 693.4°
8. (a) 306.9° (b) 143.1° (c) 220° (d) 270°
9. (b) 180° (c) 120° , 720°
10. (a) $y = 5 \cos 4x$ (b) $y = 4 \sin\left(\frac{3x}{2}\right)$ (c) $y = 0.2 \cos 10x$
(d) $y = 0.7 \sin\left(\frac{x}{3}\right)$
13. $y = 10.5 \sin 30(x-4) + 10.5$; 19.6°C , 1.4°C
14. (b) $T = 98.6 + 0.3 \cos 15(t-17)$
15. (a) 60° , 300° (b) 330° (d) $r = q + 180^\circ$
16. (b) 60° (c) 300° , 420°

5 Probability

5.1 Probabilities

1. (a) 0 (b) about 250 (c) about 250
2. (a) 50 (b) 50 (c) 0
3. (a) Impossible (b) Unlikely (c) Likely or Unlikely
(d) Likely or Unlikely (e) Unlikely (f) Likely (g) Likely
5. (a) 10 (b) 20 (c) 1000 (d) 600
6. About 900
7. (a) about 1500 (b) about 250
8. (a) 50 (b) 50 (c) 25 (d) 25

5.2 Simple Probability

1. (a) 0.1 (b) $\frac{1}{4}$ (c) $\frac{1}{2}$ (d) $\frac{4}{5}$
2. (a) 0.2 (b) 0.4
3. 0.98
4. $\frac{4}{5}$
5. (a) $\frac{4}{7}$ (b) not to snow
6. 0.99
7. (a) $\frac{2}{5}$ (b) 12
8. (a) 0.6 (b) 0.9 (c) 0.1
9. (a) $\frac{9}{20}$ (b) $\frac{10}{11}$ (c) $\frac{9}{13}$
10. No
11. 0.15
12. (a) C (b) B
13. (a) near to 0 (b) near to 1

5.3 Outcome of Two Events

2. VC, VS, MC, MS, RC, RS
3. GG, RG, GR, RR
4. (a) Nigel wins sit ups and Ben wins press ups
 (b) BJ, BN, BB, JB, JN, JJ, NB, NJ, NN (c) BJ, BB, JB, JJ
 (d) BJ, BN, BT, BB, JB, JN, JT, JJ, NB, NJ, NT, NN, TB, TN, TJ, TT
5. BS, BT, BD, BB, ST, SD, SS, TD, TT, DD
6. CD, CB, CC, DB, DD, BB
7.

	F	M
H	HF	HM
T	TF	TM
C	CF	CM
8. HHH ; HHT, HTH, THH ; HTT, THT, TTH ; TTT
9. (b) $\frac{4}{9}$

5.4 Finding Probabilities Using Relative Frequency

4. $\frac{1}{4}$
5. (a) $\frac{4}{5}$
6. (a) $\frac{2}{7}, \frac{7}{10}, \frac{1}{4}, \frac{1}{5}, \frac{1}{3}, \frac{2}{3}$ (b) Andrew (c) Rachel (d) Charles
7. (a) $\frac{3}{8}$ (b) $\frac{5}{12}$ (c) $\frac{5}{24}$
8. (a) $\frac{4}{5}$ (b) 96

5.5 Determining Probabilities

1. (a) $\frac{1}{4}$ (b) $\frac{1}{4}$ (c) $\frac{1}{13}$ (d) $\frac{1}{13}$ (e) $\frac{4}{13}$
2. (a) $\frac{13}{54}$ (b) $\frac{13}{54}$ (c) $\frac{2}{27}$ (d) $\frac{2}{27}$ (e) $\frac{8}{27}$
3. (a) $\frac{1}{6}$ (b) $\frac{1}{6}$ (c) $\frac{1}{2}$ (d) $\frac{1}{2}$
4. (a) $\frac{1}{8}$ (b) $\frac{1}{8}$ (c) $\frac{1}{2}$ (d) $\frac{5}{8}$ (e) $\frac{1}{4}$ 5. $\frac{3}{8}$
6. (a) $\frac{2}{5}$ (b) $\frac{4}{5}$ (c) $\frac{1}{5}$ (d) $\frac{4}{5}$ (e) $\frac{9}{49}$ (f) $\frac{39}{49}$ (g) $\frac{10}{49}$
7. (a) $\frac{9}{25}$ (b) $\frac{6}{25}$ (c) $\frac{3}{5}$ (d) $\frac{16}{25}$
8. (a) $\frac{2}{5}$ (b) $\frac{1}{5}$ (c) 1 (d) $\frac{4}{5}$

9. (a) $\frac{2}{5}$ (b) $\frac{1}{5}$ (c) $\frac{1}{5}$
10. (a) $\frac{3}{10}$ (b) $\frac{2}{9}$ (c) $\frac{1}{8}$ (d) $\frac{3}{8}$
11. (a) $\frac{7}{30}$ (b) $\frac{23}{30}$
12. (a) $\frac{1}{2}$ (b) $\frac{1}{6}$
13. (a) $\frac{1}{200}$ (b) 20
14. (a) $\frac{3}{10}$ (b) $\frac{4}{5}$
15. (a) Mint (b) $p(\text{mint}) = \frac{2}{3}$, $p(\text{toffee}) = \frac{1}{4}$, $p(\text{pen}) = \frac{1}{12}$ (c) $\frac{1}{12}$ (d) 0

5.6 Probability of Two Events

1. (a) $\frac{1}{4}$ (b) $\frac{1}{2}$ (c) $\frac{1}{2}$
2. (a) $\frac{1}{12}$ (b) $\frac{1}{4}$ (c) $\frac{1}{4}$ (d) $\frac{1}{3}$ (e) $\frac{1}{2}$
3. (a) (i) $\frac{1}{6}$ (ii) $\frac{1}{9}$ (iii) $\frac{1}{2}$ (iv) $\frac{5}{18}$ (v) $\frac{5}{18}$ (b) 7
4. (b) (i) $\frac{1}{9}$ (ii) $\frac{1}{3}$ (iii) $\frac{8}{9}$ (c) $\frac{1}{9}$
5. (a) $\frac{1}{4}$ (b) $\frac{1}{2}$
6. (a) $\frac{1}{8}$ (b) $\frac{5}{8}$ (c) 5
7. (a) 6 (b) $\frac{2}{3}$ (c) $\frac{1}{3}$
8. (a) 400 (b) $\frac{1}{400}$ (c) $\frac{1}{20}$ (d) $\frac{1}{25}$
9. (a) $\frac{1}{4}$ (b) $\frac{1}{8}$ (c) $\frac{7}{8}$
10. (a) (i) 1, 2 ; 1, 3 ; 2, 2 ; 2, 3 ; 3, 2 ; 3, 3 (ii) $\frac{1}{3}$ (iii) $\frac{2}{3}$ (b) (i) 9
11. (a) $\frac{1}{5}$ (b) $\frac{2}{5}$ (c) AX, AY, AZ, BW, BX, BY, BZ, CW, CX, CY, CZ, DW, DX, DY, DZ, EW, EX, EY, EZ
12. (b) $\frac{1}{8}$
13. (b) $\frac{4}{9}$

5.7 Use of Tree Diagrams

- (b) $0.6 \times 0.6 = 0.36$; $0.6 \times 0.4 = 0.24$; $0.4 \times 0.6 = 0.24$; $0.4 \times 0.4 = 0.16$
(c) 0.16 (d) 0.36 (e) 0.48
- (a) $\frac{1}{6}$ (c) (i) $\frac{1}{36}$ (ii) $\frac{5}{18}$ (iii) $\frac{25}{36}$
- (a) $\frac{1}{4}$ (b) $\frac{1}{4}$ (c) $\frac{1}{2}$
- (a) $\frac{81}{100}$ (b) $\frac{99}{100}$ (c) $\frac{1}{100}$
- (a) $\frac{1}{4}$ (c) (i) $\frac{9}{16}$ (ii) $\frac{3}{8}$ (iii) $\frac{1}{16}$
- (b) (i) 0.54 (ii) 0.36 (iii) 0.04
- (a) (i) 0.2 (ii) 0.4 (b) (i) 0.48 (ii) 0.08
- (a) (i) 0.2704 (ii) 0.2304 (iii) 0.4992 (b) (iii)
- (a) 0.56 (b) 0.38 (c) 0.04 (d) 0.64
- (a) $\frac{7}{18}$ (b) $\frac{1}{36}$ (c) $\frac{3}{4}$
- (b) (i) $\frac{1}{4}$ (ii) $\frac{1}{2}$ (iii) $\frac{3}{8}$
- (b) 0.52
- (a) $\frac{7}{13}$ (b) $\frac{43}{91}$
- (b) $\frac{3}{14}$
- (a) 0.6 (b) 0.16
- (a) $\frac{1}{216}$ (b) $\frac{5}{216}$ (c) $\frac{5}{72}$ (d) $\frac{2}{27}$

5.8 Multiplication for Independent Events

- NI - not independent I - independent (a) NI (b) I (c) I
(d) NI (e) NI (f) NI
- (a) (i) $\frac{5}{8}$ (ii) $\frac{3}{8}$ (iii) $\frac{25}{64}$ (iv) $\frac{9}{64}$ (v) $\frac{15}{64}$ (vi) $\frac{15}{64}$
(b) (i) $\frac{9}{64}$ (ii) $\frac{15}{32}$ (iii) $\frac{17}{32}$

3. (a) (i) $\frac{7}{10}$ (ii) $\frac{3}{10}$ (iii) $\frac{9}{100}$ (iv) $\frac{49}{100}$ (v) $\frac{21}{100}$
 (vi) $\frac{21}{100}$ (b) (i) $\frac{49}{100}$ (ii) $\frac{21}{50}$ (iii) $\frac{29}{50}$
4. (a) $\frac{1}{4}$ (b) $\frac{1}{6}$
5. (a) 0.06 (b) No
6. (a) 0.72 (b) 0.02 (c) 0.08
7. (a) 0.1 (b) 0.4 (c) 0.4 (d) 0.1
8. (a) 0.42 (b) 0.16
9. (a) $\frac{1}{49}$ (b) $\frac{36}{49}$ (c) $\frac{12}{49}$ (d) $\frac{1}{343}$
10. (a) No (b) $\frac{171}{250}$ (c) $\frac{283}{1000}$
11. (a) 0.003 (b) 0.833
12. (a) $\frac{1}{25}$ (b) $\frac{8}{25}$
13. (a) 0.58 (b) 0.44
14. 0.04
15. (a) (i) $\frac{1}{6}$ (ii) $\frac{1}{36}$ (b) $\frac{13}{36}$

5.9 Mutually Exclusive Events

1. B ; C
2. (a) Yes (b) No (c) No (d) Yes (e) No
3. 0.3
4. $\frac{1}{6}$
5. (a) $\frac{3}{7}$ (b) 12 (c) 14
6. (a) $\frac{7}{20}$ (b) Not mutually exclusive
7. (a) $\frac{2}{3}$ (b) $\frac{11}{15}$ (c) $\frac{3}{5}$ (d) $\frac{3}{5}$
8. (a) $\frac{5}{8}$ (b) $\frac{11}{20}$ (c) $\frac{7}{40}$
9. (a) 0.1 (b) 0.7
10. Pink : $\frac{2}{3}$ Yellow : $\frac{2}{7}$ Black : $\frac{11}{35}$
11. (a) $\frac{13}{25}$ (b) $\frac{22}{25}$ (c) No (d) No (e) Yes : $\frac{12}{25}$
12. (a) 0.2 (b) 0.7 (c) 20
13. (a) 0.7 (b) 0.7 (c) 0.6 (d) not mutually exclusive
14. (a) (i) 0.25 (ii) 0.75 (b) (i) 0.4 (ii) not mutually exclusive

5.10 Tree Diagrams and Conditional Probability

1. (a) $\frac{1}{7}$ (b) $\frac{3}{7}$ (c) $\frac{4}{7}$
2. (a) (i) $\frac{1}{17}$ (ii) $\frac{13}{34}$ (iii) $\frac{19}{34}$ (b) (i) $\frac{1}{221}$ (ii) $\frac{188}{221}$ (iii) $\frac{32}{221}$
3. $\frac{43}{91}$
4. (a) 0.24 (b) 0.09
5. (a) (i) 0.16 (ii) 0.06 (iii) 0.78 (b) 0.01
6. (a) $\frac{1}{12}$ (b) $\frac{1}{4}$ (c) $\frac{3}{4}$
7. (a) $\frac{11}{46}$ (b) $\frac{7}{69}$ (c) $\frac{1}{46}$ (d) $\frac{25}{69}$ (e) $\frac{8}{69}$
8. (a) $\frac{585}{812}$ (b) $\frac{801}{4060}$ (c) $\frac{34}{203}$
9. 0.52
10. (a) $\frac{1}{4}$ (b) $\frac{1}{2}$ (c) $\frac{1}{2}$; $\frac{47}{108}$
11. (b) 0.15
12. (b) 0.42 (c) 0.4998
13. (a) $\frac{7}{75}$ (b) $\frac{3}{76}$ (c) $\frac{7}{15}$
14. (b) 0.384 (c) 0.388
15. (a) $\frac{7}{11}$ (c) PP, CPP, PCP (d) $\frac{126}{165} \approx 0.764$

5.11 Using Venn Diagrams to Find Probabilities

1. (i) (a) $\frac{7}{20}$ (b) $\frac{4}{20}$ (c) 1 (d) $\frac{9}{20}$
 (ii) (a) $\frac{4}{17}$ (b) $\frac{6}{17}$ (c) 1 (d) $\frac{7}{17}$
 (iii) (a) 0 (b) $\frac{1}{5}$ (c) $\frac{9}{10}$ (d) $\frac{7}{10}$
 (iv) (a) $\frac{1}{8}$ (b) $\frac{2}{5}$ (c) $\frac{3}{4}$ (d) $\frac{9}{40}$
2. (a) $\frac{1}{26}$ (b) $\frac{7}{13}$ (c) $\frac{6}{13}$
3. (a) 0.4 (b) 0 (c) 0.4

4. (a) $\frac{5}{6}$ (b) $\frac{1}{6}$ (c) $\frac{1}{3}$ (d) $\frac{1}{6}$

5. (a) $\frac{2}{5}$ (b) $\frac{1}{6}$ (c) $\frac{1}{2}$

6. (i) (a) $\frac{3}{40}$ (b) $\frac{29}{40}$ (c) $\frac{21}{40}$ (d) $\frac{1}{8}$ (e) $\frac{3}{5}$ (f) $\frac{1}{4}$

(ii) (a) $\frac{1}{12}$ (b) $\frac{47}{60}$ (c) $\frac{7}{12}$ (d) $\frac{7}{60}$ (e) $\frac{13}{20}$ (f) $\frac{11}{30}$

(iii) (a) 0 (b) $\frac{4}{5}$ (c) $\frac{31}{50}$ (d) $\frac{7}{50}$ (e) $\frac{16}{25}$ (f) $\frac{11}{50}$

(iv) (a) 0 (b) $\frac{9}{10}$ (c) $\frac{23}{50}$ (d) $\frac{1}{5}$ (e) $\frac{2}{3}$ (f) $\frac{13}{30}$

7. 0.558

6 Number system

6.1 Decimals

- (a) 0.7 (b) 0.8 (c) 0.3 (d) 0.05 (e) 0.21 (f) 0.42
 (g) 0.005 (h) 0.151 (i) 0.022 (j) 0.08 (k) 0.13
 (l) 0.016 (m) 0.5 (n) 0.04 (o) 0.321
- (a) $\frac{4}{10}$ (b) $\frac{3}{10}$ (c) $\frac{4}{100}$ (d) $\frac{32}{100}$ (e) $\frac{45}{100}$
 (f) $\frac{6}{100}$ (g) $\frac{8}{100}$ (h) $\frac{14}{100}$ (i) $\frac{8}{1000}$ (j) $\frac{147}{1000}$
 (k) $\frac{36}{1000}$ (l) $\frac{4}{100}$ (m) $\frac{1}{10}$ (n) $\frac{9}{1000}$ (o) $\frac{107}{1000}$
- (a) 5.6 (b) 3.3 (c) 7.8 (d) 6.42 (e) 7.17 (f) 3.73
 (g) 4.6 (h) 4.8 (i) 3.16 (j) 3.94 (k) 10.2 (l) 1.4
- (a) 1.51 (b) 0.424 (c) 0.282 (d) 0.839 (e) 1.102
 (f) 0.281 (g) 0.858 (h) 0.738 (i) 0.372 (j) 11.87
 (k) 12.291 (l) 17.48 (m) 8.73 (n) 130.65 (o) 50.006
- (a) hundredths (b) tenths (c) hundredths (d) tenths
 (e) thousandths (f) thousandths
- (a) £5.16, £3.08, £4.56, £5.50 (b) £9.15 (c) £2.11
- (a) £3.28 (b) £1.52 (c) £8.42 (d) £11.21 (e) £0.48
 (f) £1.27 (g) £0.64 (h) £320.11 (i) £84.21
- (a) £1.78 (b) £3.22
- (a) £2.40 (b) £3.50
- 1.87
- 76 cm
- 0.8 kg
- (a) 5 (b) 5p
- (a) 10.85 kg (b) 26.55 kg (c) 105 dollars

6.2 Multiplying and Dividing with Decimals

- (a) 47.4 (b) 632 (c) 4.16 (d) 1274 (e) 0.1658
 (f) 3.24 (g) 630 (h) 4700 (i) 32000 (j) 47000
 (k) 0.0068 (l) 0.82 (m) 0.192 (n) 0.014 (o) 180
- (a) 36 (b) 1410 (c) 10500 (d) 132000 (e) 6000
 (f) 10400 (g) 3.3 (h) 0.37 (i) 0.007 (j) 0.007
 (k) 0.171 (l) 0.13 (m) 10860 (n) 23600 (o) 0.099
 (p) 0.06 (q) 0.6 (r) 0.0035

6.2

3. (a) 40 (b) 2500 (c) 80 (d) 600 (e) 13 200
(f) 3100 (g) 5200 (h) 4000 (i) 700
4. (a) (i) 360 p (ii) 60 000 p (iii) 4800 p (b) (i) £3.60 (ii) £600
(iii) £48 (c) 300 000
5. £124.87, £413, £107, £122.40
6. (a) 0.012 miles (\approx 21 yards \approx 63 ft \approx 760 inches \approx 19 m)
(b) (i) 5000 hours (ii) 90 hours
7. (a) (i) £108 (ii) £459 (iii) £810 (b) (i) £20 (ii) £88 (iii) £120
8. (a) 1500 (b) 500
9. 21 120 litres
10. (a) (i) £350 000 (ii) £560 000 (iii) £770 000 (b) 2000
11. (a) 540 (b) 50
12. (a) 6500 (b) 1037 (c) 7537
13. (a) $72 \times 100 = 7200$ (b) $60 \times 30 = 1800$
14. (a) (i) 18 (ii) 81 (b) 261

6.3 Fractions and Decimals

1. (a) (i) 18.64 (ii) 19 (b) (i) 1024.84 (ii) 1000 (c) (i) 16.04 (ii) 16
(d) (i) 181.44 (ii) 180 (e) (i) 16.82 (ii) 17 (f) (i) 0.08 (ii) 0.084
(g) (i) 0.01 (ii) 0.0096 (h) (i) 4.84 (ii) 4.8 (i) (i) 3.86 (ii) 3.9
2. (a) 48 600 (b) 48 637.01 (c) 48 637.0125 (d) 48 640
(e) 48 637.012 (f) 49 000
3. (a) 0.0047 (b) 48.2 (c) 20 (d) 4.86 (e) 18.42
(f) 21.80 (g) 15 000 (h) 0.005 (i) 0.00418
(j) 15 700 (k) 55 000 (l) 31.4 (m) 14.18 (n) 0.82
(o) 1.841 (p) 15.0 (q) 14.170 (r) 201
4. (a) 40 000, 45 000, 44 900, 44 850 (b) (i) 2 s.f. (ii) 1 s.f.
5. (a) 0.5 (b) 0.75 (c) 0.4 (d) 0.6 (e) 0.125 (f) 0.625
(g) 0.375 (h) 0.875 (i) 0.2
6. (a) 0.3333 (b) 0.1667 (c) 0.5714 (d) 0.1429 (e) 0.7143
(f) 0.8333
7. (a) 0.11111, 0.22222, 0.44444, 0.55556
(b) Recurring decimal which is the same as the numerator
(c) 0.7777..., 0.8888...

8. (a) 0.09091, 0.18182, 0.27273, 0.36364
 (b) 0.45455, 0.54545, 0.63636, 0.72727, 0.81818, 0.90909
10. (a) 0.8 (b) $0.096, \frac{4}{5}, 0.805, 0.85$

6.4 Long Multiplication and Division

1. (a) 345 (b) 684 (c) 513 (d) 9088 (e) 7308 (f) 15408
 (g) 2548 (h) 1920 (i) 23 328 (j) 10 164 (k) 2352
 (l) 5586 (m) 88 192 (n) 134 096 (o) 56 616
2. (a) 152 (b) 254 (c) 173 (d) 251 (e) 452 (f) 428
 (g) 123 (h) 35 (i) 12 (j) 32 (k) 24 (l) 153
 (m) 134 (n) 214 (o) 13
3. £2112
4. 700
5. 13
6. 350 kg
7. £333.33
8. (a) 13 (b) 7 ; 240
9. £154
10. (a) 35616 (b) 34132
11. 39
12. (a) 770 (b) (i) 19 (ii) 9

6.5 Estimating Answers

1. (a) 50 (b) 20 (c) 30 (d) 10 (e) 20 (f) 100
 (g) 60 (h) 0.2 (i) 0.04 (j) 2 (k) 20 (l) 2
2. Approximate answers are (a) 56 (b) 48 (c) 960 (d) 51
 (e) 600 (f) 540 (g) 10 (h) 7 (i) 20 (j) 120
 (k) 5 (l) 45
 Actual answers are (a) 56.01 (b) 54.20 (c) 1020 (d) 53.51
 (e) 623.4 (f) 545.5 (g) 11.11 (h) 7.634 (i) 18.59
 (j) 113.8 (k) 4.446 (l) 46.10
3. Approximate answers are (a) 2 (b) 0.5 (c) 3 (d) 7
 (e) 40 (f) 20 (g) 15 (h) 70 (i) 150
4. (a) 200 m (b) 233.28 m (c) 264.06 m
5. (a) Estimate 1200, Actual 1286 (b) Estimate 250 s, Actual 229 s
6. (a) About 40 ms^{-1} (b) 40.04, 39.67, 39.02
7. (a) 10 or 11, 11.08 km (b) about 480 km, 360 km
8. (a) Estimate £70, Actual £63.06 (b) Estimate £30, Actual £24.86
 (c) Estimate £40, Actual £38.19

6.5

9. (a) Estimate 72 , Actual 91.25 (b) Estimate 48 , Actual 48.5
 (c) Estimate 80 , Actual 86.02
10. (a) 60×30 (b) 1800 (c) 88
11. No ; it should be £7.02 (accurate answer: £7.03)

6.6 Using Brackets and Memory on a Calculator

1. (a) 97.2 (b) 27.40 (c) 3.55 (d) 2.69 (e) 0.767
 (f) 1.54 (g) 0.348 (h) 1.28 (i) 1.65 (j) 0.372
 (k) 0.0587 (l) 0.726
3. (a) 17.3 (b) 25.75 (c) 124
4. (a) 5.5 , 3.6591 , 3.1960 , 3.1625 , 3.1623 , 3.1623
 (b) 3.5 , 3.1786 , 3.1623 , 3.1623 , 3.1623 , 3.1623
 (c) Both sequences are converging to 3.1623, which is $\sqrt{10}$, but using 2 converges more quickly.
5. (a) (i) 141 , 141 (ii) 468 , 57 (iii) 3.2 , 28.8 , 3.2
 (b) (i) $3 \times 6 + 5 \times 51 + 15 \times 2 =$ (ii) $(3+6) \times 5 \times 2 =$
 (iii) & (iv) need all the brackets (v) $3 \times 4 \div (5+2) =$ (vi) $3 \times 2 \div (4 \times 6) =$
6. (a) 603.2 cm^2 (b) 258.1 cm^2
7. (a) (i) 2120575 mm^3 (ii) 5089 cm^3 (b) (i) 53.6 cm (ii) 88.4
8. 11.1
9. 7.00
10. (a) 4.29 (b) 4.652 (c) 50 (d) 2.5
11. (a) 36.6025 (b) 7.35
12. (a) Question 3 (b) Question 2
13. (a) (i) $v = 120 , u = 20 , t = 5$ (ii) $a = 20$ (b) $\boxed{=}$ needed after $\boxed{6}$
14. Last $\boxed{\times}$ should be replaced by $\boxed{\div}$, or insert brackets around 3.2×0.47

6.7 Upper and Lower Bounds

1. (a) $4.65 \leq x < 4.75$ (b) $41.5 \leq l < 42.5$ (c) $15.615 \leq A < 15.625$
 (d) $16.15 \leq d < 16.25$ (e) $11.675 \leq r < 11.685$ (f) $14.235 \leq m < 14.245$
 (g) $217.5 \leq w < 218.5$ (h) $15.195 \leq l < 15.205$ (i) $4.995 \leq w < 5.005$
 (j) $19.95 \leq v < 20.05$ (k) $18.085 \leq A < 18.095$ (l) $31.4505 \leq v < 31.4515$
2. (a) $41.5 \leq l < 42.5$, $31.5 \leq w < 32.5$
 (b) (i) $146 \leq \text{perimeter} < 150$ (ii) $1307.25 \leq \text{area} < 1381.25$
3. (a) $11.5 \leq \text{radius} < 12.5$
 (b) (i) $23 \leq \text{diameter} < 25$ (ii) $72.3 \leq \text{circumference} < 78.5$
 (iii) $415.5 \leq \text{area} < 490.9$

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4. (a) 50 (b) 10 (c) 525 (d) 0.333... (e) 1.4
5. (a) 7.743 to 7.882 (b) 7.782 to 7.844
6. 1.595 m^2 to 2.605 m^2
7. (a) $116\,865.25 \text{ cm}^2$, $116\,181.25 \text{ cm}^2$ (b) 20989 cm^2
8. 0.0044 to 0.0064
9. 68.5 miles, 71.5 miles
10. (a) $54.11 \leq \text{area} < 56.75$, $26.08 \leq \text{circumference} < 26.70$,
(b) $5.383 \leq \text{radius} < 5.397$ (c) $2.417 \leq \text{radius} < 2.423$
11. (a) $2.4735 \leq \text{mass} < 2.4745$ (b) 1.62805, 1.62795
12. (a) 251 kg (b) 2 kg
13. (a) 29.5 cm (b) $18.35 \leq \text{length} < 18.45$
14. 210 g, 200 g
15. 2 m 97 cm
16. (a) 3.65 cm, 3.65 cm (b) 15 cm, 14.6 cm (c) (i) Two
(d) (i) No ; one significant figure
17. (a) 3.75 hours; 195 miles, 205 miles (b) 63.1 mph, 52.0 mph

6.8 Number System

1. Rational (terminating), Rational (recurring), Irrational, Rational (recurring), Rational (terminating), Irrational, Irrational, Rational (terminating), Irrational, Rational (recurring), Irrational, Rational (terminating)
2. (a) $\frac{49}{100}$ (b) $\frac{1}{3}$ (c) $\frac{7}{4}$ (d) - (e) $\frac{417}{1000}$ (f) $\frac{1}{9}$
(g) $\frac{1}{11}$ (h) $\frac{6}{11}$ (i) $\frac{1}{8}$ (j) $\frac{481}{500}$
3. (a) $\frac{41}{99}$ (b) $\frac{67}{1665}$ from $\frac{402}{9990}$ (c) $\frac{1}{7}$ (d) $\frac{8}{9}$ (e) $\frac{812}{999}$
(f) $\frac{5}{9}$ (g) $\frac{101}{111}$
5. Irrational, Irrational, Rational, Irrational, Irrational, Rational
10. $p + q$ can be rational or irrational
12. recurring, non-recurring, recurring, non-recurring, recurring
13. (a) 13, Rational (b) $\sqrt{61}$, Irrational (c) 3, Rational
(d) $\frac{5}{7}$, Rational

14. (b) 2^{-2} , $4^{\frac{1}{2}}$, 4^{-2}
15. (a) (i) any recurring decimal (ii) "and does not repeat itself"
 (b) Irrational, Rational $\left(\frac{5}{2}\right)$, Irrational, Rational $\left(\frac{1}{3}\right)$
16. (a) e.g. any square root larger than 16 and less than 25
17. (a) (i) 237 (ii) any n between $225 < n < 256$ is such that \sqrt{n} is irrational
 (b) 10.24 which has 3.2 or $\frac{16}{5}$ as a square root

6.9 Surds

1. (a) $1 + \sqrt{2} + \sqrt{3} + \sqrt{6}$ (b) $4 - 2\sqrt{3} + 2\sqrt{5} - \sqrt{15}$ (c) $\sqrt{3} - 3$
 (d) $-14 + 2\sqrt{11} + 7\sqrt{3} - \sqrt{33}$ (e) 11 (f) $30 + 4\sqrt{2}$ (g) $-16\sqrt{17}$
 (h) -7 (i) $1 - \pi$ (j) -4 (k) 4 (l) $\pi^2 - \pi$
 (m) $5 + \sqrt{2} + \sqrt{3} + 2\sqrt{6}$ (n) $-6 - 2\sqrt{10}$ (o) $7 + 4\sqrt{3}$
 (p) $8 - 2\sqrt{7}$ (q) $14 - 6\sqrt{5}$ (r) $7 + 5\sqrt{2}$
2. (a) $\frac{\sqrt{2}}{2}$ (b) $\frac{2}{5}\sqrt{5} + 1$ (c) $\frac{1}{2}(\sqrt{2} - \sqrt{6})$ (d) $-6 + 5\sqrt{2}$
 (e) $-\frac{1}{2}(5 + \sqrt{7} - 5\sqrt{3} - \sqrt{21})$ (f) $\frac{1}{22}(15 - 5\sqrt{2} - 3\sqrt{3} + \sqrt{6})$
 (g) $-\frac{1}{2} - \frac{1}{2}\sqrt{3}$ (h) $3 - 2\sqrt{2}$ (i) $\frac{4 - \sqrt{7}}{3}$ (j) $1 + \sqrt{22} + \sqrt{11} + \sqrt{2}$
 (k) $-(\sqrt{2} + \sqrt{3})$ (l) $\sqrt{3} + \sqrt{5} - \frac{1}{2}\sqrt{15} - \frac{5}{2}$
6. (a) Yes / No ; No / Yes ; No / Yes
 (b) 2π etc. or the square root of any number between 36 and 49
 (c) (i) Irrational (ii) Irrational
7. (a) (i) $x = 4$ etc. (ii) $y = 27$ etc.
 (b) (i) $\sqrt{2}, \sqrt{3}$ etc. (ii) $1 + \sqrt{2}, 1 - \sqrt{2}$ etc.
8. (a) (i) Rational, $\frac{3}{11}$ (ii) Irrational (iii) Rational, $\frac{21}{16}$ (b) $b = 8$ etc.
 (c) a