Pearson

Pearson Edexcel

Level 2

Extended Mathematics Certificate

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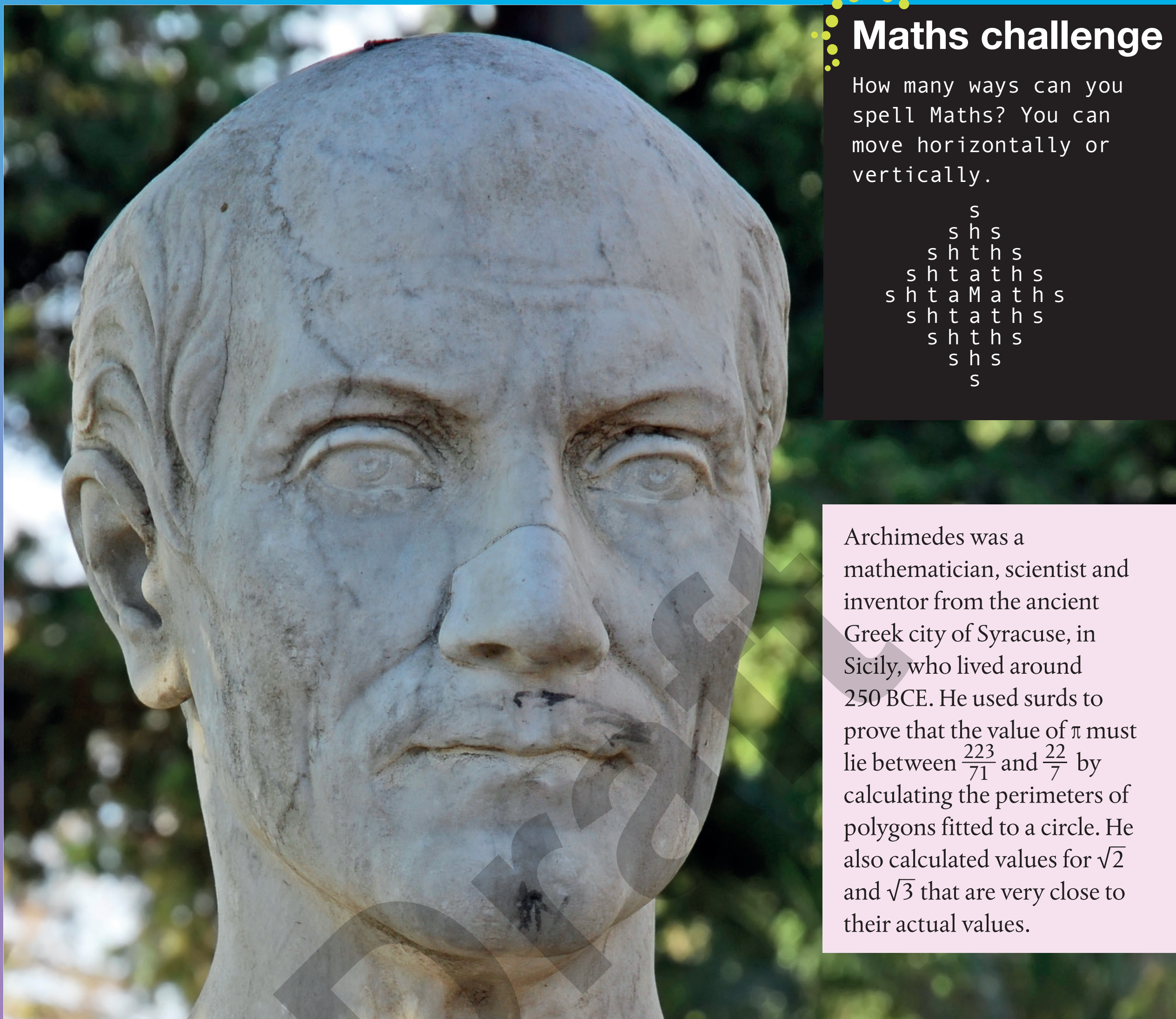

Maths challenge

How many ways can you spell Maths? You can move horizontally or vertically.

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        s
      s h s
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Archimedes was a mathematician, scientist and inventor from the ancient Greek city of Syracuse, in Sicily, who lived around 250 BCE. He used surds to prove that the value of π must lie between $\frac{223}{71}$ and $\frac{22}{7}$ by calculating the perimeters of polygons fitted to a circle. He also calculated values for $\sqrt{2}$ and $\sqrt{3}$ that are very close to their actual values.

Chapter 1: Number

In this chapter you will:

- use the laws of indices with positive, negative and fractional indices
- simplify and manipulate surds
- rationalise denominators

Prior knowledge

- use negative indices
- use fractional indices
- simplify surds
- rationalise denominators

1.1 Laws of indices

Use these laws of indices to simplify powers of the same base.

$x^m \times x^n = x^{m+n}$

$x^m \div x^n = x^{m-n}$

$(x^m)^n = x^{mn}$

$\left(\frac{a}{b}\right)^m = \frac{a^m}{b^m}$

$x^{\frac{1}{n}} = \sqrt[n]{x}$ — The *n*th root of *x*.

$x^{\frac{m}{n}} = \sqrt[n]{x^m}$

$x^0 = 1$, where $x \neq 0$

$x^{-n} = \frac{1}{x^n}$, where $x \neq 0$

Example

Evaluate:

a $9^{\frac{1}{2}}$ **b** $64^{\frac{1}{3}}$ **c** $49^{\frac{3}{2}}$ **d** $25^{-\frac{3}{2}}$ **e** $\left(\frac{9}{25}\right)^{-\frac{3}{2}}$

a $9^{\frac{1}{2}} = \sqrt{9}$ — Using $x^{\frac{1}{n}} = \sqrt[n]{x}$

$= \pm 3$ — A square root can be positive or negative, as + × + = +, and − × − = +.

b $64^{\frac{1}{3}} = \sqrt[3]{64}$ — This means the cube root of 64.

$= 4$

c $49^{\frac{3}{2}} = (\sqrt{49})^3$ — Using $x^{\frac{m}{n}} = \sqrt[n]{x^m}$. This means the square root of 49, cubed.

$= \pm 343$

d $25^{-\frac{3}{2}} = \frac{1}{25^{\frac{3}{2}}}$ — Using $x^{-n} = \frac{1}{x^n}$

$= \frac{1}{(\sqrt{25})^3}$ — $\sqrt{25} = \pm 5$

$= \frac{1}{(\pm 5)^3}$

$= \pm\frac{1}{125}$

e $\left(\frac{9}{16}\right)^{-\frac{3}{2}} = \frac{1}{\left(\frac{9}{16}\right)^{\frac{3}{2}}} = \left(\frac{16}{9}\right)^{\frac{3}{2}}$ — Using $x^{-n} = \frac{1}{x^n}$

$= \frac{(\sqrt{16})^3}{(\sqrt{9})^3} = \frac{(\pm 4)^3}{(\pm 3)^3} = \pm\frac{64}{27}$

Practice

Solution Bank

1 Evaluate

a $49^{\frac{1}{2}}$ **b** $\left(\frac{1}{81}\right)^{\frac{1}{2}}$ **c** $\left(\frac{25}{36}\right)^{\frac{1}{2}}$

d $125^{\frac{1}{3}}$ **e** $\left(\frac{1}{8}\right)^{\frac{1}{3}}$ **f** $\left(-\frac{27}{64}\right)^{\frac{1}{3}}$

2 Evaluate

a $25^{-\frac{1}{2}}$ **b** $\left(\frac{1}{16}\right)^{-\frac{1}{2}}$ **c** $\left(\frac{49}{100}\right)^{-\frac{1}{2}}$

d $8^{-\frac{1}{3}}$ **e** $\left(\frac{1}{64}\right)^{-\frac{1}{3}}$ **f** $\left(-\frac{343}{1000}\right)^{-\frac{1}{3}}$

3 Evaluate

a $25^{\frac{3}{2}}$ **b** $8^{\frac{2}{3}}$ **c** $81^{-\frac{3}{4}}$

d $\left(\frac{1}{36}\right)^{\frac{3}{2}}$ **e** $\left(-\frac{8}{27}\right)^{\frac{4}{3}}$ **f** $\left(\frac{1}{64}\right)^{-\frac{2}{3}}$

4 Work out the value of n.

a $32 = 2^n$ **b** $\frac{1}{8} = 2^n$ **c** $(\sqrt{5})^3 = 5^n$

5 Write these as single powers of 3.

a $9^{-\frac{1}{2}}$ **b** $27^{\frac{1}{5}}$ **c** $81^{\frac{4}{3}}$

6 $5^a \times 125^{\frac{2}{3}} = 25^{\frac{5}{2}}$
Work out the value of a.

Hint for Q6

Use $x^m \times x^n = x^{m+n}$ and $x^{\frac{m}{n}} = \sqrt[n]{x^m}$.

7 $16^{\frac{3}{2}} \times 2^x = 8^{\frac{1}{5}}$
Work out the value of x.

8 $9^{\frac{3}{2}} \times 3^{2t-1} \times \frac{1}{9^2} = 81$
Work out the value of t.

9 Solve $\frac{25^{\frac{3x+1}{2}}}{125^{1.5x}} = 5^{10-x}$

Exam-style question

10 $8^{\frac{2}{3}} \times \frac{1}{4^2} \times 2^{3y-4} \times 32^{\frac{3}{5}} = 64$

Find the value of y. **(6 marks)**

11 Solve $-27^{-\frac{2}{3}} \times 9^3 \times (-3)^{2x} = -243$

Talking point

How do you know what the base number is?

GCSE

1.2 Surds

Talking point

Why are square roots of square numbers, such as $\sqrt{4}$ and $\sqrt{25}$, not surds?

Surds are irrational numbers. A surd is a multiple of $\sqrt{n}$, where n is an integer that is not a square number. For example, $\sqrt{2}$, $\sqrt{3}$, $\sqrt{6}$ and $4\sqrt{5}$ are surds but $\sqrt{4}$ and $\sqrt{25}$ are not surds.

The following rules apply to surds:

- $\sqrt{mn} = \sqrt{m} \times \sqrt{n}$
- $\sqrt{\frac{m}{n}} = \frac{\sqrt{m}}{\sqrt{n}}$

Example 1

Using the positive values of the surds, simplify

a $\sqrt{45}$ **b** $\frac{\sqrt{12}}{2}$ **c** $3\sqrt{6} - 2\sqrt{96} + \sqrt{486}$

a $\sqrt{45} = \sqrt{9 \times 5}$ — Find a factor of 45 that is a square number. Use the rule $\sqrt{ab} = \sqrt{a} \times \sqrt{b}$

$= \sqrt{9} \times \sqrt{5}$ — $\sqrt{9} = 3$

$= 3\sqrt{5}$

b $\frac{\sqrt{12}}{2} = \frac{\sqrt{4} \times \sqrt{3}}{2}$ — $\sqrt{12} = \sqrt{4} \times \sqrt{3}$; $\sqrt{4} = 2$

$= \frac{2 \times \sqrt{3}}{2}$ — Cancel by 2.

$= \sqrt{3}$

c $3\sqrt{6} - 2\sqrt{96} + \sqrt{486} = 3\sqrt{6} - 2\sqrt{16}\sqrt{6} + \sqrt{81} \times \sqrt{6}$ — $\sqrt{6}$ is a common factor.

$= \sqrt{6}(3 - 2\sqrt{16} + \sqrt{81})$ — Work out the square roots $\sqrt{16}$ and $\sqrt{81}$.

$= \sqrt{6}(3 - 2 \times 4 + 9)$ — $3 - 8 + 9 = 4$

$= \sqrt{6}(4)$

$= 4\sqrt{6}$

Example 2

Expand and simplify $(3 - \sqrt{5})(7 + \sqrt{5})$

$(3 - \sqrt{5})(7 + \sqrt{5}) = 3(7 + \sqrt{5}) - \sqrt{5}(7 + \sqrt{5})$ — Expand the brackets completely before simplifying.

$= 21 + 3\sqrt{5} - 7\sqrt{5} - \sqrt{25}$

$= 16 - 4\sqrt{5}$ — Collect like terms, $3\sqrt{5} - 7\sqrt{5} = -4\sqrt{5}$. Simplify any roots if possible: $\sqrt{25} = 5$

Practice

Solution Bank

1 Using the positive values of the surds, simplify

a $\sqrt{20}$ b $\sqrt{18}$ c $\sqrt{44}$

d $\sqrt{63}$ e $\sqrt{98}$ f $\sqrt{700}$

Exam-style question

2 Write $\sqrt{180}$ in the form $a\sqrt{b}$ where a and b are integers. **(2 marks)**

3 Using the positive values of the surds, simplify

a $\frac{\sqrt{18}}{3}$ b $\frac{\sqrt{75}}{5}$ c $\frac{\sqrt{48}}{2}$

4 Using the positive values of the surds, simplify

a $\sqrt{12} + \sqrt{75}$ b $\sqrt{192} - \sqrt{48}$

c $\sqrt{500} + \sqrt{20} - \sqrt{45}$ d $\sqrt{50} - \sqrt{18} + 2\sqrt{32}$

e $2\sqrt{75} - 2\sqrt{12} + \sqrt{147}$ f $3\sqrt{20} + 2\sqrt{125} - 4\sqrt{180}$

5 Expand and simplify if possible

a $\sqrt{5}(2 - \sqrt{3})$ b $\sqrt{3}(4 - \sqrt{5})$ c $\sqrt{2}(7 + \sqrt{2})$

d $(4 + \sqrt{2})(5 - \sqrt{3})$ e $(4 + \sqrt{5})(2 - \sqrt{3})$ f $(2 + \sqrt{3})(4 + \sqrt{3})$

g $(2 - \sqrt{2})(3 - \sqrt{2})$ h $(3 - \sqrt{7})(2 + \sqrt{7})$ i $(4 - \sqrt{5})^2$

j $(\sqrt{2} + \sqrt{3})(\sqrt{2} - \sqrt{3})$ k $(\sqrt{3} + \sqrt{5})^2$ l $(\sqrt{5} - \sqrt{2})^2$

Hint for Q5a

$\sqrt{5}(2 - \sqrt{3}) = \sqrt{5} \times 2 - \sqrt{5} \times \sqrt{3}$

Hint for Q5i

$(4 - \sqrt{5})^2 = (4 - \sqrt{5})(4 - \sqrt{5})$

Exam-style question

6 a Find the value of $(3\sqrt{8})^2$. **(2 marks)**

b Simplify $(\sqrt{5}) + (\sqrt{5})^2 + (\sqrt{5})^3 + (\sqrt{5})^4$. **(3 marks)**

7 Sara writes:

$(3 + \sqrt{5})^2 = 9 + 5 = 14$

Sara is incorrect. Explain why.

8 Show that $(\sqrt{7} - \sqrt{5})(\sqrt{7} + \sqrt{5}) = 2$.

Talking point

When the brackets for **Q5d-i are expanded,** some of the expressions can be simplified and some cannot. How do you know when they can be simplified? Explain why.

1.3 Rationalising denominators

It is not good practice to have a fraction with a surd in the denominator. The process of finding an equivalent fraction with a rational denominator is called rationalising the denominator.

Talking point

When rationalising the denominator, why do you need to multiply the numerator and denominator by the same surd?

The rules for rationalising denominators are:

- for fractions of the form $\frac{a}{\sqrt{b}}$, multiply the numerator and denominator by $\sqrt{b}$.
- for fractions of the form $\frac{1}{a+\sqrt{b}}$, multiply the numerator and denominator by $a-\sqrt{b}$.
- for fractions of the form $\frac{1}{a-\sqrt{b}}$, multiply the numerator and denominator by $a+\sqrt{b}$.

Example

Rationalise each denominator.

a $\frac{1}{\sqrt{7}}$ **b** $\frac{1}{2-\sqrt{5}}$ **c** $\frac{\sqrt{3}+\sqrt{7}}{\sqrt{3}-\sqrt{7}}$ **d** $\frac{1}{(1+\sqrt{5})^2}$ **e** $\frac{2+\sqrt{3}}{\sqrt{8}+\sqrt{18}}$

a $\frac{1}{\sqrt{7}} = \frac{1\times\sqrt{7}}{\sqrt{7}\times\sqrt{7}}$ — Multiply the numerator and denominator by $\sqrt{7}$.

$= \frac{\sqrt{7}}{7}$ — $\sqrt{7}\times\sqrt{7} = (\sqrt{7})^2 = 7$

b $\frac{1}{2-\sqrt{5}} = \frac{1\times(2+\sqrt{5})}{(2-\sqrt{5})\times(2+\sqrt{5})}$ — Multiply the numerator and denominator by $(2+\sqrt{5})$.

$= \frac{2+\sqrt{5}}{4+2\sqrt{5}-2\sqrt{5}-5}$ — $\sqrt{5}\times\sqrt{5} = 5$

$= \frac{2+\sqrt{5}}{-1}$ — $4-5=-1$, $2\sqrt{5}-2\sqrt{5}=0$

$= -2-\sqrt{5}$ — Divide each term by -1.

c $\frac{\sqrt{3}+\sqrt{7}}{\sqrt{3}-\sqrt{7}} = \frac{(\sqrt{3}+\sqrt{7})\times(\sqrt{3}+\sqrt{7})}{(\sqrt{3}-\sqrt{7})\times(\sqrt{3}+\sqrt{7})}$ — Multiply the numerator and denominator by $(\sqrt{3}+\sqrt{7})$.

$= \frac{3+\sqrt{3}\sqrt{7}+\sqrt{3}\sqrt{7}+7}{3+\sqrt{3}\sqrt{7}-\sqrt{3}\sqrt{7}-7}$ — $\sqrt{3}\sqrt{7}-\sqrt{3}\sqrt{7}=0$

$= \frac{10+2\sqrt{21}}{-4}$ — $\sqrt{3}\sqrt{7}=\sqrt{21}$

$= \frac{5+\sqrt{21}}{-2}$ — Divide each term by 2.

d $\frac{1}{(1+\sqrt{5})^2} = \frac{1}{(1+\sqrt{5})(1+\sqrt{5})}$ — Expand the brackets.

$= \frac{1}{1+\sqrt{5}+\sqrt{5}+5}$ — Simplify and collect like terms.

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

$= \frac{1\times(6-2\sqrt{5})}{(6+2\sqrt{5})(6-2\sqrt{5})}$ — Multiply the numerator and denominator by $(6 - 2\sqrt{5})$.

$= \frac{6-2\sqrt{5}}{36-12\sqrt{5}+12\sqrt{5}-20}$ — $36 - 20 = 16, -12\sqrt{5} + 12\sqrt{5} = 0$

$= \frac{6-2\sqrt{5}}{16} = \frac{3-\sqrt{5}}{8}$

e $\frac{2+\sqrt{3}}{\sqrt{8}+\sqrt{18}} = \frac{2+\sqrt{3}}{2\sqrt{2}+3\sqrt{2}} = \frac{2+\sqrt{3}}{5\sqrt{2}}$ — Simplify the denominator before rationalising.

$= \frac{(2+\sqrt{3})\times 5\sqrt{2}}{5\sqrt{2}\times 5\sqrt{2}}$ — Multiply the numerator and denominator by $5\sqrt{2}$.

$= \frac{10\sqrt{2}+5\sqrt{2}\sqrt{3}}{50}$ — $5\sqrt{2} \times 5\sqrt{2} = 25 \times 2 = 50$

$= \frac{2\sqrt{2}+\sqrt{6}}{10}$

Practice

Solution Bank

1 Rationalise the denominators and simplify if possible.

a $\frac{1}{\sqrt{3}}$ b $\frac{1}{\sqrt{7}}$ c $\frac{3}{\sqrt{2}}$

d $\frac{2}{\sqrt{2}}$ e $\frac{5}{\sqrt{5}}$ f $\frac{3}{\sqrt{6}}$

g $\frac{\sqrt{2}}{\sqrt{3}}$ h $\frac{\sqrt{2}}{\sqrt{5}}$ i $\frac{\sqrt{3}}{\sqrt{7}}$

2 Rationalise the denominators and simplify if possible.

a $\frac{1}{5+\sqrt{3}}$ b $\frac{1}{3-\sqrt{2}}$ c $\frac{2}{1-\sqrt{5}}$

d $\frac{2}{1+\sqrt{2}}$ e $\frac{3}{2-\sqrt{3}}$ f $\frac{4}{5+\sqrt{7}}$

g $\frac{\sqrt{2}}{1+\sqrt{3}}$ h $\frac{\sqrt{3}}{1-\sqrt{3}}$ i $\frac{\sqrt{3}}{2-\sqrt{2}}$

j $\frac{\sqrt{5}}{3+\sqrt{3}}$ k $\frac{\sqrt{5}}{4-\sqrt{5}}$ l $\frac{\sqrt{7}}{7-\sqrt{7}}$

3 Rationalise the denominators and simplify.

a $\frac{1}{\sqrt{2}-\sqrt{3}}$ b $\frac{5}{\sqrt{3}+\sqrt{5}}$ c $\frac{2\sqrt{3}}{\sqrt{3}-\sqrt{7}}$

d $\frac{2+\sqrt{3}}{\sqrt{3}+\sqrt{5}}$ e $\frac{\sqrt{2}+\sqrt{3}}{\sqrt{2}-\sqrt{3}}$ f $\frac{\sqrt{7}-\sqrt{11}}{\sqrt{11}+\sqrt{7}}$

Talking point

Why is $\frac{a - b\sqrt{c}}{-d}$ equivalent to $\frac{1}{d}(b\sqrt{c} - a)$?

4 Rationalise the denominators and simplify.

a $\frac{1}{(2+\sqrt{3})^2}$ **b** $\frac{1}{(2-\sqrt{5})^2}$ **c** $\frac{3}{(5-\sqrt{3})^2}$

d $\frac{4}{(6+\sqrt{2})^2}$ **e** $\frac{1}{(3-\sqrt{2})(2+\sqrt{2})}$ **f** $\frac{3}{(2+\sqrt{5})(4-\sqrt{5})}$

g $\frac{\sqrt{3}}{(1+\sqrt{3})^2}$ **h** $\frac{\sqrt{5}}{(5-\sqrt{2})^2}$ **i** $\frac{\sqrt{2}}{(5-\sqrt{2})(1+\sqrt{2})}$

5 **a** Simplify $\sqrt{75} - \sqrt{12}$.

b Hence, rationalise the denominator and simplify $\frac{4+\sqrt{5}}{\sqrt{75}-\sqrt{12}}$.

Hint for Q6

Simplify the denominator before rationalising.

6 Rationalise the denominators and simplify.

a $\frac{2+\sqrt{5}}{\sqrt{50}-\sqrt{8}}$ **b** $\frac{3-\sqrt{3}}{\sqrt{27}+\sqrt{75}}$ **c** $\frac{1+\sqrt{2}}{\sqrt{80}+\sqrt{45}}$

d $\frac{\sqrt{3}-4}{2\sqrt{32}-\sqrt{18}}$ **e** $\frac{2+\sqrt{5}}{1-2\sqrt{48}+\sqrt{12}}$ **f** $\frac{5+\sqrt{3}}{2-3\sqrt{20}+\sqrt{80}}$

Exam-style question

7 Rationalise the denominator of $\frac{\sqrt{7}+7}{7-\sqrt{7}}$.

Give your answer in the form $\frac{a+\sqrt{7}}{b}$ where a and b are integers. **(3 marks)**

8 Show that

$$\frac{2+\sqrt{3}}{\sqrt{80}-\sqrt{20}} = \frac{2\sqrt{5}+\sqrt{15}}{15}$$

Chapter 1: Number

1.1 Laws of indices

1 a ± 7 **b** $\pm\frac{1}{9}$ **c** $\pm\frac{5}{6}$ **d** 5

e $\frac{1}{2}$ **f** $-\frac{3}{4}$

2 a $\pm\frac{1}{5}$ **b** ± 4 **c** $\pm\frac{10}{7}$ **d** $\frac{1}{2}$

e 4 **f** $-\frac{10}{7}$

3 a ± 125 **b** 4 **c** $\pm\frac{1}{27}$ **d** $\pm\frac{1}{216}$

e $-\frac{16}{81}$ **f** 16

4 a $n = 5$ **b** $n = -3$ **c** $n = \frac{3}{2}$

5 a 3^{-1} **b** $3^{\frac{3}{5}}$ **c** $3^{\frac{16}{3}}$

6 $a = 3$

7 $x = -5\frac{2}{5}$

8 $t = 3$

9 $x = -18$

10 See Exam-style question mark scheme on page 10.

11 $x = \frac{1}{2}$

1.2 Surds

1 a $2\sqrt{5}$ **b** $3\sqrt{2}$ **c** $2\sqrt{11}$ **d** $3\sqrt{7}$

e $7\sqrt{2}$ **f** $10\sqrt{7}$

2 See Exam-style question mark scheme on page 10.

3 a $\sqrt{2}$ **b** $\sqrt{3}$ **c** $2\sqrt{3}$

4 a $7\sqrt{3}$ **b** $4\sqrt{3}$ **c** $9\sqrt{5}$ **d** $10\sqrt{2}$

e $13\sqrt{3}$ **f** $-8\sqrt{5}$

5 a $2\sqrt{5} - \sqrt{15}$ **b** $4\sqrt{3} - \sqrt{15}$

c $7\sqrt{2} + 2$ **d** $20 + 5\sqrt{2} - 4\sqrt{3} - \sqrt{6}$

e $8 + 2\sqrt{5} - 4\sqrt{3} - \sqrt{15}$ **f** $11 + 6\sqrt{3}$

g $8 - 5\sqrt{2}$ **h** $-1 + \sqrt{7}$

i $21 - 8\sqrt{5}$ **j** -1

k $8 + 2\sqrt{15}$ **l** $7 - 2\sqrt{10}$

6 See Exam-style question mark scheme on page 10.

7 Sara has missed some terms out when expanding the brackets.

$(3 + \sqrt{5})^2 = 14 + 6\sqrt{5}$

8 $(\sqrt{7} - \sqrt{5})(\sqrt{7} + \sqrt{5}) = \sqrt{7}\sqrt{7} + \sqrt{7}\sqrt{5} - \sqrt{5}\sqrt{7} - \sqrt{5}\sqrt{5}$

$= \sqrt{49} - \sqrt{25}$

$= 7 - 5$

$= 2$

1.3 Rationalising denominators

1 a $\frac{\sqrt{3}}{3}$ **b** $\frac{\sqrt{7}}{7}$ **c** $\frac{3\sqrt{2}}{2}$ **d** $\sqrt{2}$

e $\sqrt{5}$ **f** $\frac{\sqrt{6}}{2}$ **g** $\frac{\sqrt{6}}{3}$ **h** $\frac{\sqrt{10}}{5}$

i $\frac{\sqrt{21}}{7}$

2 a $\frac{5 - \sqrt{3}}{22}$ **b** $\frac{3 + \sqrt{2}}{7}$ **c** $\frac{1 + \sqrt{5}}{-2}$ **d** $-2 + 2\sqrt{2}$

e $6 + 3\sqrt{3}$ **f** $\frac{10 - 2\sqrt{7}}{9}$ **g** $\frac{\sqrt{2} - \sqrt{6}}{-2}$ **h** $\frac{3 + \sqrt{3}}{-2}$

i $\frac{2\sqrt{3} + \sqrt{6}}{2}$ **j** $\frac{3\sqrt{5} - \sqrt{15}}{6}$ **k** $\frac{4\sqrt{5} + 5}{11}$ **l** $\frac{1 + \sqrt{7}}{6}$

3 a $-\sqrt{2} - \sqrt{3}$ **b** $\frac{5}{2}(-\sqrt{3} + \sqrt{5})$ **c** $\frac{3 + \sqrt{21}}{-2}$ **d** $\frac{2\sqrt{3} - 2\sqrt{5} + 3 - \sqrt{15}}{-2}$

e $-\sqrt{5} - 2\sqrt{6}$ **f** $\frac{\sqrt{77} - 9}{2}$

4 a $7 - 4\sqrt{3}$ **b** $9 + 4\sqrt{5}$ **c** $\frac{42 + 15\sqrt{3}}{242}$ **d** $\frac{38 - 12\sqrt{2}}{289}$

e $\frac{4 - \sqrt{2}}{14}$ **f** $\frac{-9 + 6\sqrt{5}}{11}$ **g** $\frac{2\sqrt{3} - 3}{2}$ **h** $\frac{27\sqrt{5} + 10\sqrt{10}}{529}$

i $\frac{8 - 3\sqrt{2}}{23}$

5 a $3\sqrt{3}$ **b** $\frac{4\sqrt{3} + \sqrt{15}}{9}$

6 a $\frac{2\sqrt{2} + \sqrt{10}}{6}$ **b** $\frac{\sqrt{3} - 1}{8}$ **c** $\frac{5 + 5\sqrt{5} + \sqrt{3} + \sqrt{15}}{-8}$

c $\frac{\sqrt{5} + \sqrt{10}}{35}$ **d** $\frac{\sqrt{6} - 4\sqrt{2}}{10}$ **e** $\frac{2 + 12\sqrt{3} + \sqrt{5} + 6\sqrt{15}}{-107}$

7 See Exam-style question mark scheme on page 10.

8 $\frac{2 + \sqrt{3}}{\sqrt{80} - \sqrt{20}} = \frac{2 + \sqrt{3}}{4\sqrt{5} - 2\sqrt{5}}$

$= \frac{2 + \sqrt{3}}{2\sqrt{5}}$

$= \frac{(2 + \sqrt{3}) \times \sqrt{5}}{2\sqrt{5} \times \sqrt{5}}$

$= \frac{2\sqrt{5} + \sqrt{15}}{10}$

Exam-style question mark scheme

1.1 Laws of indices

10

Answer	Mark	Mark scheme	Additional guidance
y = 3	B1	for simplifying $8^{\frac{2}{3}}$, e.g. 2^2	
	B1	for simplifying $\frac{1}{4^2}$, e.g. 2^{-4}	
	B1	for simplifying $32^{\frac{3}{5}}$, e.g. 2^3	
	M1	for $2^2 \times 2^{-4} \times 2^{3y-4} \times 2^3 = 2^6$ or equivalent	
	M1	for forming an equation in y, e.g. $2 - 4 + 3y - 4 + 3 = 6$	
	A1	correct answer only of $y = 3$	

1.2 Surds

2

Answer	Mark	Mark scheme	Additional guidance
$6\sqrt{5}$	M1	for a correct first step to show a square number within the factorisation e.g. $180 = 10 \times 3 \times 3 \times 2$ or $180 = 4 \times 9 \times 5$	
	A1	correct answer only	

6

Answer	Mark	Mark scheme	Additional guidance
72	M1	for $3^2 = 9$ or $(\sqrt{8})^2 = \sqrt{8} \times \sqrt{8} (= 8)$	
	A1	cao	
$6\sqrt{5} + 30$	M1	for simplifying one term e.g. $(\sqrt{5})^2 = 5$ or $(\sqrt{5})^3 = 5\sqrt{5}$	
	M1	for $\sqrt{5} + 5 + 5\sqrt{5} + 5 \times 5$ or equivalent or one correct term e.g. $6\sqrt{5}$ or 30	
	A1	or $6(\sqrt{5} + 5)$	

1.3 Rationalising denominators

7

Answer	Mark	Mark scheme	Additional guidance
$\frac{4 + \sqrt{7}}{3}$	M1	for rationalising e.g. multiplication by $\frac{7 + \sqrt{7}}{7 + \sqrt{7}}$ or equivalent	
	M1	for a complete method to an unsimplified answer e.g. $\frac{56 + 14\sqrt{7}}{42}$	
	A1	correct answer only	

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