Student Name

Mathematics Stage 5 Paths

INDICES C

Book 1 Describe surds

Version: 260207

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CONTENTS

OVERVIEW

SYLLABUS CONTENT

MA5-IND-P-02 describes and performs operations with surds and fractional indices

Describe surds

- Describe a real number as a number that can be represented by a point on the number line
- Examine the differences between rational and irrational numbers and recognise that all rational and irrational numbers are real
- Convert between recurring decimals and their fractional form using digital tools
- Describe the term *surd* as referring to irrational expressions of the form $\sqrt[n]{x}$ where x is a rational number and n is an integer such that $n \geq 2$, and $x > 0$ when n is even
- Recognise that a surd is an exact value that can be approximated by a rounded decimal
- Demonstrate that $\sqrt{x}$ is undefined for $x < 0$ and that $\sqrt{x} = 0$ when $x = 0$ using digital tools
- Describe $\sqrt{x}$ as the positive square root of x for $x > 0$ and $\sqrt{0} = 0$

REVIEW OF PRIOR KNOWLEDGE

1 Express these recurring decimals using dot or bar notation.

a $0.777777777777\ldots$	**b** $0.37777777777777\ldots$	**c** $0.82828282828282\ldots$
d $0.872872872872872\ldots$	**e** $0.702170217021\ldots$	**f** $0.82555555555555\ldots$

2 Using a calculator, express these fractions as decimals using division.

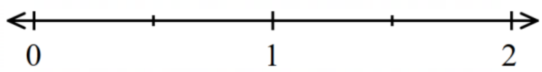
a $\frac{1}{3}$	**b** $\frac{1}{6}$	**c** $\frac{10}{12}$
d $\frac{17}{18}$	**e** $\frac{293}{300}$	**f** $\frac{4}{9}$

3 Round these decimals to two decimal places.

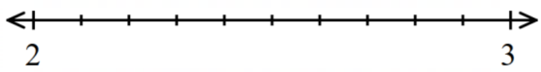
a 3.4567	**b** 2.3479	**c** 0.7
d 89.231	**e** 9.499	**f** 5.5851

4 Place a dot to represent these decimals on the number lines.

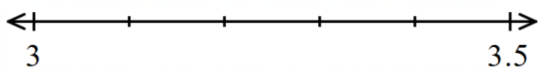
a 1.7



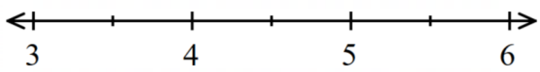
b 2.35



c 3.15



d 4.75



TERMINATING AND RECURRING DECIMALS AS FRACTIONS

TERMINATING AND RECURRING DECIMALS

- **Terminating** decimals **end**, for example: 0.25
- **Recurring** decimals **repeat forever**, for example: 0.3333333333333333333333333333…
- Recurring digits are shown as:
  - a dot for a single recurring digit. $0.666666\ldots = 0.\dot{6}$
  - a bar for many recurring digits. $0.686868\ldots = 0.\overline{68}$

TERMINATING AND RECURRING DECIMALS ARE RATIONAL

- Every terminating decimal can be written as a fraction using knowledge of place value:

$$\begin{aligned} 0.827 &= 827 \text{ thousandths} \\ &= \frac{827}{1000} \end{aligned}$$

- Every recurring decimal can also be written as a fraction by looking at patterns.
  You will learn a formal proof after learning algebraic equations.

$$0.\dot{3} \rightarrow \frac{1}{3}$$

1 $\frac{1}{3}$ as a decimal is 0.333333333333333…

a Express this recurring decimal using the correct notation.

$0.\dot{3}$

b Without using a calculator, what would $\frac{2}{3}$ be?

$0.\dot{6}$

c Check $2 \div 3$ on a calculator. Explain why it is different to your answer to part **b**.

The calculator ran out of digits in its display, so it rounded the last digit up to 7.

2 Convert to a decimal:

a $\frac{1}{3} = 0.3333333333333333 \ldots = 0.\dot{3}$

b $\frac{2}{3} =$ $0.\dot{6}$

c $\frac{2}{6} =$ $0.\dot{3}$

d $\frac{3}{6} =$ 0.5

e $\frac{4}{6} =$ $0.\dot{6}$

f $\frac{6}{6} =$ 1

g $\frac{7}{6} =$ $1.1\dot{6}$

h $\frac{1}{7} =$ $0.\overline{142857}$

i $\frac{2}{7} =$ $0.\overline{285714}$

j $\frac{3}{7} =$ $0.\overline{428571}$

k $\frac{4}{7} =$ $0.\overline{571428}$

l $\frac{5}{7} =$ $0.\overline{714285}$

m $\frac{6}{7} =$ $0.\overline{857142}$

3 Using a calculator, convert these to decimals.

a $\frac{1}{9}$ $0.\dot{1}$

b $\frac{2}{9}$ $0.\dot{2}$

c $\frac{3}{9}$ $0.\dot{3}$

d $\frac{4}{9}$ $0.\dot{4}$

e $\frac{7}{9}$ $0.\dot{7}$

f $\frac{8}{9}$ $0.\dot{8}$

Using the pattern above, express these as fractions:

g $0.\dot{4}$ $\frac{4}{9}$

h $0.\dot{8}$ $\frac{8}{9}$

i $0.\dot{6}$ $\frac{6}{9} = \frac{2}{3}$

4 Using a calculator, convert these to decimals.

a $\frac{1}{99}$ $0.\overline{01}$	**b** $\frac{8}{99}$ $0.\overline{08}$	**c** $\frac{14}{99}$ $0.\overline{14}$
d $\frac{48}{99}$ $0.\overline{48}$	**e** $\frac{72}{99}$ $0.\overline{72}$	**f** $\frac{87}{99}$ $0.\overline{87}$

Using the pattern above, express these as fractions:

g $0.\overline{64}$ $\frac{64}{99}$	**h** $0.\overline{05}$ $\frac{5}{99}$	**i** $0.\overline{93}$ $\frac{93}{99}=\frac{31}{33}$

5 Using a calculator, convert these to decimals.

a $\frac{1}{999}$ $0.\overline{001}$	**b** $\frac{12}{999}$ $0.\overline{012}$	**c** $\frac{412}{999}$ $0.\overline{412}$

Using the pattern above, express these as fractions:

d $0.\overline{942}$ $\frac{942}{999}=\frac{314}{333}$	**e** $0.\overline{023}$ $\frac{23}{999}$	**f** $0.\overline{138}$ $\frac{138}{999}$

6 Convert these decimals to fractions.

a $0.\dot{3}$ $\frac{1}{3}$	**g** $0.1\dot{4}$ $\frac{1}{10}+\frac{4}{90}=\frac{13}{90}$	**m** $1.0\overline{14}$ $1\frac{144}{990}=1\frac{7}{445}$
b $0.\overline{34}$ $\frac{34}{99}$	**h** $0.01\dot{4}$ $\frac{1}{100}+\frac{4}{900}=\frac{13}{900}$	**n** $2.\dot{4}$ $2\frac{4}{9}$
c $0.\overline{35}$ $\frac{35}{99}$	**i** $0.\overline{014}$ $\frac{14}{999}$	**o** $2.\overline{43}$ $2\frac{43}{9}$
d $0.\overline{357}$ $\frac{357}{999}$	**j** $1.\dot{4}$ $1\frac{4}{9}$	**p** $3.\overline{43}$ $3\frac{43}{99}$
e $0.\dot{4}$ $\frac{4}{9}$	**k** $1.0\dot{4}$ $1\frac{13}{90}$	**q** $3.0\overline{43}$ $3\frac{43}{990}$
f $0.0\dot{4}$ $\frac{4}{90}=\frac{2}{45}$	**l** $1.\overline{14}$ $1\frac{14}{99}$	

7 Here is an example of converting recurring decimals to fractions without using a calculator. Read the example carefully and answer the questions.

Worked Solution	**Explanation**
Convert $0.\dot{6}$ to a fraction. Let $x = 0.6666666 \ldots$ (1) $10x = 6.6666666 \ldots$ (2) Using subtraction: (2) – (1): $9x = 6$ $x = \frac{6}{9}$ $\therefore x = 0.6666666 \ldots = \frac{6}{9}$	Why is $10x = 6.6666666 \ldots ?$ How did we get the equation $9x = 6$? How did we determine that $0.6666666 \ldots = \frac{6}{9}$?

Convert these recurring decimals to fractions using the above method.

a $0.\dot{8}$

$x = 0.8888888 \ldots$

$10x = 8.8888888 \ldots$

$9x = \ldots\ldots\ldots\ldots\ldots\ldots$

$\therefore x = \ldots\ldots\ldots\ldots\ldots\ldots$

$\frac{8}{9}$

b $0.\dot{4}$

$x = 0.4444444 \ldots$

$10x = \ldots\ldots\ldots\ldots\ldots\ldots$

$9x = \ldots\ldots\ldots\ldots\ldots\ldots$

$\therefore x = \ldots\ldots\ldots\ldots\ldots\ldots$

$\frac{4}{9}$

c $0.\dot{7}$

$\frac{7}{9}$

d $1.\dot{2}$

$1\frac{2}{9}$

e $5.\dot{7}$

$5\frac{7}{9}$

f $8.\dot{2}$

$8\frac{2}{9}$

g $0.\overline{81}$

$x = 0.8181818181 \ldots$

$100x = 81.8181818181 \ldots$

$99x = \ldots\ldots\ldots\ldots\ldots\ldots$

$\therefore x = \ldots\ldots\ldots\ldots\ldots\ldots$

$\frac{9}{11}$

h $0.\overline{69}$

$\frac{23}{33}$

i $1.\overline{43}$

$1\frac{43}{99}$

j $3.\overline{72}$

$3\frac{8}{11}$

k $9.\overline{75}$

$9\frac{25}{33}$

l $0.\overline{132}$

$\frac{44}{333}$

m $9.\overline{04}$

$9\frac{4}{99}$

n $0.\overline{037}$

$\frac{37}{999}$

o $2.\overline{917}$

$2\frac{917}{999}$

p $6.\overline{0125}$

$6\frac{125}{9999}$

q $13.\overline{1375}$

$13\frac{1375}{9999}$

r $165.\overline{005}$

$165\frac{5}{999}$

8 Using a similar method, show that 8.122222222222… = $\dfrac{731}{90}$

$x = 8.1222 \ldots$

$10x = 81.222 \ldots$

$100x = 812.222 \ldots$

$90x = 731$

$x = \frac{731}{90}$

Convert these decimals to fractions.

a $0.3\dot{5}$

$\frac{16}{45}$

b $0.51\dot{2}$

$\frac{461}{900}$

c $0.0\dot{9}$

$\frac{1}{10}$

9 Convert these to fractions.

a $0.\dot{1}$ $\frac{1}{9}$	**b** $0.0\dot{1}$ $\frac{1}{90}$	**c** $0.8\dot{1}$ $\frac{73}{90}$	**d** $0.\overline{18}$ $\frac{18}{99}=\frac{2}{11}$	**e** $0.1\overline{18}$ $\frac{13}{110}$
f $0.\dot{2}$ $\frac{2}{9}$	**g** $0.0\dot{2}$ $\frac{2}{90}=\frac{1}{45}$	**h** $0.7\dot{2}$ $\frac{65}{90}=\frac{13}{90}$	**i** $0.\overline{27}$ $\frac{27}{99}=\frac{3}{11}$	**j** $0.5\overline{27}$ $\frac{29}{55}$
k $0.\dot{3}$ $\frac{3}{9}=\frac{1}{3}$	**l** $0.0\dot{3}$ $\frac{3}{90}=\frac{1}{30}$	**m** $0.6\dot{3}$ $\frac{55}{90}=\frac{11}{18}$	**n** $0.\overline{36}$ $\frac{36}{99}=\frac{4}{11}$	**o** $0.4\overline{36}$ $\frac{24}{55}$
p $0.\dot{4}$ $\frac{4}{9}$	**q** $0.0\dot{4}$ $\frac{4}{90}=\frac{2}{45}$	**r** $0.5\dot{4}$ $\frac{49}{90}$	**s** $0.\overline{45}$ $\frac{45}{99}=\frac{5}{11}$	**t** $0.3\overline{45}$ $\frac{19}{55}$
u $0.\dot{5}$ $\frac{5}{9}$	**v** $0.0\dot{5}$ $\frac{5}{90}=\frac{1}{18}$	**w** $0.4\dot{5}$ $\frac{41}{90}$	**x** $0.\overline{54}$ $\frac{54}{99}=\frac{6}{11}$	**y** $0.9\overline{54}$ $\frac{21}{22}$
z $0.\dot{6}$ $\frac{6}{9}=\frac{2}{3}$	**aa** $0.0\dot{6}$ $\frac{6}{90}=\frac{1}{15}$	**bb** $0.3\dot{6}$ $\frac{33}{90}=\frac{11}{30}$	**cc** $0.\overline{63}$ $\frac{63}{99}=\frac{7}{11}$	**dd** $0.2\overline{63}$ $\frac{29}{110}$
ee $0.\dot{7}$ $\frac{7}{9}$	**ff** $0.0\dot{7}$ $\frac{7}{90}$	**gg** $0.2\dot{7}$ $\frac{25}{90}=\frac{5}{18}$	**hh** $0.\overline{72}$ $\frac{72}{99}=\frac{8}{11}$	**ii** $0.7\overline{72}$ $\frac{17}{22}$
jj $0.\dot{8}$ $\frac{8}{9}$	**kk** $0.0\dot{8}$ $\frac{4}{45}$	**ll** $0.1\dot{8}$ $\frac{17}{90}$	**mm** $0.\overline{81}$ $\frac{81}{99}=\frac{9}{11}$	**nn** $0.6\overline{81}$ $\frac{15}{22}$

IRRATIONAL NUMBERS

RATIONAL NUMBERS

- **Rational numbers** are a way to represent values between integers.
- A rational number can be written as a ratio (or fraction):

$$\frac{a}{b}$$

$$\text{where } a \text{ and } b \text{ are integers, and } b \neq 0$$

- Rational numbers include:

Fractions	Integers	Percentages	Terminating Decimals	Recurring Decimals
$\frac{2}{3}$	$2 \rightarrow \frac{2}{1}$	$47\% \rightarrow \frac{47}{100}$	$0.125 \rightarrow \frac{125}{1000}$	$0.333333 \rightarrow \frac{1}{3}$

IRRATIONAL NUMBERS

- **Irrational numbers** are **non-terminating non-recurring** decimals, such as π and $\sqrt{2}$.
- All numbers are collectively known as **real numbers**.

Real Numbers

All numbers we have been working with so far are collectively called real numbers.

Rational Numbers

A number that can be written as $\frac{a}{b}$ where a and b are integers.

$-\frac{12}{5}$ 68% 0.42 $\frac{8}{3}$ $0.\dot{3}$ $4\frac{2}{5}$

Integers

Whole numbers, including negative numbers.

-2 $\sqrt{9}$ $\frac{18}{3}$ 8 -183

Natural Numbers

Positive whole numbers

1 2 3 62 2719

Irrational Numbers

Irrational numbers cannot be written as $\frac{a}{b}$ where a and b are integers.
As decimals, they are non-terminating and non-recurring.
They go on forever with no repeating pattern.

$\pi \approx 3.141592\ldots$ $\sqrt{2} \approx 1.4142135\ldots$ $\sqrt{3} \approx 1.7320508\ldots$ $e \approx 2.718281\ldots$

Example Classify numbers as rational or irrational.

Using a calculator, determine whether these numbers are irrational or rational.

a	$\frac{1}{3}$	Rational	Irrational	**i**	$\sqrt{4}$	Rational	Irrational
b	3	Rational	Irrational	**j**	$\sqrt{5}$	Rational	Irrational
c	0.3	Rational	Irrational	**k**	$\sqrt{5}+1$	Rational	Irrational
d	$0.\dot{3}$	Rational	Irrational	**l**	$\frac{\sqrt{2}}{2}$	Rational	Irrational
e	$\sqrt{3}$	Rational	Irrational	**m**	$2\sqrt{2}$	Rational	Irrational
f	$\sqrt{9}$	Rational	Irrational	**n**	π	Rational	Irrational
g	0.25	Rational	Irrational	**o**	$-\frac{22.5}{7}$	Rational	Irrational
h	25%	Rational	Irrational	**p**	$3.\overline{14}$	Rational	Irrational

Example Approximate irrational numbers.

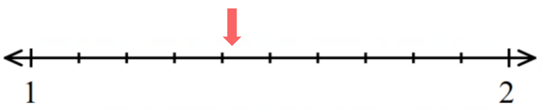
Approximate $\sqrt{2}$ to 2 decimal places. $\sqrt{2} = 1.414213562\ldots$ ≈ 1.41	When rounding to 2 decimal places, which is the critical digit that we look at?
Approximate e to 2 decimal places. $e = 2.718281828\ldots$ ≈ 2.72	How do we know whether to round up to down?

Approximate these numbers to 2 decimal places.

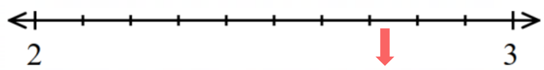
a $\sqrt{3}$ 1.73	**b** π 3.14	**c** $\sqrt[3]{25}$ 2.92
d $\sqrt{18}$ 4.24	**e** $\frac{1}{\pi}$ 0.32	**f** $2\sqrt{2}$ 2.83

Example Locate the approximate position of irrational numbers on a number line.

$\sqrt{2} \approx 1.41$

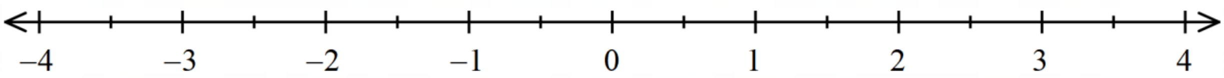


$e \approx 2.72$



Using a calculator, locate these numbers on the number line.

$\sqrt{3}$ $\qquad$ $\sqrt[3]{7}$ $\qquad$ $-\pi$



Key ideas

1. Rational numbers can be written as a fraction $\frac{a}{b}$, where a and b are ………………… and b …… 0.
2. If a number can be written as a terminating or ……………… decimal, then it is rational.
3. Irrational numbers cannot be written as a fraction with integers, when written as a decimal, they are non-…………………………… and non-……………………………

Check your understanding

1	Which of these two numbers are rational? 7 and 7.27629845							
	a	7	**b**	7.27629845	**c**	Neither	**d**	Both
2	Which of these two numbers are rational? π and 3.142							
	a	π	**b**	3.142	**c**	Neither	**d**	Both
3	Which of these two numbers are rational? 3.5 and -3.5							
	a	3.5	**b**	-3.5	**c**	Neither	**d**	Both
4	Which of these two numbers are rational? $\frac{1}{3}$ and $\frac{4}{1}$							
	a	$\frac{1}{3}$	**b**	$\frac{1}{4}$	**c**	Neither	**d**	Both
5	Which of these two numbers are rational? $\sqrt{36}$ and $\sqrt{12}$							
	a	$\sqrt{36}$	**b**	$\sqrt{12}$	**c**	Neither	**d**	Both

1 Circle which of these numbers are integers.

$10 \qquad 9.6 \qquad \frac{3}{4} \qquad -3 \qquad 117$

$10,\ -3,\ 117$

Explain why all integers are rational numbers.

Integers can be written with a denominator of 1.

2 Circle which of these numbers are rational.

$\frac{7}{2} \qquad \sqrt{3} \qquad 1.5 \qquad 11$

$\frac{7}{2}, 1.5, 11$

Explain how you know whether a number is rational.

The number can be written as a fraction with whole number numerator and denominator.

3 Explain why $\sqrt{4}$ is a rational number.

$\sqrt{4} = 2$, which is an integer, so it's rational.

4 Look at these numbers.

$\boxed{\sqrt{2}} \quad \boxed{\sqrt{3}} \quad \boxed{\sqrt{4}} \quad \boxed{\sqrt{5}} \quad \boxed{3\sqrt{7}} \quad \boxed{2\sqrt{100}} \quad \boxed{-\sqrt{3}} \quad \boxed{-\sqrt{25}}$

a Which numbers are irrational?

$\sqrt{3}, \sqrt{5}, 3\sqrt{7}, -\sqrt{3}$

b Which numbers are rational?

$\sqrt{4}, 2\sqrt{100}, -\sqrt{25}$

5 Emily says:

0.7777... recurring is irrational as you cannot write it as a fraction.

Explain why she is incorrect.

$0.777\ldots$ can be written as $\frac{7}{9}$, so it's rational.

6 Darius says:

π is a rational number, since it is roughly equal to $\frac{22}{7}$

Explain why Darius is incorrect.

π is roughly equal to $\frac{22}{7}$ but not exactly. π is a non-terminating, non-recurring decimal, so it is irrational.

7 Becky says:

$\sqrt{25}$ is not rational, because it is a square root.

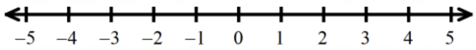
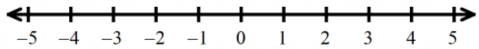
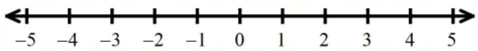
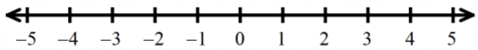
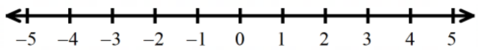
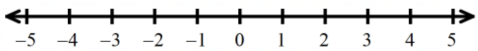
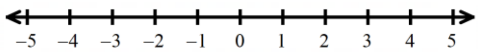
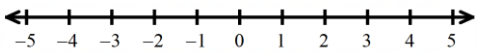
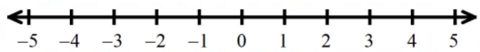
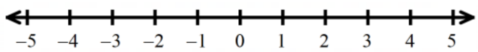
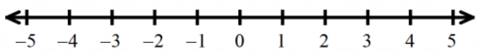
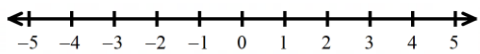
Explain why Becky is incorrect.

$\sqrt{25}$ simplifies to 5, which is rational.

8 Using a calculator, approximate these numbers to 2 decimal places.

a $\sqrt{5}$ 2.24	**b** $2\sqrt{5}$ 4.47	**c** 1.61803399 1.62
d $\frac{22}{7}$ 3.14	**e** $\frac{\pi}{2}$ 1.57	**f** e^2 7.39

9 Complete the table.

Number	Rational/ Irrational?	Approximation (2 d.p.)	Approximation (3 d.p.)	Approximate location on number line
e	Irrational	≈ 2.72	≈ 2.718	
$\sqrt{6}$	Irrational	2.45	2.449	
$2\sqrt{6}$	Irrational	4.90	4.899	
$\sqrt{24}$	Irrational	4.90	4.899	
$\sqrt{13}$	Irrational	3.61	3.606	
$\sqrt{16}$	Rational	4.00	4.000	
π	Irrational	3.14	3.142	
3π	Irrational	9.42	9.425	
$0.\dot{3}$	Rational	0.33	0.333	
$\frac{7}{3}$	Rational	2.33	2.333	
-5	Rational	-5.00	-5.000	
$-\sqrt{3}$	Irrational	-1.73	-1.732	

SURDS

Prior knowledge check

1 Complete the sentences:

a A rational number can be written as $\frac{a}{b}$ where a and b are …………………

b A number is irrational if its decimal representation is non-………………… and non-…………………

c All recurring decimals are ………………………, since they can be written as a fraction.

d All numbers are collectively called ……………… numbers; they can be represented on a number line.

2 Determine whether these numbers are rational or irrational by entering each number in the calculator.

a $\sqrt{5}$	**b** 18%	**c** $\frac{2}{5}$	**d** -124%
e $1\frac{5}{7}$	**f** $-\sqrt{4}$	**g** $2\sqrt{3}$	**h** π
i $0.\dot{8}$	**j** $0.1\dot{8}$	**k** $0.\overline{18}$	**l** $0.41\dot{6}$

3 Solve these equations. Leave your answer in exact form.

a $x^2 = 4$	**b** $x^2 = 5$	**c** $x^2 = -1$	**d** $x^2 + 3 = 12$
e $x^2 - 5 = 18$	**f** $x^3 = 27$	**g** $x^3 = -8$	**h** $4x^3 = 12$

ROOTS AND SURDS

- Square rooting $\sqrt{x}$ is the inverse operation of squaring x^2.
- We call a root a **surd** if it is irrational: E.g., $\sqrt{2}, \sqrt{3}, \sqrt{5}, \sqrt[3]{7}$
- It is best to leave surds in exact form, rather than a rounded decimal.
- It is impossible (for now) to square root a negative number $\sqrt{-4}$, we say it is **not real**.

Example Identify surds.

Determine whether these roots are surds

a	$\sqrt{3}$	Surd	Rational	Not real
b	$2\sqrt{3}$	Surd	Rational	Not real
c	$\sqrt{4}$	Surd	Rational	Not real
d	$\sqrt{8}$	Surd	Rational	Not real
e	$\sqrt{16}$	Surd	Rational	Not real
f	$2\sqrt{16}$	Surd	Rational	Not real
g	$3+\sqrt{16}$	Surd	Rational	Not real
h	$\sqrt[3]{16}$	Surd	Rational	Not real
i	$\sqrt[3]{8}$	Surd	Rational	Not real
j	$\sqrt[3]{6}$	Surd	Rational	Not real
k	$\sqrt{6}$	Surd	Rational	Not real
l	$\sqrt{9}$	Surd	Rational	Not real
m	$-\sqrt{9}$	Surd	Rational	Not real
n	$\sqrt[3]{9}$	Surd	Rational	Not real
o	$\sqrt{0}$	Surd	Rational	Not real
p	$\sqrt{-0}$	Surd	Rational	Not real
q	$\sqrt{-1}$	Surd	Rational	Not real
r	$-\sqrt{1}$	Surd	Rational	Not real
s	$-\sqrt{-1}$	Surd	Rational	Not real
t	$\sqrt[3]{-8}$	Surd	Rational	Not real
u	$\sqrt{-(-25)}$	Surd	Rational	Not real

Key ideas

1. A number that cannot be expressed as a fraction with integer numerator and denominator is called ……………………………………
2. A ………………… is an irrational root, for example $\sqrt{2}$ or $\sqrt[3]{5}$
3. The decimal representation of a surd is a decimal that goes on ……………………… and never ………………………………
4. $\sqrt{7}$ is a surd because its ………………… representation doesn't repeat and goes on forever.
5. $\sqrt{25}$ is …………… a surd because its decimal representation is …………

Check your understanding

1 Tom says $\sqrt{1}$ is a surd
Katie says $\sqrt{2}$ is a surd
Who is correct?

a Only Tom **b** Only Katie **c** Both **d** Neither

2 Tom says $\sqrt{9}$ is not a surd
Katie says $\sqrt{3}$ is not a surd
Who is correct?

a Only Tom **b** Only Katie **c** Both **d** Neither

3 Which of the following is **not** a surd?

a $\sqrt{45}$ **b** $\sqrt{47}$ **c** $\sqrt{49}$ **d** $\sqrt{51}$

4 Which of the following is **not** a surd?

a $\sqrt{84}$ **b** $\sqrt{83}$ **c** $\sqrt{82}$ **d** $\sqrt{81}$

1 Jono says $\sqrt{18}$ is a surd. Explain why he is correct.

$\sqrt{18}$ cannot be expressed as a fraction with integers. It is a non-terminating, non-recurring decimal.

2 Becky says $\sqrt{25}$ is not a surd. Explain why she is correct.

$\sqrt{25}$ can be simplified to 5

3 Circle the surds.

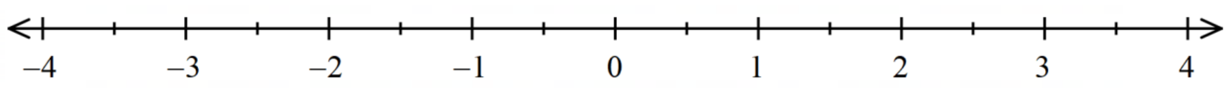
$\sqrt{25}$ $\quad$ $\sqrt{24}$ $\quad$ $\sqrt{2}$ $\quad$ $\sqrt{1}$ $\quad$ $\sqrt{169}$ $\quad$ $\sqrt{8}$ $\quad$ $\sqrt[3]{8}$ $\quad$ $\sqrt{130}$

$\sqrt{24}, \sqrt{2}, \sqrt{8}, \sqrt{130}$

4 Express each number as a decimal using a calculator and then decide whether they are irrational or rational. Round the decimals to 2 d.p.

a $\sqrt{5}$ Irrational, 2.24	**b** 18% Rational, 0.18	**c** $\frac{2}{5}$ Rational, 0.4	**d** -124% Rational, -1.24
e $1\frac{5}{7}$ Rational, $1.\overline{714285}$	**f** $-\sqrt{2}$ Irrational, -1.41	**g** $2\sqrt{3}$ Irrational, 3.46	**h** π Irrational, 3.14

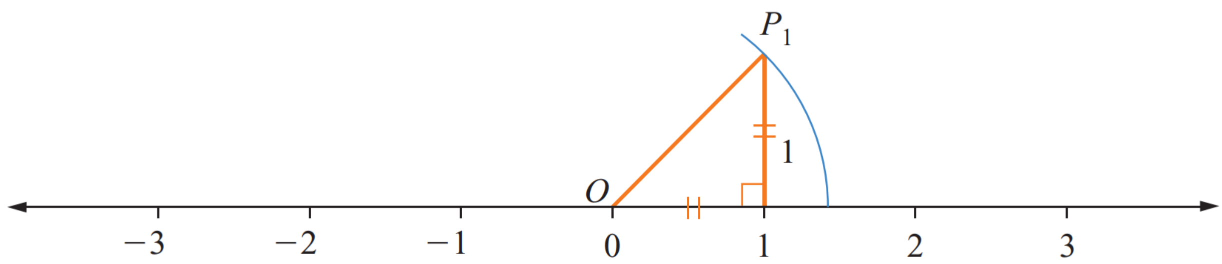
Show each number's approximate location on the number line.



5 Using a calculator, or otherwise, classify these numbers as either surds, rational, or not real.

a $\sqrt{7}$ surd	**b** $2\sqrt{11}$ surd	**c** $2\sqrt{25}$ rational	**d** $-5\sqrt{144}$ rational
e $\frac{3\sqrt{9}}{2}$ rational	**f** $\frac{-5\sqrt{3}}{2}$ surd	**g** $1-\sqrt{3}$ surd	**h** $2+\sqrt{4}$ rational
i $\sqrt{\frac{4}{25}}$ rational	**j** $\sqrt{\frac{5}{16}}$ surd	**k** $\sqrt{-11}$ Not real	**l** $\sqrt{99}$ surd

10 Consider the number line:



a Use Pythagoras' Theorem to calculate the length of OP_1

$\sqrt{2}$

b Using a pair of compasses, with point at O, the location of $\sqrt{2}$ on the number line has been accurately marked. What is the approximate value of $\sqrt{2}$?

1.41

c $\sqrt{2}$ can be placed on a number line. Is it a real number?

yes

d Use the following diagram to accurately place $\sqrt{3}$, $\sqrt{4}$, $\sqrt{5}$, $\sqrt{6}$ on the number line.