IWCF United Kingdom Branch

Drilling Calculations
Distance Learning Programme

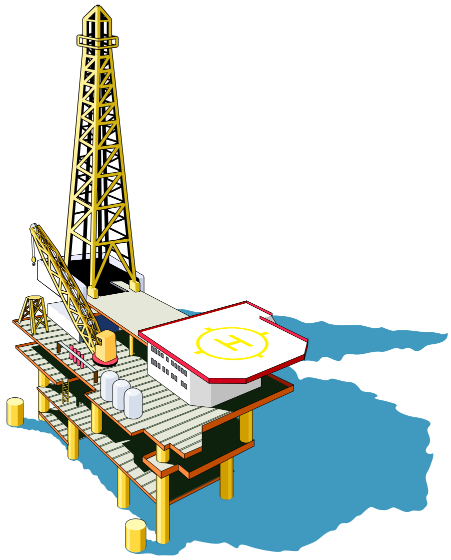
Part 1 – Introduction to Calculations

Contents

Introduction

Welcome to the IWCF UK-Branch Drilling Calculations Distance Learning Programme.

Nowadays, mathematics is used almost everywhere, at home at leisure and at work. More than ever knowledge of mathematics is essential in the oil industry.



The aim of this programme is to introduce basic mathematical skills to people working in or around the oilfield.

The programme will lead on to some of the more complex calculations required when working in the industry.

By the end of the programme, the user should have acquired the knowledge and skills required prior to taking an IWCF Well Control certification programme.

Training Objectives

When you have completed the package you should: -

- Have a good understanding of basic mathematics including;
  - Rounding and estimating
  - The meaning and use of mathematical symbols
  - The use of the calculator
  - Fractions and decimals
  - Ratios and percentages
  - How to solve equations.

- Have a knowledge of the most common oilfield units and how they are used

- Be able to calculate volumes in the appropriate units including
  - Square sided tanks
  - Cylindrical tanks

- Have an understanding of borehole geometry and be able to carry out calculations regarding the same

- Be able to carry out calculations for trip monitoring

- Be able to carry out the more common well control calculations including;
  - Hydrostatic pressures
  - Formation pressures

- Understand and list the concepts of kick prevention and recognition

- Understand how the circulating system works and carry out calculations regarding the same.

A more detailed set of objectives is stated at the start of each section of the programme.

How to use this training programme

Using the materials

This programme is designed as a stand-alone training programme enabling you to work through without external support. No one, however, expects you to work entirely by yourself. There may be times when you need to seek assistance. This might be in the form of a discussion with colleagues or by seeking the help of your supervisor. Should you require guidance, the best person to speak to would normally be your supervisor, failing this contact the Training department within your own company?

Planning

Whether you plan to use this programme at work or at home, you should organise the time so that it is not wasted. Set yourself targets to reach during a certain time period. Do not try to use the material for 5 minutes here and there, but try to set aside an hour specifically for study. It may even be useful to produce a timetable to study effectively.

	Week 1	**Week 2**	**Week 3**	**Week 4**
Monday		Revise section 3 Work through sections 4.1 to 4.2		Work through section 8
Tuesday	Work through section 1 18:30 – 19:30		Work through section 5	
Wednesday		Work through sections 4.3 to 4.5		Work through section 9
Thursday			Work through section 6	
Friday	Revise section 1 Work through section 2 10:00 – 11:00			Discuss with colleagues and/or supervisor
Saturday			Discuss with colleagues and/or supervisor	
Sunday	Revise section 2 Work through section 3	Discuss sections 1 to 4 with colleagues and/or supervisor on rig	Work through section 7	

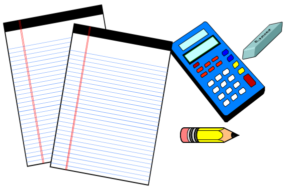
Organising your study

Once you have prepared a study timetable, think about what you have decided to do in each session. There are a few basic guidelines to help you plan each session

Do

- Find somewhere suitable to work, for example a desk or table with chair, comfortable lighting and temperature etc.

- Collect all the equipment you may need before you start to study, e.g. scrap paper, pen, calculator, pencil etc.



- Know what you plan to do in each session, whether it is an entire section or a subsection
- Work through all the examples, these give you an explanation using figures. Each section contains "try some yourself …" you should do all these.
- Make notes, either as you work through a section or at the end

- Make notes of anything you wish to ask your colleagues and/or supervisor.

Don't

- Just read through the material. The only way to check whether you have understood is to do the tests.
- Try to rush to get through as much as possible. There is no time limit, you're only aim should be to meet the training objectives.
- Keep going if you don't understand anything. Make a note to ask someone as soon as possible.
- Spend the entire session thinking about where to start.

How the programme is laid out

The programme is split into three parts. Each part is further divided into sections covering specific topics.

At the start of each section there is information and objectives detailing what are to be covered. Also at the start is an exercise called “Try these first . . . “.

Try these first . . . Exercise 1.1

?

These are questions covering the material in the section and are designed for you to see just how much you already know. Do just as it says and try these first! You can check your answers by looking at the end of the section.

Answers look like this;

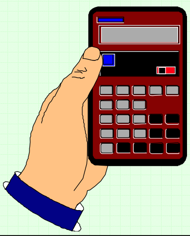
Answers – Exercise 1.1

Throughout each section you will find worked examples.

Examples

Following these examples you will find exercises to try yourself.

Try some yourself - Exercise 1.2



They are shown with a calculator although not questions will require one.

Check your answers before carrying on with the sections. If necessary, go back and check the material again.

Throughout the section there are boxes with other interesting facts.

Of interest / Other facts

The “Of interest” boxes are not core material but provide background knowledge.

Section 1: Whole Numbers

The first section of this book discusses the use of whole numbers and how we represent them. We will also discuss the terminology used.

Objectives

- To introduce the concept of numbers.
- To introduce the terminology.
- To explain why the position of each digit is important.
- To explain the use of the decimal system and the conventions for writing numbers.

Try these first . . .Exercise 1.1

1. Write the following numbers in figures;
   a. thirty five.
   b. three hundred and five.
   c. three hundred and fifty.

2. Write the following in words:
   a. 110
   b. 101
   c. 1
   d. 11

3. Write the following in figures:
   a. Seven hundred and twelve thousand, two hundred and one.
   b. Sixteen million, nine hundred and eighty seven thousand, eight hundred and fifty three.

4. Complete the following table:

Number in words	millions	hundred thousands	ten thousands	thousands	hundreds	tens	units
Sixty-two thousand							
Eight million, thirty thousand and fifty-three							
One hundred and six thousand and thirty-three							

The Number System

We use the symbols 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, to represent numbers.

> In fact….
>
> The proper name for these symbols is *Arabic Numbers*

When writing a number such as 324, each number is called a *digit*.

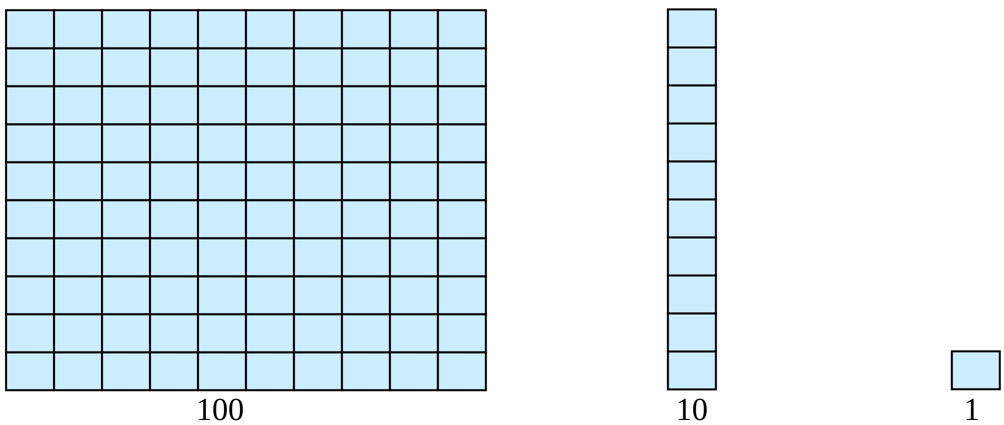
It is the position of these digits in the number which give us the value of the number.

3	**2**	**4**
Hundreds	Tens	Units
100	10	1
100	10	1
100		1
		1

So 324 is three hundred and twenty-four or three hundreds, 2 tens and 4 units.

A unit is one.

When we use the *Decimal system*, as we move to the left, each number is ten times more.



> In fact….
>
> Decimal means relating to the number ten.

The decimal system will be discussed in more detail in section 5.

The importance of position

In 614 the 4 means 4 *units*
In 146 the 4 means 4 *tens*
In 461 the 4 means 4 *hundreds*

In the three numbers above, the 4 stands for a different value when it is in a different place.

It is important to remember when dealing with whole numbers that the *smallest* number (the units) is always on the right.

The following are Arabic numbers in:

Figures

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29

Tens

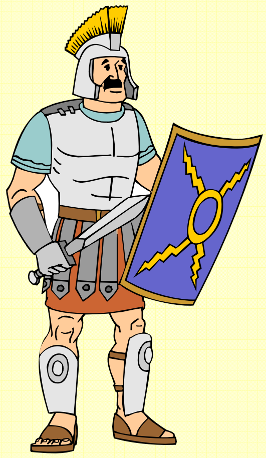
Counting in tens:

10	ten
20	twenty
30	thirty
40	forty
50	fifty
60	sixty
70	seventy
80	eighty
90	ninety
100	one hundred

The above shows how important the 0 (zero) is in the decimal system. For example;

205 is 2 hundreds, 0 tens and 5 units
250 is 2 hundreds, 5 tens and 0 units

Of interest:



The Romans did not have a symbol for 0

Roman Numbers	Value
I	1
II	2
III	3
IIII or IV	4
V	5
VI	6
VII	7
VIII	8
VIIII or IX	9
X	10
L	50
C	100
D	500
M	1,000

Roman numbers are written by putting the numbers side by side:

MMCCCV	2,305
CCCLXIII	363
MCMXCIX	1,999

For some reason, dates on films are still written in Roman Numerals.

Example – Numbers 1

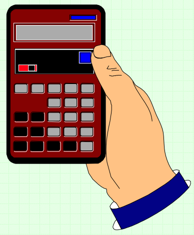
1. Write the following in numbers:
   a. sixty five — ***Answer:*** 65
   b. six hundred and five — ***Answer:*** 605
   c. six hundred and fifty — ***Answer:*** 650

2. Write the following in words:
   a. 14 — ***Answer:*** fourteen
   b. 140 — ***Answer:*** one hundred and forty
   c. 104 — ***Answer:*** one hundred and four

3. The numbers a. 123, b. 132, c. 321, d. 312, e. 231, f. 213 placed in order of size with the smallest first.

   Answer:
   a. 123
   b. 132
   f. 213
   e. 231
   d. 312
   c. 321

Try some yourself – Exercise 1.2



Write the following numbers in figures

1. a. thirty five
   b. three hundred and five
   c. three hundred and fifty

2. a. seventy nine
   b. seven hundred and nine
   c. seven hundred and ninety

Write the following in words

3. a. 980 b. 98 c. 908

4. a. 800 b. 80 c. 8

5. a. 89 b. 890 c. 809

6. Complete the table below by filling in the missing numbers and words.

Number in words	Figures		
	hundreds	tens	units
twenty four			
nineteen			
seventy six			
eight			
one hundred and sixty four			
seven hundred and eight			
three			
		6	1
	2	5	4
		5	8

7. Fill in the missing numbers:
   542 is _______ hundreds __________ tens ________ units

8. What quantity does the number 3 represent in the following?
   a. 113 b. 300 c. 35 d. 13

9. For which of these numbers does the number 8 mean 8 hundreds?
   a. 678 b. 890 c. 384 d. 508

10. Put these numbers in order of size with the smallest first.
    a. 103 b. 301 c. 130 d. 31
    e. 13 f. 310

Thousands

999 is the largest whole number using hundreds. For larger numbers we use *thousands.*

Example - Thousands

1,000	is *one thousand*
10,000	is *ten thousand*
100,000	is *one hundred thousand*
999,999	is nine hundred and ninety-nine thousand, nine hundred and ninety-nine

The convention for large numbers

In the UK and USA we separate each group of three digits (thousands) in a number by a comma (,).

In many European countries the comma is used to separate whole numbers from decimals (where we in the UK would use a decimal point). For this reason, these same countries do not use the comma as a thousand separator.

For example;

UK	Europe
1,000	1000
100,000	100000
999,999	999999

In this book we will follow the convention used in the UK.

IWCF examinations for well control, being International use the European convention.

Care must be taken with zeros in the middle of numbers.

Example - Thousands

5,008	is five thousand and eight
16,012	is sixteen thousand and twelve
505,040	is five hundred and five thousand and forty

Larger numbers

Numbers larger than 999,999 are counted in *millions*.

1,000,000	is *one million*
10,000,000	is *ten million*
100,000,000	is *one hundred million*

Example – Larger numbers

6,789,435	is six million, seven hundred and eighty nine thousand, four hundred and thirty five.
16,987,853	is sixteen million, nine hundred and eighty seven thousand, eight hundred and fifty three
235,634,798	is two hundred and thirty five million, six hundred and thirty four thousand, seven hundred and ninety eight.

Of interest…

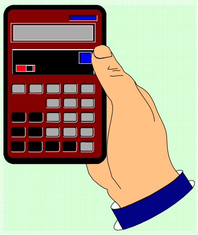
1,000,000,000 is *one billion*.
(This is the U.S. billion, the British billion is 1,000,000,000,000 but it is not used often.)

Try some yourself – Exercise 1.3

1. Write the following in figures.
   a. Two thousand, four hundred and fifty-one
   b. Five thousand, three hundred
   c. Seventy five thousand, one hundred and forty-two
   d. One hundred and fourteen thousand, six hundred and thirteen

2. Write the following in words
   a. 5,763
   b. 809,000
   c. 7,009
   d. 304,021

Try some yourself – Exercise 1.3 continued



3. Fill in the missing numbers in the table.

Number in words	hundred thousands	ten thousands	thousands	hundreds	tens	units
Five thousand						
Sixty two thousand						
Three hundred thousand						
Seventy four thousand and nine						
Six hundred thousand, two hundred						
Seventy thousand and fifty						
Ninety nine thousand						
Six thousand						

Write the following in figures.

4. Six hundred million

5. Three hundred and twenty four million, five hundred and sixty seven

6. Nine hundred and ninety nine million

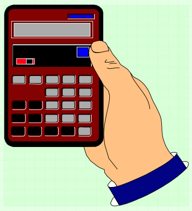
Write the following in words:

7. 189,000,000

8. 5,869,014

9. 167,189,112

Try some yourself – Exercise 1.3 continued



10. Fill in the missing numbers in the table:

Number in words	billions	hundred millions	ten millions	millions	hundred thousands	ten thousands	thousands	hundreds	tens	units
One billion, six hundred and ten million										
Eight million, thirty thousand and fifty three										
Seven hundred and six million										

Section 2: Estimating and Rounding

In the previous section we looked at how we write numbers down. When using numbers, it is often useful to approximate (or round) them to allow rough estimates to be made. This is important in checking the accuracy of calculations we might make on the rig. This section shows how to do this.

Objectives

- To introduce the concept of rounding numbers.
- To explain the rules of rounding numbers.
- To introduce the concept of estimating to check a calculation.

Try these first . . .Exercise 1.4

1. Round off 74,965 to;
   a. the nearest 10
   b. the nearest 100
   c. the nearest 1000

2. Give a rough estimate of 3,839,322 + 6,753,418

3. If mortgage payments are £172 per month, estimate the cost over a year.

4. If nine stands of drill pipe, each approximately 93 feet long are run into the hole, estimate how much pipe is in the hole.

2.1 Rounding

Drilling record set – 5,000 feet in 3 days

Thieves escape with $10,000,000 in jewels

Company collapses with debts of

Information is often given using numbers. There are a few examples on the right.

It is unlikely that the thieves escaped with *exactly* $10,000,000 worth of jewels, or that the company concerned owed *exactly* £4,000,000. The exact numbers are much more likely to be numbers such as $9,853,947 or £4,000,103.

The *rounded* numbers however give a good approximation of the size of the amounts concerned. Equally the drilling record was very unlikely to have been set in 3 days to the exact minute!

Numbers (particularly large ones) are often rounded in this way for easier understanding and to enable us to estimate amounts.

Rounding to the nearest 10

This new tyre costs about £40. The actual cost was £38. £40 is a reasonable approximation. 38 has been rounded up to 40. If the price was £32 we would round it down to £30 because it is closer.

In both cases the numbers have been rounded to the nearest 10.

The process of rounding to the nearest 10 can be summarised as follows.

If the last digit is

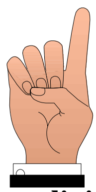
$\underbrace{1\ 2\ 3\ 4}_{\text{Round down}}$ $\underbrace{5\ 6\ 7\ 8\ 9}_{\text{Round up}}$

The numbers 0,1,2,3,4,5,6,7,8,9 are individually called digits.

With very few exceptions (which will be discussed in the appropriate sections), we will follow the above rules.

Example: -

63 rounded to the nearest 10 is 60
88 rounded to the nearest 10 is 90
15 rounded to the nearest 10 is 20



one digit

Try some yourself – Exercise 1.5

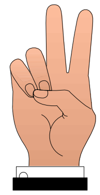
1. Round off the following to the nearest 10.
   a. 43 b. 58 c. 204 d. 96 e. 1,005

Rounding to the nearest 100

When rounding to the nearest 10, we looked at the last digit (or units digit) of the number. To round to the nearest 100 we must check the tens digit.

Example

267 rounded to the nearest 100 is 300
243 rounded to the nearest 100 is 200

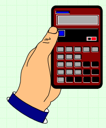


two digits

If the tens digit is less than 5 round down. If the tens digits is 5 or more, round up.

Try some yourself – Exercise 1.6

1. Round off the following to the nearest 100.
   a. 157   b. 119   c. 1,132   d. 4,979   e. 31,350



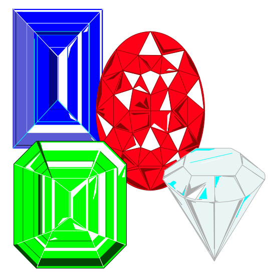
Rounding larger numbers

Rounding to the nearest 10 or even 100 does not help us when dealing with large numbers.

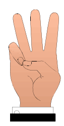
The quantity $9,853,947 of jewels is not an easy number to deal with in your head.

Numbers can be rounded to any level of accuracy…..

$10,000,000

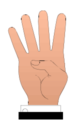


…. to the nearest 1,000



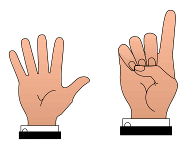
three digits

…. to the nearest 10,000



four digits

…. to the nearest 1,000,000



six digits

The rounding process

No matter how large a number, to round it is only necessary to check one digit.

Example

Using the number 1,281,729

<u>To round to the nearest 10</u>
Check the units digit

If this is 1, 2, 3, 4	round down
If this is 5, 6, 7, 8, 9	round up

1,281,72***9*** → 1,281,730

<u>To round to the nearest 100</u>
Check the tens digit

If this is 1, 2, 3, 4	round down
If this is 5, 6, 7, 8, 9	round down

1,281,7***2***9 → 1,281,700

<u>To round to the nearest 1,000</u>
Check the hundreds digit

If this is 1, 2, 3, 4	round down
If this is 5, 6, 7, 8, 9	round down

1,281,***7***29 → 1,282,000

and so on, always checking the digit immediately to the right of the one to be rounded to.

<u>To round to the nearest million</u>
Check the hundred thousand digit

If this is 1, 2, 3, 4	round down
If this is 5, 6, 7, 8, 9	round down

1,***2***81,729 → 1,000,000

Thus $9,853,947 rounded to the nearest 1,000,000 is $10,000,000.

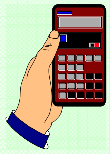
Example

A rig is drilling at a depth of 8,257 feet.

This is *approximately*:

8,260 feet to the nearest 10
8,300 feet to the nearest 100
8,000 feet to the nearest 1,000

Try some yourself – Exercise 1.7



1. Round off 1,213,888 to the nearest:
   (a) 10
   (b) 100
   (c) 10,000
   (d) 1,000,000

2. From Aberdeen to Montrose is 37 miles. Round this to the nearest useful number.

3. A drilling contractor has 1,763 offshore employees. Round this off to a number that is easy to handle.

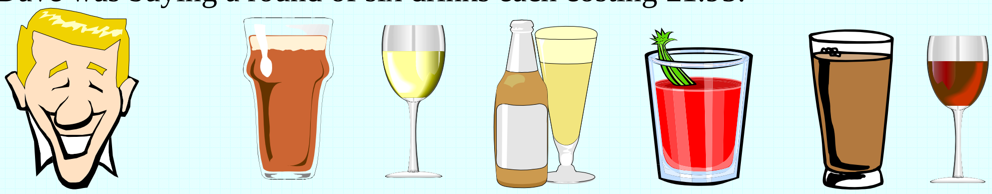
4. A farmer produces 42,105 pounds of turnips in one year. What is the annual production to the nearest 10,000 pounds?

2.2 Estimating Calculations

Approximations are most useful when it comes to making rough estimates – like adding up a bill to see if it is right. Estimating is also used to check the answers when using a calculator.

Example

Dave was buying a round of six drinks each costing £1.95.



A rough estimate of the cost of a round:

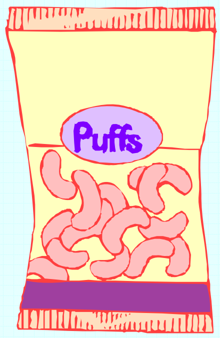
£1.95 rounds up to £2.00
6 times £2.00 is £12.00

The exact cost of the round is £11.70 so the estimate is quite close.

To make a rough estimate the numbers must be easy, so being able to round off numbers is a very useful skill.

Example

Mike buys 9 packets of crisps at 47 pence each. The shopkeeper asks for £42.30. Estimate the total cost to see if this is correct.



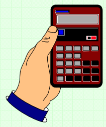
9 rounds up to 10
47 pence rounds up to 50 pence
10 x 50 pence is £5.00.

So the shopkeeper is 10 times out.

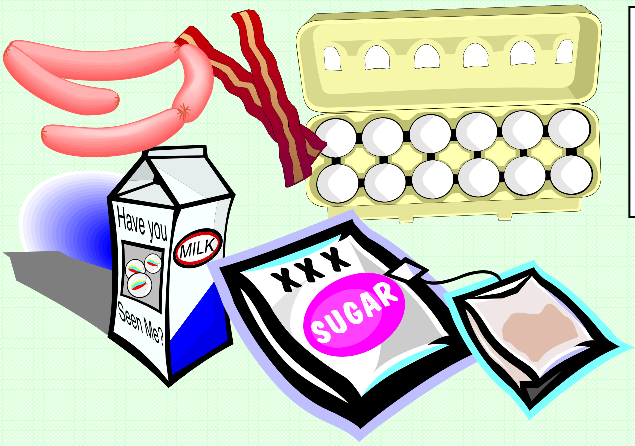
* The actual cost should be £4.23.

In this above example, estimation showed the calculation to be wrong.

Try some yourself – Exercise 1.8

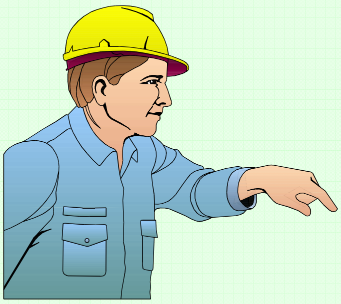


1. Estimate a rough total for the supermarket bill.



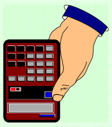
Sausages	£0.59
Bacon	£0.91
Eggs	£0.48
Milk	£0.27
Sugar	£0.89
Tea bags	£1.47

2. A roustabout earns £9.85 per hour and works 168 hours per month. Which is the closest approximation of his monthly income?

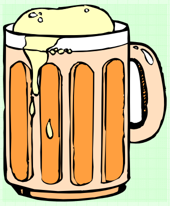


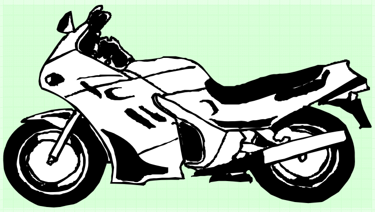
(a) £1,000 (b) £1,500 (c) £3,000

Try some yourself – Exercise 1.8 continued



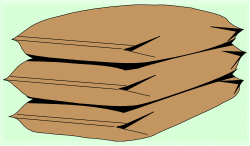
3. Estimate which of the following costs about £1,000?

(a)  11 at £2.30

(b)  52 payments of £49

(c)  2 at £475

4. 108 sacks of mud chemicals each weighing 50 pounds.
What is the total weight to the nearest 1,000 pounds?



5. Steve took a taxi home from the night club, 19 miles at 93 pence a mile.
Estimate the cost of the journey to the nearest ten pounds.

Section 3: Basic Mathematical Calculations and the use of the Calculator

In order to use numbers at work we must also understand what the various mathematical symbols mean and how to use them. This section discusses these symbols and describes how they are used both with a calculator and manually.

Objectives

- To introduce the basic mathematical symbols and explain their use.
- To discuss the use of calculators.
- To explain the basic mathematical operations of;
  - addition;
  - subtraction;
  - multiplication
  - division;

  both manually and using a calculator.

3.1 The Calculator

Rounding and estimating are very useful tools to be able to use but most of the time we need to be more accurate, for example when dealing with money.

A calculator is useful for more exact calculations. There are many types and makes of calculator and you should refer to the instructions that came with *your* calculator when working through the following examples.

There are however a number of basic features which apply to all calculators; these include a display area and a range of keys.

The main keys are:

ON	The on/off key. Your calculator may not have this key if it is solar powered.

C	CE	These are 'clear' keys which clear the display – either the last item entered or the entire calculation

7	8	9	The digits
4	5	6	
1	2	3	
0			

.	Decimal place

+	-	x	÷	The operation keys

=	The equals key

To perform calculations on your calculator you have to enter the data in the correct sequence.

Example

Add 3 and 1 together

This is written as 3 + 1 or 1 + 3

The sequence of keys to press on your calculator would be:

3	+	1	=

Always working from the left hand side first.

The display would show:

4

You can draw a breakdown of any calculation into a key sequence no matter how complicated.

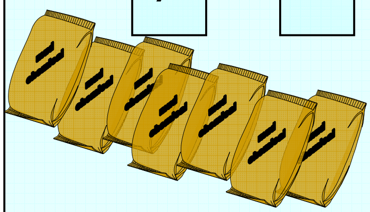
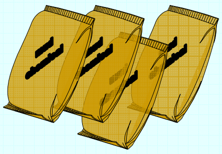
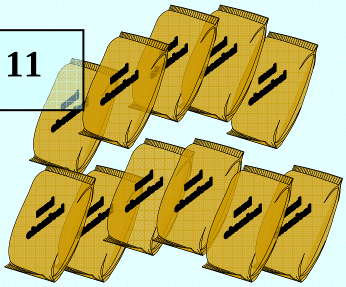
3.2 Addition

This is concerned with putting things together. The symbol we use is **+**
for example 7 + 3 = 10.

Example

1. Over one hour, seven sacks of mud chemicals are added into the drilling mud via a hopper. Half an hour later a further four have been added. How many have been added in total?

7 **+** **4** **=** **11**

Example

Buying a round of drinks consisting of three glasses of wine and two gin and tonics means that you have bought five drinks in total.



3 + 2 = 5

(The <u>sum</u> of 3 + 2 is 5 or 5 is the sum of 3 + 2).

Example - Manual addition

Add 1,831 and 247 and 699 (1,831 + 247 + 699)

Again to make the calculation easier the numbers should be written underneath each other lining up the thousands, hundreds, tens and units in columns. (You can draw a grid if this makes it easier)

THTU
1,831
247
699
2,777

Thousands	Hundreds	Tens	Units
1	8	3	1
	2	4	7
	6	9	9

THTU
1,83 1
24 7
69 $_1$9
7

Start with the units column on the right hand side and add downwards:

1 + 7 = 8, 8 + 9 = 17

This is seven units and one ten, the 7 is written under the line at the bottom of the units column, the 1 is written above the line in the tens column to be added into that column.

This can also be done by adding upwards so that 9 + 7 = 16, 16 + 1 = 17.

Then the tens column is added, then the hundreds and the thousands etc.

1 8 3 1	This can	1 8 3 1
2 4 7	also be	2 4 7
$_1$6$_1$9$_1$9	written as	6 9 9
2 7 7 7		2 7 7 7
		1 1 1

Example - Calculator addition

The sequence of keys to press to do the above calculation on a calculator is:

1	8	3	1	+	2	4	7	+	6	9	9	=

The display will show

2777.

Checking using estimating

You should always make a rough estimate of your calculation when using a calculator.

For example:

Rough estimate: 785 + 87 + 101+ 90 + 100 = 990

Accurate calculation: 785 + 87 + 101 = 973

The rough estimate shows that the answer is sensible i.e. that you haven't put in 1,001 instead of 101.

Try some yourself – Exercise 1.9

1. Estimate the answers to the following;

   a. 145 + 2,035
   b. 5,763 + 12 + 300
   c. 389,917 + 188,709 + 45,101 + 7
   d. 23 + 196
   e. 448 + 21
   f. 119,987 + 219,998 + 503,945 + 754,730

2. Now calculate manually;

   a. 145 + 2,035
   b. 5,763 + 12 + 300
   c. 389,917 + 188,709 + 45,101 + 7
   d. 23 + 196
   e. 448 + 21
   f. 119,987 + 219,998 + 503,945 + 754,730

3. Now confirm using your calculator;

   a. 145 + 2,035
   b. 5,763 + 12 + 300
   c. 389,917 + 188,709 + 45,101 + 7
   d. 23 + 196
   e. 448 + 21
   f. 119,987 + 219,998 + 503,945 + 754,730

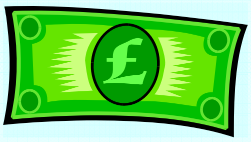
3.3 Subtraction

This is concerned with taking things away.

The symbol we use is **-**, for example 3 – 1 = 2.

Example

The five drinks that you bought before costs you £10.77. You give the barman £15 then you take away the £10.77 to calculate how much change you should have.



.

£15 - £10.77 = £4.23

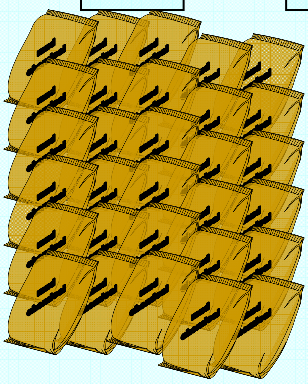
(£4.23 is the difference between £15 and £10.77)

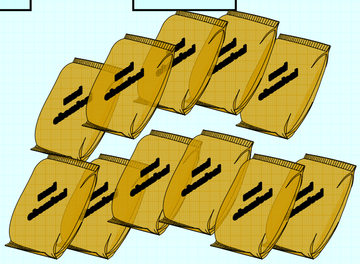
Example

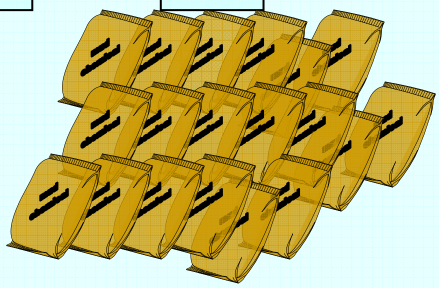
The eleven sacks of mud chemicals added to the drilling mud previously were removed from a pallet holding 30 sacks.

How many sacks are left?

30 **-** **11** **=** **19**







Example – Manual Subtraction 1

Subtract 14 from 365 (365- 14)

The calculation should be written in the same way as the addition calculation with the units figures lined up underneath each other at the right hand side.

```
HTU
365
 14 –
  1
```

Start with the units column, 4 from 5 is 1. This is placed under the top line in the units column.

```
HTU
365
 14 –
 51
```

Next take the tens column, 1 from 6 is 5. This is placed under the top line in the tens column.

```
HTU
365
 14 –
351
```

Next take the hundreds column, 0 from 3 is 3. This is placed under the top line in the hundreds column.

The answer is 351.

One way to check you are correct is to add the answer and the number taken away together – this should equal the original number.

e.g. 351 + 14 = 365

Example – Calculator subtraction 1

3	6	5	-	1	4	=

The display will show

351.

Example - Manual subtraction 2

Subtract 86 from 945 (945 – 86

HTU
945
86 –
859

The calculation should be written in the same way as the addition calculation with the units figures lined up underneath each other at the right hand side.

Start with the units column, 6 is larger than 5 and 'won't go' so we have to 'borrow' one from the tens column. This is added to the 5 to get 15. We can then take 6 away from 15 to get 9.
This is written under the line at the bottom of the units column.

HTU
945
86 –
9

The ten that we 'borrowed' now has to be 'paid back'. This can be shown in two ways

H T U
9 4 5
8 6
1
8 5 9

The ten is 'paid back' at the bottom. The 1 is added to the 8 to make 9, this won't go into 4 so we borrow again this time from the hundreds column. This is added to the 4 to become 14, 9 from 14 is 5. The 5 is put at the bottom of the tens column and the borrowed 10 is paid back at the bottom of the hundreds column.

$\cancel{9}^{8}\cancel{4}^{3}5$
8 6
8 5 9

In the second method we cross off the figures on the top row.

You should use whichever you are most familiar with.

600
4 –
596

The second method can be confusing when dealing with zeros i.e. take 4 away from 600 (600 – 4), 4 from 0 won't go so we have to borrow from the next column. As the next column is also a 0 you have to go across the columns until you reach the 6. The 6 is crossed out and 5 is put in, 1 is put next to the 0 in the next column. This is then crossed out and replaced by 9 as we borrow a ten. We then continue as before.

Example - Calculator subtraction 2

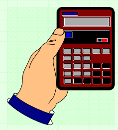
The sequence of keys to press to do the above calculation on a calculator is:

9	4	5	-	8	6	=

The display will show

859.

Try some yourself - Exercise 1.10



1. Estimate the answers to the following;
   - a. 47 - 12
   - b. 78 - 45
   - c. 5,000 - 441
   - d. 8,001 – 4,098
   - e. 117,097 – 98,320

2. Now calculate manually;
   - a. 47 - 12
   - b. 78 - 45
   - c. 5,000 - 441
   - d. 8,001 – 4,098
   - e. 117,097 – 98,320

3. Now confirm using your calculator;
   - a. 47 - 12
   - b. 78 - 45
   - c. 5,000 - 441
   - d. 8,001 – 4,098
   - e. 117,097 – 98,320

3.4 Multiplication

This is a quick way of adding equal numbers. The symbol we use is **x**.

Example

6 + 6 + 6 + 6 = 24 or 4 x 6 = 24

24 is called the *product* of 4 and 6.

It can also be written as 6 x 4 this is called commutative law (and also applies to addition).

Calculator

4 | x | 6 | =

The display will read

24.

Example

In the sack room are 3 pallets each with 25 sacks. How many sacks are there in total?

3 | x | 25 | = | 75

Commutative Law

Means it does not matter which order things are written.

For example

1 + 2 + 3 = 6
3 + 2 + 1 = 6
2 + 1 + 3 = 6

Or

2 x 3 x 4 = 24
4 x 3 x 2 = 24
3 x 2 x 4 = 24

This applies to both addition and multiplication, but not to subtraction and division.

Try some yourself - Exercise 1.11

1. Estimate the answers to the following;
   - a. 9 x 9
   - b. 4 x 9
   - c. 3 x 2 x 4
   - d. 6 x 7
   - e. 8 x 2

2. Now calculate manually;
   - a. 9 x 9
   - b. 4 x 9
   - c. 3 x 2 x 4
   - d. 6 x 7
   - e. 8 x 2

3. Now confirm using your calculator;
   - a. 9 x 9
   - b. 4 x 9
   - c. 3 x 2 x 4
   - d. 6 x 7
   - e. 8 x 2

Example – Manual multiplication

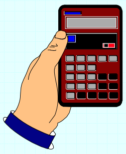
Multiply 67 by 5 (67 x 5)
This means '5 lots of 67'

HTU	
67	Starting from the right hand side again, 7 times 5 is 35. 5 is put in the
5 x	units column and the 3 tens are carried over to the tens column (note
335	this on the calculation). 6 times 5 is 30, add the 3 carried forward to give
3	33 which is put in as 3 tens and 3 hundreds.

Try some yourself – Exercise 1.12

1. 567 x 8
2. 244 x 9
3. 903 x 6
4. 758 x 7
5. 307 x 7

Example – Calculator multiplication



214 x 8

2	1	4	x	8	=

The display shows 1712.

Example – Multiplying by ten

To multiply a whole number by 10 add a zero, this moves the figures along one column.

HTU		HTU
64	x 10	640

To multiply by 100 add two zeros, to multiply by 1,000 add 3 zeros etc.

Example – Multiplying by multiples of ten

To multiply a whole number by a number which is a multiple of 10 such as 60, 70 etc. multiply by the single figure and add a zero.

32 x 40
32 x 4 = 128
32 x 40 = 1,280

When multiplying by larger numbers e.g. 200, 3,000, 40,000, we multiply by the single figure and then add the appropriate number of zeros.

5 x 40,000
5 x 4 = 20
5 x 40,000 = 200,000

Try some yourself . . . Exercise 1.13

Multiply the following manually;

1. 19 x 10
2. 38 x 1,000
3. 87 x 10,000
4. 24 x 60
5. 65 x 80
6. 20 x 312
7. 1,762 x 10

3.5 Division

This is concerned with sharing into equal parts and the symbol we use is .

> Example
> Share £6 equally between three people
> $6 \div 3 = 2$

There are other ways to write divisions which all mean the same thing.

e.g. $6 \div 3$ is the same as $\frac{6}{3}$ is the same as $^{6}/_{3}$

These other methods of notation will be discussed further in Part 7.

> Example
>
> 16 sacks of chemical are to be added to the drilling mud.
>
> If two roustabouts both share the work equally, how many sacks will each have added?
>
> $\boxed{16}$ $\boxed{\div}$ $\boxed{2}$ $\boxed{=}$ $\boxed{8}$
>
> They will each have added 8 sacks.

> Example – Manual Division
> Divide 432 by 8
>
> This is the same as how many 8's are there in 432?
>
> 8 is called the *divisor*
> 432 is called the *dividend*
> the answer is called the *quotient*
>
> $\underline{54}$
> 8/432
>
> 8 won't go into 4. 8's into 43 go 5. Put the 5 above the 3; 5 times 8 is 40; take 40 away from 43 leaving 3; put 3 by the 2 to make 32; 8's go into 32 4 times; put the 4 above the 2.
>
> 432 ÷ 8 = 54
>
> $\underline{54}$
> 8/432
>
> $\underline{54}$
> 8/432
> $\underline{40}$
> 32
> $\underline{32}$

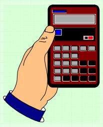
Example – Manual division

Divide 4,205 by 3

In this example there is a remainder. When 4,205 is divided by 3 there will be 2 left over.

1401
3/4205
3
12
12
000
0
05
3
2 remainder

Try some yourself - Exercise 1.14



Manually work out the following;

1. 500 ÷ 5
2. 7,343 ÷ 7
3. 1,446 ÷ 6
4. 3,488 ÷ 8
5. 2,313 ÷ 9

Example – Division by Calculator

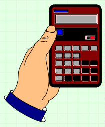
Divide 576 by 21

5	7	6	÷	2	1	=

The display shows:

27.

Try some yourself – Exercise 1.15



In the sack room are 5 pallets each holding 80 sacks of mud chemicals.

1. How many sacks are there in total? _____________ sacks

2. If 3 roustabouts add 8 sacks each to the drilling mud, how many have they added in total?
   _____________ Sacks

3. How many sacks are left in the sack room?
   _____________ sacks

4. We estimate the requirement for these chemicals to be 10 sacks per day. How many full days will the sacks last?
   _____________ sacks

5. How many sacks will be left over?
   _____________ sacks

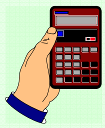
Example

With all four engines running the rig has 4,800 horsepower available.

What is the output of each engine?

$$4{,}800 \div 4 = 1{,}200 \text{ horsepower}$$

Try some yourself – Exercise 1.16



With 5 engines running, your rig develops 6,500 horsepower.

What will the available horsepower be if one engine goes offline?

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Section 4: Fractions, Decimals, Percentages and Ratios

Up to now we have dealt only with whole numbers. We must also be able to work with numbers which are parts of whole numbers. This section covers the use of fractions and decimals. We will also discuss percentages and the use of ratios in this section.

Objectives

- To discuss the need to use numbers less than or parts of whole numbers.
- To explain the methods of notation.
- To explain the system of representing numbers using fractions.
- To explain the decimal system of representation.
- To explain what percentages mean.
- To explain what ratio means.

Try these first . . .Exercise 1.17

1. Complete the following table

Fraction	Decimal	Percentage
$\frac{3}{4}$		
	0.6	
		84%
	0.35	
$\frac{5}{8}$		

2. Place these numbers in order of size, starting with the smallest:

   0.19 0.9 0.091 0.109

3. Place these fractions in order of size, starting with the smallest:

   $\frac{1}{2}$ $\frac{1}{3}$ $\frac{5}{12}$ $\frac{5}{6}$

4. Write these numbers in order of size, starting with the smallest:

   1.01 1.001 1.101 1.11

Try these first . . . Exercise 1.17 Continued

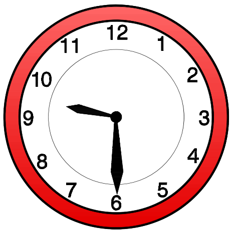
5. Which of these fractions is closest in value to $\frac{1}{3}$?

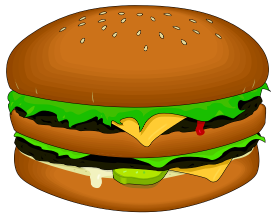
$$\frac{10}{31} \quad \frac{20}{61} \quad \frac{30}{91} \quad \frac{40}{121} \quad \frac{50}{151}$$

6. Paint is mixed with thinners at a ratio of 2:1. (Two parts paint to one part thinners.)

How many gallons of thinners should be added to one gallon of paint?

Examples of fractions are half an hour or quarter pound burger.

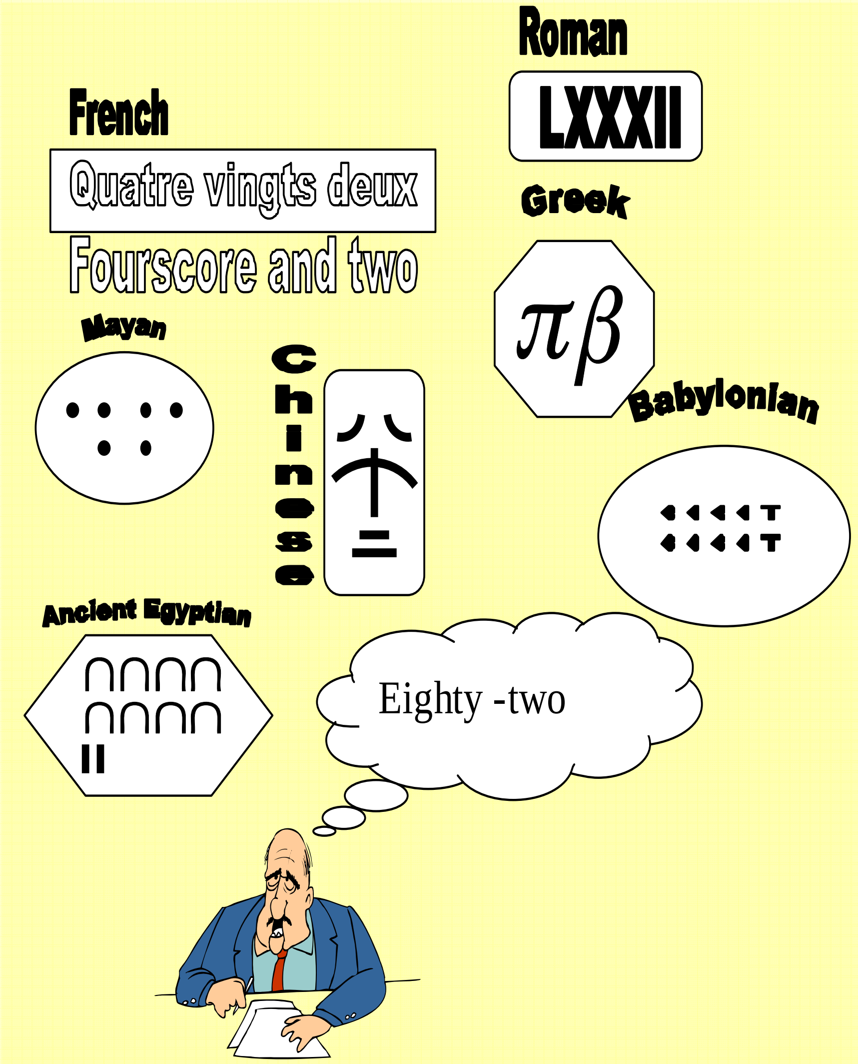




Fractions can also be written as decimals to make addition, subtraction etc. easier (including using a calculator). An everyday example is money, so that we would write £2.30, with the decimal point separating the whole number from the part number.

Of interest;

Lots of different systems of counting have been used at other times and in other parts of the world. How many of the following systems shown below can you explain and understand?



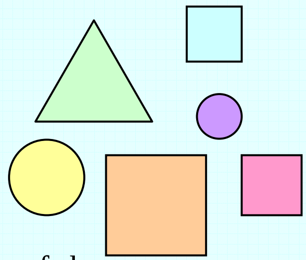
4.1 Fractions

Fractions are a way of expressing a part of a whole or in other words, fractions are parts of something.

Meaning of a fraction

Example

1. Shown are a group of shapes



What fraction are triangles?
What fraction are circles?
What fraction are squares?

First of all, count the <u>total</u> number of shapes;

Total number = 6

Then count the number of each shape;

Triangles = 1

So there is one triangle out of six shapes or the fraction is 1 out of 6.

As a fraction this is written as $\frac{1}{6}$

Circles = 2

So the fraction of the shapes which are circles is $\frac{2}{6}$

Squares = 3

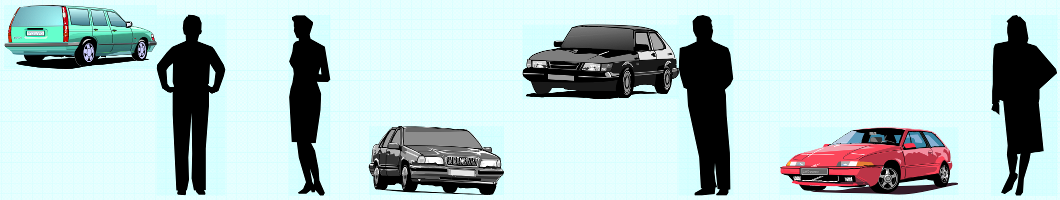
So the fraction of the shapes which are squares is $\frac{3}{6}$

Example 2

Four people sat their driving tests.

3 out of 4 passed; $\frac{3}{4}$ of them passed.

1 out of 4 failed; $\frac{1}{4}$ of them failed.



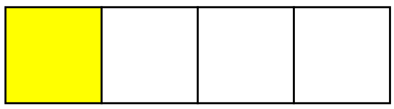
In the fraction $\frac{1}{4}$, 1 is the **numerator** and 4 is the **denominator**.

Fractions can be easier to see in diagram form;

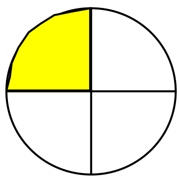
$$\frac{1}{4}$$

means the whole has been divided into 4 pieces

and that we have 1 piece

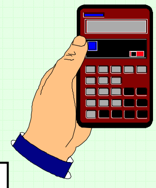


The shape has been divided into four parts and 1 part is shaded.



$$\frac{1}{4} = \frac{\text{Number of shaded parts}}{\text{Total number of parts}} = \frac{\text{Numerator}}{\text{Denominator}}$$

Try some yourself – Exercise 1.18



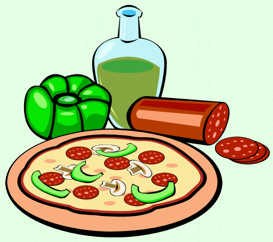
1. Sketch these fractions

a. $\frac{5}{12}$

b. $\frac{1}{3}$

c. $\frac{5}{6}$

2. If four people share a pizza, how much will each person get?



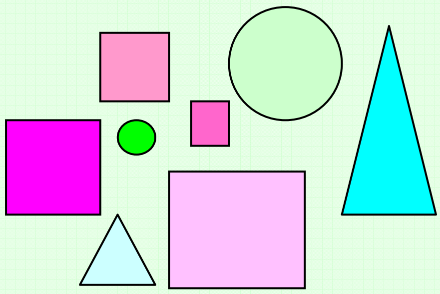
a. $\frac{1}{2}$

b. $\frac{1}{3}$

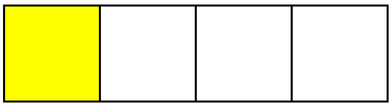
c. $\frac{1}{4}$

3. What fraction of shapes are;

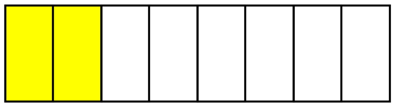
a. Triangles?
b. Circles?
c. Squares?



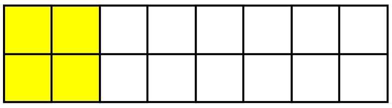
Equal or Equivalent fractions



$\frac{1}{4}$



$\frac{2}{8}$



$\frac{4}{16}$

$$\text{Fraction} = \frac{\text{Number of shaded parts}}{\text{Total number of parts}}$$

These appear to be three different fractions, but the area shaded is equal in each one.

$$\frac{1}{4} = \frac{2}{8} = \frac{4}{16}$$

These are called equivalent fractions.

To change $\frac{1}{4}$ into $\frac{2}{8}$ we have multiplied the top and bottom by 2.
To change $\frac{2}{8}$ into $\frac{4}{16}$ we also multiplied the top and bottom by 2.
To change $\frac{1}{4}$ directly to $\frac{4}{16}$ we would need to multiply the top and bottom by 4.

If we drew more sketches of fractions we would find that if we multiply the top and bottom of a fraction by the same number (not zero) its value is not altered.

The same rule would also apply if we divide the top and bottom by the same number.

$$\frac{15}{20} = \frac{15 \div 5}{20 \div 5} = \frac{3}{4}$$

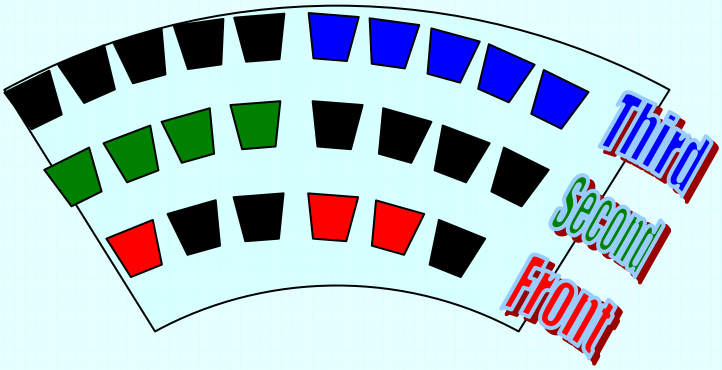
Example

In the theatre

Front row 3 out of 6 seats taken. $\frac{3}{6}$ full or $\frac{1}{2}$ full.

Second row 4 out of 8 seats taken. $\frac{4}{8}$ full or $\frac{1}{2}$ full.

Third row 5 out of 10 seats taken. $\frac{5}{10}$ full or $\frac{1}{2}$ full.



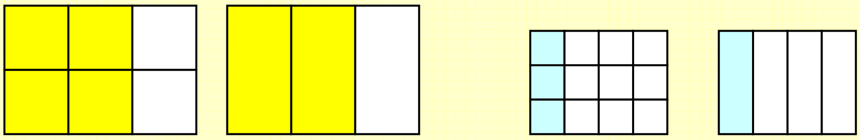
In the whole balcony, 12 out of 24 seats are taken. $\frac{12}{24}$ full or $\frac{1}{2}$ full.

So $\frac{1}{2} = \frac{3}{6} = \frac{4}{8} = \frac{5}{10} = \frac{12}{24}$. The **simplest** of these equal fractions is $\frac{1}{2}$.

To get equal fractions, multiply or divide the numerator and denominator by the same number.

Reducing a fraction to its lowest terms

By drawing you can see



$$\frac{4}{6} = \frac{2}{3} \qquad \frac{3}{12} = \frac{1}{4}$$

We can divide the top and bottom of a fraction by the same number (not zero) without altering the value of the fraction.

Fractions like $\frac{1}{4}$ and $\frac{1}{3}$ are said to be in their <u>lowest terms</u> (there is no number other than 1 which will divide into the top and bottom).

Examples

1. Reduce $\frac{4}{6}$ to its lowest terms.

   Both numbers will divide by 2

   $$\frac{4 \div 2}{6 \div 2} = \frac{2}{3}$$

2. Sometimes it may be necessary to divide more than once.

   Reduce $\frac{42}{56}$ to its lowest terms.

   $$\frac{42 \div 7}{56 \div 7} = \frac{6}{8}$$

   Both numbers will divide by 2

   $$\frac{6 \div 2}{8 \div 2} = \frac{3}{4}$$

Example

Find some equivalent fractions for $\frac{1}{2}$

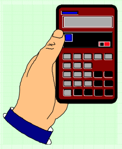
$$\frac{1\times 2}{2\times 2}=\frac{2}{4}$$

$$\frac{1\times 4}{2\times 4}=\frac{4}{8}$$

$$\frac{1\times 8}{2\times 8}=\frac{8}{16}$$

$\frac{1}{2}\quad \frac{2}{4}\quad \frac{4}{8}\quad \frac{8}{16}$ are all equivalent fractions

Try some yourself . . . Exercise 1.19



1. Draw sketches to show that;

a. $\frac{4}{5} = \frac{8}{10}$

b. $\frac{2}{3} = \frac{4}{6}$

c. $\frac{3}{4} = \frac{9}{12}$

2. Fill in the missing numbers.

a. $\frac{1}{4} = \frac{?}{20}$

b. $\frac{5}{6} = \frac{?}{12}$

c. $\frac{2}{3} = \frac{?}{6}$

d. $\frac{4}{5} = \frac{?}{20}$

3. Reduce the following to their lowest terms.

a. $\frac{4}{6}$

b. $\frac{5}{20}$

c. $\frac{15}{25}$

d. $\frac{5}{15}$

e. $\frac{9}{18}$

f. $\frac{56}{64}$

Types of Fractions

A note about writing down fractions

Fractions can be written in several different ways;

$\frac{1}{2}$ or ½

In this document we will use the first way of writing fractions, except when using fractions as names or to describe something.

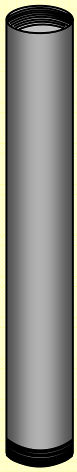
e.g. $13^{3}/_{8}$ inch casing
$8^{1}/_{2}$ inch drill bit

Mixed Numbers

A mixed number has both whole numbers and fractions, e.g. $2\frac{1}{2}$, $1\frac{7}{8}$, $12\frac{5}{6}$, $15\frac{2}{7}$.

When are mixed numbers used?

$12\ ^{1}/_{4}$” diameter drill bit



$9\ ^{5}/_{8}$” diameter casing

Improper fractions

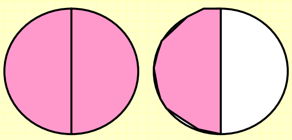
These are sometimes called top heavy fractions. They are fractions where the numerator is more than the denominator e.g.

$\frac{5}{4}$ $\frac{10}{6}$ $\frac{12}{6}$ $\frac{10}{3}$

Improper fractions usually come from adding fractions together.

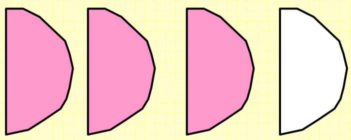
Improper fractions may be changed to whole numbers or mixed numbers.

Mixed number



1 $\frac{1}{2}$

Top heavy (improper) fraction



$\frac{3}{2}$

Converting Fractions

Improper fractions to mixed numbers

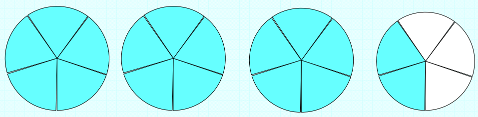
Example

Convert $\frac{17}{5}$ into a mixed number.

Divide the top number (numerator) by the bottom number (denominator)

$17 \div 5 = 3$ remainder 2 (there are $\frac{2}{5}$ left over)

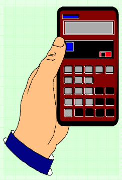
$\frac{17}{5} = 3\frac{2}{5}$



The rule is;

Divide the numerator by the denominator. The answer goes as the whole number. The remainder goes on top of the fraction and the denominator stays the same.

Try some yourself . . . Converting fractions 1



Convert the following improper fractions into mixed numbers

1. $\frac{9}{4}$

2. $\frac{11}{3}$

3. $\frac{15}{7}$

4. $\frac{17}{8}$

5. $\frac{51}{8}$

Mixed fractions to improper fractions

Example

1. Convert $2\frac{3}{4}$ to an improper fraction

Multiply the whole number (2) by the denominator (4)

$2 \times 4 = 8$

Add the numerator (3)

$8 + 3 = 11$

Thus the improper fraction is $\frac{11}{4}$

2. Convert $3\frac{2}{5}$ to an improper fraction

$3 \times 5 = 15$

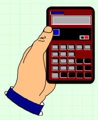
$15 + 2 = 17$

$$3\frac{2}{5} = \frac{17}{5}$$

The rule is: -

Multiply the whole number by the denominator. Then add the numerator. The answer is the new numerator. The denominator stays the same.

Try some yourself . . . Exercise 1.21



Convert the following to improper fractions

1. $3\frac{1}{2}$
2. $5\frac{3}{4}$
3. $6\frac{1}{3}$
4. $4\frac{2}{3}$
5. $7\frac{1}{2}$
6. $2\frac{1}{2}$

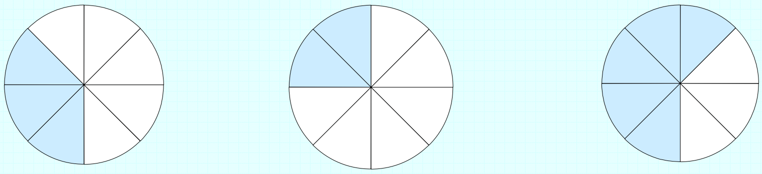
Adding and Subtracting Fractions

It is easy to add and subtract fractions if they have the same denominator.

If we are dealing with different fractions we must change them all to the same before we can add or subtract. We need to find a <u>common denominator</u>.

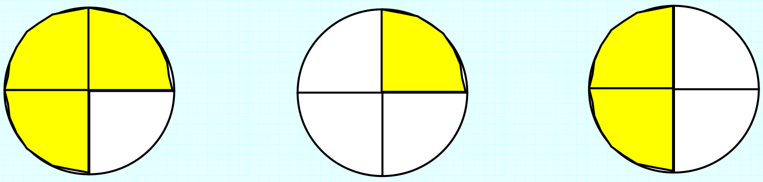
Example

Addition



$$\frac{3}{8} + \frac{2}{8} = \frac{5}{8}$$

Subtraction



$$\frac{3}{4} - \frac{1}{4} = \frac{2}{4}$$

If the denominator is the same we simply add or subtract the numerators.

Example – Adding fractions 1

Add $\frac{2}{5} + \frac{3}{10}$

The common denominator could be 10 because;

5 will divide into 10

10 will divide into 10

so we convert both fractions to tenths

$$\frac{2}{5} = \frac{2 \times 2}{5 \times 2} = \frac{4}{10}$$

$\frac{3}{10}$ does not need to be changed

Then add

$$\frac{4}{10} + \frac{3}{10} = \frac{7}{10}$$

Example – Adding fractions 2

Add $3\frac{1}{3}+1\frac{1}{2}$

Add the whole numbers first

$3 + 1 \quad = \quad 4$

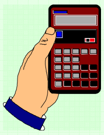
Change the fractions to a common denominator;

$\frac{1}{3}=\frac{2}{6}$ $\qquad\qquad$ $\frac{1}{2}=\frac{3}{6}$

$\frac{2}{6}+\frac{3}{6}=\frac{5}{6}$

So the answer is $4\frac{5}{6}$

Try some yourself . . . Exercise 1.22



1.	$\frac{3}{4}+\frac{1}{2}$	6.	$5\frac{1}{2}+2\frac{3}{4}$
2.	$\frac{1}{3}+\frac{1}{2}$	7.	$3\frac{3}{4}+4\frac{1}{8}$
3.	$\frac{3}{4}+\frac{1}{3}$	8.	$5\frac{3}{8}+4\frac{1}{4}$
4.	$\frac{5}{6}+\frac{2}{3}$	9.	$1\frac{1}{5}+2\frac{1}{4}$
5.	$\frac{7}{8}+\frac{2}{3}$	10.	$6\frac{3}{5}+2\frac{1}{10}$

Example – Subtracting fractions

Subtract $\frac{2}{3}-\frac{1}{2}$

The common denominator could be 6 because
3 will divide into 6
2 will divide into 6

So convert both fractions to sixths

$\frac{2}{3}=\frac{2\times2}{3\times2}=\frac{4}{6}$ $\frac{1}{2}=\frac{1\times3}{2\times3}=\frac{3}{6}$

Then subtract

$\frac{4}{6}-\frac{3}{6}=\frac{1}{6}$

Example – Subtracting mixed numbers

Subtract $2\frac{3}{4}-1\frac{1}{3}$

The easiest way to subtract mixed numbers is to convert to improper fractions.

$2\frac{3}{4}=\frac{11}{4}$ $1\frac{1}{3}=\frac{4}{3}$

We now have

$\frac{11}{4}-\frac{4}{3}$

The lowest common denominator is 12 because 3 x 4 = 12

$\frac{11}{4}=\frac{11\times3}{4\times3}=\frac{33}{12}$ $\frac{4}{3}=\frac{4\times4}{3\times4}=\frac{16}{12}$

We now have

$\frac{33}{12}-\frac{16}{12}=\frac{17}{12}$

$\frac{17}{12}$ must be converted to a mixed number $1\frac{5}{12}$

Try some yourself . . . Exercise 1.23

1. $\frac{1}{5} - \frac{1}{10}$

2. $\frac{2}{7} - \frac{1}{14}$

3. $\frac{1}{2} - \frac{3}{8}$

4. $\frac{3}{8} - \frac{1}{4}$

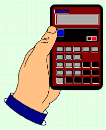
5. $1\frac{3}{4} - \frac{3}{4}$

Important Note

Whilst we still use fractions on the rig for some measurements, particularly diameters, we do not normally have to use them in calculations.

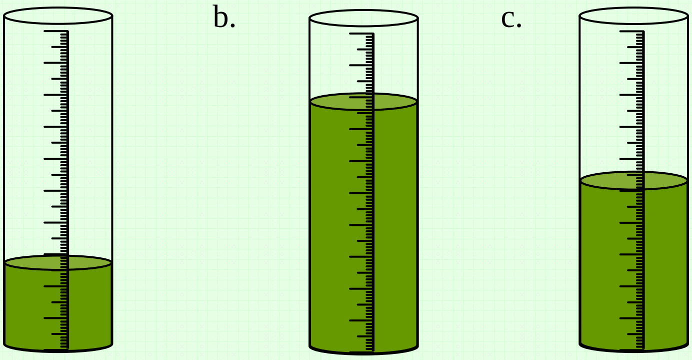
On the rig we would normally convert the fractions to decimals and perform the calculations with a calculator.

Try some yourself . . . Exercise 1.24

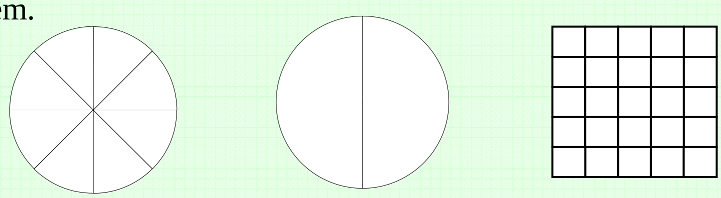


1. What fraction of each bottle is filled with water?

a. b. c.



2. Each shape is divided into equal parts. Shade the fractions shown below them.



$\frac{6}{8}$ $\frac{1}{2}$ $\frac{10}{25}$

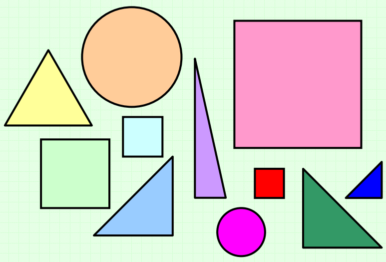
3. a. How many days in the week are there?
   b. How many days start with an S?
   c. What fraction of the days start with an S?

4. a. How many months are there in a year?
   b. What fraction of them are winter months (December, January, February)?

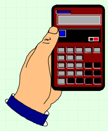
5. a. How many fingers and thumbs are there on two hands?
   b. What fraction of them are;
      (i) fingers?
      (ii) thumbs?

6. What fraction of these shapes are;

   a. triangles?
   b. circles?
   c. squares?



Try some yourself Exercise 1.24 continued



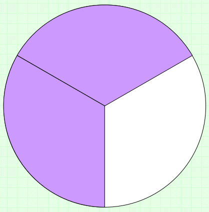
7. Write the following in number form (for example $\frac{1}{4}$)

   a. one quarter
   b. two thirds
   c. six tenths
   d. one twelth
   e. four fifths

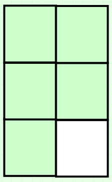
8. Complete the table for the six diagrams below;

Shape	a	b	c	d	e	f
Fraction shaded						
Fraction unshaded						

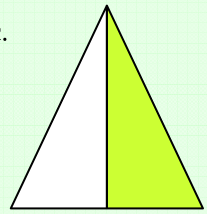
a.



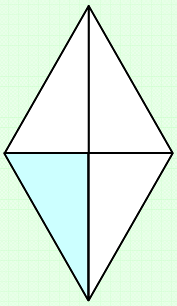
b.



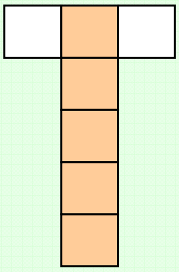
c.



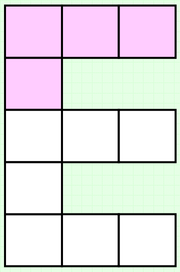
d.

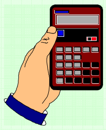


e.



f.





Try some yourself Exercise 1.24 continued

9. Fill in the missing numbers

a. $\frac{1}{4} = \frac{?}{20}$

b. $\frac{5}{6} = \frac{?}{12}$

c. $\frac{1}{2} = \frac{?}{10}$

d. $\frac{9}{11} = \frac{?}{88}$

e. $\frac{3}{7} = \frac{?}{49}$

10. Reduce the following to their lowest terms;

a. $\frac{3}{9}$

b. $\frac{5}{20}$

c. $\frac{7}{49}$

d. $\frac{21}{35}$

e. $\frac{6}{10}$

11. Turn the following improper fractions into mixed fractions

a. $\frac{9}{4}$

b. $\frac{11}{3}$

c. $\frac{15}{7}$

d. $\frac{21}{5}$

e. $\frac{53}{12}$

Try some yourself Exercise 1.24 continued

12. Turn the following into improper fractions.

a. $1\frac{3}{4}$

b. $2\frac{7}{8}$

c. $4\frac{11}{15}$

d. $9\frac{5}{8}$

e. $13\frac{3}{8}$

13. Work out the following;

a. $\frac{3}{4}+\frac{2}{3}$

b. $3\frac{3}{4}+2\frac{2}{3}$

c. $\frac{3}{4}-\frac{2}{3}$

d. $3\frac{3}{4}-2\frac{2}{3}$

4.2: Decimals, Percentages and Ratios

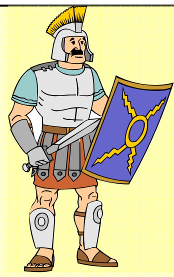
As we mentioned in Section 1, the decimal system we use is based on ten, so that the position of a digit in a number gives us its value.

3	2	4
Hundreds	Tens	Units
100	10	1
100	10	1
100		1
		1

324 is three hundreds, two tens and one unit or three hundred and twenty four.

Of interest

DECIMAL comes from decem, the Latin for ten

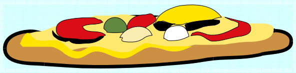
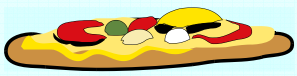
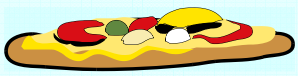


In the decimal system as we move to the left, each number is ten times bigger and as we move to the right the number is ten times smaller.

However, in the decimal system we must be able to deal with numbers which are not whole numbers.

The decimal system uses a decimal point (.) to separate whole numbers from fractions or parts of numbers.

Example

Four people go out for a pizza but can only afford to buy three pizzas. Obviously each person cannot have a whole pizza. How much will each person get?

Try dividing 3 by 4 on a calculator. The answer should be;

0.75

This shows that the answer is not a whole number but lies somewhere between zero (0) and one (1). The decimal point indicates that the answer shows decimal parts of a whole number.

Building up a number with a decimal fraction

Look at the length of the golfers tee shot. The number is built up like this;

H	T	U		t	h
1	0	0		0	0
	0	0		0	0
		6		0	0
				8	0
					2
1	0	6	.	8	2

The ball travelled 106 metres, 8 tenths and 2 hundredths of a metre. .82 is a decimal fraction. If there were no whole number in front of it, it would be written 0.82.

The decimal point separates the whole number from the fraction.

What the positions represent

Take the number 212.46895

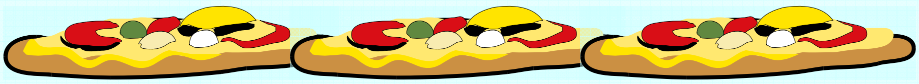
Hundreds	Tens	Units		Tenths	Hundredths	Thousandths	Ten thousandths	Hundred thousandths
2	1	2	.	4	6	8	9	5

Decimal point Decimal places

The <u>first</u> place after the decimal represents tenths.
The <u>second</u> place after the decimal represents hundredths.
The <u>third</u> place after the decimal represents thousandths.
The <u>fourth</u> place after the decimal represents ten thousandths.
The <u>fifth</u> place after the decimal represents hundred thousandths.

The position of the digit either before or after the decimal point gives us its value. Before the decimal point each column represents a number ten times bigger than the one before it, after the decimal point each column represents a number ten times smaller than the one before it.

Example



Going back to pizzas, 3 pizzas shared between 4 people means each person gets:

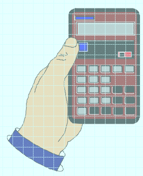
3 ÷ 4 = 0.75 pizzas

or

Units		tenths	hundredths
0	.	7	5

So each person would get 7 tenths and 5 hundredths (or 75 hundredths) of a pizza.

Example – What decimal numbers mean



6.2 means 6 units and 2 tenths of a unit

Units		tenths
6	**.**	**2**

0.04 means 0 units, 0 tenths, 4 hundredths

Units		tenths	hundredths
0	**.**	**0**	**4**

0.728 means 0 units, 7 tenths, 2 hundredths, 8 thousandths

Units		tenths	hundredths	thousandths
0	**.**	**7**	**2**	**8**

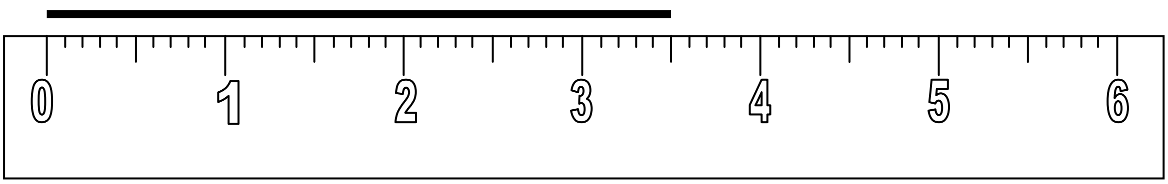
Try some yourself . . . Exercise 1.25

What do these decimals mean?
1. 0.2
2. 3.4
3. 10.04
4. 50.207
5. 3.817

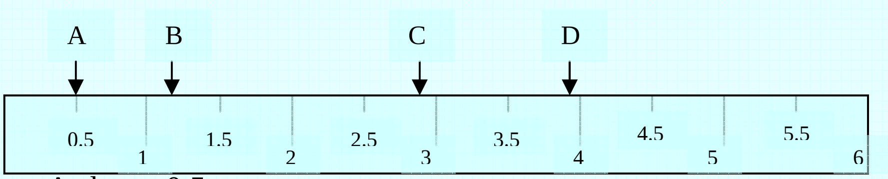
	Tens	Units	.	tenths	hundredths	thousandths
1.						
2.						
3.						
4.						
5.						

Using a ruler or a scale

When measurements are taken with a ruler lengths between whole numbers can be written as decimals.



Example



A shows 0.5
B shows 1.2
C shows 2.8
D shows 3.9

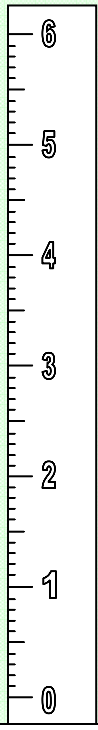
Try some yourself . . . Exercise 1.26

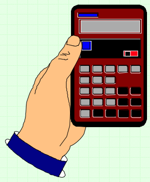
1. Draw arrows and label these points

   a. 0.7
   b. 5.8
   c. 5.3
   d. 0.2
   e. 1.2

2. Which is larger?

   a. 0.7 or 0.2
   b. 5.3 or 5.8
   c. 1.2 or 0.2





Decimal points and zeros

The use of zeros in the decimal system is important but can cause confusion.

2	means 2 units
2.0	means 2 units and 0 tenths
2.00	means 2 units 0 tenths 0 hundredths
2.000	means 2 units 0 tenths 0 hundredths 0 thousandths

2 = 2.0 = 2.00 = 2.000

To make a whole number into a decimal, put the decimal point after the number and add a zero.

Zeros placed after decimal point at the end of figures do not need normally to be put in. However they can be put in to show the level of accuracy that has been used.

E.g. 2.700 m would indicate that the measurement has been taken correct to one millimetre (one thousandth of a metre).

Necessary zeros

20 0.306 600 0.4009

The zeros in the above examples are necessary as they are put in to keep places for missing digits.

0.306 is not the same as 0.36

Important

Always put a zero in if front of a decimal place if there are no units. For example it is written 0.5. This makes the number clear and leads to less mistakes.

Unnecessary zeros

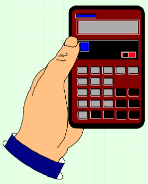
02 002 05.7

It is not necessary to use zeros in front of whole numbers.

The above numbers should be written;

2 2 5.7

Try some yourself . . . Exercise 1.27



1. Copy these numbers out leaving out the unnecessary zeros.
   Use a zero before the decimal point when required for clarity.

   a. 0048.80
   b. 4.0000
   c. 006.00
   d. 08
   e. .70
   f. 0.0055
   g. 11.0001
   h. 300.0
   i. 002.0200
   j. .001

2. Are these numbers equal? If not, which is higher?

   a. 6.05 and 6.5
   b. 6.50 and 6.5
   c. 5.063 and 5.036

Try some yourself . . . Exercise 1.28

1. Arrange in order, smallest to largest:
   5.04, 5.004, 4.965, 5, 5.104

2. Looking back at the golfers tee shot example, write down the following numbers:

a.

U	t
2	0
	4

b.

T	U	t
7	0	0
	3	0
		2

c.

H	T	U	t
3	0	0	0
	1	0	0
		2	0
			1

3. Write these numbers in figures:

   a. Five point six
   b. Thirty one point two
   c. Nought point three.
   d. Twenty point five
   e. One hundred point four
   f. Nought point nought one

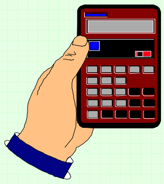
4. Complete this table:

Numbers	8.35	1.7	0.04	0.2	5.08	15.63
Tenths	3					
Hundredths	5	0				

5. Which is greater in each pair?

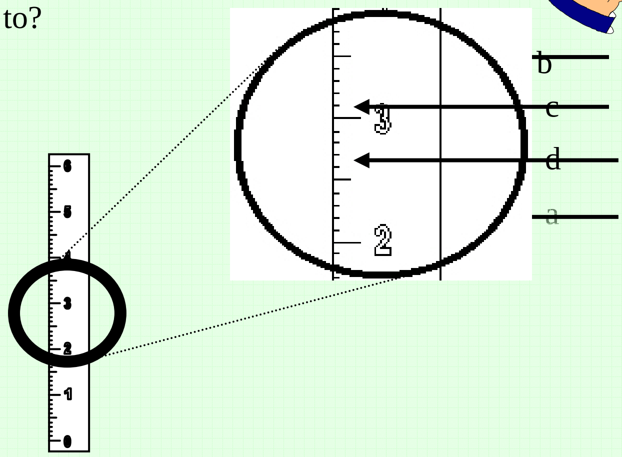
   a. £5.56 or £5.65
   b. 1.9 metres or 2.1 metres
   c. 0.71 or 0.17
   d. 1.22 or 2.11
   e. £10.01 or £9.99
   f. 76.04 or 76.40
   g. 3.09 or 3.10
   h. 0.1 or 0.02

Try some yourself … Exercise 1.28 continued



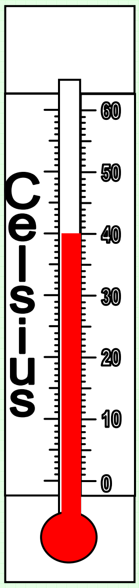
6. The magnifying glass shows part of a ruler between 1.8 and 3.7. The first arrow (a) points to 2.2. Which numbers do the other arrows point to?

   a.
   b.
   c.
   d.

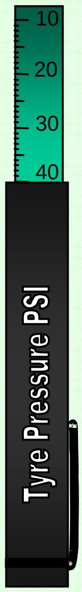


7. Write down the readings on the scales on these instruments.

   a. Thermometer



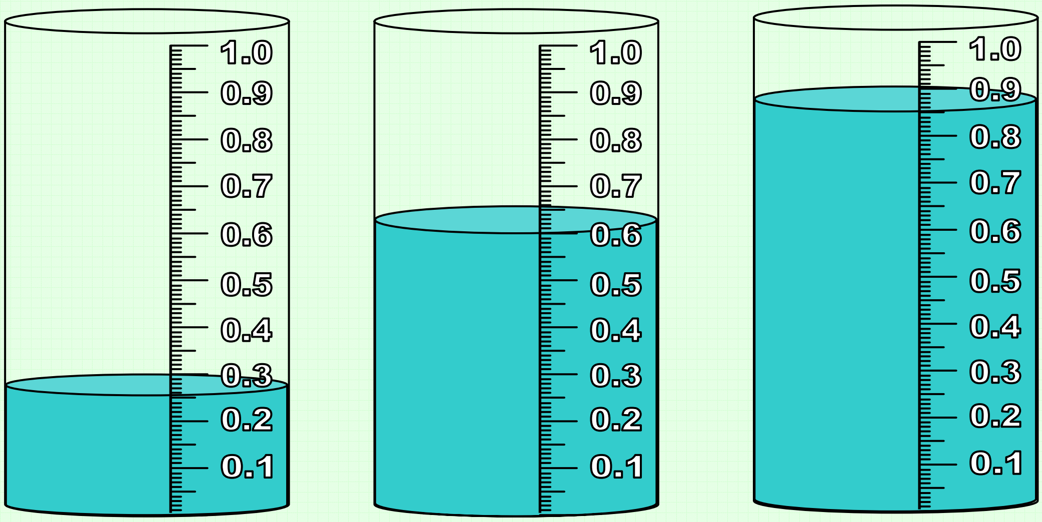
   b. Tyre pressure gauge



Try some yourself … Exercise 1.28 continued

8. Each jar can hold one litre of liquid.

a. Write down the volume of liquid in each jar as a decimal of a litre.
b. What volume of each jar is empty?



Jar 1. Volume
Fraction

Jar 2. Volume
Fraction

Jar 3. Volume
Fraction

Adding, subtracting, multiplying and dividing decimals

Calculations using decimals are carried out in exactly the same manner as with whole numbers, the point simply indicates the magnitude of the digits.

The process for addition, subtraction, multiplication and division of whole numbers is dealt with in section 3.

Example - Manual decimal addition

Add 62.1 and 0.53 and 215 (62.1 + 0.53 + 215)

215 is the same as 215.00

It is important to line up the decimal points

HTU.tu
62.10
0.53
215.00
277.63

Hundreds	Tens	Units	.	tenths	hundredths
	6	2	.	1	
		0	.	5	3
2	1	5	.	0	0
2	**7**	**7**	**.**	**6**	**3**

The decimal point in the answer goes in the column below the other decimal points

Example - Calculator decimal addition

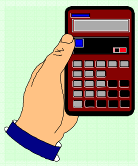
Add 62.1 + 0.53 + 215

6	2	.	1	+	.	5	3	+	2	1	5	=

The display will show **277.63**

Note it is not necessary to key in the zero in 0.53 although it will make no difference if you do.

Try some yourself . . . Exercise 1.29



1. Work out the following manually

   a. 62.34 + 41.11
   b. 1.3 + 4.2 + 3.1
   c. 12.11 + 8.71 + 29.11
   d. 89.71 + 4.91 + 98
   e. 761.3 + 291.1 + 497.4

2. Now check your answers on your calculator.

Example - Manual decimal subtraction

Subtract 17.6 – 3.4

The decimal points must again be lined up.

TU.t
17.6
 3.4
13.2

Tens	Units	.	tenths
1	7	.	6
	3	.	4
1	**3**	**.**	**2**

Subtract 500 – 0.14

HTU.th
500.00
 0.14
499.86

If you need to review the process of manual subtraction, look back to section 3.2.

Example - Calculator decimal subtraction

Subtract 17.6 – 3.4

1	7	.	6	-	3	.	4	=

The display will show

14.2

Subtract 500 – 0.14

	0	0		.	1	4	=

The display will show

499.86

Try some yourself . . . Exercise 1.30

1. Work out the following manually;

 a. 15.38 – 11.06
 b. 2.75 – 1.36
 c. 14.2 – 9.1
 d. 70.08 – 13.59
 e. 315.75 – 0.93

2. Check the answers using your calculator.

Example - Calculator decimal multiplication

Multiply 6.23 x 3.1

6	.	2	3	x	3	.	1	=

The display will show

19.313

Multiplying and dividing decimals by 10, 100 etc.

To multiply a decimal by 10 move the decimal point to the right.

1.52 x 10 = 1 . 5 2 = 15.2

To divide by 10 move the decimal point to the left

152.0 ÷ 10 = 1 5 2 . 0 = 15.2

Add or leave out zeros as necessary.

To multiply or divide by 100, move the decimal point two places.

To multiply or divide by 1000, move the decimal point by three places, etc.

Try some yourself . . . Exercise 1.31

1. Calculate the following (using your calculator).

   a. 2.251 x 9
   b. 3.02 x 0.08
   c. 0.013 x 1.8
   d. 34.2 x 7
   e. 8.7 x 0.003
   f. 0.02 x 1,500
   g. 1,670 x 0.015
   h. 12,190 x 0.02
   i. 9.625 x 9.625
   j. 13.375 x 12.25

2. Work out the following by moving the decimal point (without a calculator).

   a. 1,000 x 10
   b. 1,000 ÷ 10
   c. 0.052 x 10
   d. 0.052 x 1,000
   e. 0.052 x 10,000
   f. 1.1 ÷ 10
   g. 1.1 ÷ 100
   h. 187.234 x 10
   i. 187.234 ÷ 10
   j. 2,943 ÷ 1,000

Example - Calculator decimal division

Divide 54.63 by 0.04

5	4	.	6	3	÷	.	0	4	=

The display will show

1365.75

It is not necessary to key in the zero before the point in 0.04.

Example – Repeating and recurring decimals

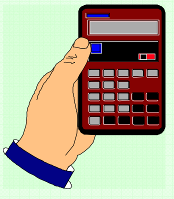
Sometimes one number will not divide into another exactly. Try $22 \div 7$ for example. The answer on your calculator should be 3.1428571.

If we could see them, the answer would run on to an infinite number of decimal places (that is they would never stop). This is known as a repeated or recurring decimal.

Try $10 \div 3$
The answer is 3.3333333
Again the actual answer would run to an infinite number of decimal places. Where the same number appears over and over again, it is called a recurring decimal.

In the next section we will discuss how to round these numbers.

Try some yourself . . . Exercise 1.32



1. Calculate the following (using your calculator).

a.	52.5	÷	3
b.	48.5	÷	5
c.	8.12	÷	4
d.	0.552	÷	3
e.	2.55	÷	5
f.	4.24	÷	0.04
g.	5.25	÷	0.5
h.	120	÷	0.1
i.	105	÷	0.18
j.	210	÷	0.109

4.3: Rounding off and Decimal Places

We discussed rounding for whole numbers in section 2.1. Rounding can also be done for decimals.

Example

Change $\frac{3}{7}$ to decimal

= 0.4285714

We do not usually need this amount of accuracy in rig calculations so we need to be able to round this figure to an acceptable level of accuracy.

We need to specify the number of decimal places.

Decimal places means the number of figures after the decimal point. (Decimal place is sometimes abbreviated to d.p.)

Show 0.4285714 to 4 decimal places.

This means that we only wish to have 4 figures after the decimal point.

Remember the rounding rule

If the last digit is

$\underbrace{1\ 2\ 3\ 4}_{\text{Round down}}$ $\qquad$ $\underbrace{5\ 6\ 7\ 8\ 9}_{\text{Round up}}$

If we need 4 decimal places, check the fifth decimal place

0.4285714 If this is 1,2,3,4 round down

If this is 5,6,7,8,9 round up

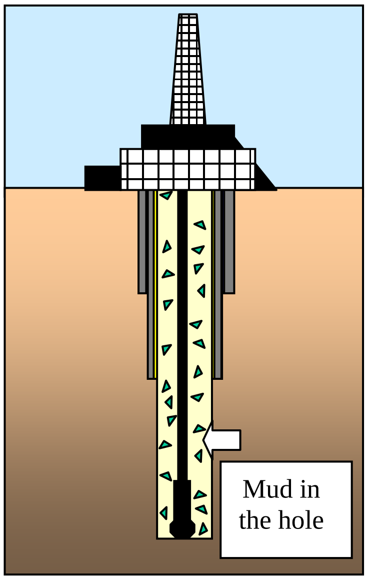
So 0.4285714 to 4 decimal places is 0.4286.

Example

105.15471

To	1 decimal place	=	105.2
	2 decimal places	=	105.15
	3 decimal places	=	105.155
	4 decimal places	=	105.1547

In drilling calculations you will need to become aware of the required accuracy.



For instance, if you calculate the volume of mud in the hole to be 1547.68214 barrels.

What is required is a volume to a round number. This would be 1548 barrels.

However if you calculate the drill pipe capacity to be 0.0177 barrels per foot but round this off to 0.02 then this would seriously affect your answer.

For example with 10,000 feet of pipe the difference in capacity would be significant;

0.02 x 10,000 = 200 barrels
0.0177 x 10,000 = 177 barrels

A difference of 23 barrels is significant.

The accuracy required in calculations should depend on how the original measurements were taken and how the information is to be used.

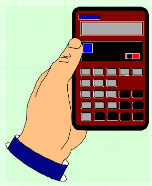
In the oil industry we follow certain conventions with regard to rounding and accuracy.

For example;

	Accuracy required
Depth of a well in feet	round number
Length of a joint of drill pipe in feet	2 decimal places
Capacity of drill pipe in barrels per foot	3 or 4 decimal places

In most cases it is preferable to quote the required accuracy for a calculation, or state the accuracy of an answer.

Try some yourself . . . Exercise 1.33



1. Round the following to 1 decimal place:
   a. 10.32
   b. 9.75
   c. 156.119
   d. 32.876
   e. 9.625

2. Round the following to 4 decimal places:
   a. 0.0177688
   b. 0.0242954
   c. 0.3887269
   d. 0.1738489
   e. 0.0119047

4.4: Estimating with decimals

Even using a calculator you can get sums wrong. It is worthwhile taking time before using a calculator to work out a rough estimate of what you expect your answer to be. This was also discussed in section 2.2.

Multiplying a number by 10 moves all the digits one place to the left and adds a zero to the right hand side. If you divide by 10 this moves all the digits one place to the right. Multiplying or dividing by 100 shifts everything 2 places, 1,000 3 places and so on. This also applies when using the decimal point.

Example

26,971 x 10 = 269,710
26,971 x 100 = 2,697,100
26,971 ÷ 10 = 2,697.1
26,971 ÷ 100 = 269.71

Example

Multiply 0.1952 by 10,000

Answer
1,952

This can be useful in estimating.
Lets look at a series of examples which are similar to the calculations used to work out mud volumes in a well.

Example

0.0177 x 9,472

9,472 is almost 10,000, therefore a rough estimate that you can calculate in your head is
0.0177 x 10000 = 177

As you have rounded up then the answer is less than 177.

To get an accurate figure use your calculator

0.0177 x 9472 = 167.6544

Example

0.1215 x 710

710 is roughly 700. Multiplying by 100 moves the digits 2 places to the left.
0.1215 x 100 = 12.15 This is approximately 12.

There are 7 hundreds so the 12 has to be multiplied by the 7

7 x 12 = 84

The answer is roughly 84.

0.1215 x 710 = 86.265

Estimates may be give a good enough answer but even if they don't they give you a good idea of what the answer should be.

Example

0.148 x 12,480

12,480 is roughly 12 thousands
0.148 x 1,000 = 148

a. As there are 12 thousands then the sum is now 148 x 12
This can be estimated to 150 x 10 = 1,500

b. Another way to look at this is;
12 consists of 10 and 2
148 x 10 = 1,480
148 x 2 = 296
296 + 1,480 = 1,776

0.148 x 12480 = 1,847.04

Try some yourself . . Exercise 1.34

Which of the following are correct? Answer Yes/No.

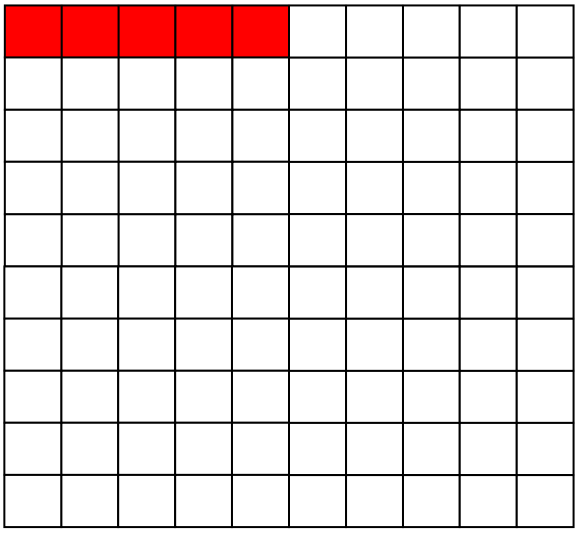
a. 0.0178 x 10,000 = 178.0
b. 0.0178 x 15,000 = 356.0
c. 0.1215 x 9,000 = 10,935.0
d. 0.00768 x 883 = 67.8
e. 0.109 x 140 = 16.7

4.5: Percentages

Per <u>cent</u> means for every <u>hundred</u>.

The sign for percent is %.

The drawing shows 100 squares.
5 are shaded.
95 are not shaded.



As a fraction of the whole;

$\frac{5}{100}$ are shaded

$\frac{95}{100}$ are not shaded

A fraction with a denominator of 100 is a percentage.

So

$\frac{5}{100} = 5\%$ shaded squares

$\frac{95}{100} = 95\%$ not shaded

A percentage is another way of writing a fraction or a decimal.

$$10\% = \frac{10}{100} = \frac{1}{10} = 0.1$$

$$20\% = \frac{20}{100} = \frac{2}{10} = 0.2$$

$$50\% = \frac{50}{100} = \frac{5}{10} = 0.5$$

$$75\% = \frac{75}{100} = 0.75$$

$$100\% = \frac{100}{100} = 1$$

Calculators may have a percentage key $\boxed{\%}$

Example – Calculating percentages

Find 20% of 10

1. Calculator

1	0	x	2	0	%

Display shows

2.

So 20% of 10 = 2

2. Manually

100% = 10

$1\% = \frac{10}{100} = 0.1$

$20\% = 0.1 \times 20 = 2$

This can be written as;

$10 \times \frac{20}{100}$

This is also the same as $\frac{20}{100} = 0.2$

10 x 0.2 = 2.

We can also place the decimal point in front of the percentage required 0.20

Then multiply by the original value

0.20 x 10 = 2

Calculating percentages of a quantity

Example

A coat has been reduced by 15% in a sale. The old price was £40.
How much has the coat been reduced?

We need to find 15% of £40

Calculator

4	0	x	1	5	%

6.

Manually

$$£40 \times \frac{15}{100} = £6$$

What should the sale price of the coat be?

The new price should be 85% of the original price (100% - 15%)

The sale price is either:

£40 x 85% = £34

or

£40 - £6 = £34

Try some yourself . . Exercise 1.35

1. Find 10% of

   a. £30
   b. 40 centimetres
   c. 90 metres
   d. 60 minutes
   e. £3.20

2. Find the following.

   a. 15% of £60
   b. 25% of 36 centimetres
   c. 50% of 4 kilometres
   d. 5% of 20 pence
   e. 20% of 30 millimetres

4.6: Ratios

A ratio is a way of comparing quantities and proportions, they work in a similar way to fractions.

If we have 4 apples and 1 pear, the ratio of apples to pears is four to one.

This would be written as;

4:1 (we use the colon : sign to indicate a ratio).

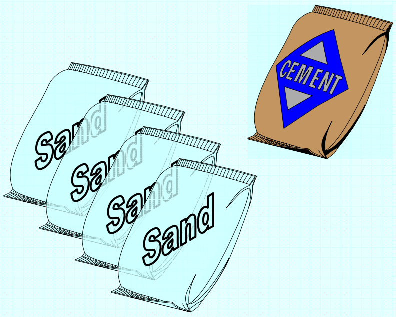
Example

Mortar is made up of 4 parts sand and 1 part cement.
The ratio is 4:1
We could also say the proportion of cement to sand is 4:1

This means that there are 5 parts all together and

$\frac{4}{5}$ of the mortar is sand

$\frac{1}{5}$ is cement



The actual quantities can vary;
4 bags of sand to 1 bag of cement
4 buckets of sand to 1 bucket of cement
4 teaspoons of sand to 1 teaspoon of cement

The proportions remain the same and they have the same ratio.

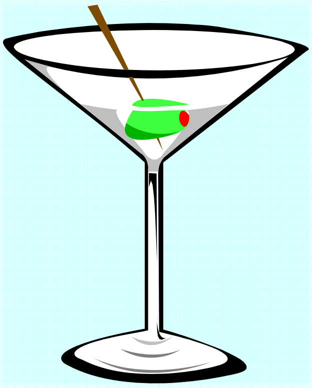
Example

A cocktail is made of gin, vermouth and orange juice in the ratio 2:3:1.
What quantity of each is required to make 2 litres of the cocktail?

6 parts all together $\frac{2}{6}$ gin or $\frac{1}{3}$

$\frac{3}{6}$ vermouth or $\frac{1}{2}$

$\frac{1}{6}$ orange juice



6 parts = 2 litres

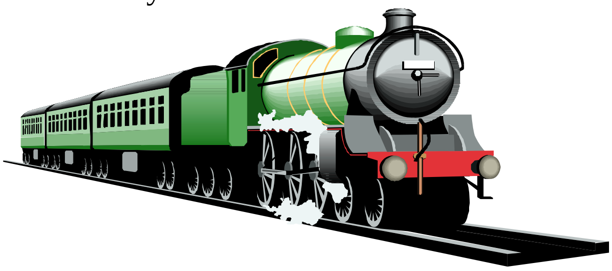
Gin $\frac{1}{3} \times 2 = \frac{2}{3}$ litre

Vermouth $\frac{1}{2} \times 2 =$ 1 litre

Orange juice $\frac{1}{6} \times 2 = \frac{2}{6}$ or $\frac{1}{3}$ litre

To check you add up the quantities – $\frac{2}{3} + \frac{1}{3} + 1 = 2$ litres

Model trains are usually made to a scale of 1:72. Every measurement on the model is $\frac{1}{72}$th of the real measurement. They are in the ratio of 1:72.



The ratio shows how much bigger one quantity is than another. The real measurements are 72 times bigger.

Simplifying ratios

Sometimes problems are made easier by first putting the ratios into "simpler terms". These ratios are already in their simplest terms:

3:1 5:7 10:9 1:100 500:3

The numbers on the ratios are all whole numbers. No number divides exactly into both sides of the ratio.

These ratios are not in their simplest terms:

6:4 15:3 100:50 40 cm:50 cm 1 m:1 cm

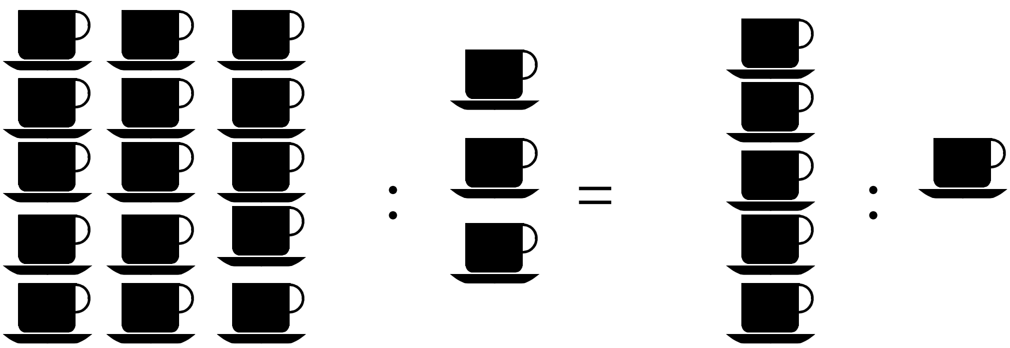
2 will divide into both 6 and 4. We can simplify the ratio 6:4 by dividing both sides by 2:

6:4 is the same ratio as 3:2

In the second example, 3 divides into both 15 and 3:

15:3 is the same ratio as 5:1

If you put 15 cups to 3 cups you would get the same mix as if you put 5 cups to 1 cup.



In the third example, 50 divides into both 100 and 50 (50 is a "common factor"):

100:50 is the same ratio as 2:1

To simplify a ratio you may divide both sides by the same number.

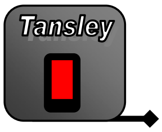
Simplifying ratios with units

We can simplify the ratio 40 centimetres:50 centimetres by:

(a) removing the units (because they are the same) and;
(b) dividing both sides by 10.

40 centimetres:50 centimetres is the same ratio as 4:5

The ratio 1 metre:1 centimetres can be simplified by making the units the same and then removing them:



1 metre:1 centimetres is the same ratio as 100 centimetres:1 centimetres
(because 1metre = 100 centimetres)

100 centimetres:1 centimetres is the same as 100:1

To simplify a ratio, make the units the same and then remove them. Then simplify as before if possible.

Try some yourself . . . Exercise 1.36

1. A litre of cordial is mixed at a ratio of 9:1 (water to concentrate):
   a. What fraction of the finished cordial is
      (i) water?
      (ii) concentrate?

   b. If a litre of concentrate is used
      (i) how much water is required?
      (ii) how much cordial is obtained?

2. Simplify the following ratios:
   a. 3:6
   b. 5:20
   c. 8:16
   d. 4:12
   e. 4:10
   f. 7:21
   g. 3:9
   h. 3:15
   i. 42:49
   j. 25:30

3. Simplify the following ratios:
   a. 300 centimetres:100 centimetres
   b. 500 metres:1 kilometre
   c. 40 grams:1 kilogram
   d. £1.50:50 pence
   e. 6 kilograms: 60 grams
   f. 2 kilometre:500 m
   g. 100 grams: 0.5 kilograms
   h. 30 pence:90 pence
   i. 75 pence:25 pence
   j. 75 pence:£1.00

Different units

There are;

1,000 grams in a kilogram
1,000 metres in a kilometre
100 pence in a pound

4.7: Converting between Fractions, Decimals and Percentages

Fractions, decimals and percentages are different ways of representing the same thing.

It is useful to be able to change from one form to another depending on the problem to be solved.

Example – Fractions, decimal and percentages

A school has 500 pupils
300 are boys
200 are girls

As a fraction

$\frac{300}{500} = \frac{3}{5}$ are boys

$\frac{200}{500} = \frac{2}{5}$ are girls

As a decimal

$\frac{300}{500} = 0.6$ are boys

$\frac{200}{500} = 0.4$ are girls

As a percentage

$\frac{300}{500} \times 100 = 60\%$ are boys

$\frac{200}{500} \times 100 = 40\%$ are girls

The above example shows three ways of representing the same proportions. These can all be used to compare numbers of boys and girls.

Fractions to decimals

A fraction can be changed into a decimal by carrying out the division implied in the written form i.e. dividing the top number by the bottom number.

Example

Find the decimal equivalent of $\frac{3}{20}$

In your calculator enter

[ ] [☜] [2] [0] [=]

The display will show

[0.15]

Top heavy fractions can also be converted into decimals

Example

Turn $\frac{23}{7}$ into a decimal [2] [3] [÷] [7] [=]

The display should show **[3.28571422]**

$\frac{23}{7} = 3.28571422$

Mixed fractions can also be converted to decimals

Example

Turn $6\frac{3}{5}$ into a decimal

[3] [÷] [5] [=]

The display should show **[0.6]**

You then need to remember to add the whole number

[+] [6] [=] **[6.6]**

$6\frac{3}{5} = 6.6$

Decimals to fractions

Decimals can also be written as fractions. Write it as so many tenths and hundredths, then reduce it to its simplest form.

$0.1 = \frac{1}{10} =$ one tenth

$0.01 = \frac{1}{100} =$ one hundredth

Example

$$0.35 = \frac{35}{100} = \frac{7}{20}$$

$0.001 = \frac{1}{1000} =$ one thousandth

Decimals to percentages

To change a decimal to a percentage, multiply by 100 as a decimal gives the tenths and hundredths out of 1 and a percentage is the number of parts out of 100.

Example

0.15 = 15%

Fractions to percentages

To change a fraction to its percentage form, then either calculate the decimal form first and then multiply by 100 or multiply by 100 and then carry out the division to calculate the decimal equivalent.

Example

What percentage is $\frac{1}{5}$

(a) $\frac{1}{5} = 0.2$

$0.2 \text{ x } 100 = 20\%$

(b) $\frac{1}{5} \text{ x } 100 = \frac{100}{5} = 20\%$

Using fractions to calculate percentages

Simple percentages can often be done without using a calculator by changing them to fractions.

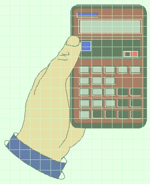
Example

What is 20% of £25?

20% is $\frac{1}{5}$

$\frac{1}{5}$ of £25 is £5

Try some yourself . . . Exercise 1.37



1. Change the following to decimals:

   a. $\frac{1}{2}$

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

   c. $\frac{1}{3}$

   d. $\frac{1}{8}$

   e. $\frac{1}{7}$

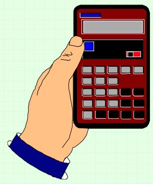
2. Change the following to fractions in their simplest form:

   a. 0.2
   a. 0.75
   b. 0.03
   c. 0.125
   d. 0.375

3. Change the following to percentages:

   a. 0.2
   a. 0.75
   b. 0.03
   c. 0.125
   d. 0.375

Try some yourself . . . Exercise 1.37 continued



4. Change the following to percentages:

a. $\frac{1}{2}$

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

c. $\frac{1}{3}$

d. $\frac{5}{8}$

e. $\frac{3}{8}$

f. $\frac{16}{8}$

g. $1\frac{3}{4}$

5. Change the following fractions to decimals

a. $9\frac{5}{8}$

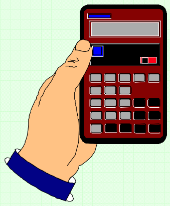
b. $13\frac{3}{8}$

c. $12\frac{1}{4}$

d. $8\frac{1}{2}$

e. $6\frac{5}{8}$

Try some yourself - Exercise 1.38



When running casing into a well, we have to run 240 joints of casing.

So far we have run 60 joints.

1. What proportion of the casing has been run . . .

   a. as a fraction? ____________
   b. as a percentage? ____________

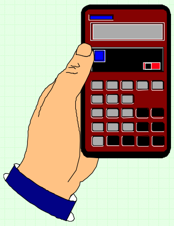
2. What proportion is still to run . . .
   a. as a fraction? ____________
   b. as a percentage? ____________

3. If every joint of casing is fitted with 2 centralizers how many centralizers are required?

4. What is the overall ratio of centralizers to joints of casing?

5. If the total length of the casing is 9,760 feet, what is the length of each joint of casing? (Answer to 2 decimal places)

Try some yourself – Exercise 1.39



Taking into account the gearbox and axle ratios, the ratios between engine speed and road wheel speed are as follows;

1st gear	14:1
2nd gear	8:1
3rd gear	6:1
4th gear	4:1

If the engine speed is 5,000 rpm, how fast are the wheels turning in each of the following cases?

<u>Example:</u>
First gear
Ratio 14:1
Engine speed 5,000 rpm
Wheel speed $5{,}000 \div 14 = 357$ rpm
(Answer to nearest whole number)

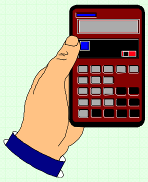
Try some yourself . . .

1. Second gear Wheel speed ____________ rpm

2. Third gear Wheel speed ____________ rpm

3. Fourth gear Wheel speed ____________ rpm

Try some yourself . . . Exercise 1.40



1. A slick 8 inch drill collar weighs 147 pounds per foot. The same diameter spiral collar weighs 4% less. What is the weight of the spiral collar?

2. The recommended diameter of the Crown block sheaves depends on the diameter of the drilling line.

   A 57 inch diameter sheave is recommended for $1^1/_2$ inch diameter line.

   a. What is the ratio for sheave diameter: line diameter?
   b. What size sheave would you recommend for 1 inch diameter line?

3. A chain drive has a sprocket ratio of 18:6.

   If the large sprocket turns once, how many times will the small sprocket turn?

4. A manufacturer recommends replacing a chain when 3% elongated.

   If the new chain had 12 links (pitches) in one foot, at what measurement for 12 links would you replace the chain?

   __________________ inches

5. If working a rota of 2 weeks on and 3 weeks off, how many days per year (365 days) would be spent;

   a. on the rig?
   b. off the rig?

Example – Safe working load

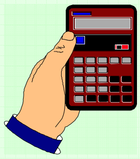
A wire rope has been tested to 40 tonnes by the manufacturer.

When calculating the Safe Working Load (SWL) a safety factor of 5:1 is applied.

What is the SWL?

$40 \div 5 = 8$ tonnes

Try some yourself - Exercise 1.41



1. A wire rope has been tested to 30 tonnes by the manufacturer.

   When calculating the Safe Working Load (SWL) a safety factor of 6:1 is applied.

   What is the SWL?

Example – Slip and cut

A rig has in place a schedule to cut and slip drill line after 1,200 ton-miles.

If a safety factor of 0.75 or 75% is taken into account, after how many ton-miles should we slip and cut the drill line?

1,200 x 0.75 = 900 ton-miles

Try some yourself - Exercise 1.42

1. A rig has in place a schedule to cut and slip drill line after 1,500 ton-miles.

   If a safety factor of 0.8 or 80% is taken into account, after how many ton-miles should we slip and cut the drill line?

2. A rig slips and cuts after 980 ton-miles although the calculated schedule was 1,400 ton-miles.

   What safety factor has been taken into account (as a percentage)?

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Section 5: Units of Measurement

In order to accurately describe and compare things, we need to be able to measure them. For example, we measure the length of drill pipe, volumes of mud, mud density and pump pressure. This section deals with the types of measurements we take and the systems of units used in the oil industry.

Objectives

- To discuss the general principles of measurement.
- To outline the two main systems of measurement.
- To define the types of measurements we make.
- To explain the systems of units used in the oil industry.

Try these first . . . Exercise 1.43

1. Which definition is which?
   a. The amount of space inside a container.
   b. The amount of space taken up by a solid object.
   c. The weight per unit volume of a substance.

   Capacity _____ Volume ______ Density ______

2. Write down the types of measurement for the following;
   a. Feet or metres e.g. Length
   b. Pounds per gallon ____________
   c. Pounds ____________
   d. Barrels ____________
   e. Inches ____________
   f. Pounds per square inch ____________
   g. Litres ____________

3. To which system of measurement do each of the above belong?

4. Convert the following;
   a. 1000 cubic feet to barrels
   b. 288 square inches to square feet
   c. 12 feet to inches
   d. 17 pounds per gallon to pounds per cubic foot
   e. 2 barrels to US gallons

5. What unit of measurement measures the force required to pump mud around a circulating system?
   a. weight
   b. density
   c. pressure

What is measurement?

Measurement is really only a system for describing things, for example;

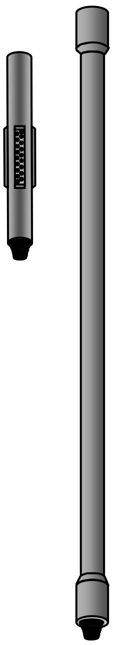
How tall?

How heavy?

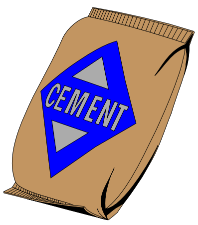
It is easy to describe the difference between things, for example;

Doctor Bob is taller than Mike.

A football is bigger than a golf ball.



A stabiliser is shorter than a joint of drill pipe.

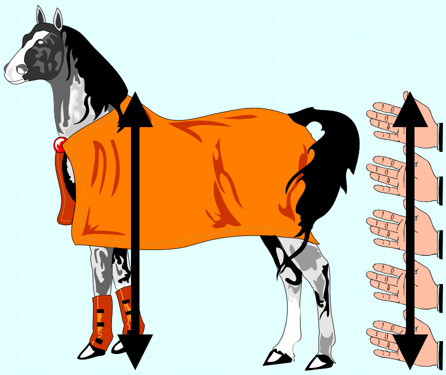


A bag of cement is heavier than a bag of sugar.

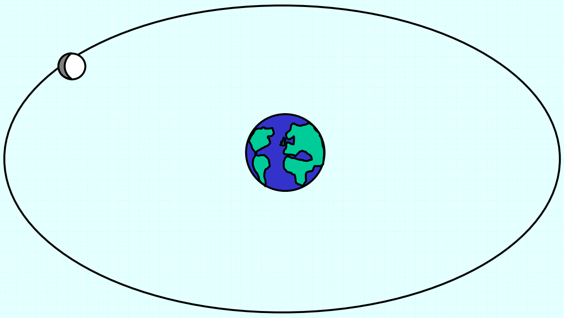
This method of comparison is not however very practical because we cannot always compare one thing with another. What we need is a standard system of measurement. In fact what is required is a standard <u>*Unit of Measurement*</u> against which all things can be compared. In the past, theses <u>*Units of Measurement*</u> were common everyday things.

Example

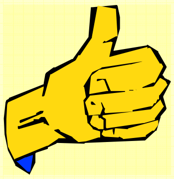
The height of a horse was measured in hands



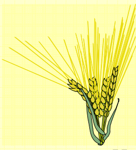
A month is approximately how long the moon takes to move around the earth.



Of interest

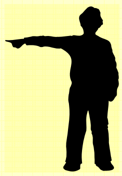


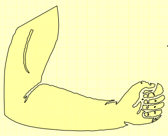
In many countries the inch was originally the width of a thumb. In Anglo-Saxon England (before 1066) it was defined as the length of three barleycorns.



A foot was originally a measurement based on the length of a persons foot.

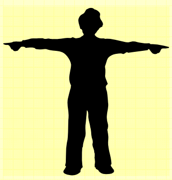
A yard (or 3 feet) was the measurement from the tip of your nose to the end of the middle finger of the outstretched hand.





A cubit was the length of a forearm.

A fathom is a unit of depth and was the distance from one fingertip to the other with the arms stretched out as far as possible.



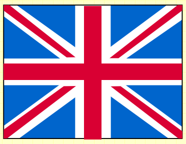
Systems of Measurement

Around the world there are two main systems of measurement;

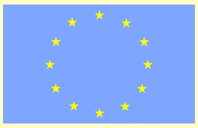
Imperial
Metric (Systeme Internationale)

Each of these systems has its own subdivisions and variations depending on the country (or industry) in which it is used.

Of interest



Imperial is the system used by the British in the days of the Empire.



The metric system is based around the unit of length of a metre. The current standard for the metric system is the Systeme Internationale.

The Imperial system has a standard set of units of measurement. These do however vary from country to country. For example, a U.S. gallon is not the same as an Imperial gallon.

In the oilfield we use a version of the Imperial system using units defined by the American Petroleum Institute or API (or field units) system of measurement.

The metric system was developed in France during the Napoleonic period in the 1790's. Several different systems developed over time. In 1960 the Systeme Internationale (SI) was adopted as a standard. In this document we will concentrate on the system most commonly used in the oil industry, that is, the API version of the Imperial system.

In the oilfield, a variety of metric systems are in use depending on country.

In this book we will use the API (Imperial) system of units when performing oilfield calculations.

Other day to day examples will refer to metric units when these are in daily use.

What do we measure?

Some of the most common measurements we take are;

- the distance between two objects;
- the distance from one end of an object to another;
- how heavy an object is;
- how hot an object is;
- the size of an object.

What we actually measure are the dimensions which describe an object. These include;

Length (or distance)
Weight (or mass)

From these basic dimensions we also describe objects and situations by;

Area
Volume
Density
Pressure

Lets discuss each of these in turn.

A word about abbreviations

At the end of this section is a list of the most commonly used API units and the metric equivalents. Also included are the standard abbreviations.

When should we use abbreviations?

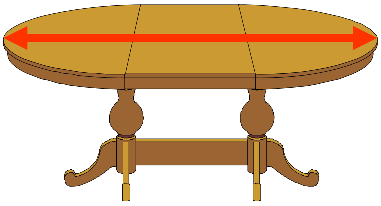
The word should always be written out in full the first time it is used and the abbreviation stated. E.g. the depth of the well is 10,000 feet (ft). Once the abbreviated form has been introduced, it can now be used for the rest of the text.

In other cases, a standard list of abbreviations to be used will be included at the beginning of a section.

Length

The length of something tells us how far it runs from end to end.

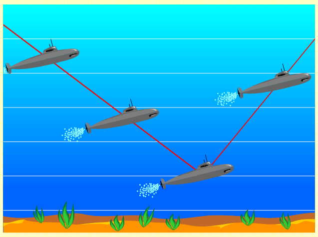
The length of a table



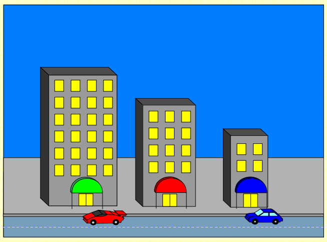
Depth, height, width, diameter and distance are also measurements of length.

Measurements of length

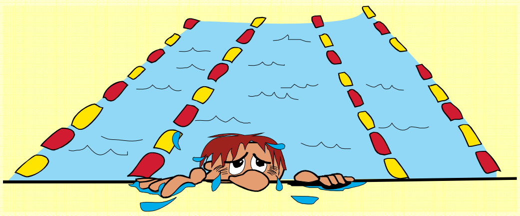
The depth of a submarines dive



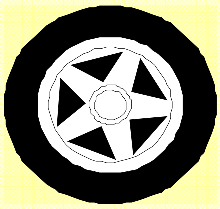
The height of a building



The width of a swimming pool



The diameter of a wheel



The distance between two towns or cities

Measuring length

Length is measured with a variety of measuring tools depending on scale. These include tape, ruler, calipers and distance wheel.

Of interest

Odd units of length:

Chain – is the length of a cricket pitch. Each chain is 100 links and 10 chains make a furlong.

Furlong – In the Saxon land measuring system this was the length of the traditional furrow ploughed by an ox team. This was made up of 40 *rods* another Saxon unit probably equal to 20 “natural feet”. It is still used today in horse racing. There are 8 furlongs to the mile.

Hand - Many units of measurement were based on “natural” units, for example the hand, which is still used today to measure the height of horses.

Pace - This is a Roman unit and is based on two steps (right and left) of a Roman legion. There were 1000 paces in a mile (another Roman unit).

And of course we have already mentioned cubits and fathoms as old measures of length.

Try some yourself . . . Exercise 1.44

1. Pick the correct definition of length.

   a. How heavy an object is.
   b. The distance from one end of an object to another.
   c. How much liquid something will contain.

2. Which of the following are measurements of length?

   a. The height of a person.
   b. The weight of a person.
   c. The distance from Aberdeen to Montrose.
   d. The journey time from Aberdeen to Manchester.
   e. The depth of the ocean.

3. Which of the following might be used to measure length?

   a. A bucket.
   b. A spring balance.
   c. Calipers.
   d. Pressure gauge.

Units of length

Units of length in the Imperial system are

Unit	Abbreviation
inch	**in**
foot	**ft**
yard	**yd**
mile	**mile**

Conversions

12 inches	=	1 foot
3 feet	=	1 yard
1,760 yards	=	1 mile
5,280 feet	=	1 mile

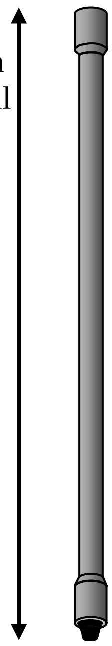
For example

Diameter of a bit (inches)

12 ¼ inches

Length of a joint of drill pipe

31.20 feet



API Units

The most commonly used units of length in the oil industry;

inch
foot

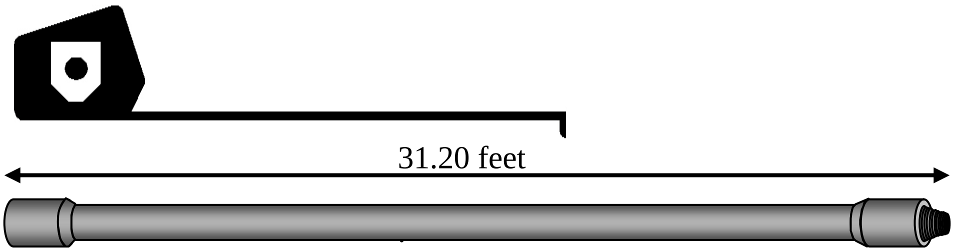
The most common units of length used day to day are feet and inches. Performing calculations in feet and inches can be time consuming.

Example

Two lengths of hose measure 31 feet 8 inches and 31 feet 11 inches.
What is the total of their length?

1. Add lengths in feet
   31 ft + 31 ft = 62 ft
2. Add inches
   8 ins + 11 ins = 19 ins
3. Convert inches to feet and inches
   19 ins – 12 ins = 7 ins and 1 ft
4. Add answers 1. and 3. together
   62 ft + 1 ft 7 ins = 63 ft 7 ins

On the rig, length is measured in feet and tenths of feet to make addition using calculators easier. We use a tape measure that is marked in feet, tenths and hundredths of a foot. We therefore talk about tenths of a foot. A single joint of drill pipe of 31.20 feet is **not** 31 feet and 2 inches, it is 31 feet and $^{2}/_{10}$ inches. When measuring pipe lengths we normally work to the nearest hundredth of a foot (i.e. 2 decimal places).



Example

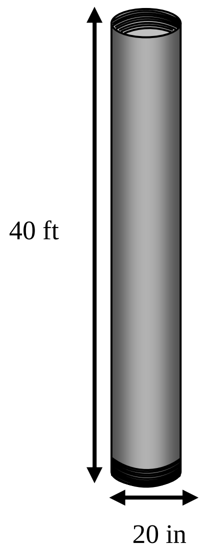
1. Convert 78 inches to feet and tenths of a foot.
   12 in = 1 ft, so divide by 12
   $78 \text{ in} = \frac{78}{12} \text{ ft} = 6.5 \text{ ft}$

2. Convert 40 feet and 6 inches to feet and tenths of a foot.
   40 feet is already in feet
   $6 \text{ in} = \frac{6}{12} \text{ ft} = 0.5 \text{ feet}$
   40 ft 6 in = 40.5 ft

3. Convert 30.25 feet to feet and inches
   30 feet is already in feet
   0.25 feet = 0.25 x 12 = 3 inches

   So 30.25 feet is 30 feet and 3 inches.

Smaller dimensions such as pipe diameter and bit diameter as measured in the conventional way using inches and parts (or fractions) of an inch. (More on fractions in Section 4).



20 in casing	$13\ ^3/_8$ in casing
Diameter 20 in	Diameter $13\ ^3/_8$ in
Length 40 ft	Length 40 ft

Try some yourself . . . Exercise 1.45

1. Given the following units of length:
   - inch;
   - foot;
   - yard;
   - mile.

   Which would you use to measure the following?

   a. The length of a football pitch. ________
   b. The length of a pencil. ________
   c. The length of a stabiliser. ________
   d. The distance from Manchester to Sheffield. ________

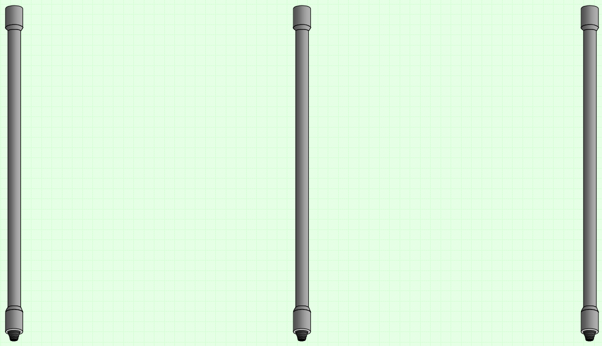
2. Change the units of the following:

   a. 1 foot equals _______ inches.
   b. 1 yard equals _______ feet.
   c. 1 yard equals _______ inches.
   d. 1 mile equals _______ feet.

3. Convert the following:

   a. 63 inches to feet and inches. ________
   b. 63 inches to feet and tenths of a foot. ________
   c. 30 feet and 9 inches to feet and tenths of a foot. ________
   d. 29.50 feet to feet and inches. ________

4. 1 stand of drill pipe consists of the following 3 joints:

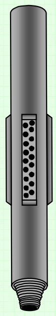


29.85 ft 31.23 ft 30.75 ft

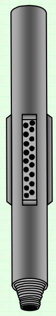
What is the length of the stand?

Try some yourself - Exercise 1.45 continued

5. The previous stand has 2 stabilisers added:



Stabiliser 1
4.31 ft



Stabiliser 2
3.89 ft

What is the new length of the stand?

6. Measure the following lines to the nearest 8th of an inch.

______________________________ in

____ in

________________ in

What is the total length?

7. Give the following to the nearest inch.

a. $9\ {}^{5}/_{8}$ inches
b. $13\ {}^{3}/_{8}$ inches
c. 12.41 inches
d. 12.25 inches

8. Give the following to the nearest foot.

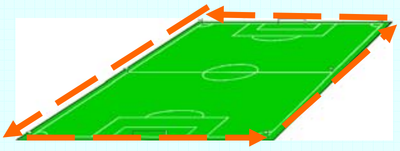
a. 31.27 feet
b. 30.81 feet
c. 40.75 feet
d. 18.46 feet.

Area

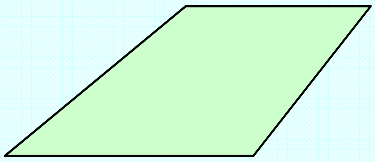
The perimeter is the distance all the way round a flat shape.

The area is the amount of surface space inside the perimeter.

For example



The perimeter of a football pitch



The area of the same football pitch

Area is used to measure the size of the flat surface of an object.

For example

The area of Spain is greater than the area of Portugal

Area is calculated from the length and width (or height /depth) of an object and is usually given in “square” units.

Try some yourself . . . Exercise 1.46

1. Pick the correct definition of perimeter.

   a. The distance from one end of an object to another.
   b. The amount of surface space inside a flat shape.
   c. The distance all the way around a flat shape.

2. Pick the correct definition of area.

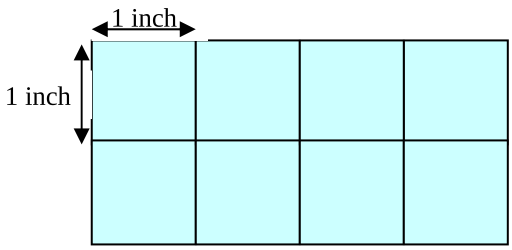
   a. The distance from one end of an object to another.
   b. The amount of surface space inside a flat shape.
   c. The distance all the way around a flat shape.

3. Which of the following is a unit of area?

   a. Feet
   b. Yards
   c. Cubic feet
   d. Square feet

Units of area

This rectangle is 4 inches long and 2 inches high. If we mark squares 1 inch by 1 inch inside the rectangle then we can see that we can fit in eight 1 inch squares.



The area of this rectangle is therefore 8 square inches.

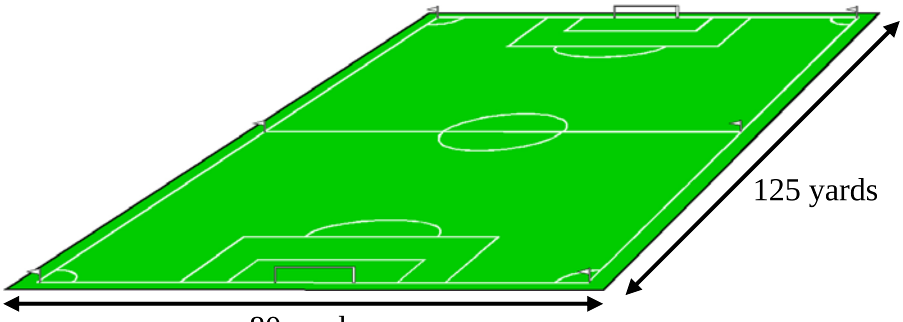
A square inch is the amount of space taken up by a square with 1inch sides.

The Imperial system of measurement uses the following units of measurement;

square inches (sq.in. or in^2)
square feet (sq.ft. or ft^2)
square yards
square miles

Conversions

144 square inches	=	1 square foot
9 square feet	=	1 square yard
3,097,600 square yards	=	1 square mile



The area of a football pitch is approximately 10,000 square yards.

Of interest

Other units

Acre - An Old Saxon unit still in use today for measuring areas of land. It also means "field" and was originally the size of field that a farmer could plough in one day. It is not based on a square as Anglo-Saxon fields were long and thin (1 furlong or 40 rods long by 4 rods wide).

API Units

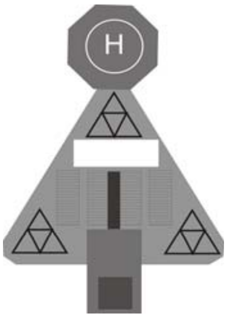
On the rig when we need to measure areas we mainly use;

square inches

square feet.

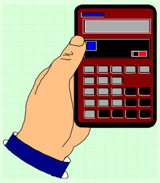
Area of helideck = 5,000 square feet

Area of the nozzles on a bit in square inches = 1.2 square inches



Topside deck area = 15,000 square feet

Try some yourself . . . Exercise 1.47



1. Given the following units of area:

   square inch
   square foot
   square yard
   square mile

   Which would be the most appropriate for the following?

   a. The area of this page.
   b. The surface area of a mud pit.
   c. The area of a football pitch.
   d. The area of Scotland.

2. Change the units of the following:

   a. 144 square inches equals __________ square feet.
   b. 288 square inches equals __________ square feet.
   c. 1 square yard equals ________ square feet.
   d. 3,097,600 square yards equals ____________ square miles.

3. Convert the following (answers to 1 decimal place):

   a. 273 square inches to square feet.
   b. 7 square yards to square feet.
   c. 33 square feet to square yards.
   d. $\frac{1}{2}$ square mile to square yards.

4. A section of deck space measures 50 feet by 40 feet.

   a. What is its area in square feet?

   What area would the following take up?

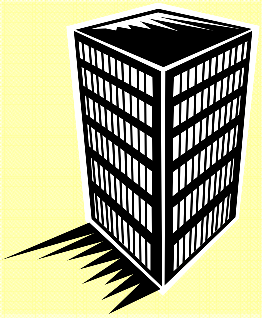
   b. A half height container 40 feet by 5 feet.

   c. Two nitrogen tanks each 8 feet by 15 feet.

   d. What area of the above deck is left over?

5.2: Volume

Volume is the amount of space taken up by a solid shape or object.




A skyscraper takes up a larger volume than a house.

Capacity is the amount of space inside a container.

The empty bottle/jar has a *capacity* of 2 litres

The *volume* of water in the jar is 1 litre

Volume and capacity are calculated from the length, width and height (or depth) of objects and usually use *cubic* units.

Of interest

Old measurements of volume and capacity

Gallon - This is the basic British unit of volume. In England it was originally the volume of 8 pounds of wheat. It has been revised many times, one of which was around the time of the American Revolution leading to the American dry gallon and liquid gallon. These are both different to the British gallon, which was redefined in 1824 and called the Imperial gallon.

1 US gallon	=	0.86268 Imperial gallon
1 Imperial gallon	=	1.20095 US gallons

Quart - This was a traditional division of a gallon into four.

Pint - This is a traditional division of a quart into two. There are 8 pints in a gallon.

Barrels - These were traditional larger measures for liquids.

1 Imperial barrel	=	36 Imperial gallons.
1 US barrel	=	42 US gallons

Hogshead – This is 54 Imperial gallons

Peck - A traditional measure for dry goods equal to 2 Imperial gallons.

Bushel - There are 4 pecks in a bushel.

Volume can be calculated from length, width and height measurements.

Liquid volumes can be measured with a calibrated measuring cylinder, jug or tank.

Try some yourself . . . Exercise 1.48

1. Pick the correct definition of volume.

   a. The distance from one end of an object to another.
   b. The amount of surface space inside a flat shape.
   c. The amount of space taken up by a solid shape.

2. Pick the correct definition of capacity.

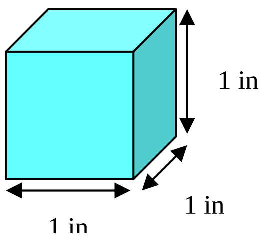
   a. The amount of space inside a container.
   b. The distance across the top of the container.
   c. How many handles a container has.

3. Which of the following is a unit of volume?

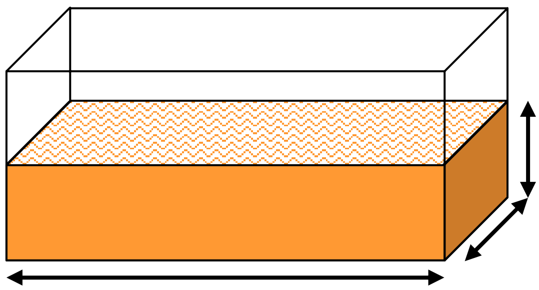
   a. Feet
   b. Metres
   c. Cubic feet
   d. Square metres

Units of volume

Units of volume are either cubic units used for solids and liquids or specific units for liquids such as gallons.



A cubic inch is the amount of space taken up by a cube with height, width and length of 1 inch.



Volume of mud pit usually measured in cubic feet or barrels

The units of volume used in the Imperial system are;

cubic inches	(cu.in. or in^3)
cubic feet	(cu.ft. or ft^3)
gallons	(gal)

API Units

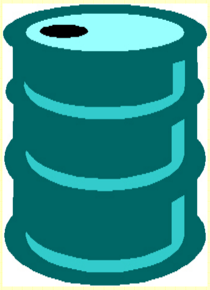
The API (field units) system also uses;

US gallons	
barrels	(bbl)

Of interest - Why is the abbreviation for barrels bbl?

In the early days of the oil industry there were two major operators supplying fuel to petrol stations in the US. One used blue barrels and one used red.

The abbreviation bbl comes from “blue barrels”.



1 bbl of rig wash or
42 US gallons

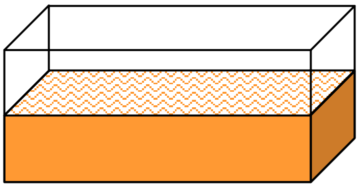
Conversion from one unit to another requires some care.

Conversions

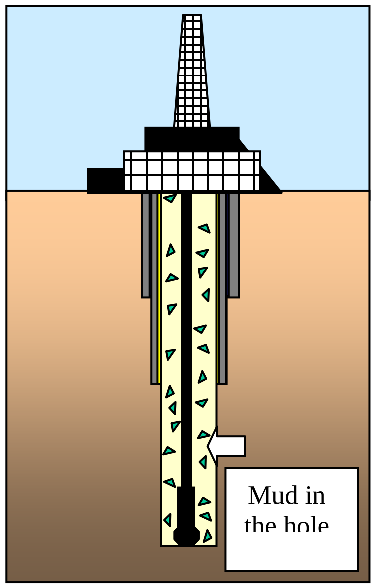
1,728 cubic inches	=	1 cubic foot
42 US gallon	=	1 barrel
5.6146 cubic feet	=	1 barrel
7.4809 US gallons	=	1 cubic foot
1 US gallon	=	0.83268 Imperial gallon

<u>In these lessons we will use US gallons unless stated otherwise</u>.

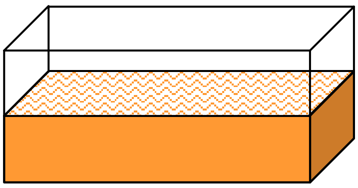
On the rig we measure many volumes e.g. tanks, wellbore, pipe etc.

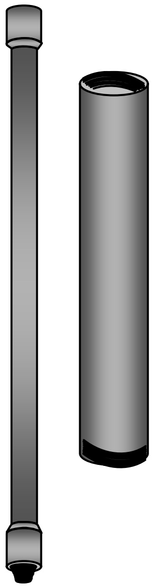


Volume of mud in a mud pit

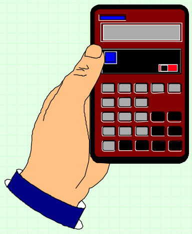


Volume of mud inside casing and drill pipe





Try some yourself . . . Exercise 1.49



1. Given the following units:

    cubic inch
    cubic foot
    pint
    gallon
    barrel

    which would be most appropriate for the following?

    a. The volume of a bucket.
    b. The volume of a mud pit.
    c. The volume (size) of a room.
    d. The volume of a beer glass.
    e. The size of the engine on a Harley Davidson motorbike.

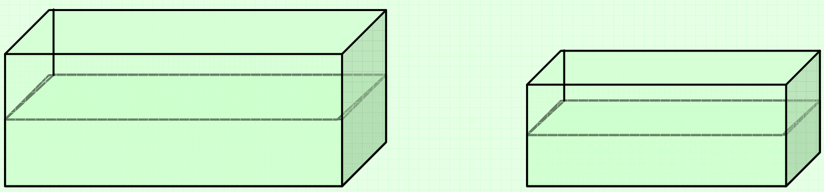
2. Convert the following:

    a. 1,728 cubic inches equals __________ cubic foot.
    b. 5.6146 cubic feet equals ___________ bbl.
    c. 42 US gallons equals _______ bbl.
    d. 7.48 gallons equals _________ cubic foot.

3. Convert the following:

    a. 100 cubic feet to US gallons.
    b. 1,800 cubic feet to barrels.
    c. 12 barrels to US gallons.
    d. ½ barrel to US gallons.
    e. 1,550 cubic feet to barrels.

4. Two mud pits contain the following volumes of mud:



Pit 1 – 436 barrels   Pit 2 – 328 barrels

What is the total volume of mud?

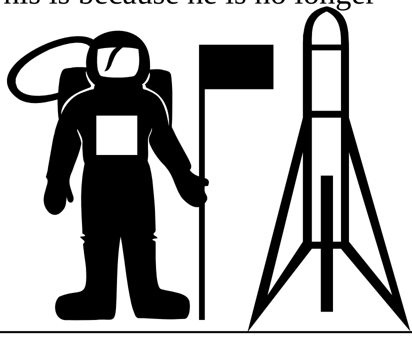
Weight and Mass

The *mass* of an object is the amount of matter or substance in that object.
The *weight* is the amount of pull on that object by the Earth's gravity.

We talk about an astronaut being "weightless" in space. This is because he is no longer affected by the earth's gravity.

On earth the astronaut has a *weight*, in space he does not.

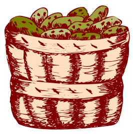
His *mass* however has not changed – he is still the same man with the same insides.



Normally this difference between weight and mass does not affect our daily lives. We buy food stuffs by weight, we weigh things for cookery and we measure the mass of our bodies with weighing scales and talk about our weight.

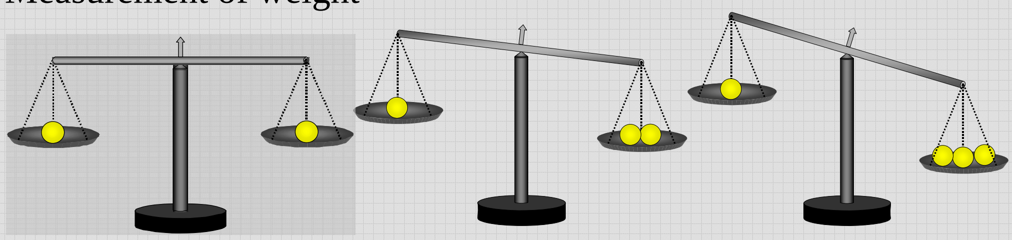
For example

The weight of a bag of potatoes



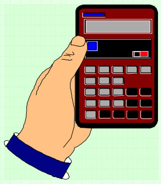
The weight of a person

Measurement of weight



Weight is usually measured with some type of weighing scales

Try some yourself . . . Exercise 1.50



1. Here are two definitions;

   a. The amount of matter in an object.
   b. The amount of pull on an object by the Earth gravity.

   Which one represents? Weight ____________

   Mass ____________

2. Are the following statements true or false?

   a. An astronaut has the same mass in space as on earth.
   b. An astronaut has the same weight in space as on earth.

3. Which of the following might be used to measure weight?

   a. Tape measure
   b. Measuring jug
   c. Pressure gauge
   d. Scales

Units of weight (or mass)

The units of weight/mass in the Imperial system are;

ounce	(oz)
pound	(lb)
stone	(st)
hundredweight	(cwt)
ton	(t)

Of interest

The abbreviation for pounds is lb, which is from the Latin Libra meaning pound. (Hence the £ symbol for pound Sterling.)

Other units;
Grain – This was originally the weight of a single barleycorn and formed the basis for English weight units.

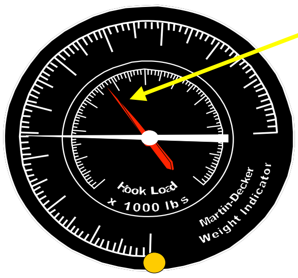
Conversions

16 ounces	=	1 pound
14 pounds	=	1 stone
112 pounds	=	1 hundredweight
20 hundredweight	=	1 long ton
2,240 pounds	=	1 long ton

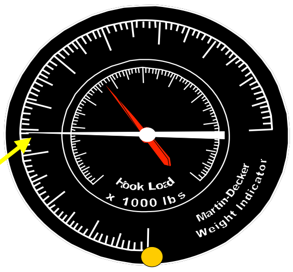
In the US;

2,000 pounds	=	1 ton = 1 SHORT TON

The weight of the drill string is generally measured in kilopounds, which is equal to 1,000 pounds.



Weight of drill string (including travelling equipment and lines)
250,000 lb (250 klb)



Weight on bit
20,000 lb (20 klb)

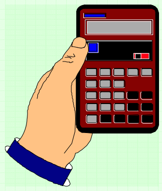
API Units

In the oil industry we use a mixture of units for measuring large weights;

Short ton	=	2,000 pounds
Metric tonne	=	2,205 pounds (1,000 kilograms)
Kilopounds	=	1,000 pounds

Nowadays we would usually measure weights on deck in metric tonnes.

Try some yourself . . . Exercise 1.51



1. Given the following units:

   ounce;
   pound;
   stone;
   hundredweight;
   ton;

   which is most appropriate for the following?

   a. The weight of a bag of sugar. _________
   b. The weight of a car. _________
   c. The weight of a person. _________
   d. The weight of 4 sacks of coal. _________
   e. The weight of a piece of cheese. _________

2. Change the following units:

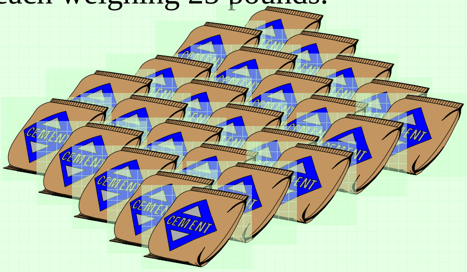
   a. 16 ounces equals ___________ pound.
   b. 20 hundredweight equals ___________ long ton.
   c. 2,205 pounds equals ________ metric tonne.
   d. 14 pounds equals ___________ stone.

3. Convert the following:

   a. $\frac{1}{4}$ pound to ounces.
   b. 32 ounces to pounds
   c. 3 metric tonnes to pounds.
   d. 11,025 pounds to metric tonnes.

Try some yourself … Exercise 1.51 continued

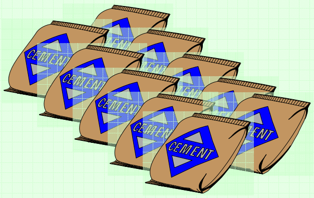
4. A pallet contains 30 sacks, each weighing 25 pounds.



What is the total weight:

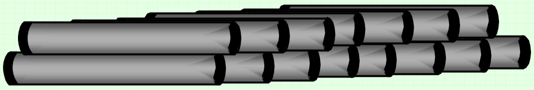
a. in pounds?
b. in metric tonnes? (2 decimal places)

5. If 10 sacks are used, what is the new weight:



a. in pounds?
b. in metric tonnes? (2 decimal places)

6. On deck are 120 joints of casing, each weighing 1,880 pounds.



What is the total weight on deck:

a. in pounds?
b. in metric tonnes? (2 decimal places)

Remember
1 metric tonne = 2205 pounds

Example

5 inch heavy weight drill pipe weighs approximately 1,500 pounds per joint.
How many joints could be bundled to be lifted with 2 x 5 tonne slings?

Remember

Angle between slings less than 90^o and each sling must have a safe working load (SWL) of the full weight of the load.

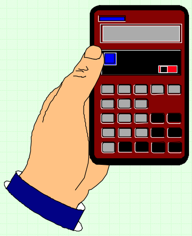
Sling SWL in pounds
$5 \times 2{,}204 = 11{,}020 \text{ lbs}$

Number of joints that can be lifted
$11{,}020 \div 1{,}500 \text{ lbs} = 7.34 \text{ joints}$

This must of course be rounded to a whole number.

Answer is 7 joints

Try some yourself - Exercise 1.52



Given the following pipe weights;

1.	$4^1/_2$ inch HWDP	1,250 lbs
2.	8 inch drill collars	4,600 lbs
3.	5 inch (S grade) drill pipe	950 lbs
4.	$6^5/_8$ inch drill pipe	850 lbs

How many of each should be bundled for lifting with;

a. A pair of 3 tonne slings?
b. A pair of 5 tonne slings?

Example

You are required to mix 40 sacks (25 kilograms each) of lime at 15 minutes per sack.

What is the total weight added?

$$40 \times 25 \text{ kilograms} = 100 \text{ kg}$$

How long will this take?

$$40 \times 15 \text{ minutes} = 600 \text{ hours}$$

$$600 \text{ minutes} \div 60 = 10 \text{ hours}$$

Try some yourself - Exercise 1.53

You are required to mix 10 sacks (25 kilograms each) of lime at 30 minutes per sack.

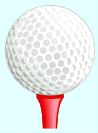
1. What is the total weight added?

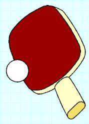
2. How long will this take?

Density

Density is the measurement of the weight of a unit volume of a substance.

For example

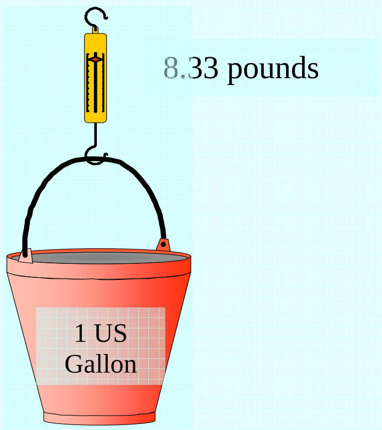




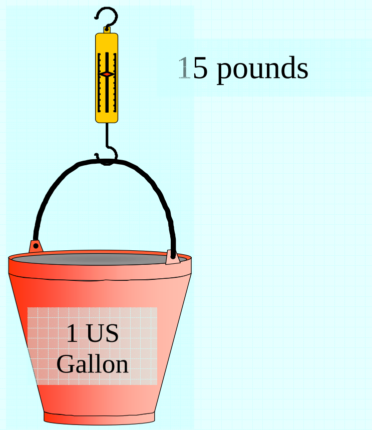
A golf ball and a ping pong ball are the same size.
The golf ball is much heavier.
The golf ball has a greater density than the ping pong ball.

In the oilfield we need to measure the density of fluids such as water and mud.

Water



Mud

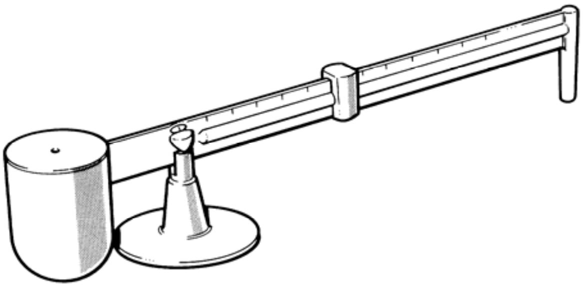


One gallon of mud weighs more than one gallon of water.
Mud is more dense than water.

Measurement of density

Density is measured by weighing a specific volume of a substance.

In the oilfield we measure drilling fluid (mud) density with a mud balance which weighs a known volume of mud.



Try some yourself . . . Exercise 1.54

1. Pick the correct definition of density.

   a. The weight of a unit volume of a substance.
   b. The weight of ten objects together.
   c. The number of people in a shopping centre.

2. Which of the following are used to measure density?

   a. Scales and a container.
   b. Calipers and a gauge.
   c. Ruler and pencil.
   d. Guesswork.

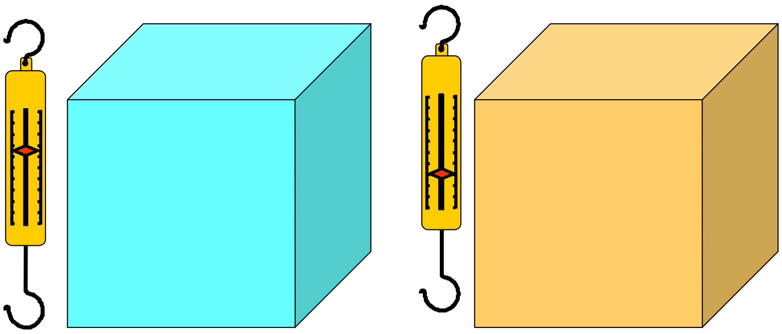
3. Which of the following can require the measurement of density?

   a. Drill pipe
   b. Mud
   c. Weight on bit
   d. Rate of penetration.

Units of density

The units of density in the Imperial system are;

Pounds per cubic foot (lb/cu.ft. or pcf)



1 cubic foot of water
weighs 62.4 lbs
Density = 62.4 pcf

1 cubic foot of mud
weighs 74.8 lbs
Density = 74.8 pcf

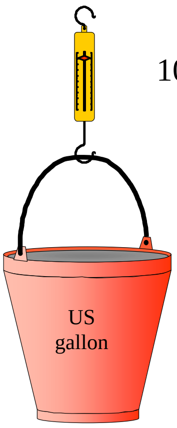
API Units

The unit also used in the API (field units) system is

pounds per gallon (ppg)

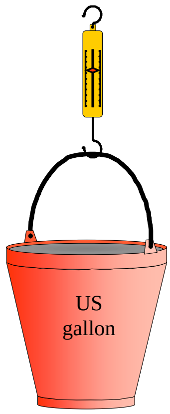
Note that some companies use a slightly different unit to monitor density e.g. psi per foot and psi per 1,000 feet. These will be discussed later.

Imagine an empty one gallon bucket which weighs 10 pounds. When filled with water the combined weight is 18.33 pounds. The weight of one gallon of water is 8.33 pounds or its density is 8.33 pounds per gallon.



10 lbs

1 empty gallon bucket



18.33 lbs

1 gallon bucket of water (Density of water = 8.33 pounds per gallon)

A UK gallon weighs 10 pounds whereas a US gallon is only 8.33 pounds. In the oilfield the US gallon is used.

Conversions

1 pound per gallon	=	7.4809 pounds per cubic foot
1 pound per cubic foot	=	0.1337 pounds per gallon

Remember

In the API system used in the oilfield, a gallon is a US gallon

On the rig we measure mud density in either ppg or pcf. We commonly refer to a *mud weight* when we are actually talking about density.

Try some yourself . . Exercise 1.55

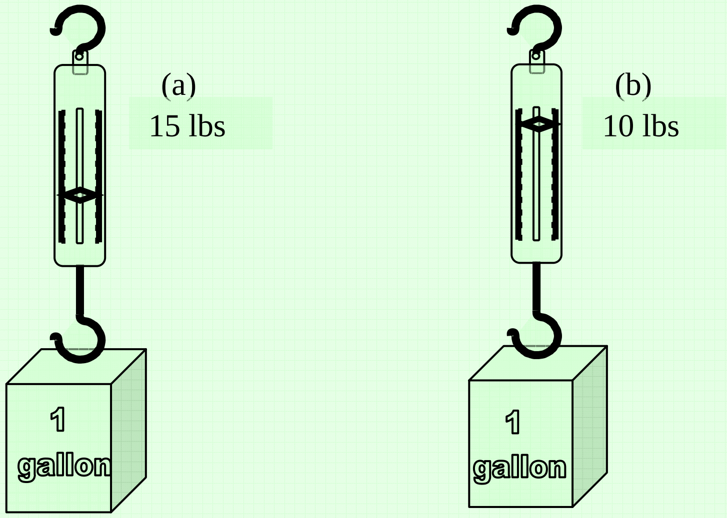
1. Put the following in order of increasing density.
   (That is; least dense first, most dense last).

   a. Drilling mud, oil, water, gas
   b. Ping-pong ball, golf ball, lead fishing weight.

2. Convert the following:

   a. 74.809 pounds per cubic foot equals _______ ppg.
   b. 13.37 ppg equals ___________ pcf

3. Which of the following is denser?



4. What are the above densities in ppg?

   a. _____________

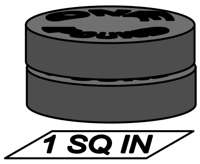
   b. _____________

5.3: Pressure

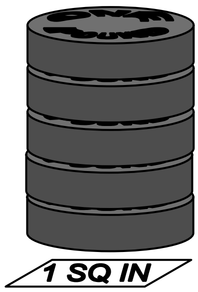
Pressure is the measurement of force applied to a unit of area.

The one pound weight exerts a force of one pound.
If the area on which it rests is one square inch, then the pressure would be one pound per square inch.

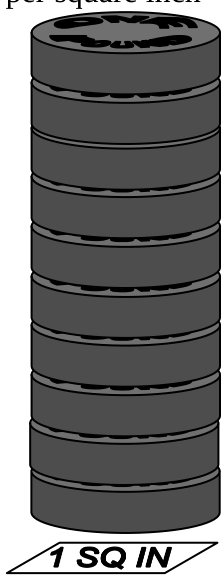
As more weights are added, the force increases. We now have two pounds acting on the same square inch. The pressure is now two pounds per square inch.



Five pounds per square inch

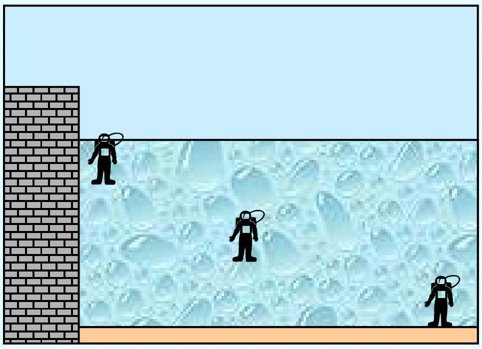


Ten pounds per square inch



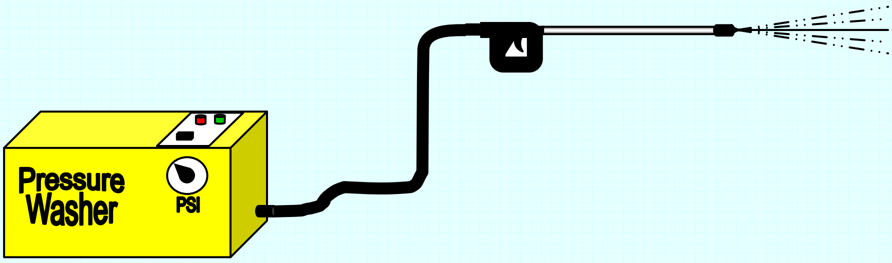
Pressure measurements are also used for liquids.

Example



The deeper the diver dives the greater the pressure.
This is due to the weight of water above.

Example

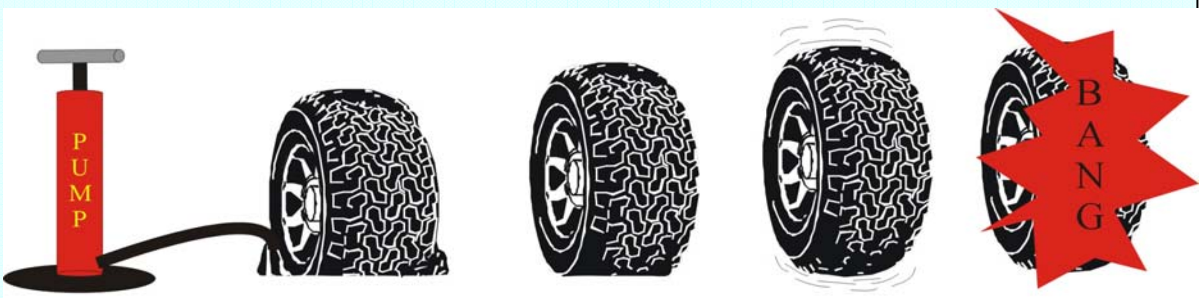


A pump is used to force water through a very small nozzle in a "pressure washer".

Pressure also describes the force exerted by gas in a container.

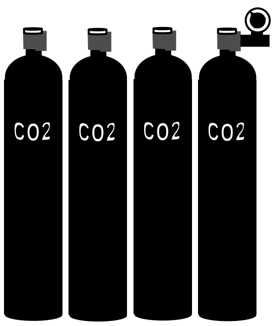
For example

As more air is forced into the tyre, the pressure increases until . . . .

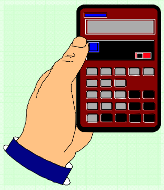


On the rig we use pressure measurements for;

- pressure due to the mud in the hole;
- pressure of gas stored in gas bottles;
- pump pressure required to move mud around a well.



Try some yourself . . . Exercise 1.56



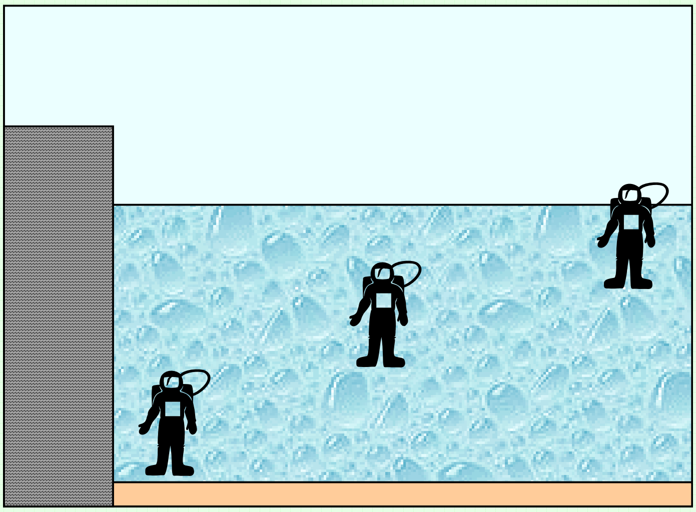
1. Pick the correct definition of pressure.

   a. The amount of matter in an object.
   b. The weight of a unit volume of substance.
   c. The force applied to a unit of area.

2. What is happening to the pressure in the tyre?

   a. Increasing
   b. Decreasing

3. What is happening to the pressure on the diver as he surfaces?

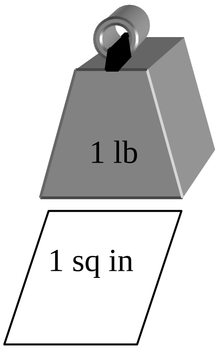


   a. Increasing
   b. Decreasing

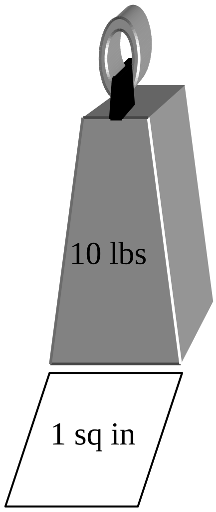
Units of pressure

The units used in the Imperial system are pounds per square inch (psi)

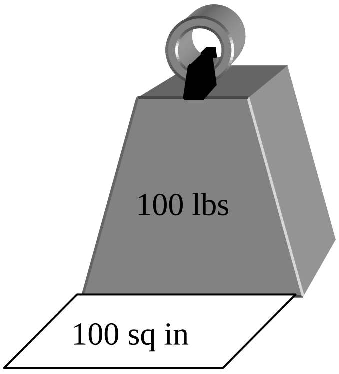
Pressure =



1pound per square inch (1 psi)



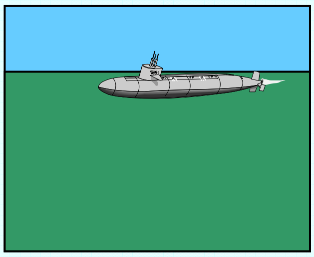
10 pounds per square inch (10 psi)

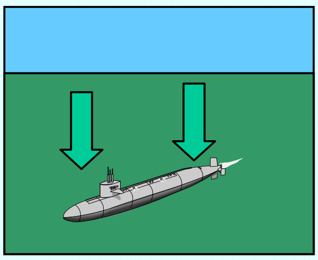


Pressure = 1 pound per square inch (1 psi)

Example

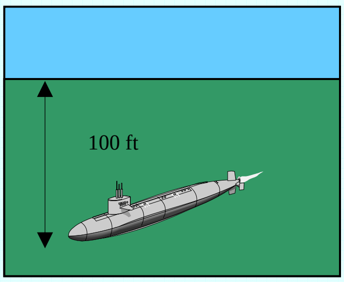
A submarine is on surface.
The only pressure on the hull is due to atmosphere





As the submarine dives, the pressure on the hull will increase.

If the pressure increases approximately 0.5 psi for each foot dived, the pressure on the hull will now be
0.5 x 100 = 50 psi.



Of interest . . . Pressure gradients

In fresh water the increase in pressure with depth would be 0.433 psi per foot. In sea water this would be more like 0.45 psi per foot. These are known as “pressure gradients” and are a reflection of the density of the fluid.

The density of drilling fluid is often referred to in terms of its gradient in psi per foot (psi/ft) or in psi per thousand feet (pptf).

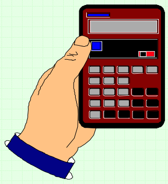
On the rig we use pressure measurements for;

- pressure due to the column of mud in the hole;
- pressure in gas bottles
- pump pressure required to move mud.

API Units

Pounds per square inch = psi

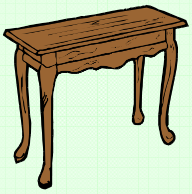
Try some yourself . . Exercise 1.57



1. Which of the following are units of pressure?

   Pint, ounce, pound, hectare,
   pounds per gallon, pounds per square inch

2. A table has an area of 1 square inch. Each book weighs 1 pound.



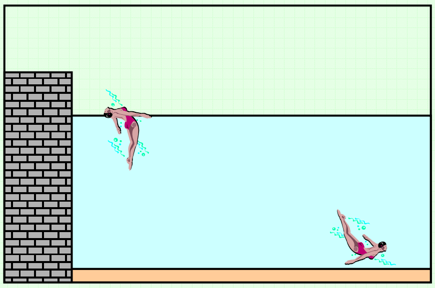
   a. What is the pressure if one book is placed on the table?

   ___________________ Psi

   What is the pressure for the following number of books?

   b. 10
   c. 100
   d. 237

3. A swimmer is on the surface in the harbour at Banff.



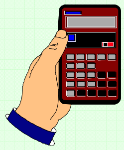
   What will happen to the pressure on the swimmer when she dives under the water, will it Increase or Decrease?

   ____

4. If the pressure increase is 0.5 psi for each foot of depth, what is the pressure on the swimmer when 10 feet under?

   ___________________ psi

Try some yourself… Exercise 1.58



50 joints of 20 inch casing are laid out on deck, three high.

The weight of the casing is 105 pounds per foot and the length of each joint is 40 feet.

What is: -

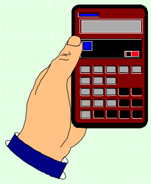
1. The total length of casing? _____________ feet

2. The total weight of the casing? _____________ pounds

When stacked 3 high the casing takes up a total deck area of 1,350 feet.

3. What is the loading on the deck in pounds per square foot?
(1 decimal place)

Try some yourself… Exercise 1.59



8 stands of drill collars are racked in the derrick.
Each stand is 93 feet long.

1. What is the total length?

_____________ Feet

2. If the weight of the collars is 150 pounds per foot, what is the weight of each stand?

_____________ pounds

3. If the stands take up an area of 10 square feet, what is the pressure (loading) on that part of the deck?

a. _____________ pounds per square foot

b. _____________ pounds per square inch
(whole number)

A review of units

The following is a list of units commonly used in the oil industry today, together with the standard abbreviations. Also listed are the metric equivalents.

Length

Imperial (API)		Metric	
inch	in	millimetre	mm
foot	ft	centimetre	cm
mile		metre	m

Area

Imperial (API)		Metric	
square inch	sq in or in^2	square centimetre	cm^2
square foot	sq ft or ft^2	square metre	m^2

Volume and capacity

Imperial (API)		Metric	
cubic inch	cu in or in^3	cubic centimetre	cm^3
cubic foot	cu ft or in^3	cubic metre	m^3
US gallon	gal	litre	l
US barrel	bbl		

Weight and mass

Imperial (API)		Metric	
pound	lb	gram	g
short ton	t	kilogram	kg
		metric tonne	mt

Density

Imperial (API)		Metric	
pounds per gallon	ppg	kilograms per cubic metre	kg/m^3
pounds per cubic foot	pcf	specific gravity	S.G.

Pressure

Imperial (API)		Metric	
pounds per square inch	psi	kilograms peer square centimetre	kg/cm^2
		bar	bar
		kilopascal	kPa

Temperature

Imperial (API)		Metric	
Degrees Fahrenheit	^oF	Degrees Celcius	^oC

Section 6: Mathematical Symbols, Equations and Arithmetical Operations

In section 3 we discussed the four basic arithmetical operations;

Addition
Subtraction
Multiplication
Division

In this section we will discuss further mathematical operations and their symbols.

We will also discuss equations how to solve expressions. This will enable you to correctly use formulae when performing rig calculations.

Objectives

- To review the basic arithmetical operations.
- To explain further mathematical operations.
- To detail the order of operations in arithmetic.
- To explain the use of brackets and multiple brackets.

Try these first . . . Exercise 1.60

1. What do the following signs mean?

   (a) $\sqrt{}$
   (b) %
   (c) x
   (d) x^2
   (e) =

2. Calculate the following

   (a) 8.5^2 (answer to 2 decimal places)
   (b) $\sqrt{169}$
   (c) $\dfrac{2600}{5000 \times 0.052}$
   (d) $\dfrac{6^2}{1029}$ (answer to 3 decimal places)
   (e) $\dfrac{(12.4^2 - 5^2)}{1029}$ (answer to 4 decimal places)
   (f) $4500 \times \left(\dfrac{80}{60}\right)^2$ (answer to whole number)
   (g) $[(10.9 - 2.1) \times 0.052 \times 350] + 400$ (answer to whole number)

Review of basic operations

Addition
Adding up or the sum of.

$3 + 2 = 5$

Subtraction
Taking away.

$4 – 1 = 3$

Multiplication
Adding quantities of the same number.

$5 \times 4 = 20$

Division
Dividing into equal groups or sharing.

$10 \div 2 = 5$

Operations involving division can be written in several ways;

e.g. $15 \div 3 = 5$

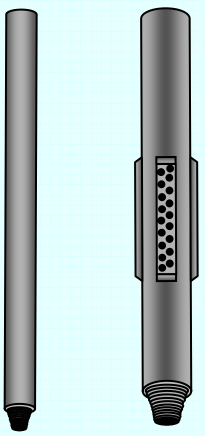
or $\frac{15}{3} = 5$ (sometimes $^{15}/_{3} = 5$)

Example

Addition

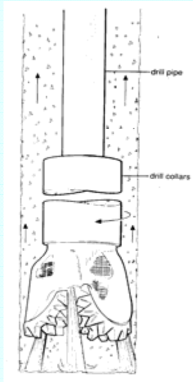
Calculate the length of the stand.

	Length
Drill collar	29.83 ft
Stabiliser	7.31 ft
Drill collar	30.19 ft
Stabiliser	8.28 ft
Drill collar	31.35 ft
Total length	106.96 ft



Example

Subtraction

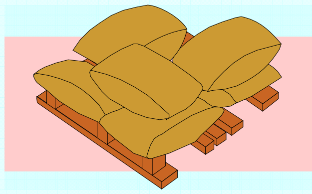


After drilling to 10,000 feet, the Driller picks up 30 feet off bottom.
What is the bit depth now?

= 10,000 – 30
= 9,970 feet

Example

Multiplication

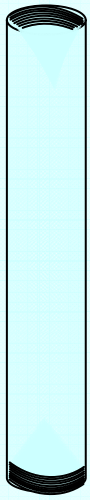


There are 8 pallets in the sack room, each with 50 sacks.
How many sacks are there in total?

= 8 x 50
= 400 sacks

Example

Division



A casing string 4,500 feet long consists of 112 joints of casing.
What is the average length of each joint? (answer to 2 decimal places)

= 4500 ÷ 112
= 40.178571 feet
= 40.18 feet

Equations

Equations are really mathematical "sentences" or "statements".

Example

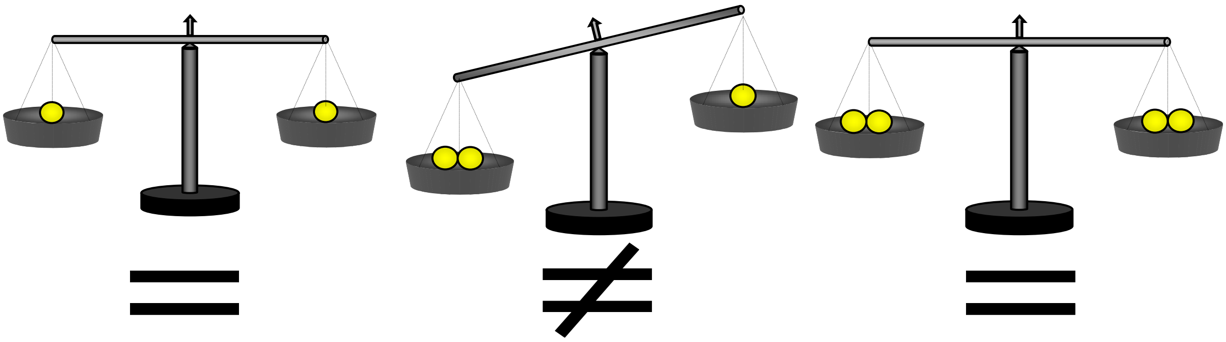
A cup of tea costs £1.00, then six cups cost £6.00.

Written mathematically;

6 x £1.00 = £6.00

= is the equals sign, indicating equivalence
or
whatever is on one side of the equation is worth the same as the other side.

Equations are like balancing scales – the amount on one side must always equal the amount on the other side. If you add something to one side you must add the same to the other. If you subtract from one side you must subtract from the other. It is the same with multiplication and division.



Whatever is done to one side must be done to the other.

Equations can be changed and manipulated as long as;
- the same is done to both sides.

Example - Manipulating equations

$2 + 4 = 6$

1. Add 1 to both sides
   $2 + 4 + 1 = 6 + 1$
   $2 + 4 + 1 = 7$

2. Subtract 1 from both sides
   $2 + 4 – 1 = 6 – 1$
   $2 + 4 – 1 = 5$

3. Multiply both sides by 2
   $(2 + 4) \times 2 = 6 \times 2$
   $(2 + 4) \times 2 = 12$

4. Divide each side by 3
   $(2 + 4) \div 3 = 6 \div 3$
   $(2 + 4) \div 3 = 2$

Sometimes one of the numbers in an equation may be missing, so you have to find the missing number.

e.g. $8 + ? = 10$

How do we find the missing number?

This involves manipulating the equation.

$8 + ? = 10$

Take 8 from both sides of the equation:

$8 + ? – 8 = 10 – 8$

becomes

$8 – 8 + ? = 10 – 8$

or

$? = 2.$

By doing the same thing to both sides of an equation it is possible to “solve” that equation and find the missing number. This will be dealt with in more detail in section 7.

6.1 Further Operations

Squares and other powers

To square a number is to multiply that number by itself.

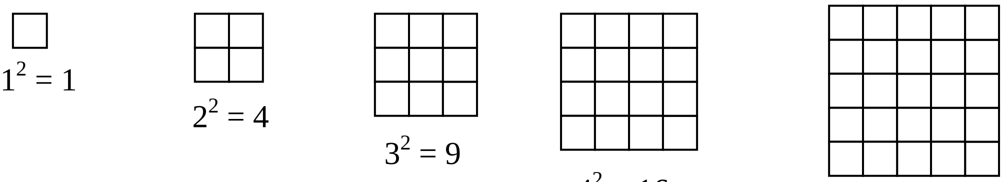
e.g. $10 \times 10 = 100$

ten squared equals one hundred

This is written as 10^2

therefore $10^2 = 100$

Square Numbers



$1^2 = 1$ $2^2 = 4$ $3^2 = 9$ $4^2 = 16$ $5^2 = 25$

The next square numbers:
$36 = 6^2$ $49 = 7^2$ $64 = 8^2$ $81 = 9^2$ $100 = 10^2$ etc.

Ten squared can also be referred to as “ten to the power two”.

Of interest

Other powers

A power is the product of a number multiplied by itself a given number of times.

e.g. 10 to the power 2 is 10×10 or 10^2
10 to the power 3 is $10 \times 10 \times 10$ or 10^3
10 to the power 5 is $10 \times 10 \times 10 \times 10 \times 10$ or 10^5

The power shows the times the number is to be multiplied.

Squaring on a calculator

Squares can be calculated in several ways.

Using 5 as an example.
If the calculator has a square function (usually x^2):

5	x^2	=	25

Without a square function

5	x	5	=	25

or

5	x	=	25

Try some yourself . . . Exercise 1.61

Calculate (remember to check by estimating):
(answers to 2 decimal places)

1. 2^2
2. 8^2
3. 75^2
4. 7.5^2
5. 9.625^2

Square and other roots

The square root of a number is the number which when multiplied by itself will give that number.

e.g. What is the square root of 100?
or
what number when multiplied by itself gives 100?
or
what number squared equals 100?

The answer in each case is 10 because;

$10 \times 10 = 100$ or $10^2 = 100$

Square roots are written using the symbol $\sqrt{\ }$

e.g. $\sqrt{100} = 10$ $(10 \times 10 = 100)$

$\sqrt{16} = 4$ $(4 \times 4 = 16)$

Square roots on a calculator

All calculators should have a square root function, although they work slightly differently on different calculators.

$\boxed{\sqrt{\ }}$

Example 1

Find the square root of 64

$\boxed{64}$ $\boxed{x}$ $\boxed{\sqrt{\ }\ =}$ $\boxed{8}$

or simply $\boxed{64}$ $\boxed{\sqrt{\ }}$ $\boxed{8}$

Example 2

Find the square root of 64

$\boxed{\sqrt{\ }}$ $\boxed{64}$ = $\boxed{8}$

Check how your calculator works before using in calculations.

Of interest

Other roots

$\sqrt[3]{64}$ Indicates the number which when multiplied to the power 3 will give 64.

The answer is 4 because 4 x 4 x 4 = 64

Or $\sqrt[3]{64} = 4$

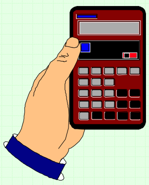
$\sqrt[5]{32}$ Indicates the number that when multiplied to the power 5 will give 32.

The answer is 2 because 2 x 2 x 2 x 2 x 2 = 32

Or $\sqrt[5]{32} = 2$

When carrying out calculations on the rig, it is not normally necessary to do more than square numbers and occasionally find a square root.

Try some yourself . . . Exercise 1.62



Calculate the square roots of the following:

1. 49
2. 81
3. 400
4. 178.89 (answer to 3 decimal places)
5. 72.25

6.2 Review of symbols

Symbol	Meaning	Example
=	equals	2 + 3 = 5
+	add plus positive	2 + 3 = 5 $+3^{o}$ C (a temperature of plus 3 degrees)
-	subtract minus negative	5 – 3 = 2 -3^{o} C (a temperature of minus 3 degrees)
x	multiply	4 x 2 = 8
÷	divide	8 ÷ 2 = 4
n^2	squared	$4^2 = 16$
$\sqrt{\ }$	square root	$\sqrt{16} = 4$
%	percent	200 x 10% = 20
>	greater than	10 > 3 10 is greater than 3
<	less than	3 < 10 3 is less than 10

Order of operations

Just as it is necessary to understand the symbols used in mathematics, we must also understand the rules regarding the order in which they are applied.

For example

2 x 3 + 5 = ?
6 + 12 ÷ 3 = ?

In the first case the answer on most calculators is 11.

In the second case, two answers are possible;

1. 6 + 12 = 18
   18 ÷ 3 = 6

   Or;

2. 12 ÷ 3 = 4
   6 + 4 = 10

Which is the correct answer?

The second method gives the correct answer.

Below are two examples of formulae used in well control calculations.

$$\text{Kill mud weight} = \left(\frac{\text{SIDPP}}{\text{TVD} \times 0.052}\right) + \text{Mud weight}$$

$$\text{Annular capacity} = \left(\frac{\text{ID}^2 - \text{OD}^2}{1029}\right)$$

These are shown without units or explanation, purely to show how important it is to carry out mathematical operations in the correct order. (The use of these formulae will be fully discussed at a later stage).

To make the order clear we use brackets in addition to the other mathematical symbols.

We also have a set of rules covering the order in which things should be done.

Brackets

In formulae brackets are used to indicate which operation to carry out first.

Example

1. $(6 + 12) \div 3 = ?$

   Perform the operation in the brackets first;
   $18 \div 3 = 6$

2. $6 + (12 \div 3) = ?$

   Perform the operation in the brackets first;
   $6 + 4 = 10$

In this way we can make it clear in exactly what order the steps of an expression should be carried out.

Lets look at another example

$$6 + 3 \text{ x } (4 - 2) + 8 \text{ x } 3 - 14 \div 2 = ?$$

Without rules, depending on the type of calculator a number of answers (or solutions) are possible. However, if we follow the rules, step by step we can find the solution.

Of interest

The correct name for the above is an EXPRESSION.

The result or answer is known as the SOLUTION.

In mathematics there is a standard way to work out the above expression.

Order of operations	**Operation**	**Expression**
		3 x (4 – 2) + 8 ÷ 2 - 1
The operations inside the brackets are carried out first	(4 - 2) = 2	3 x 2 + 8 ÷ 2 - 1
Next the multiplication and division operations are worked out	3 x 2 = 6 8 ÷ 2 = 4	6 + 4 - 1
Finally the addition and subtraction calculations are completed		9

The rules state that:

FIRST, operations inside brackets or root signs should be completed. **B**
SECOND, all indices (powers), division and multiplication operations should be calculated. **IDM**
FINALLY, addition and subtraction should be carried out. **AS**

This can be summarised as BIDMAS. It does not matter how it is remembered, but it is essential that the operations be carried out in the correct order.

B - brackets
I – indices
D – division
M – multiplication
A – addition
S - subtraction

Examples

Calculate 2 + (10 – 1) ÷ 3

1. Calculate inside the brackets
   = 2 + 9 ÷ 3
2. Calculate indices, multiplication, division
   = 2 + 3
3. Calculate addition and subtraction
   = 5

Calculate 32 – 2 x (4 + 3)

4. Brackets
   = 32 – 2 x 7
5. Indices, multiplication, division
   = 32 - 14
6. Addition and subtraction
   = 18

Different ways of showing division

So far we have used the ÷ sign to represent division.

As we have previously discussed 1 ÷ 3 can also be written $\frac{1}{3}$

This method of representation can also be used when writing equations.

Take the following;

$$(8 + 2) \div (10 - 5) \qquad = \qquad 2$$

could also be written as

$$\frac{(8+2)}{(10-5)} \qquad = \qquad 2$$

or without the brackets

$$\frac{8+2}{10-5} \qquad = \qquad 2$$

It is important to carry out all the operations <u>above</u> the line and <u>below</u> the line <u>before</u> the final division.

Example

Calculate $\dfrac{1{,}300}{10{,}000 \times 0.052} + 10$

Carry out the operations on the bottom of the line first

$$= \frac{1{,}300}{520} + 10$$

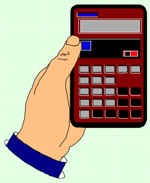
Carry out the division

$$= 2.5 + 10$$

Carry out the addition

$$= 12.5$$

Try some yourself . . . Exercise 1.63



1. $\dfrac{6{,}240}{(10{,}000 \times 0.052)}$

2. $\dfrac{8{,}866}{(11{,}000 \times 0.052)}$

3. $\dfrac{5^2}{1{,}029}$ (answer to 3 decimal places)

Example

The calculation

Applying the previous rules, brackets are done first, then multiplication and division, then addition and subtraction. (**BIDMAS**)

1. $(12.25^2 - 5^2)$ Brackets worked out first
2. 12.25^2
   5^2 These are indices so have to be done first
3. Subtraction within the brackets then done
4. The result of the brackets calculations is then divided
5. The result of this is then multiplied.

Example

The above calculation can be done on a calculator as follows;

Step 1

1	2	.	2	5	X^2	-	5	X^2	=

Display shows

125.0625

If you don't have a square key on your calculator then the sum can be done using the memory (or you can write the answer to each part down, this will enable you or anyone else to check your workings more easily).

Step 2
First find 5^2

5	X^2	=	25.	M+

Memory plus or the equivalent button on your calculator.

Step 3
Next find 12.25^2

CE

1	2	.	2	5	X^2	=	150.0625	-	$M^R{}_C$	=

125.0625

Example continued

Step 4
Next do the subtraction inside the brackets

1	5	0	.	0	6	2	5	-	2	5	=

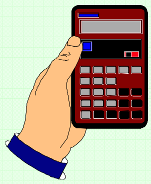
125.0625

Step 5

Either way you then complete the calculation

÷	1	0	2	9		0.1215379
x	9	8	5	0	=	1197.1433

Try some yourself . . . Exercise 1.64



Give answers to 1 decimal place

1. $$\frac{\left(36^2 - 30^2\right)}{1{,}029} \times 1{,}000$$

2. $$\frac{\left(9.625^2 - 5^2\right)}{1{,}029} \times 5{,}000$$

Multiplication sign

Sometimes multiplication signs are missed out in formulae, e.g

$2(4 + 2)$

Where formulae are written like this, the calculation must be treated as the though the sign is there;

$2(4 + 2) =$

Step 1

$4 + 2 \quad = \qquad 6$

Step 2

$2 \times 6 \quad = \qquad 12$

Example

$2{,}000 \text{ x } \left(\frac{100}{80}\right)^2$ can also be written as $2{,}000\left(\frac{100}{80}\right)^2$

Again following the rules we work out what is in the brackets first;

Step 1

$\frac{100}{80} \qquad = \qquad 1.25$

You then square the result of the brackets

Step 2

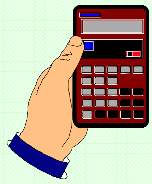
$1.25^2 \qquad = \qquad 1.5625$

Step 3

$1.5625 \text{ x } 2{,}000 \qquad = \qquad 3125$

Therefore $2{,}000\left(\frac{100}{80}\right)^2 = 3{,}125$

Try these yourself . . . Exercise 1.65



1. $1500 \times \left(\frac{120}{100}\right)^2 =$

2. $2800\left(\frac{40}{100}\right)^2 =$

3. $300\left(\frac{160}{40}\right)^2 =$

4. 10 x (5200 + 15) =

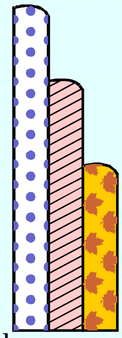
5. $\frac{10(5200 + 15)}{50} =$

Multiple brackets

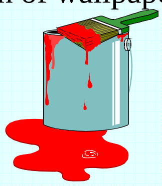
In some expressions there may be several sets of brackets. They may be separate or sometimes inside one another.

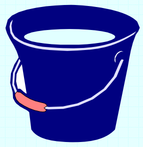
Example

Your local DIY store offers white matt emulsion at £8.00 per 5 litre can, wallpaper at £5.10 per roll and ½ gallon of wallpaper paste at 58pence.



You buy; 4 cans emulsion
8 rolls wallpaper
2 packets paste





If you spend over £50 the store will give you a 5% reduction. How much have you spent?

Emulsion	4 cans	x	£8
Wallpaper	8 rolls	x	£5.10
Paste	2 packets	x	£0.58

This can be written as;

(4 x 8) + (8 x 5.10) + (2 x 0.58)

= £32 + £40.80 + £1.16
= £73.96

This is more than £50 so you get a 5% discount, so the amount you pay is 95%

73.96 x 95% or 73.96 x 0.95
= £70.26

This can be written as;
Cost = [(4 x 8) + (8 x 5.10) + (2 x 0.58)] x 0.95

The square brackets [ ] in this case mean that the totals of the calculations within the round brackets ( ) have to be added together before the percentage calculation is done.

Whenever the brackets appear inside each other, we must always calculate the inner brackets first.

Example

Calculate [(11.3 – 1.3) x 0.052 x 500] + 600

Firstly calculate the inside brackets

= [(11.3 – 1.3) x 0.052 x 500] + 600

becomes

= [10 x 0.052 x 500] + 600

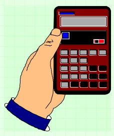
Secondly calculate the next brackets

= 260 + 600

Finally complete the calculation

= 860

Try some yourself . . . Exercise 1.66



Calculate the following

1. [(9.8 – 2.3) x 0.052 x 1000] + 500
2. [(8.0 – 2.5) x (10.2 – 1.2)] – 9.5
3. 100 – [10 x (10 – 2)]

Review of the order of operations

<table>
<tr><td>B</td><td>Brackets</td><td>Carry out all operations inside brackets

Remember to calculate the <u>inside</u> brackets first</td></tr>
<tr><td>I</td><td>Indices</td><td>Calculate the indices
i.e. squares
square roots
cubes
etc.</td></tr>
<tr><td>D
M</td><td>Division
Multiplication</td><td>Carry out all operations of division and multiplication</td></tr>
<tr><td>A
S</td><td>Addition
Subtraction</td><td>Carry out all addition and subtraction operations</td></tr>
<tr><td colspan="3">When a formula is written;
$\frac{x + y + z}{p + q}$

Carry out all the calculations <u>above</u> and <u>below</u> the line prior to the final division</td></tr>
</table>

Try some yourself . . . Exercise 1.67

1. Match the following symbols to the functions.

   a. Percent
   b. Divide
   c. Square root
   d. Squared
   e. Equals

   (i) $=$
   (ii) $\%$
   (iii) $\div$
   (iii) x^2
   (iv) $\sqrt{}$

2. Calculate the following

a.	8^2	
b.	7^2	
c.	12.25^2	(answer to 2 decimal places)
d.	8.5^2	(answer to 2 decimal places)
e.	9.625^2	(answer to 2 decimal places)
f.	$\sqrt{81}$	
g.	$\sqrt{144}$	
h.	$\sqrt{400}$	
i.	$\sqrt{121}$	
j.	$\sqrt{4}$	

3. Calculate the following

a.	$\dfrac{5200}{10000 \times 0.052}$	
b.	$\dfrac{5^2}{1029}$	(answer to 3 decimal places)
c.	$\dfrac{\left(12.25^2 - 5^2\right)}{1029}$	(answer to 3 decimal places)
d.	$3750 \times \left(\dfrac{110}{100}\right)^2$	
e.	$\left[(15.2 - 3.2) \times 0.052 \times 400\right] + 500$	

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Section 7: Introduction to Solving Equations and the use of Formulae

In order to perform calculations at work we often need to find and use a formula. This section deals with rearranging equations to find the missing number and how to correctly use and rearrange formulae.

Objectives

- To explain how an equation works.
- To discuss the conventions used when writing algebraic equations.
- To explain how to manipulate to solve for missing numbers.
- To discuss the use of formulae.
- To explain how to change the subject of a formula.
- To discuss the importance of units.

Try these first . . . Exercise 1.68

1. Find x when;

   a. $x + 5 = 9$
   b. $x - 8 = 4$
   c. $100 - x = 33$

2. Find x when;

   a. $\frac{x}{5} = 3$

   b. $\frac{x}{4} = 3$

   c. $\frac{x}{11} = 3$

3. Find x when;

   a. $\frac{3x + 10}{2} = 11$

   b. $\frac{6x + 3}{3} = 11$

   c. $7(x + 5) = 49$

   d. $2(3x + 1) = 20$

Try these first . . . Exercise 1.68 continued

4. Given the following formula;

$$\text{Speed (mph)} = \frac{\text{Distance travelled (miles)}}{\text{Time taken (hours)}}$$

Calculate the speed (mph) for the following;

a. A car travels 78 miles in 2 hours
b. A plane travels 1,521 miles in 3 hours

5. Rearrange the formula to calculate;

a. The distance a car travels in 3 hours at 68 miles per hour.
b. How long will it take a plane to travel 5,040 miles at 560 miles per hour?

7.1 Solving equations

The process of solving problems (equations) using mathematical knowledge is known as algebra.

Of interest

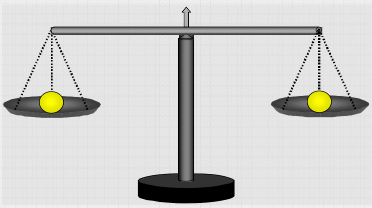
The word algebra comes from a ninth century book by an Arab mathematician called Hisab al-jabr w'al-muqabala (Calculations by Restoration and Reduction).

Review of equations

Equations are mathematical statements where one side is equal to the other side.

e.g. $2 + 4 = 6$

Equations must always balance



Manipulating Equations

Equations can be manipulated and changed so long as the same is done to both sides.

e.g. $2 + 4 = 6$

We can;

add 1 to both sides

$2 + 4 + 1 = 6 + 1$
$2 + 4 + 1 = 7$

or subtract 1 from both sides

$2 + 4 - 1 = 6 - 1$
$2 + 4 - 1 = 5$

or multiply both sides by 2

$(2 + 4) \times 2 = 6 \times 2$
$(2 + 4) \times 2 = 12$

or divide each side by 3

$(2 + 4) \div 3 = 6 \div 3$
$(2 + 4) \div 3 = 2$

Equations can be changed and manipulated as long as;
the same is done to both sides.

Solving equations

Sometimes one of the numbers in an equation may be missing, so you have to find the missing number.

e.g. $8 + \boxed{?} = 10$

How do we find the missing number?

This involves manipulating the equation.

$8 + \boxed{?} = 10$

Take 8 from both sides of the equation:

$8 + \boxed{?} - 8 = 10 - 8$

In this case it does not matter which order the numbers are written, so the equation becomes:

$8 - 8 + \boxed{?} = 10 - 8$

or $\boxed{?} = 2$

By doing the same thing to both sides of an equation it is possible to "solve" that equation and find the missing number.

Example

Find the missing number

$$11 + \boxed{?} = 14$$

Take 11 from each side

$$11 + \boxed{?} - 11 = 14 - 11$$

$$11 - 11 - \boxed{?} = 3$$

Therefore $\boxed{?} = 3$

The missing number is 3

Example

A well is 10,000 feet deep. If the Bottom Hole Assembly (BHA) is 1,000 feet long, how long is the drill pipe?

Length of drill pipe + length of BHA = Well depth

or

Length of drill pipe + 1,000 ft = 10,000 ft

Manipulating the equation to find the length of the drill pipe.

Length of drill pipe = 10,000 – 1,000
= 9,000 ft

Try some yourself – Exercise 1.69

Find the missing number

1.	8 +	?	=	20
2.	17.5 +	?	=	27.5
3.	3.8 +	?	=	5.0
4.	1143 +	?	=	1567
5.	10.85 +	?	=	11.0
6.	Well depth		=	15,330 feet
	Drill pipe length		=	14,210 feet
	BHA length		=	?

Using letters

In algebra the missing numbers are usually represented by a letter such as *x*. (All the letters of the alphabet are also used at times.)

So our previous example

$$11 + \boxed{?} = 14$$

would be written

$$11 + x = 14$$

Remember the *x* simply represents a missing number.

Example

Find x when $11 + x = 14$

$$11 + x = 14$$

Take 11 from each side

$$11 + x - 11 = 14 - 11$$

therefore $x = 3$

Example

Find x when $x + 4 = 6$

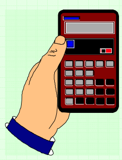
$$x + 4 = 6$$

Take 4 from each side

$$x + 4 - 4 = 6 - 4$$

therefore $x = 2$

Try some yourself – Exercise 1.70



1. $x + 6 = 8$
2. $x - 5 = 15$
3. $x + 3 = 5$
4. $x + 127 = 200$
5. $1029 + x = 1500$
6. $x - 22 = 47$
7. $x + 7 = 14$
8. $x - 5 = 9$
9. $10 + x = 72$
10. $x - 3 = 10$

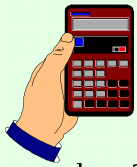
Example

The number of sheaves on the Crown block must always be one more than the lines reeved on the travelling block.

Write a formula for calculating the number of sheaves reeved on the crown.

Sheaves reeved on crown = sheaves reeved on travelling block + 1

Try some yourself – Exercise 1.71



1. When using 8 lines, how many sheaves are reeved on the crown?
2. If you are at the crown and 15 sheaves are reeved, how many lines are there?

Multiplication in algebra

Let's say we know that 3 times a number equals 27. What is the number?

$$3 \text{ x } \boxed{?} = 27$$

So long as we do the same to both sides, the equation will be valid.

Divide each side by 3

$$3 \text{ x } \boxed{?} \div 3 = 27$$

The 3's on the left (multiply by 3 then divide by 3) will cancel out to leave;

$$\boxed{?} = 27$$

When using *x* to represent the missing number, things can look confusing;

$$x \text{ x } 3 = 27$$

It is normal in algebra to miss out the multiplication sign and write

3*x* (means 3 times *x*)

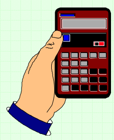
Example

x + *x* + *x* is 3 times *x* and is written 3*x*

y + y is 2 times *y* written 2y

t + t + t + t is 4 times *t* written as 4t

Try some yourself - Exercise 1.72



Write these numbers algebraically

1. z + z + z
2. 5 times y
3. p + p + p + p + p
4. w + w + w
5. 10 times *x*

Division in Algebra

In algebra (and therefore when using any formula) the correct way to write division is to use a horizontal line.

So $10 \div 2 = 5$

would always be written $\frac{10}{2} = 5$

When we have a missing number we would write

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

That is, what number when divided by 10 will equal 5.

Example

Find x when x divided by 10 equals 5

$$\frac{x}{10} = 5$$

Multiply each side by 10

$$\frac{x}{10} \text{ x } 10 = 5 \text{ x } 10$$

The 10's on the left cancel out

Therefore $x = 50$

Try some yourself – Exercise 1.73

1. $\frac{x}{10} = 15$
2. $\frac{x}{10} = 80$
3. $\frac{x}{2} = 8$
4. $\frac{x}{11} = 6$
5. $\frac{x}{2} = 0.5$

Multiple steps

It is not always possible to solve an equation in one step.

Take this equation;

$$5x + 10 = 25$$

First we must take 10 from each side.

$$5x = 25 - 10$$

Then we must divide each side by 5

$$x = \frac{25-10}{5}$$

Therefore $x = 3$

Even very complex equations can be solved in this manner.

> Remember, so long as we do the same to both sides of the equation, it will remain valid.

Example – Multiple steps 1

Find x when $\frac{2x+4}{10} = 2$

Multiply each side by 10

$$2x - 4 = 2 \text{ x } 10$$

$$2x - 4 = 20$$

Subtract 4 from each side

$$2x = 20 - 4$$

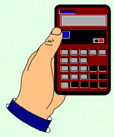
$$2x = 16$$

Divide each side by 2

$$x = \frac{16}{2}$$

$$x = 8$$

Try some yourself - Exercise 1.74



Find x when

1. $\dfrac{3x-3}{2}=9$

2. $5x + 4 = 29$

3. $\dfrac{4x-4}{11}=4$

4. $9x - 7 = 20$

5. $\dfrac{9x-7}{2}=10$

Example - Multiple steps 2

Find x when $10(x+2)=40$

Divide each side by 10

$$10(x+2)=40$$

becomes

$$(x+2)=\frac{40}{10}$$

$$x+2=4$$

subtract 2 from each side

$$x=4-2$$

$$x=2$$

Alternative method

Multiply out the brackets

$$10x+20=40$$

Subtract 20 from each side

$$10x=40-20$$

$$10x=20$$

Divide both sides by 10

$$x=\frac{20}{10}$$

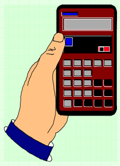
$$x=2$$

It does not matter which method is used so long as the rules are followed. The answer is still the same.

Try some yourself - Exercise 1.75

1. $8(x + 2) = 32$
2. $11(x - 3) = 44$
3. $3(x + 5) = 21$
4. $8(2x + 4) = 160$
5. $10(8x + 6) = 300$

Try some yourself - Exercise 1.76



Solve the following (that is, find the value of the letter x).

1. a. $7x + 5 = 26$
   b. $4x - 1 = 3$
   c. $6x - 1 = 35$
   d. $2x + 11 = 17$
   e. $9x + 2 = 20$

2. a. $\frac{x}{3} = 9$
   b. $\frac{x}{5} = 15$
   c. $\frac{x}{4} = 0.25$
   d. $\frac{x}{10} = 10$
   e. $\frac{x + 1}{4} = 0.5$

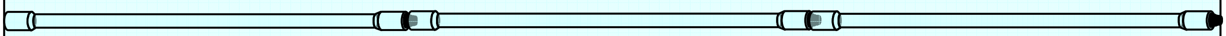
3. a. $\frac{2x - 4}{2} = 10$
   b. $\frac{7x + 5}{10} = 4$
   c. $8(x - 3) = 32$
   d. $2(x + 4) = 20$
   e. $\frac{5(2x + 6)}{10} = 5$

7.2 Using Formulae

A formula is a way of writing down a mathematical rule. They are used when two or more things are always related in the same way.

Formulae is the plural of formula

Example



In drilling, a stand of drill pipe is made of 3 singles. If we have 10 stands in the derrick, how many singles is that?

The answer must be
= 10 x 3
= 30 singles

The formula would be

Number of singles of pipe = Number of stands x 3

Example

If we had 50 stands of drill pipe in the derrick, how many singles of pipe are there?

Number of singles = 50 x 3
= 150 singles

The above example is a simple formula with no units involved and only one variable.

What is a variable?

Number of singles of pipe = Number of stands x 3

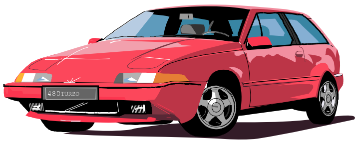
This is the variable – it will change for each calculation

3 is a constant. It does not change as there are always 3 joints in a stand.

Using a formula

A car travels a distance of 80 miles in 2 hours. What is its speed?

The answer is probably obvious to most of us . . . it is 40 miles per hour (mph), but how did we work it out? How would we write down how we worked it out?
We did this;



$$\begin{aligned}\text{Speed} &= 80 \div 2\\ &= 40 \text{ mph}\end{aligned}$$

We could do this same calculation for any distance and time, so we can write it down as a formula.

$$\text{Speed (mph)} = \frac{\text{Distance (miles)}}{\text{Time (hours)}}$$

Note that the units are included in the formula. This particular formula will work with other units e.g.

$$\text{Speed (km/hr)} = \frac{\text{Distance (kilometres)}}{\text{Time (hours)}}$$

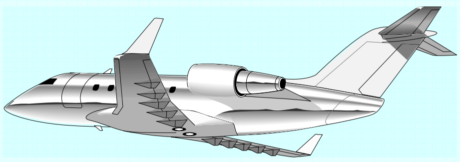
$$\text{Speed (cm/sec)} = \frac{\text{Distance (centimetres)}}{\text{Time (seconds)}}$$

In other cases a formula may not be useable with other units – it always best to clearly state the units being used.

Now we have a formula which will work with any distance and time in the correct units.

Examples

A plane flies 6000 miles in 10 hours. What is its speed?



Formula $\quad \text{Speed (mph)} = \frac{\text{Distance (miles)}}{\text{Time (hours)}}$

$$= \frac{6000}{10}$$

$$= 600 \text{ mph}$$

Try some yourself – Exercise 1.77

1. Calculate the speed (mph) if a car travels the following distances in 2 hours;

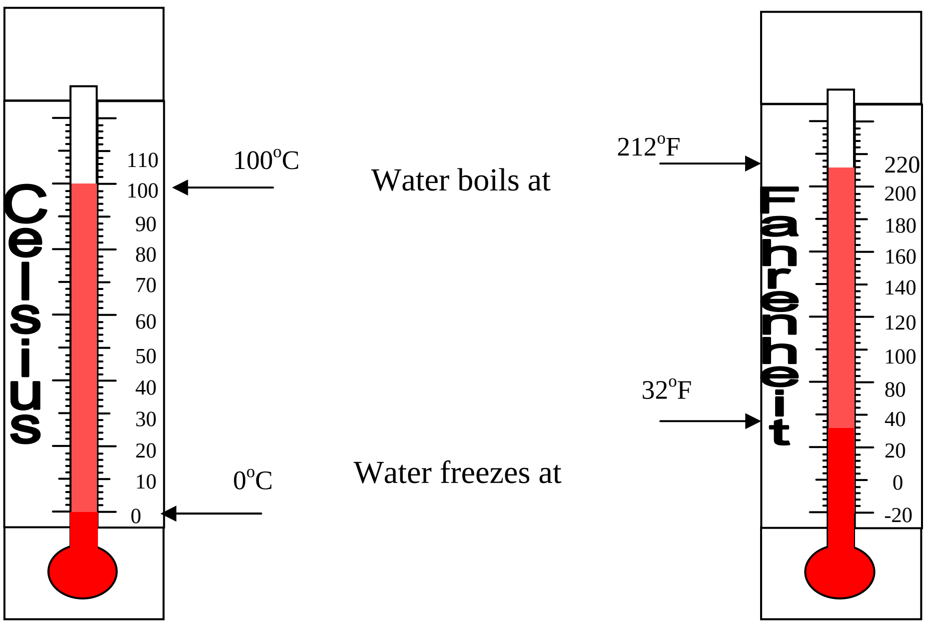
   a. 70 miles
   b. 140 miles
   c. 100 miles

2. Calculate the speed (mph) if a car travels for 200 miles in the following times;

   a. 4 hours
   b. 5 hours
   c. 6 hours

There are many formulae used within our industry and for many everyday things.

Lets look at temperature, which can be measured in degrees Celsius (°C) or in degrees Fahrenheit (°F).



A formula can be used to convert one to the other;

$$C = \frac{5}{9}(F - 32)$$

Let's try it for 212 ^{o}F;

$$C = \frac{5}{9}(212 - 32)$$

Work out the brackets

$$C = \frac{5}{9} \times 180$$

$$C \quad = \quad 100\,^{o}F$$

Example

The temperature outside today is 72 ^{o}F (Fahrenheit)/

What is this in ^{o}C (Celsius)?

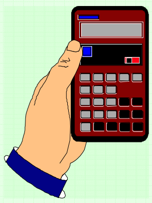
$$C = \frac{5}{9}(F - 32)$$

$$= \frac{5}{9}(72 - 32)$$

$$= \frac{5}{9} \times 40$$

$$= \quad 22.2\,^{o}C$$

Try some yourself – Exercise 1.78



What is the temperature in ^{o}Celsius when the temperature in ^{o}Fahrenheit is?
(Answer to 1 decimal place)

1. 212
2. 112
3. 85
4. 70
5. 32

So far we have used three formulae: -

Number of singles of pipe = Number of stands x 3

$$\text{Speed (mph)} = \frac{\text{Distance (miles)}}{\text{Time (hours)}}$$

$$C = \frac{5}{9}(F - 32)$$

Let's look more closely at the first formula: -

Written more simply Singles = stands x 3

This is perfectly adequate if we always know the number of stands and <u>need to know</u> the number of joints.

> The number we need to know is the <u>subject</u> of the formula

What happens if we <u>know</u> how many singles we have and <u>need to know</u> how many stands this will be?

Using common sense we could work it out, but what would the formula look like?

What we must do is rearrange the formula so that the number of stands is the subject.

The method we use is exactly the same as we used for solving equations in section 6.

> As long as we do the same thing to each side, the equation (or formula) will remain valid.

Rearranging the formula

We start with

$$\text{Singles} = \text{Stands} \times 3$$

Divide both sides by 3

$$\frac{\text{singles}}{3} = \frac{\text{stands} \times 3}{3}$$

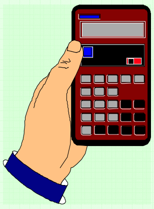
$$\frac{\text{singles}}{3} = \text{stands}$$

So written the correct way round

$$\text{Number of stands} = \frac{\text{singles}}{3}$$

Any formula, no matter how complex, can be rearranged in this fashion.

Try some yourself – Exercise 1.79



Rearrange the following

1. Pounds sterling = Euros x 0.63
   to make Euros the subject.

2. Pressure gradient = Mud density x 0.052
   to make mud density the subject.

3. $\text{Height of wall} = \dfrac{\text{rows of bricks}}{3}$
   to make rows of bricks the subject.

Example – Rearrange the speed formula 1

Original formula

$$\text{Speed (mph)} = \frac{\text{Distance (miles)}}{\text{Time (hours)}}$$

What we know is the speed (60 mph) and the time (2 hours) and need to know the distance travelled. We must rearrange the formula;

Start with $\text{Speed} = \dfrac{\text{Distance}}{\text{Time}}$ (units left out for clarity *)

Multiply each side by time

$$\text{Speed} \times \text{Time} = \frac{\text{Distance}}{\text{Time}} \times \text{Time}$$

Cancelling out

$$\text{Speed} \times \text{Time} = \text{Distance}$$

Written correctly

Distance (miles) = Speed (mph) x Time (hours)

* Rearranging a formula does not change the units.

Now try to make time the subject.

Example – Rearrange the speed formula 2

Original formula

$$\text{Speed (mph)} = \frac{\text{Distance (miles)}}{\text{Time (hours)}}$$

Multiply by time

$$\text{Speed} \times \text{Time} = \frac{\text{Distance}}{\text{Time}} \times \text{Time}$$

Cancel out

$$\text{Speed} \times \text{Time} = \text{Distance}$$

Divide by Speed

$$\frac{\text{Speed} \times \text{Time}}{\text{Speed}} = \frac{\text{Distance}}{\text{Speed}}$$

Cancel out

$$\text{Time (hours)} = \frac{\text{Distance (miles)}}{\text{Speed (mph)}}$$

Try some yourself – Exercise 1.80

‘Area = length x width’

Rearrange to make the following the subject.

1. Width.
2. Length.

Now let's rearrange the Celsius and Fahrenheit formula: -

Starting with

$$C = \frac{5}{9}(F - 32)$$

Multiply by 9

$$9C = \frac{5}{9}(F - 32) \times 9$$

Cancel out

$$9C = 5(F - 32)$$

Divide by 5

$$\frac{9C}{5} = \frac{5(F - 32)}{5}$$

Cancel out

$$\frac{9C}{5} = F - 32$$

Add 32

$$\frac{9C}{5} + 32 = F$$

Or written the right way round

$$F = \frac{9C}{5} + 32$$

And to see if it works lets try an example.

Example

Calculate ^{o}F equivalent to 100 ^{o}C.

$$F = \frac{9C}{5} + 32$$

$$F = \frac{9 \times 100}{5} + 32$$

$$F = \frac{900}{5} + 32$$

$$F = 180 + 32$$

$$F = 212^{o}C$$

Try some yourself – Exercise 1.81

1. Make M the subject if

   $P = M \times 0.052$

2. Make H the subject if

   $F = H + S$

3. Make L the subject if

   $V = L \times A$

Example - Hydrostatic pressure formula

The formula for calculating hydrostatic pressure from mud density and depth is;

$$\text{Hydrostatic pressure (psi)} = \text{Depth (feet)} \times \text{Mud density (ppg)} \times 0.052$$

(How and when this is used will be dealt with in later sections.)

Divide both sides by Depth x 0.052

$$\frac{\text{Hydrostatic Pressure}}{\text{Depth} \times 0.052} = \frac{\text{Mud Density} \times \text{Depth} \times 0.052}{\text{Depth} \times 0.052}$$

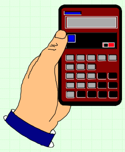
Cancelling

$$\frac{\text{Hydrostatic Pressure}}{\text{Depth} \times 0.052} = \text{Mud Density}$$

Written the right way round

$$\text{Mud density (ppg)} = \frac{\text{Hydrostatic pressure (psi)}}{\text{Depth (feet)} \times 0.052}$$

Try some yourself - Exercise 1.82



Using the previous example formulae:

1. Calculate the hydrostatic pressure (psi) if;

a.	Mud density	=	10 ppg
	Depth	=	10,000 ft
b.	Mud density	=	12 ppg
	Depth	=	10,000 ft
c.	Mud density	=	12 ppg
	Depth	=	11,000 ft

2. Calculate the mud density (ppg) if;

a.	Hydrostatic pressure	=	5,720 psi
	Depth	=	10,000 ft
b.	Hydrostatic pressure	=	6,760 psi
	Depth	=	10,000 ft
c.	Hydrostatic pressure	=	8,736 psi
	Depth	=	12,000 ft

3. Calculate the depth if;

a.	Hydrostatic pressure	=	7,852 psi
	Mud density	=	10 ppg
b.	Hydrostatic pressure	=	9,984 psi
	Mud density	=	12 ppg
c.	Hydrostatic pressure	=	7,072 psi
	Mud density	=	17 ppg

Example

The cost of changing a bit depends on several things:

1. The cost of the new bit.
2. The cost of the round trip – which depends on the rigs hourly rate and the trip time.

Write a formula for calculating this cost.

Cost of bit change ($) = bit cost ($) + trip cost ($)

Trip cost ($) = trip time (hours) + rig hourly rate($/hour)

So

Cost of bit change = bit cost + (trip time x hourly rate)

Example

New bit cost	=	$10,000
Trip time	=	8 hours
Rig cost per hour	=	$6,500

What is the average cost of the bit change?

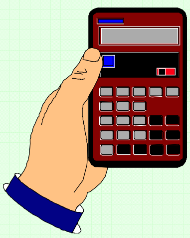
Cost of bit change = bit cost + (trip time x hourly rate)

= 10,000 + (8 x 6,500)

= 10,000 + 52,000

= $62,000

Try some yourself – Exercise 1.83



1. Bit cost $25,000
   Trip time 6 hours
   Rig cost per hour $9,800

   Calculate the cost of the bit change.

2. The total cost of a bit change was $103,000.
   The bit cost $13,000
   The rig cost per hour was $10,000

   How long must the trip have been?

Checking and using units

As we have mentioned previously, units we use are important, especially when using a formula.

In some cases;

Number of singles = Number of stands x 3

There are no units, the data put in and the answer are simply units.

In other cases;

$$\text{Speed (mph)} = \frac{\text{Distance (miles)}}{\text{Time (hours)}}$$

The units are given in the formula. If we are to calculate speed in miles per hour we <u>must</u> have the distance in <u>miles</u> and the time in <u>hours</u>. A distance in feet would not work.

In fact if we look a little closer, the formula tells the units of the answer.

$$\text{Speed (mph)} = \frac{\text{Distance (miles)}}{\text{Time (hours)}}$$

Examine the units only;

$$? = \frac{\text{miles}}{\text{hours}}$$

Miles divided by hours must give the answer as miles per hour (mph)

Example

If the distance were in feet and the time in seconds, what units would the speed be in?

$$\text{Speed} = \frac{\text{Distance (feet)}}{\text{Time (seconds)}}$$

The units for speed must be feet per second.

It is important to check the units in a formula as formulae for different units can look very similar.

Example

1. Hydrostatic pressure (psi) = Depth (ft) x Mud density (ppg) x 0.052
2. Hydrostatic pressure (psi) = Depth (ft) x Mud density (pcf) x 0.0069

The two formulae look very similar and both give an answer in pounds per square inch (psi).

What is important is that;

Formula 1 uses a mud density in pounds per gallon (ppg) and a constant 0.052
Formula 2 uses a mud density in pounds per cubic foot (pcf) and a constant 0.0069

Units are not interchangeable and should not be mixed.

The best way to use a formula is to put your information into the correct units <u>before</u> performing the calculation.

This may require the use of conversion tables.

Section 8: Converting and Conversion Tables

Conversion tables are useful when converting between units, whether Imperial or metric or from one system to another.

This section contains a set of conversion tables and instructions on how to use them.

Objectives

- To discuss converting between units
- To explain how to use the conversion tables

Try these first . . . Exercise 1.84

Convert the following (answers to 2 decimal places unless stated).

1.	3 metre to feet	
2.	8 inches to centimetres	
3.	3.5 square metres to square feet	
4.	84 square centimetres to square inches	
5.	10 square feet to square metres	
6.	115 US gallons to barrels	(1 decimal place)
7.	20 barrels to US gallons	
8.	400 barrels to cubic metres	
9.	800 barrels to litres	(whole number)
10.	13 cubic metres to barrels	(1 decimal place)
11.	13.5 ppg to SG	
12.	1.85 SG to ppg	(1 decimal place)
13.	1.75 SG to pcf	(1 decimal place)
14.	12 kg to lbs	
15.	143 lbs to kg	
16.	2,500 psi to kPa	(whole number)
17.	3,450 psi to bar	(whole number)
18.	1,200 bar to psi	(whole number)
19.	6,400 cubic feet to bbl	(1 decimal place)
20.	200 US gallons to barrels	(1 decimal place)

Converting from one unit to another

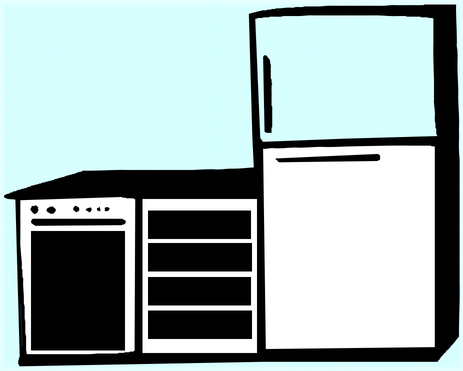
Previously in each section we have converted from units within each group. For example;

12 inches	=	1 foot
100 centimetres	=	1 metre

Sometimes it may be necessary to convert between systems, for example how many centimetres are in one foot?

Example

You have a space in your kitchen which you have measured as 2 feet by 3 feet (ft).



The washing machine you are thinking of buying is 60 centimetre by 85 centimetre (cm).

Will it fit?

In order to find out we must convert either feet to centimetres or centimetres to feet.

In this case it is easier to convert the size of the space in feet to centimetres.

1 ft = 30.5 cm (approximately)

So the dimensions of the space are;

2 ft x 30.5	=	61 cm
3 ft x 30.5	=	91.5 cm

So the washing machine (60 cm by 85 cm) will fit.

30.5 is called a conversion constant to convert from feet to centimetres.

It could also be used to convert the other way from centimetres to feet.

Conversion constant to convert feet to centimetres

Measurement in feet x 30.5 = measurement in centimetres

To convert centimetres to feet

Measurement in centimetres ÷ 30.5 = measurement in feet

Other examples include;

Example

1 kilogram (kg)

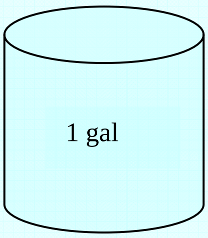
2.2 pounds (lbs)

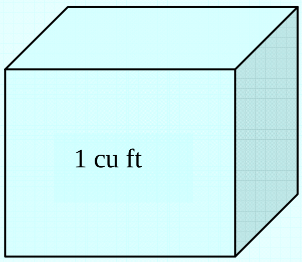
Conversion factor

$$\text{kilograms} \underset{\div\, 2.2}{\overset{\times\, 2.2}{\rightleftarrows}} \text{pounds}$$

So	5 kg of sugar	=	5 x 2.2 lbs
		=	11 lbs
or	19 lbs of sugar	=	19 ÷ 2.2 kg
		=	8.64 kg

Example - Water





Weight = 8.33 pounds
Density = 8.33 pounds per gallon (ppg)

Weight = 62.4 pounds
Density = 62.4 pounds per cubic foot (pcf)

Conversion Factor

$$\text{ppg} \underset{\div\, 7.48}{\overset{\times\, 7.48}{\rightleftarrows}} \text{pcf}$$

So a mud density of 11 ppg	=	11 x 7.48 pcf
	=	82.28 pcf
or a mud density of 95 pcf	=	95 ÷ 7.48 ppg
	=	12.7 ppg

What we require is a set of conversion tables to tell us the constants to use for converting between units. These tables look like this: -

	Multiply →	**by** →	**To obtain**
	To obtain ←	**by** ←	**divide**
Volume	bbls (US)	158.984	litre
	bbls (US)	42	galls (US)
	bbls (US)	5.61458	ft^3
	bbls (US)	0.9997	bbls (Imp)
	bbls (Imp)	159.031	litre
	bbls (Imp)	42.0112	galls (US)
	ft^3	1,728	in^3
	ft^3	28.31684	litre
	ft^3	7.4809	galls (US)
	ft^3	0.1781	bbls (US)
	ft^3	0.02831	m^3

So to convert barrels to cubic feet we multiply by 5.61458.

To convert cubic feet to barrels we divide by 5.61458.

A set of conversion tables are included at the end of this section.

Example (Using the table above)

1. Convert
   2,000 cubic feet (ft^3) to barrels (bbl)

From the table we must multiply cubic feet by 0.1781 to get barrels

So	2,000 ft^3	=	2,000 x 0.1781 bbl
		=	356.2 bbl

How to use the tables

The tables work in both directions.

To convert left to right

Multiply

To convert right to left

Divide

Firstly: Check what type of units we have. Is it a measurement of length, area, density etc?

Second: Find the appropriate section of the tables for this type of unit. This is written on the far left of the page.

Third: Find the subsection dealing with the specific unit. Usually we can find this on the left of the conversions.

Fourth: Find the units we require – on the right hand side. The number is the conversion constant.

Fifth: Multiply the original number by the conversion constant.

If we cannot find the original units on the left we must look on the right of the conversion constant.

Find the original units and the constant.

We must then divide to get back to the units on the left.

Example 1

Convert 24 feet to metres

1. Recognise the unit of measurement. In this case it is feet and relates to length.
2. Look in the length section of the conversion tables.
3. As we are converting feet find feet in the left hand column.
4. Looking across to the right we see centimetres, inches and metres.
5. The constant relating feet to metres is 0.30480.
6. As we are converting feet to metres we follow the instructions at the top of the page and multiply feet by 0.30480 to get metres.
7. 24 x 0.30480 = 7.3152 metres

Example 2

Convert 16 quarts (US) to gallons (US).

1. A quart is a unit of volume so find the volume section.
2. Look for quart on the left – not there.
3. Look for quart on the right. There is a conversion constant of 4.0 to convert gallons (US) to quarts (US).
4. To go right to left we must divide.
5. 16 ÷ 4 = 4
6. 16 quarts (US) = 4 gallons (US)

Try some yourself - Exercise 1.85

Convert the following (answers to 2 decimal places unless stated)

1.	1 m to ft	
2.	50 cm to m	
3.	9,680 ft to m	
4.	15 in^2 to cm^2	
5.	150 in^3 to ft^3	
6.	98 ft^3 to gal (US)	
7.	110 ft^3 to bbl	(1 decimal place)
8.	958 gal (US) to bbl	(1 decimal place)
9.	962 bbl to gal (US)	(whole number)
10.	1,480 bbl to ft^3	(whole number)
11.	1.5 S.G. to ppg	(1 decimal place)
12.	84 pcf into ppg	(1 decimal place)
13.	14.8 ppg to S.G.	
14.	12.2 ppg to pcf	(1 decimal place)
15.	73.8 pcf to S.G.	
16.	1.5 S.G. to pcf	(1 decimal place)
17.	8 metric tonnes to lb	(whole number)
18.	38 kg/cm^2 to psi	(whole number)
19.	20 bbl to litres	
20.	10m^3 to ft^3	

Unit	Abbreviation
inch	in
foot	ft
yard	yd
mile	mile
millimetre	mm
centimetre	cm
metre	m
kilometre	km
square inch	in^2
square foot	ft^2
square mile	square mile
square millimetre	mm^2
square centimetre	cm^2
square kilometre	km^2
cubic inch	in^3
cubic foot	ft^3
cubic yard	yd^3
pint	pint
gallon	gal
barrel	bbl
cubic centimetre	cm^3
cubic metre	m^3
litre	l
pounds per cubic foot	pcf
pounds per gallon	ppg
kilograms per cubic metre	kg/m^3
Specific Gravity	S.G.
ounce	oz
pound	lb
stone	st
hundredweight	cwt
milligrams	mg
grams	g
kilograms	kg
metric tonne	t
pounds per square inch	psi
atmosphere	atm
kilograms per square centimetre	kg/cm^2
bar	bar

Function	Symbol	Example
Plus	+	2 + 6 = 8
Minus	-	7 – 2 = 5
Multiply	X	3 x 4 = 12
Divide	÷	10 ÷ 2 = 5
Greater than	>	6 > 5
Less than	<	5 < 6
Plus or minus	$\pm$	60% $\pm$ 1%
Therefore	$\therefore$	
Square	x^2	$2^2 = 4$
Square root	$\sqrt{\ }$	$\sqrt{4} = 2$
Cube root	$\sqrt[3]{\ }$	$\sqrt[3]{16} = 2$
Pi	π	3.142
Degrees	^{o}	^{o}C or angles
Ratio	:	3:1
Percent	%	100%

	Multiply → / To obtain ←	**by → / by ←**	**To obtain / divide**
Length	inch (in)	0.08333 25.40005 2.540	ft mm cm
	foot (ft)	12. 0.3333 30.48006 0.3048	in yd cm m
	yard (yd)	36. 3. 0.9144	in ft m
	mile	5,280. 1,760. 160,900. 1,609.34 1.60934	ft yd cm m km
	millimetre (mm)	0.03937 0.01 0.001	in cm m
	centimetre (cm)	0.39370 0.03281 10. 0.01	in ft mm m
	metre (m)	39.37 3.2808 1.09361 1,000. 100. 0.001	in ft yd mm cm km
	kilometre (km)	3,281. 0.621371 100,000. 1,000.	ft mile cm m

	Multiply → / To obtain ←	by → / by ←	To obtain / divide
Area	square inch (in^2)	645.16 6.4516	mm^2 cm^2
	square foot (ft^2)	144. 929.03 0.092903	in^2 cm^2 m^2
	square yard (yd^2)	9. 0.083612	ft^2 m^2
	acre	43,560. 4,840. 0.00156 4,046.86 0.00405 0.40468	ft^2 yd^2 $miles^2$ m^2 km^2 hectares
	square mile (m^2)	640. 2.5899 258.999	acres km^2 hectares
	square millimetre (mm^2)	0.1550	in^2
	square centimetre (cm^2)	100. 0.155499	mm^2 in^2
	square metre (m^2)	1,549.9969	in^2
		10.7638 1.19599 10,000.	ft^2 yd^2 cm^2
	hectare	2.47105 10,000.	acres m^2
	square kilometre (km^2)	247.104 0.386103 100.	acres $mile^2$ hectares

	Multiply → To obtain ←	**by → by ←**	**To obtain divide**
Volume and Capacity	cubic inch (in^3)	0.000579 0.03463 0.004329 16.3870 0.00001639 0.01639	ft^3 pints (US liquid) gallons (US) cm^3 m^3 litre
	cubic foot (ft^3)	1,728. 59.4 7.48052 0.1781 28,320. 0.02832 28.32	in^3 pints gallons (US) barrels cm^3 m^3 litres
	cubic yard (yd^3)	27. 0.7646	ft^3 m^3
	pint (Imperial)	20. 4. 0.5683	fl oz gills litres
	pint (US liquid)	16. 0.8327 0.4732	fl oz pint (Imperial) litre
	gallon (Imperial)	8. 1.20095 0.77.419 4.545	pints (Imperial) gallons (US) in^3 litres
	gallon (US)	231. 0.1337 8. 4. 0.83267 0.02381 3,785. 0.00378 3.7853	in^3 ft^3 pints (US liquid) quarts (US) gallon (Imperial) barrel cm^3 m^3 litres
	barrel (bbl)	5.6146 42. 36. 158.984	cubic feet gallons (US) gallons (Imperial) litres
	cubic centimetre (cm^3)	0.06102 0.00003531 0.002113 0.0002642 1,000. 0.000001 0.001	in^3 ft^3 pint (US liquid) gallon (US) mm^3 m^3 litre

	Multiply → / To obtain ←	**by → / by ←**	**To obtain / divide**
Volume and Capacity continued	cubic metre (m^3)	61,023.	in^3
		35.3147	ft^3
		1.3079	yd^3
		2,113.	pints (US liquid)
		262.4	gallons (US)
		6.2905	barrels
		1,000,000.	cm^3
		1,000.	litres
	litre (l)	61.027	in^3
		0.03531	ft^3
		0.001308	yd^3
		1.76	pint (Imperial)
		2.113	pint (US liquid)
		0.22	gallon (Imperial)
		0.2642	gallon (US)
		0.0063	barrel
		1,000.	cm^3
		1,000.	millilitre
		0.001	m^3

	Multiply → **To obtain ←**	**by →** **by ←**	**To obtain** **divide**
Density	pounds per cubic foot (pcf)	0.13368 5.614 0.016018 16.02	ppg lb/bbl S.G. kg/m^3
	pounds per gallon (US) (ppg)	7.4809 42. 0.119826 120. 0.01175 0.052 7.48	pcf lb/bbl S.G. kg/m^3 bar/metre psi/ft pcf
	kilograms per cubic metre (kg/m^3)	0.00833 0.001	ppg S.G.
	Specific Gravity (S.G.) (grams per cubic centimetre)	0.036127 62.42976 8.34544 350.51	lb/in^3 pcf ppg lb/bbl

	Multiply → / To obtain ←	by → / by ←	To obtain / divide
Weight (Mass)	ounce (oz)	0.0625 28.349527	lb g
	pound (lb)	16. 0.005 453.5924 0.4536 0.445 4.45	oz tons short g kg decanewton newton
	stone (st)	14. 6.3503	lb kg
	hundredweight (cwt)	112. 50.8023	lb kg
	ton (long ton) (Imperial)	2,240. 20. 1.12 1016.05 1.01605	lb cwt ton short kg tonnes
	ton (short ton) (US)	2,000. 0.098421 0.90718	lb long ton tonne
	milligram (mg)	0.0154	g
	gram (g)	15.43236 0.03528 0.00220 1,000.	grain oz lb mg
	kilogram (kg)	35.274 2.2046 0.0009842 0.001102 1,000. 9.81 0.981	oz lb long ton short ton g newtons decanewtons
	tonne (t)	2,204.62 0.98421 1.10231 1,000. 981.	lb long ton short ton kg decanewtons

	Multiply → To obtain ←	**by**	**→ To obtain ← divide**
Pressure	pound per square inch (psi)	0.0680 70.3 0.0703 0.0689 6.89	atm g/cm^2 kg/cm^2 bar kPa
	atmosphere (atm)	14.696 1.03 1.01 101	psi kg/cm^2 bar kPa
	kilograms per square centimetre (kg/cm^2)	14.2 0.968 0.981 98.1	psi atm bar kPa
	bar	14.5 0.987 1.02 100	psi atm kg/cm^2 kPa
	Kilopascals (kPa)	0.145 0.00987 0.102 0.010	psi atm kg/cm^2 bar

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