

AgroSource 2

Basic Calculations in Agriculture, Irrigation and Animal Production

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Foreword

Sometimes people find it difficult to make calculations related to agriculture and animal husbandry because knowledge of basic arithmetic is lacking or is no longer ready knowledge.

BASIC CALCULATIONS provides training material for situations in which basic calculation skills need to be improved. It offers exercises at upper primary - lower secondary level. It is suitable for use in groups, but can also be used as self-tuition material.

The first chapters refresh basic arithmetic. The following chapters deal with averages, the use of formulae, proportions and scale, graphs and diagrams, the conversion of units and other topics.

The second part of BASIC CALCULATIONS is about irrigation, crop growing and animal husbandry.

The book ends with the answers to the problems given in the text.

BASIC CALCULATIONS is not meant to be a guide for learning about agriculture and animal husbandry in the usual way. It is an 'exercise book' with basic calculations related to agriculture and animal husbandry, and it does not, for instance, try to explain irrigation or livestock feeding.

This is the second edition of BASIC CALCULATIONS, since 2006 published by Agromisa.

The original contributors were Heleen Hennink and Nicolet van der Smagt - at that time freshly graduated from the (former) Larenstein Agricultural College in the Netherlands.

Agromisa is most grateful for all contributions which have been made.

Bart Gietema
compilation/editing/layout

The Netherlands
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1 Fractions

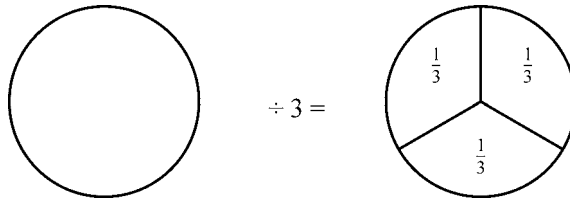
Purpose: to refresh basic knowledge

1.1 Introduction

If you have a loaf of bread and you want to share it among 4 people, everyone gets a fourth part or a quarter. We write this as $\frac{1}{4}$ or $1/4$ or $\frac{1}{4}$.

$\frac{1}{4}$ is called a **fraction**; 1 is called the numerator, the dividing line is called the mark of division, 4 is called the denominator. In our guide 'division' or 'to be divided by' is also indicated by \div .

If we divide the circle into three equal parts, each part is $\frac{1}{3}$.



When we have 5 kg of rice and we divide it equally among 8 people, everyone gets $\frac{5}{8}$ kg of rice. In fact $\frac{5}{8}$ is another way of writing $5 \div 8$.

Application

1 Write in a different way $8 \div 4$; $4 \div 3$; $3 \div 6$; $1 \div 9$

A fraction is simplified by making whole numbers of it.

First rule

We get a whole number if the numerator and the denominator are the same, or if the numerator is a multiple of the denominator.

Example:

$$\frac{3}{3} = 1;$$

$$\frac{8}{8} = 1;$$

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

$$\frac{8}{3} = 2 \frac{2}{3};$$

$$\frac{5}{4} = 1 \frac{1}{4}$$

Application

2 Simplify these fractions

$$\frac{8}{5} = \dots$$

$$\frac{3}{2} = \dots$$

$$\frac{175}{175} = \dots$$

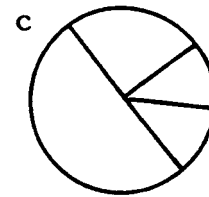
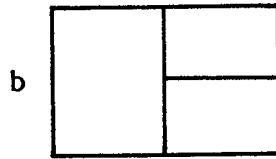
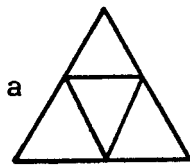
$$\frac{11}{2} = \dots$$

$$\frac{9}{4} = \dots$$

$$\frac{15}{12} = \dots$$

- An old farmer wants to divide his land equally between his four sons. How much does each son receive? Now he wants to keep an equal part for himself. What fraction is that of the whole land?
- A mother has bought a papaya fruit. She has four children. She wants to divide the papaya equally between her children, her husband and herself. How much does each person receive?

5 Name the parts of the figures as fractions.



1.2 To add and subtract fractions

When we add or subtract fractions with the same denominator, we only add or subtract the numerators; this gives the numerator of the answer. The denominator remains the same.

Example:

$$\frac{1}{3} + \frac{1}{3} = \frac{2}{3}; \quad \frac{2}{4} + \frac{1}{4} = \frac{3}{4}; \quad \frac{3}{4} - \frac{1}{4} = \frac{2}{4}$$

Second rule

When adding or subtracting fractions with the same denominator, the denominator does not change.

Application

6	$\frac{3}{5} + \frac{1}{5} = \dots$	$\frac{2}{3} - \frac{1}{3} = \dots$	$1\frac{1}{4} + \frac{2}{4} = \dots$
	$\frac{1}{2} + \frac{1}{2} = \dots$	$\frac{3}{5} - \frac{1}{5} = \dots$	$2\frac{2}{3} + \frac{1}{3} = \dots$
	$\frac{1}{4} + \frac{2}{4} = \dots$	$\frac{5}{12} - \frac{2}{12} = \dots$	$3\frac{3}{5} + \frac{3}{5} = \dots$
	$\frac{7}{8} + \frac{1}{8} = \dots$	$\frac{8}{9} - \frac{4}{9} = \dots$	$2\frac{2}{4} + 1\frac{1}{4} = \dots$
	$\frac{2}{10} + \frac{4}{10} = \dots$		$3\frac{1}{2} + 1\frac{1}{5} = \dots$
	$\frac{2}{9} + \frac{3}{9} = \dots$		$5\frac{3}{5} + 1\frac{4}{5} = \dots$

To subtract a fraction from a whole number, we write a part of the whole number as a fraction. Now it is possible to subtract the fraction.

Example:

$$8 - \frac{4}{5} = 7\frac{5}{5} - \frac{4}{5} = 7\frac{1}{5} \quad 4\frac{2}{5} - \frac{4}{5} = 3\frac{7}{5} - \frac{4}{5} = 3\frac{3}{5}$$

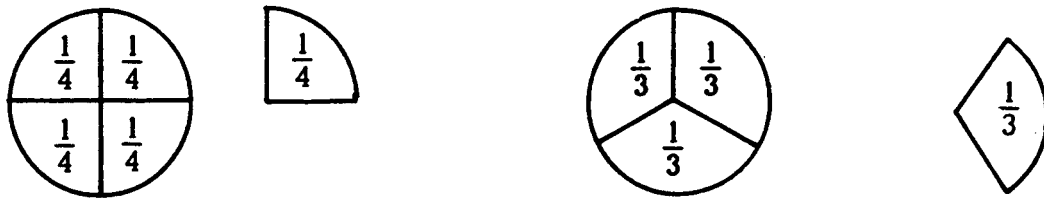
Application

7	$2\frac{2}{4} - \frac{3}{4} = \dots$	$4\frac{3}{5} - 1\frac{4}{5} = \dots$
	$3\frac{2}{3} - \frac{4}{3} = \dots$	$8\frac{2}{6} - 2\frac{4}{6} = \dots$
	$5\frac{1}{5} - \frac{4}{5} = \dots$	$10\frac{2}{4} - 1\frac{3}{4} = \dots$
	$3\frac{4}{7} - \frac{6}{7} = \dots$	$15\frac{7}{9} - 3\frac{8}{9} = \dots$

Now we come to the next problem.

Which is bigger, $\frac{1}{4}$ or $\frac{1}{3}$?

Let us see. We have two round loaves of bread; first we divide one bread into 4 parts and then we divide the other bread into 3 parts. Which pieces are bigger?



It is clear that if the denominator is big, the fraction is small. The reverse is also true: if the denominator is small, the fraction is big.

Application

8 Which is bigger?

$\frac{1}{4}$ or $\frac{1}{2}$;

$\frac{1}{2}$ or $\frac{1}{10}$;

$\frac{1}{5}$ or $\frac{1}{3}$

9 Rearrange this row so that it begins with the biggest fraction and ends with the smallest.

$\frac{1}{2}$; $\frac{1}{3}$; $\frac{1}{10}$; $\frac{1}{7}$; $\frac{1}{4}$; $\frac{1}{22}$

1.3 To reduce fractions to the same denominator

If for example we want to add $\frac{1}{4}$ and $\frac{1}{2}$, we have to change the denominators. Because we can only add fractions with the same denominators. How do we change the denominators? In our example we can write $\frac{1}{2}$ as $\frac{2}{4}$.



Now we write $\frac{1}{4} + \frac{1}{2}$ as $\frac{1}{4} + \frac{2}{4} = \frac{3}{4}$

Application

10 $\frac{1}{3} + \frac{1}{6} = \dots$

$\frac{2}{3} + \frac{1}{6} = \dots$

$\frac{5}{8} - \frac{1}{4} = \dots$

$\frac{1}{5} + \frac{1}{10} = \dots$

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

$\frac{8}{10} - \frac{1}{5} = \dots$

$\frac{1}{3} + \frac{2}{6} = \dots$

$\frac{2}{3} - \frac{1}{6} = \dots$

It is more difficult to add $\frac{1}{3}$ and $\frac{1}{4}$. How do we reduce these fractions to the same denominator? To find a common denominator, each fraction is multiplied by the denominator of the other fraction. Twelve is the new denominator.

$\frac{1}{4} = \frac{3}{12}$ because $\frac{1}{4} \begin{matrix} \times 3 \\ \times 3 \end{matrix} = \frac{3}{12}$

The denominator is multiplied by 3 so the numerator too has to be multiplied by 3.

$\frac{1}{3} = \frac{4}{12}$ because $\frac{1}{3} \begin{matrix} \times 4 \\ \times 4 \end{matrix} = \frac{4}{12}$

Now $\frac{1}{4}$ and $\frac{1}{3}$ can be added; $\frac{1}{3} + \frac{1}{4} = \frac{4}{12} + \frac{3}{12} = \frac{7}{12}$

Third rule

We can multiply the denominator by a certain number, but then the numerator must be multiplied by that number too.

Application

11 $\frac{1}{4} = \frac{\dots}{8}$	$\frac{1}{2} + \frac{1}{3} = \dots$	$\frac{3}{5} - \frac{1}{4} = \dots$
$\frac{1}{5} = \frac{\dots}{10}$	$\frac{3}{4} + \frac{1}{3} = \dots$	$\frac{7}{10} - \frac{2}{5} = \dots$
$\frac{3}{6} = \frac{\dots}{12}$	$\frac{1}{5} + \frac{1}{5} = \dots$	$\frac{6}{12} - \frac{1}{3} = \dots$
$\frac{1}{2} = \frac{\dots}{8}$	$\frac{2}{6} + \frac{1}{5} = \dots$	$\frac{7}{8} - \frac{2}{3} = \dots$

If it is possible to multiply the numerator and the denominator by the same number, it must also be possible to divide them by the same number.

Example: $\frac{3}{9} \div 3 = \frac{1}{3}$

Application

12 $\frac{4}{10} = \frac{\dots}{5}$	$\frac{4}{8} = \frac{\dots}{2}$	$\frac{12}{16} = \frac{\dots}{4}$
$\frac{10}{12} = \frac{\dots}{6}$	$\frac{3}{15} = \frac{\dots}{5}$	

13 Put these fractions into order, the biggest first.

a $\frac{4}{10}, \frac{1}{2}, \frac{3}{4}, \frac{3}{5}, \frac{19}{20}, \frac{9}{10}$
 b $\frac{1}{6}, \frac{1}{2}, \frac{1}{8}, \frac{3}{4}, \frac{2}{3}, \frac{5}{6}, \frac{5}{8}$

note: reduce all the fractions to the same denominator

1.4 To multiply fractions

To multiply fractions we multiply the denominators by each other and we multiply the numerators by each other.

Example:

$\frac{1}{3} \times \frac{1}{4} = \frac{1 \times 1}{3 \times 4} = \frac{1}{12}$ $\frac{1}{2} \times \frac{3}{5} = \frac{1 \times 3}{2 \times 5} = \frac{3}{10}$

Application

14 $\frac{1}{6} \times \frac{1}{3} = \dots$	$\frac{1}{10} \times \frac{1}{4} = \dots$	$\frac{1}{3} \times \frac{1}{3} = \dots$
$\frac{3}{4} \times \frac{2}{8} = \dots$	$\frac{2}{12} \times \frac{2}{2} = \dots$	$\frac{2}{6} \times \frac{3}{4} = \dots$

To multiply fractions by whole numbers, only the numerator is multiplied; the denominator remains the same.

Example:

$3 \times \frac{1}{4}$ means $\frac{1}{4} + \frac{1}{4} + \frac{1}{4} = \frac{1+1+1}{4} = \frac{3}{4}$
 $3 \times \frac{2}{3}$ means $\frac{2}{3} + \frac{2}{3} + \frac{2}{3} = \frac{2+2+2}{3} = \frac{6}{3} = 2$

Application

$$15 \quad 3 \times 1\frac{1}{4} = 1\frac{1}{4} + 1\frac{1}{4} + 1\frac{1}{4} = \dots$$

$$2 \times 2\frac{1}{3} = \dots + \dots = \dots$$

$$4 \times 1\frac{1}{3} = \dots = \dots$$

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

$$2 \times \frac{1}{3} = \dots$$

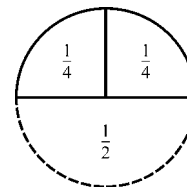
$$6 \times \frac{1}{3} = \dots$$

$$8 \times \frac{4}{5} = \dots$$

1.5 To divide fractions

When a girl gets half a melon and she wants to share it with her sister, how much does each one get?

This is written as $\frac{1}{2} \div 2$ and drawn:



The answer is $\frac{1}{4}$.

To divide a fraction by a whole number, we divide the numerator by that number.

Example:

$\frac{6}{7} \div 2 = \frac{3}{7}$. Here the denominator does not change. Or we multiply the denominator by the number

$\frac{6}{7} \div 2 = \frac{6}{14} = \frac{3}{7}$; here the numerator does not change.

Both methods are correct. Sometimes it is better to use the first one, for example when it is possible to divide the numerator by that number, like $\frac{6}{7} \div 2$; here it is possible to divide 6 by 2.

This method cannot be applied when we want to divide $\frac{3}{4}$ by 2; here we multiply the denominator by 2 so the answer is $\frac{3}{4} \div 2 = \frac{3}{8}$.

From this we learn the fourth rule.

Fourth rule

To divide a fraction by a number is the same as to multiply it by the inverted number.

Let us consider our example: $\frac{6}{7} \div 2 = \frac{6}{7} \times \frac{1}{2} = \frac{3}{7}$

What is $\frac{3}{4} \div \frac{1}{4}$?

Answer: $\frac{3}{4} \div \frac{1}{4} = \frac{3}{4} \times \frac{4}{1} = \frac{3 \times 4}{4 \times 1} = \frac{12}{4} = 3$

Application

$$16 \quad \frac{2}{5} \div 4 = \dots$$

$$\frac{6}{7} \div 3 = \dots$$

$$\frac{4}{5} \div 2 = \dots$$

$$\frac{8}{10} \div 8 = \dots$$

$$\frac{4}{8} \div 3 = \dots$$

$$\frac{2}{5} \div \frac{1}{5} = \dots$$

$$\frac{4}{6} \div \frac{1}{4} = \dots$$

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

$$\frac{3}{7} \div \frac{2}{5} = \dots$$

$$\frac{5}{8} \div \frac{2}{4} = \dots$$

What is $2\frac{3}{4} \div 1\frac{2}{5}$?

First we rewrite the sum as follows $\frac{11}{4} \div \frac{7}{5}$

Now we can solve this sum $\frac{11}{4} \div \frac{7}{5} = \frac{11}{4} \times \frac{5}{7} = \frac{55}{28} = 1\frac{27}{28}$

2 Percentages

Purpose: to understand percentages better and to use them

2.1 Introduction

One part of 100 is called 1 per cent.

One block of the 100 blocks in the picture is black, so 1 per cent is black. This is written as 1%.

If 5 blocks are black, how many per cent is that?

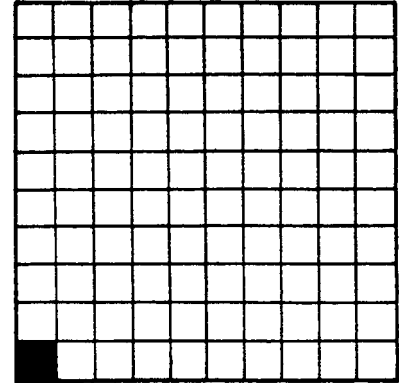
If 50 blocks are black, how many per cent is that?

If a fourth is black, this corresponds to 25%.

Because:

$$\frac{1}{4} = \frac{25}{100} = 25\% \quad \frac{3}{10} = \frac{30}{100} = 30\%$$

$$\frac{1}{2} = \frac{50}{100} = 50\% \quad \frac{2}{3} = 66\frac{2}{3}\%$$



Percentages can be written as fractions.

$$4\% = \frac{4}{100} = \frac{1}{25}$$

$$16\% = \frac{16}{100} = \frac{4}{25}$$

$$75\% = \frac{75}{100} = \frac{3}{4}$$

If you are in a room with 200 people and 50% of these people are women, this means that 50% or $\frac{50}{100} = \frac{1}{2}$ of the 200 people are women. So $\frac{50}{100}$ of 200 = 100 are women.

$$1\% \text{ of } 200 \text{ means } \frac{1}{100} \times 200 = 2$$

$$8\% \text{ of } 200 \text{ means } \frac{8}{100} \times 200 = 16$$

$$50\% \text{ of } 200 \text{ means } \frac{50}{100} \times 200 = 100$$

In the case of 50% it is easier to say $50\% = \frac{50}{100} = \frac{1}{2}$; then 50% of 200 is $\frac{1}{2} \times 200 = 100$.

Application

1 50% of 100 = ...

8% of 100 = ...

34% of 200 = ...

60% of 180 = ...

25% of 140 = ...

31% of 400 = ...

3% of 1100 = ...

86% of 50 = ...

2 If you earn 300 coins every week and you have to pay 20% of your earnings in taxes, how much do you have to pay every week?

3 Normally your yield is 550 kg beans per acre. Now you get an increase in yield of 40% by using better seed.

How many kg more do you get?

How big is your total yield now?

3 Decimals

Purpose: to count more easily with fractions

3.1 Introduction

Decimals are fractions with the denominators 10; 100; 1000; etc. $\frac{1}{10}$ is written as 0.1. The tenth parts are written just behind the decimal point.

Likewise, $\frac{2}{10} = 0.2$; $\frac{8}{10} = 0.8$ and $\frac{47}{100}$ is written as 0.47

We can write $\frac{47}{100}$ as $\frac{4}{10} + \frac{7}{100}$. The first figure behind the decimal point corresponds with the tenth parts (here 4). The second figure behind the decimal point corresponds with the hundredth parts (here 7).

The same applies to $\frac{538}{1000}$; this is written as 0.538; $\frac{5}{10} + \frac{3}{100} + \frac{8}{1000}$; $\frac{8}{1000}$ are the thousandth parts.

Application

1 Write in decimals.

$\frac{8}{10} = \dots$	$\frac{58}{100} = \dots$	$\frac{945}{1000} = \dots$
$\frac{5}{10} = \dots$	$\frac{64}{100} = \dots$	$\frac{421}{1000} = \dots$
$\frac{6}{10} = \dots$	$\frac{25}{100} = \dots$	$\frac{125}{1000} = \dots$

Is it possible to write $\frac{1}{4}$ as a decimal?

Most fractions can be reduced to the denominators 10, 100, 1000 and written as a decimal.

Example:

$$\frac{1}{4} = \frac{25}{100} = 0.25$$

How do we write $1\frac{2}{4}$? Firstly, $\frac{2}{4} = \frac{50}{100} = 0.50$; secondly, we already had 1, so $1\frac{2}{4} = 1.50 = 1.5$

Because the last figure is a zero we leave it out. This is only permitted if the last figure behind the decimal point is a zero.

Example:

$1.40 = 1.4$	$1.0 = 1$
$1.48 = 1.48$	$1.3 = 1.3$
$10.5 = 10.5$	$1.03 = 1.03$

Application

2 $\frac{3}{4} = \frac{\dots}{100} = \dots$	$\frac{4}{20} = \frac{\dots}{100} = \dots$	$1\frac{1}{4} = \dots$	$1\frac{5}{20} = \dots$
$\frac{2}{5} = \frac{\dots}{100} = \dots$	$\frac{1}{25} = \frac{\dots}{100} = \dots$	$2\frac{3}{5} = \dots$	$3\frac{4}{25} = \dots$

3.2 Rules for counting with decimals

Adding

It is important to always put the decimal points right underneath each other.

Example:

$$\begin{array}{r} 1.25 \\ 2.4 \\ \hline 3.65 \end{array} +$$

Subtracting

Here the same rule applies as in adding.

Multiplying

Here the following rule applies: when multiplying decimals, add the number of figures behind the decimal point in each number. The result corresponds with the number of figures behind the decimal point in the answer.

Example: $0.1 \times 0.01 = 0.001$

The first number has 1 figure behind the decimal point, the second number has 2 figures behind the decimal point, so the answer has $1 + 2 = 3$ figures behind the decimal point.

Other examples: $0.4 \times 0.01 = 0.004$ and $0.02 \times 0.003 = 0.00006$

Dividing

Example: $1.6 \div 0.4 = ?$

The divisor must be a whole number, so we multiply each number by 10; then we get $16 \div 4 = 4$.

Example: $0.666 \div 6 = ?$

We work this out by 'long division'

zero divided by 6 gives zero so we write down the zero; then we write the decimal point because the next figure stands behind the decimal point; then we go on by dividing 6 by 6 giving 1, etc.

$$\begin{array}{r} 6 \ / \ 0.6 \ 66 \ \backslash \ 0.111 \\ \underline{6} \\ 6 \\ \underline{6} \\ 6 \\ \underline{6} \\ 0 \end{array}$$

Example: $8.436 \div 12 = ?$

8 divided by 12 gives 0; then we write down the decimal point, because the next figure stands behind the decimal point.

Now we have 84 divided by 12, this gives 7.

Then we get 3 divided by 12, this gives 0; we bring the 6 down and we get 36 divided by 12, this gives 3. This is the answer.

$$\begin{array}{r} 12 \ / \ 8.436 \ \backslash \ 0.703 \\ \underline{0} \\ 8 \ 4 \\ \underline{8 \ 4} \\ 03 \\ \underline{0} \\ 36 \\ \underline{36} \\ 0 \end{array}$$

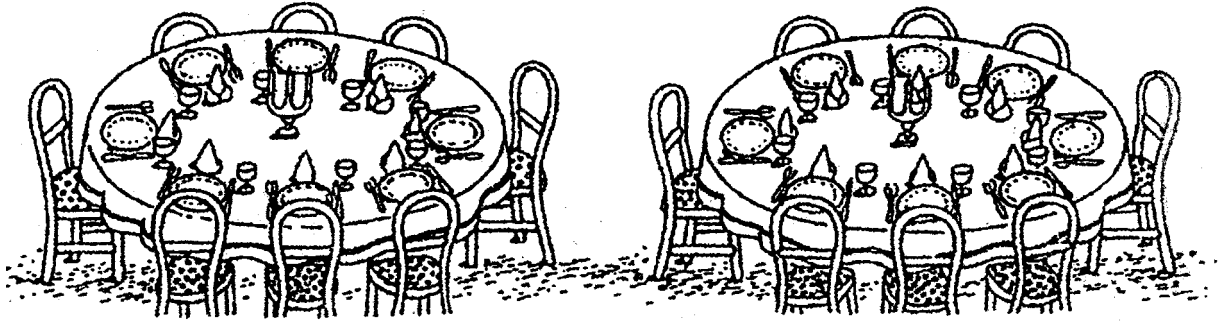
Example: $0.891 \div 1.1 = ?$

$1.1 / 0.891 \ \backslash \dots$

First we multiply each number by 10; this gives the following sum $11 / 8.91 \ \backslash \dots$ Now we can solve this sum easily, see above.

In the following example reasoning is applied, instead of tricks as in the above examples.

There is a big dinner in a hotel, for 184 persons. Each table seats 8 guests. How many tables are required?



First we subtract 8 persons which means 1 table. It is easy to see that at least 10 more tables are needed, and then another 10. This makes easy calculations. Then we have to slow down and we come to 23 tables in all.

184		
– 8	—	1 table
176		
– 80	—	10 tables
96		
– 80	—	10 tables
16		
– 8	—	1 table
8		
– 8	—	1 table
0	—	23 tables

(adapted from an article in newspaper TROUW of 28.09.2004)

And, of course, there is the **pocket calculator** which becomes widely used. With a pocket calculator, it is recommended to first roughly estimate what the answer will be; this in order to avoid ‘mechanical’ calculation errors.

Application

- | | | |
|-----------------------|-----------------|-----------------|
| 3 $0.2 + 1.3 = \dots$ | 1.5 + 0.7 = ... | 1.2 × 2 = ... |
| 1.4 – 0.2 = ... | 3.2 – 1.4 = ... | 1.6 × 2 = ... |
| 5.3 + 1.2 = ... | 5.8 + 1.6 = ... | 0.9 ÷ 3 = ... |
| 3.9 – 0.5 = ... | 2.2 – 0.3 = ... | 5.4 ÷ 6 = ... |
| 5.7 – 2.5 = ... | 4.4 – 2.5 = ... | 0.8 × 3 = ... |
| 56.4 ÷ 3 = ... | 2.5 ÷ 5 = ... | 3.608 ÷ 4 = ... |

4 Select the right answer:

$0.2 \times 1.5 =$ $0.03 / 0.3 / 3 / 30$

5 The price of a car of 22,000 euro is reduced by 20%
 The new price is yet again lowered by 10%
 How much is the total price reduction, as a percentage of the original price?

An empty page for more examples and applications:

4 Large and small numbers, powers of ten

Purpose: to write very large and very small numbers as powers of ten; to make calculations with powers of ten

4.1 Introduction

Very large numbers are often written as powers of ten.

Examples:

10 to the power of 1 is written $10^1 = 10$; '1' is the index of power

10 to the power of 2 is written $10^2 = 10 \times 10 = 100$

10 to the power of 3 is written $10^3 = 10 \times 10 \times 10 = 1000$

10 to the power of 0 is written $10^0 = 1$

$200 = 2 \times 100 = 2 \times 10^2$

$16\,000 = 1.6 \times 10\,000 = 1.6 \times 10^4 = 16 \times 1000 = 16 \times 10^3$ (we may also write 16,000)

Application

1 Write as power of ten:

$$10\,000\,000 = \dots$$

$$533 = \dots$$

$$2\,500\,000 = \dots$$

$$14 = \dots$$

$$9000 = \dots$$

2 Write without the index of power:

$$5 \times 10^1 = \dots$$

$$1.55 \times 10^{10} = \dots$$

$$3.6 \times 10^3 = \dots$$

$$3 \times 10^4 = \dots$$

Very small numbers can also be written as powers of ten.

Examples:

$$0.1 = \frac{1}{10} = 10^{-1}$$

$$0.01 = \frac{1}{100} = 10^{-2}$$

$$0.09 = \frac{9}{100} = 9 \times 10^{-2}$$

$$0.00046 = \frac{4.6}{10\,000} = 4.6 \times 10^{-4}$$

In general: $10^{-a} = \frac{1}{10^a}$; $y \times 10^{-a} = y \times \frac{1}{10^a}$

Application

3 Write as a power of 10:

$$0.0001 = \frac{1}{10\,000} = \dots$$

$$0.000\,000\,0006 = \dots$$

$$0.0365 = \dots = \dots$$

$$600\,000\,000\,000 = \dots$$

$$0.15 = \dots = \dots$$

4 Write without the index of power:

$$\begin{array}{ll} 6 \times 10^{-8} = \dots & 5.5 \times 10^3 = \dots \\ 3.5 \times 10^{-2} = \dots & 3.371 \times 10^{-1} = \dots \end{array}$$

5 Write the following answers also as a power of 10 (see also table II on page 57).

$$\begin{array}{llll} 1 \text{ kg} & = 1000 \text{ g} & = 10^3 & \text{g} \\ 1 \text{ g} & = \dots & \text{kg} & = \dots & \text{kg} \\ 350 \text{ kg} & = \dots & \text{g} & = \dots & \text{g} \\ 1 \text{ ha} & = \dots & \text{m}^2 & = \dots & \text{m}^2 \\ 0.33 \text{ ha} & = \dots & \text{m}^2 & = \dots & \text{m}^2 \\ 1 \text{ mm} & = \dots & \text{m} & = \dots & \text{m} \\ 1 \text{ mm} & = \dots & \text{km} & = \dots & \text{km} \\ 60 \text{ km} & = \dots & \text{cm} & = \dots & \text{cm} \\ 1 \text{ hr} & = \dots & \text{sec} & = \dots & \text{sec} \end{array}$$

4.2 Multiplying

Examples:

$$10^2 \times 10^2 = 100 \times 100 = 10\,000 = 10^4$$

$$10^{-1} \times 10^3 = \frac{1}{10} \times 1000 = 100 = 10^2$$

In general: $10^a \times 10^b = 10^{a+b}$

4.3 Dividing

Examples:

$$10^6 \div 10^4 = 1\,000\,000 \div 10\,000 = 100 = 10^2$$

$$10^{-1} \div 10^1 = \frac{1}{10} \div 10 = \frac{1}{100} = 10^{-2}$$

In general: $10^a \div 10^b = 10^{a-b}$

Application

$$6 \quad 10^4 \times 10^6 = \dots \quad 10^{-3} \times 10^{-2} = \dots$$

$$10^{-6} \times 10^1 = \dots \quad 10^{-2} \times 10^2 = \dots$$

$$10^8 \div 10^7 = \dots \quad 10^2 \div 10^2 = \dots$$

4.4 Adding and subtracting

Examples:

$$3 \times 10^2 + 2 \times 10^2 = 5 \times 10^2$$

$$3 \times 10^3 + 2 \times 10^2 \text{ is NOT equal to } 5 \times 10^5!!$$

$$3 \times 10^3 + 2 \times 10^2 = 3000 + 200 = 3200 = 32 \times 10^2 \text{ or}$$

$$3 \times 10^3 + 2 \times 10^2 = 30 \times 10^2 + 2 \times 10^2 = 32 \times 10^2$$

$$5 \times 10^6 - 10^5 = 50 \times 10^5 - 10^5 = 49 \times 10^5$$

In general: when you add or subtract make sure that you use equal powers!!!

Application

$$7 \quad 10^3 + 10^3 = \dots \quad 10^4 + 10^6 = \dots$$

$$2 \times 10^2 - 10^2 = \dots \quad 5 \times 10^{-3} - 2 \times 10^{-4} = \dots$$

$$10^{10} + 9 \times 10^{10} = \dots \quad 7 \times 10^8 - 9 \times 10^6 = \dots$$

$$3 \times 10^{-1} - 0.24 = \dots \quad 3.45 \times 10^4 - 497 = \dots$$

8 $5 \times 10^2 \times 3 \times 10^3 = \dots$

$$1.8 \times 10^3 \times 2 \times 10^{-2} = \dots$$

$$\frac{25 \times 10^2}{5 \times 10^1} = \dots$$

$$\frac{4 \times 10^3 - 6 \times 10^2}{8 \times 10^2 + 9 \times 10^2} = \dots$$

$$\frac{4 \times 10^2 \times 3 \times 10^2}{12 \times 10^3} = \dots$$

$$\frac{5 \times 10^3 - 3 \times 6 \times 10^2}{4 \times 10^{-1}} = \dots$$

An empty page for more examples and applications:

5 Averages

Purpose: to calculate an average when you have a number of results of which some are high and others low

5.1 Introduction

You get an average by adding up a certain number of figures and dividing the sum by the number of the figures you added.

Example:

Calculate the average of the numbers 1; 5; 6; 11; 10

The sum of the numbers is $5 + 6 + 8 + 11 + 10 = 40$

There are 5 numbers so the average is $40 \div 5 = 8$

Application

- 1 Calculate the average of the numbers 1; 5; 2; 4; 6; 4
- 2 Calculate the average of the numbers 0.1; 0.25; 0.01; 0.3
- 3 Calculate the average of the numbers $\frac{1}{10}$; $\frac{3}{5}$; $\frac{1}{2}$; $\frac{1}{15}$; $\frac{2}{20}$
- 4 The temperature in degrees Celsius ($^{\circ}\text{C}$) in La Mancha, Mexico, in 1997:

Table 1: Temperatures in La Mancha, Mexico, 1997

date	minimum	maximum	mean daily
February			
1	19	27.5	...
2	20	26	...
3	20	25	...
4	20	24	...
5	19.5	22.5	...
6	19.5	22.5	...
7	19.5	22.5	...
March			
1	17	26	...
2	20	28	...
3	22	28	...
4	21	34	...
5	16.5	31	...
6	18.5	28.5	...
7	20	30.5	...

What was the average maximum temperature in the first week of February?

Consider the average minimum temperature. Which week was colder, the first week of February or the first week of March?

The mean daily temperature is the average of the minimum and maximum daily temperatures.

- What is the main daily temperature of the 4th of March?
- Fill in the mean daily temperatures in the table.
- Which week has on average the lowest mean daily temperature?

6 The use of formulae and equations

Purpose: if you need to use a formula for a certain calculation, to learn to use that formula in the proper way

6.1 Introduction

Rule

If in a calculation you need to add, subtract, multiply and divide, first you must multiply; after that divide and then add or subtract.

Example: say you have this formula $a + b \times c \div d = \dots$

first multiply $b \times c$; the result must be divided by d and then then this result is added to a

If brackets are used in the formula, this means: first work out the calculations inside the brackets, after that apply the normal rules.

Example: $(a + b) \times c + d \div e = \dots$

first add $a + b$; the result must be multiplied by c , then d is divided e and the results are added together

If in a formula a division line is used, this means that everything above this line must be divided by what is under the line.

Example: $\frac{(a + b) \times c}{d}$

first we do the calculations above the line of division, so we add $a + b$ and multiply the result by c ; then we divide the top by the bottom

Example: $\frac{(a + b) \times c}{d + e}$

first we calculate the top, then we calculate what is under the line of division, $d + e$, this gives the bottom, after that we divide the top by the bottom and that gives the answer.

6.2 Striking out

If you have the following sum $\frac{5 \times 4 \times 3 \times 2}{8 \times 5} = \dots$

you must first multiply 5 by 4 by 3 by 2 and divide the result by 8×5 .

You get big numbers and errors are easily made.

To avoid errors it is recommended to simplify this sum in the way you learned in chapter 1 with fractions. You may divide what is under and what is above the line of division by the same number.

So first divide by 5, that gives 1 instead of 5 under and above the line.

Then you divide by 4, that gives 1 instead of 4 above the line and 2 instead of 8 under the line.

Then you divide by 2 and both two's are removed. We call this 'striking out'.

$$\frac{\overset{1}{\cancel{5}} \times \overset{1}{\cancel{4}} \times 3 \times \overset{1}{\cancel{2}}}{\underset{\cancel{8}}{\cancel{8}} \times \underset{\cancel{5}}{\cancel{5}}} = \frac{1 \times 1 \times 3 \times 1}{1 \times 1} = 3$$

7 Rounding off

Purpose: to reduce a number with many decimal places into a more convenient number;
required background information: chapters 3 and 4 (decimals, powers of ten)

7.1 Introduction

How much is $32 \div 7$?

Either you write $4\frac{4}{7}$ or 4.571428571428.... (decimal places)

You get an endless row of figures which you can round off to a more convenient number such as 4.5741 or 4.57, numbers with less decimal places.

The number of decimal places depends on the required accuracy.

The sum $32 \div 7 = 4.5741$ has an accuracy of 4 decimals.

When you give 4.6 as the answer, you are accurate to 1 decimal.

7.2 Rules for rounding off properly

- When the last figure to be retained is followed by a 5 or more, you must add 1 to this figure.
- In all other cases, everything following the last figure can be deleted.

Example: 4.53 becomes 4.5; 4.55 becomes 4.6; 4.56 becomes 4.6

Application

- 1 Round off to 1 decimal

7.81 = ...	41.499 = ...
7.85 = ...	41.500 = ...
7.90 = ...	120.5 = ...

- 2 Write down with an accuracy of 0.1 cm

20.66 cm = ...	5.97 cm = ...
1.15 cm = ...	1.01 cm = ...

7.3 More rules for rounding off properly

Now that you know how to round off, you must know to what extent you must round off your figures; in other words, how many decimals are to be retained?

If you round off for your own convenience, you must use your common sense to find out the number of decimal places that you need.

Example:

In a calculation you find that a farmer has to apply 21.893056 kg fertilizer to his land. How could a farmer possibly weigh such a quantity? It is more realistic to tell the farmer that he has to apply 22 kg fertilizer to his land.

Application

- 3 Suppose you found the following unrealistic answers in calculations which you made.
Round them off so that they make more sense:
 - Nunu needs 4.4 sprinklers to water his tomatoes.

- Abdullah has to pay 8.9301 coins to buy fertilizers.
- The average farmer in Hedanti has to walk 2.936 km to go to his field.
- I need 53.965 kg urea for my field.
- This rice crop will mature in 122.165 days.

Note: often it is possible to give more than one answer.

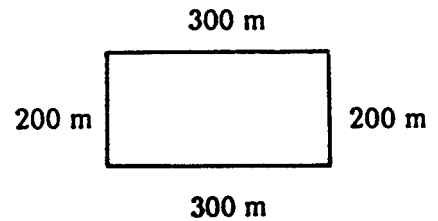
- 4 Solving a problem by making a global estimation. A student uses his pocket calculator and calculates $223,6 \times 52,125 + 89,25$. He notes down the answer which the calculator gives but forgets the comma. He writes 117444. Where should he place the comma?

8 Circumference, area and volume

Purpose: to be able to calculate areas and volumes; for instance, if you buy planting material you must know the area that is to be planted

8.1 Introduction

If you want to know the circumference of your field, you can measure the boundaries of the whole field with a measuring tape or with your footsteps. You need to measure all four sides of the land. The four sides together give the (total) circumference.

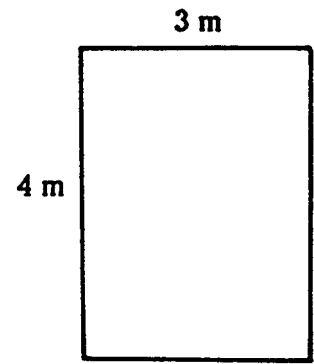


Example: circumference = 300 + 200 + 300 + 200 m = 1000 m

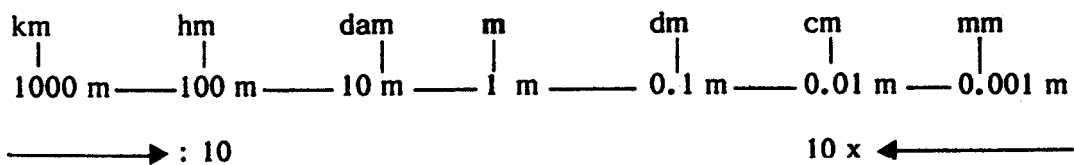
The circumference is always a line, as distinct from the area of a field which is a plane.

To calculate the area of a rectangle, we multiply one long side (the length) by one short line (the width).

Example: area = 3 m × 4 m = 12 m²

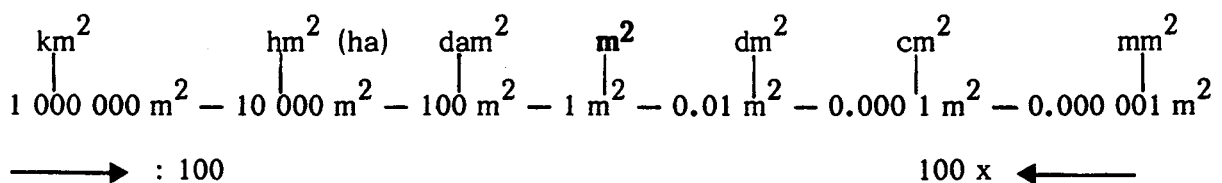


The **unit of length** is the metre (m).



Going to the right we must divide by 10 and going to the left we must multiply by 10

The **unit of area** is the square metre m²; this means m × m = m².



Going to the right we must divide by 100 and going to the left we must multiply by 100.

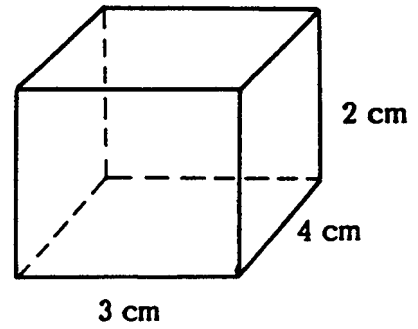
8.2 Volume

Now we take a match box. A match box has ... sides.

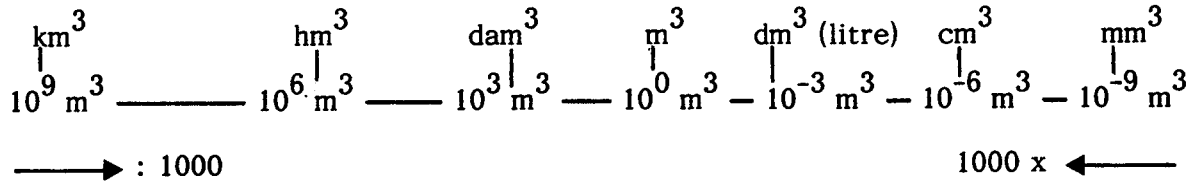
It has length, width and depth (or height).

To calculate the volume of a match box, we multiply the length by the width and by the depth or height. As follows:

$$\text{length} \times \text{width} \times \text{height} = 4 \text{ cm} \times 3 \text{ cm} \times 2 \text{ cm} = 24 \dots$$



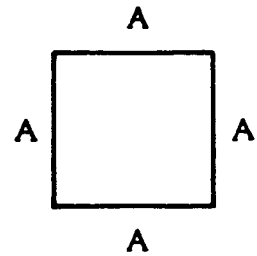
The **unit of volume** is the cubic metre m^3 ; this means $\text{m} \times \text{m} \times \text{m} = \text{m}^3$.



8.3 Objects have all kinds of shapes

Rectangles and squares

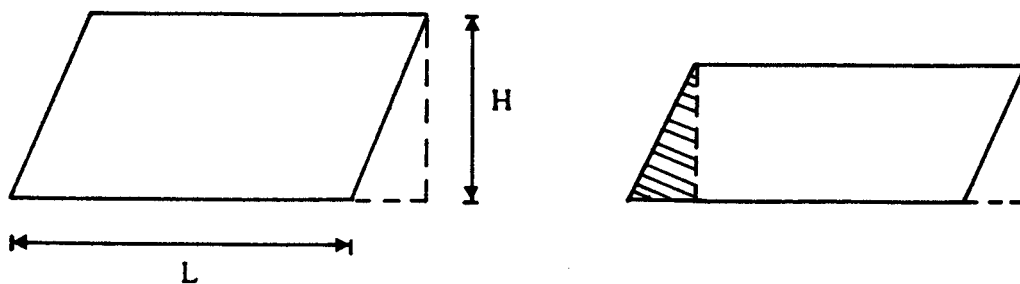
We have already seen the rectangle, a figure with 4 straight sides and 4 right angles. A special and more simple form of a rectangle is the square. A square is a rectangle with 4 equal sides:



Parallelogram

This is a figure where opposite sides are parallel but where there are no right angles as in a rectangle.

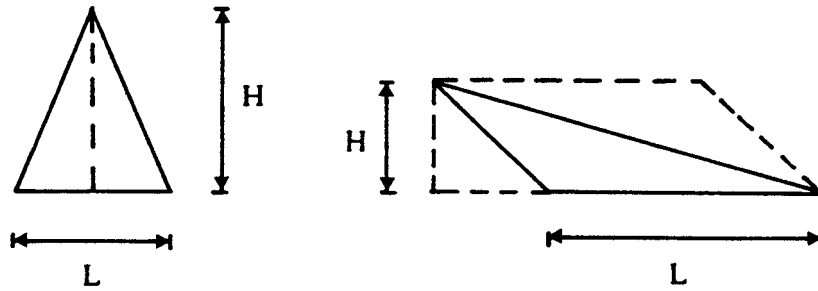
You find the total area by multiplying the length of the base by the height.



Area = $L \times H$. Because if we put the shaded part on the other side of the parallelogram, we get a rectangle and we know that the area of a rectangle is $L \times H$.

Triangle

This is a three sided figure. You find the total area by multiplying the base side by the vertical height and dividing the result by 2. Here too the height has to be perpendicular to the base.

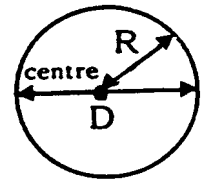


A double triangle gives one parallelogram. The area of a parallelogram is $L \times H$, so the area of a triangle is $\frac{1}{2}(L \times H)$.

Circle

The area of a circle is needed when we are dealing with circular tanks or silos. You need to find the area of the base (which is a circle) before you can find out how much it can hold.

A straight line across a circle, passing through the centre, is the **diameter** (D). Half this distance is the **radius** (R) of the circle.

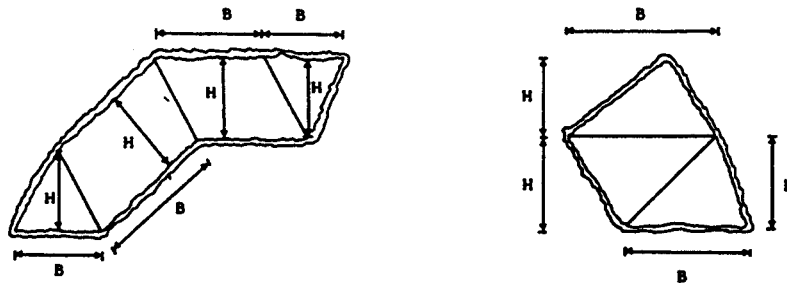


The circumference of a circle is $D \times 3.14$

The area of a circle is $R^2 \times 3.14$

3.14 is a scientific unit always used in relation to circles. Remember that $3.14 = \frac{22}{7}$ (approximately).

In practical circumstances a piece of land does not always have a regular shape. Then you can divide the land into regular pieces (rectangles, triangles and so on). You calculate the area of the pieces and all the areas together give the total area of the field.

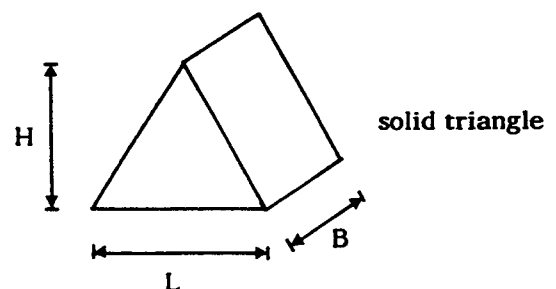


8.4 Volumes

We have already calculated the volume of a rectangular block. In a similar way we can calculate the volume of other figures.

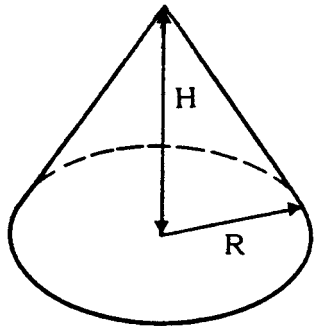
Volume of a **solid triangle**:

$$\frac{L \times B \times H}{2}$$

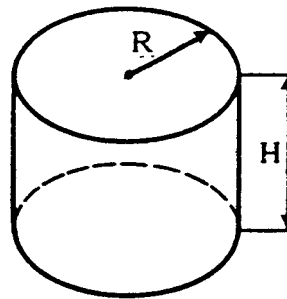


Cone: $\frac{R^2 \times 3.14 \times H}{3}$

Cylinder: $R^2 \times 3.14 \times H$



cone

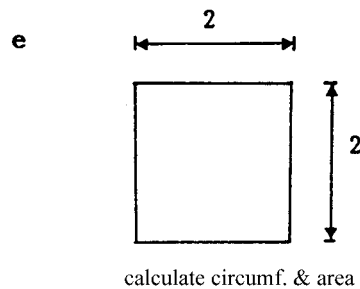
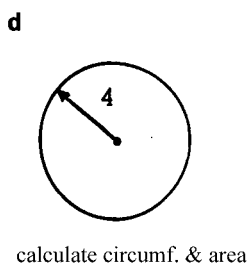
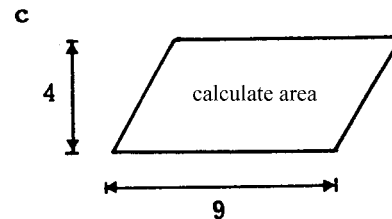
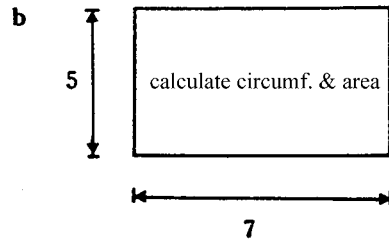
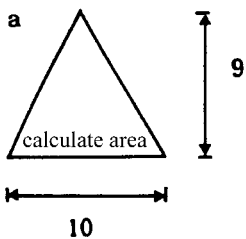


cylinder (silo!)

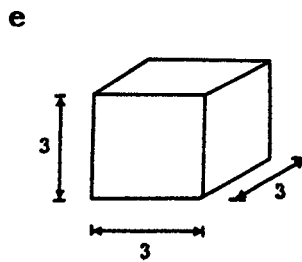
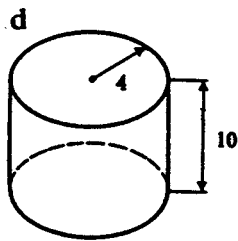
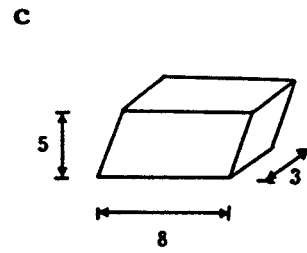
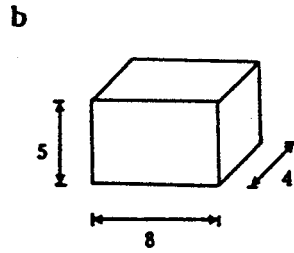
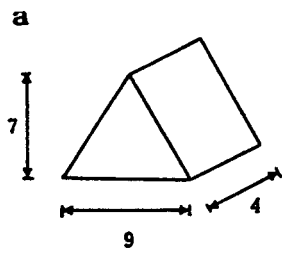
As the unit of volume we took the cubic metre (m³). It is also possible to express volume in litres. Like a 1 litre bottle, a tank containing 100 litres, or a bucket containing 5 litres. The relation between the cubic metre and the litre is as follows: 1 CUBIC METRE EQUALS 1000 LITRES.

Application

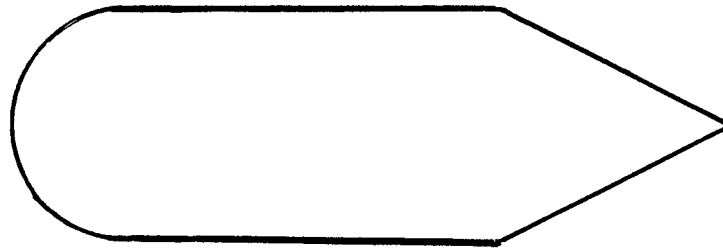
1 Calculate the area and the circumference of the following figures.



2 Calculate the volume of the following objects.



3 Calculate the area of the following field. Measure yourself, in whole centimetres, 1 cm = 100 m in reality. Express the area in square metres and in hectares.



4 Finish these calculations about circles:

Table 2: Circle calculations

radius	diameter	circumference
14 cm
...	7 cm	...
6 cm

5 Ali is digging a pit. He makes the depth of the pit 1 metre and the sides 0.70 by 1.40 m. How many cubic metres of earth does he get out of it?

6 You want to paint the walls of your house. One can of paint is enough for 4 m². Two walls are 4 m by 2 m and two are 6 × 2 m. In one wall is a door of 1 m by 1.80 and a window of 0.40 by 0.60 m. How many cans of paint do you need to buy?

7 Mister Ling has made a fish pond. The fish pond has a depth of 0.60 m and an area of 12 m². How many litres of water are there in the pond if Mr. Ling fills it up to 0.10 m below the rim (ground level)?

- 8 You have a plot of 8.80 m by 10 m.
You want to sow the whole plot with beans. You need 0.01 kg of seed per 4 square metres.
How much seed (in kg) do you need to buy?
- 9 Mr. Sakare wants to give 30 mm of water to his field.
His field is 2100 m².
How many cubic metres of water does he need?
How many litres is that?

NOTE:

The AgroSource edition PRACTICALS FOR BASIC LAND SURVEYING AND IRRIGATION contains many additional calculations, to be carried out in the classroom as well as in the field.

9 Proportions and scale

**Purpose: to understand proportions
to understand and to work with map scales**

Required background information: chapters 6 and 8, formulae and equations, circumference, area and volume.

Material needed: tape measure (self made if need be) & ruler

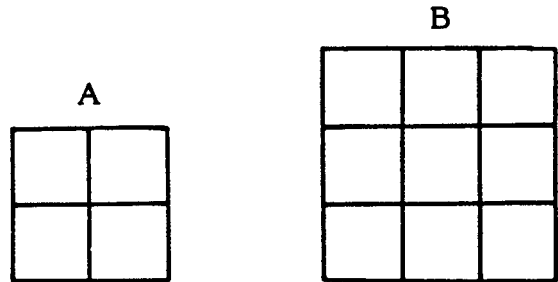
9.1 Introduction

Compare the two squares A and B.

The area of A is 4 cm^2 .

The area of B is 9 cm^2 .

We can say that the area of A is in the same ratio to the area of B as that of 4 to 9 or $A : B = 4 : 9$



Look at the trees.



The height of the big tree is 10 metres.

The other tree measures 2 metres.

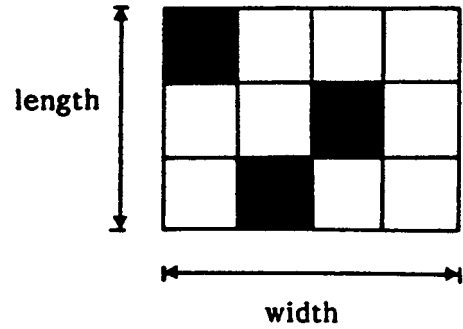
The height of the big tree and the height of the small tree are in the proportion of $10 : 2$. In our guide the trees measure only 5 and 1 cm. Their relative proportions, however, are according to reality.

So we can say: the height of the big tree and that of the small tree are in the proportion of $10 : 2$, or $5 : 1$, or $100 : 20$, or $0.5 : 0.1$, or $1 : 1/5$ or

Usually we write proportions in the smallest whole numbers. To find these we can divide or multiply both numbers by the same number.

Application

- Look at this area.
 The length is ... cm.
 The width is ... cm.
 The length and the width are in the proportion of ...
 In the area ... squares are drawn; there are ... black squares.
 The black and the white squares are in the proportion of ...
 The white and the black squares are in the proportion of ...;
 the white squares and the black and white squares together are in the proportion of ...



- Write these proportions as simply as possible:

$$30 : 40 = \dots \qquad 0.9 : 0.3 = \dots \qquad 22 : 7 = \dots$$

$$105 : 15 = \dots \qquad 1 : 0.25 = \dots \qquad 1\frac{1}{3} : 5\frac{1}{3} = \dots$$

Proportions can be written in this form $A : B = C : D$

Look at the example with the trees.

We saw big tree : small tree = 5 : 1

Suppose that we only know that the small tree measures 2 metres in reality.

How do we calculate the height of the big tree?

If we use $A : B = C : D$ we can say:

$$A = \text{big tree} \qquad C = 5$$

$$B = \text{small tree} \qquad D = 1$$

We want to know **A**. We change the equation $A : B = C : D$ and we write $A/B = C/D$. We can multiply both sides of the equation by the same number.

$$\text{This gives } \frac{A \times B}{B} = \frac{C \times B}{D} \text{ so } A = \frac{C \times B}{D}$$

$$\text{Now we can fill in the equation; big tree} = \frac{5 \times 2}{1} = 10 \text{ metres.}$$

Suppose that we only know the height of the big tree (15 metres). Then we have to change the equation in another way as we want to know **B**.

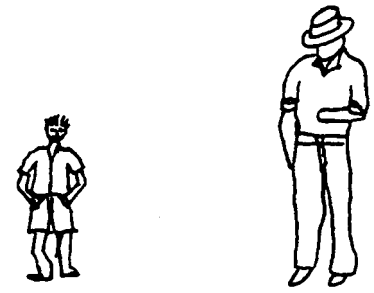
$$B = \frac{D \times A}{C} \text{ (try this yourself)}$$

$$\text{Now we can fill in the equation; small tree is } \frac{1 \times 15}{5} = 3 \text{ metres}$$

Application

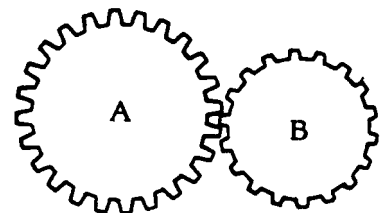
- | | | |
|-------------------|-------------|-------------|
| $A : B = 1 : 5$ | $A = 3$ | $B = \dots$ |
| $P : Q = 2 : 3$ | $P = \dots$ | $Q = 300$ |
| $F : G = 1 : 100$ | $F = \dots$ | $G = 0.5$ |

- 4 Here you see a drawing of a father and a son.
 Measure the heights of the father and the son to know the proportion of one to the other.
 In reality the father measures 1.75 m.
 What is the height of the son?

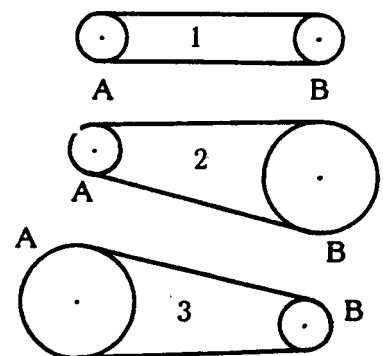


- 5 A car runs 1 : 10. This means that it uses 1 litre of fuel to cover a distance of 10 km.
 How much fuel does the car need to cover 100 km?
 How far can the car go on 21 litres of fuel?
 Suppose that the capacity of the tank is 40 litres. You want to drive from Biharamulo to Morogoro, which is about 1100 km.
 How many times will you have to fill the tank?
 How much fuel will be left in the tank when you arrive?
- 6 Some combustion engines use mixed lubrication which consists of petrol and oil in a fixed proportion.
 Suppose that your engine uses a mixed lubrication 1 : 24.
 This means that oil and petrol are in the proportion 1 : 24.
 If you have 4.8 litres of petrol, how much oil (in litres) do you need to make the right mixture?
 Using 2 litres of oil you can make ... litres of mixed lubrication.
 To make 7.5 litres of mixed lubrication you need ... litre of oil and ... litres of petrol.
- 7 A carbaryl solution has to be sprayed to control leafhoppers.
 In the solution the proportion of carbaryl to water is 9 : 10 000
 How much carbaryl (in kg) do you need if you use 100 litres of water?
 (1 litre of water is 1 kg).

- 8 A and B are cogwheels.
 You can count the teeth, they are in the proportion of 24 : 18.
 A turns round making 240 revolutions per minute (rpm).
 How many rpm does B make?

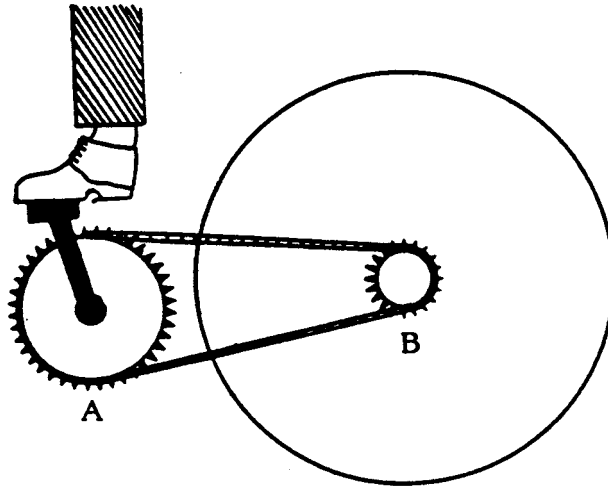


- 9 Wheel A turns and makes wheel B turn by means of a belt.
 Which statement applies to which situation:
- A and B move with equal speed
 - A moves faster than B
 - B moves faster than A



Can you give applications of this transmission principle?

- 10 Mr. Bengal makes his bike go forward by turning cogwheel A.
 The movement of A is passed on to wheel B by means of a chain, see next page.



- Why does Mr. Bengal move cogwheel A instead of cogwheel B?
- Count the teeth of both cogwheels.
- Cogwheel A makes 40 rpm. How many rpm does cogwheel B make?
- The radius of cogwheel B is 5 cm.
The radius of the 'whole' wheel is 35 cm.
How big (in cm) is the circumference of cogwheel B?
How big is the circumference of the whole wheel (see chapter 8)?
- How fast does Mr. Bengal ride, in km/hr?
To find this out you only need to know the circumference of the big wheel and the number of rpm it makes.

9.2 Map scales

Maps can be very useful if you know how to use them.

Maps are usually drawn to scale. The scale of a map is the ratio between distances on the map and distances in reality.

A map scale of 1 : 50 000 means that 1 cm on the map is in reality 50 000 cm or 500 m.

Application

11 If the map scale is

1 : 200,	2 cm on the map represents ... m
1 : 600,	12 m is represented by ... cm on the map
3 : 10 000,	9 mm on the map represents ... m
1 : 10 000,	965 m is represented by ... cm on the map

This map scale is sometimes indicated by means of a bar. Comparison with a ruler gives the map scale.

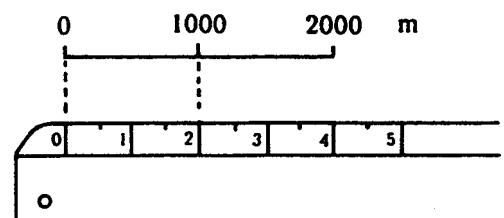
Example:

1000 m corresponds to 2 cm

1 cm corresponds to 500 m

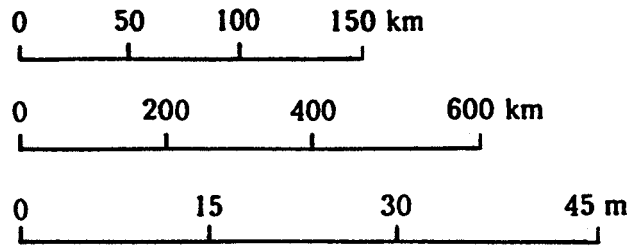
500 m = 50 000 cm

The scale is 1 : 50 000



Application

12 Use your ruler to calculate the following map scales



13 Use the map scales to design bars

1 : 10 000

1 : 10

1 : 450

14 See the maps on the pages concluding this chapter. The first one shows the polders in Holland which were reclaimed from the sea in recent times.

In the past the North Sea moved freely into the 'IJsselmeer', right up to Amsterdam. Since the construction of the enclosing dam (dyke, dike) around 1930 the water in the IJsselmeer has turned fresh. And this dam made it possible to start working on the polders. First the dykes had to be built, in the water; the pumping stations did the rest.

By now there are four polders, with rich arable land, on what used to be a (shallow) seabottom.

The fifth polder (the Markerwaard) may not become reality after all, mainly because fresh water is becoming as valuable as dry land.

A 'polder' is a piece of land reclaimed from the sea or a (fresh water) lake and surrounded by a dyke (often with sheep grazing on the dyke). Where a polder is bordering the sea, the dyke has to be enormously strong. Some polders are large and others smaller. Holland has many polders, some dating from centuries ago when the first (wooden) windmills were built. Amsterdam Airport lies in a polder which was reclaimed from a large fresh water lake in the 19th century. This polder is several metres below sea level, just like other polders in Holland.

Questions:

a 1 cm on the first map represents in reality ... km.

b What is the approximate length (in km) of the enclosing dam?

Note:

Holland is a country with lots of bicycles around. On the enclosing dam is a free bike path all along the dam (and a motor road of course). With a strong headwind blowing, for cyclists the going is really tough! The ferry between Enkhuizen and Stavoren, taking pedestrians & cyclists only, is then a pleasant alternative. By the way, there is a signposted bike route all around the IJsselmeer and passing through Amsterdam, by which one can avoid motor traffic and appreciate the (typical Dutch) countryside.

15 The map displayed two pages further shows the so-called Noordoostpolder (the second polder in this land reclamation scheme); here the seabottom turned into arable land about 50 years ago.

'meer' = lake (fresh water)

'zee' = sea (salt water)

'vaart' = canal

The total surface area of this polder is 48.000 ha.

All villages, towns, roads and canals in the polder at first existed only on the drawing board, and came into being after the land had fallen dry.

The small towns Lemmer, Kuinre, Blokzijl and Vollenhove used to have a harbour with a fishing fleet. They are still very picturesque but no longer 'look out on the sea'.

Urk (on the left of the map) used to be an island. It still has a thriving fishing industry and is involved in fisheries projects in Ethiopia.

Questions:

a If you travel from Lemmer to Urk by the road past Rutten, Creil and Espel, what distance do you then cover, in km (approx.)?

b What is the approximate area of the piece of land bordered by the road linking Emmeloord to Bant to Creil to Espel to Emmeloord, in ha?

The farms in this polder measure 24 or 48 ha; they are rainfed farms. Emmeloord has various agricultural schools and training centres. The town of Dronten in the following polder has an Agricultural College and a STOAS (Agricultural) Teacher Training College.

16 Draw a map of one wall (with a door and a window) of the room you are in now.

As follows.

First measure the length and the width of the wall, the door and the window, with a tape measure.

Then you have to decide on the scale you will use for your map.

Suppose that the wall measures 5 m; then you could draw it as 5 cm which gives a scale of ...

Then you can start making the map. Try to make it detailed.

Finally you must indicate the scale of the map by making a bar at the bottom left hand corner.

17 John's garden measures 8.40×5.60 meters.

John makes a map of his garden, with a scale 1 : 20.

What will be the length and width of the garden, on the map?

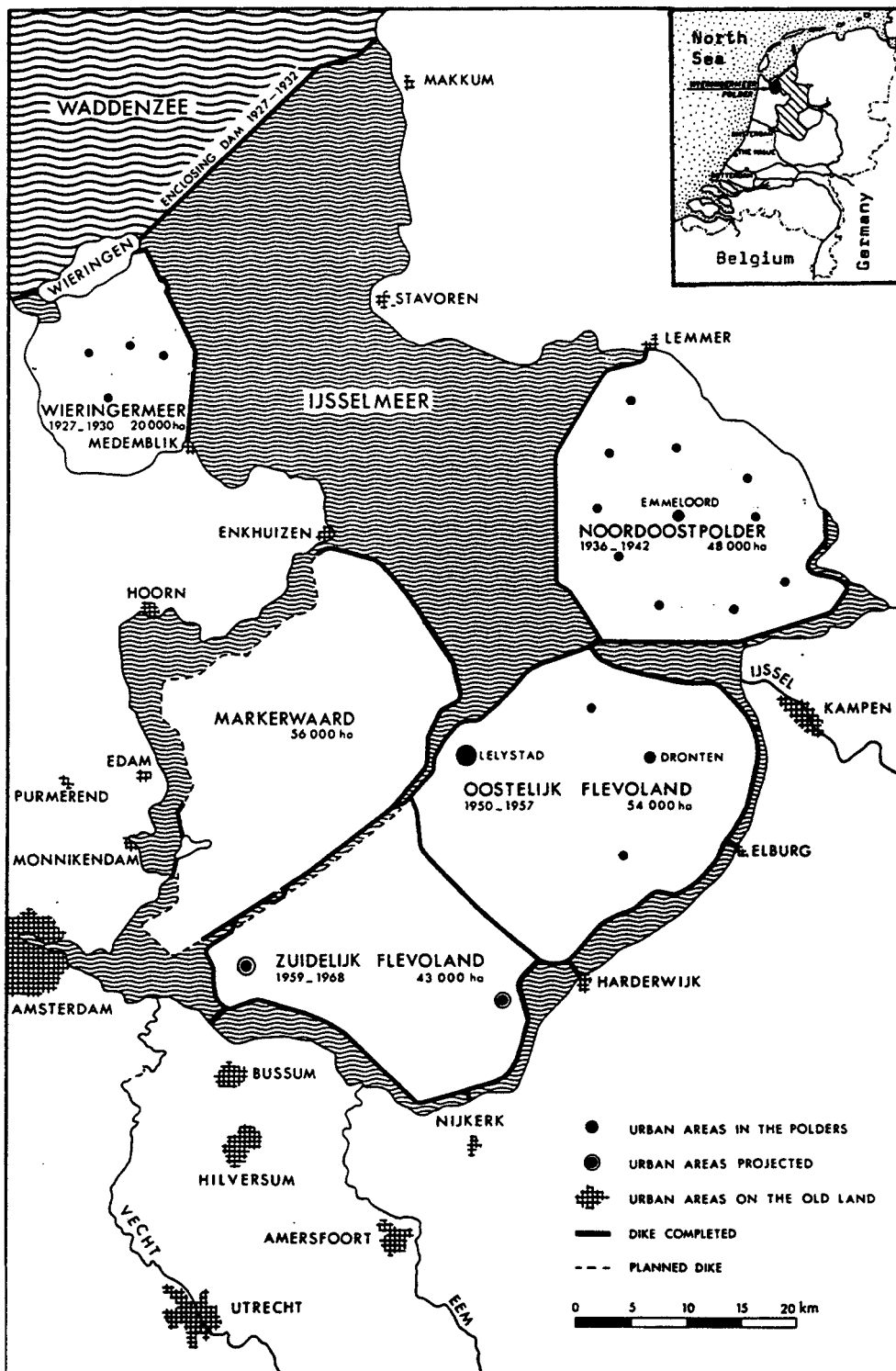


Figure 1: Polders reclaimed in the 20th. century in the Netherlands

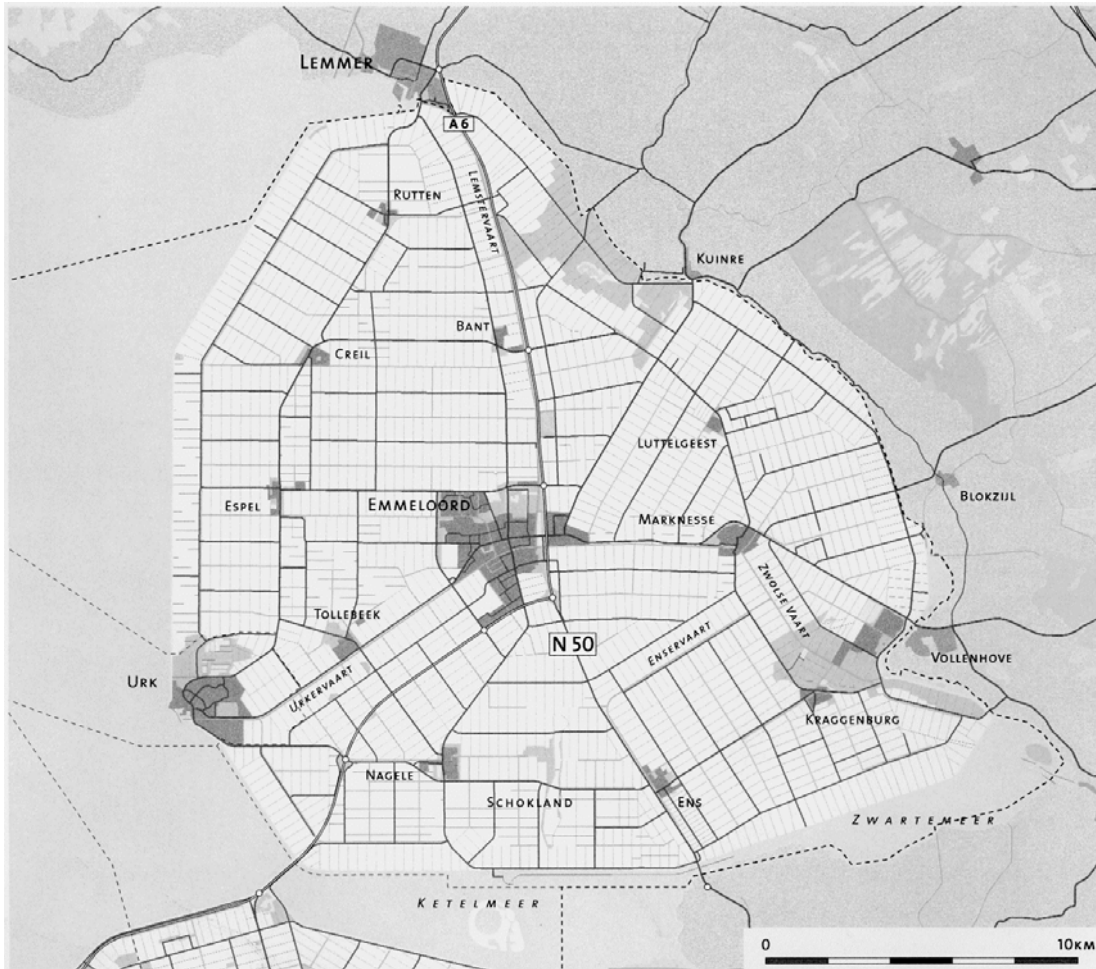


Figure 2: The Noordoostpolder

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10 Graphs, tables and diagrams

Purpose: to make you familiar with different kinds of graphs, tables and diagrams

Required background information: chapter 2, percentages.

10.1 Introduction

Data can be displayed in many ways. Very often you will find them in graphs, tables and diagrams. In this chapter you will first see how to make graphs. Then different graphs and diagrams are shown.

10.2 Making a graph

When you make a graph you start by drawing the axes (singular axis).

A level or horizontal axis, which is usually used for independent variables such as time and age.

And an upright or vertical axis, which is usually used for dependent variables such as growth and weight.

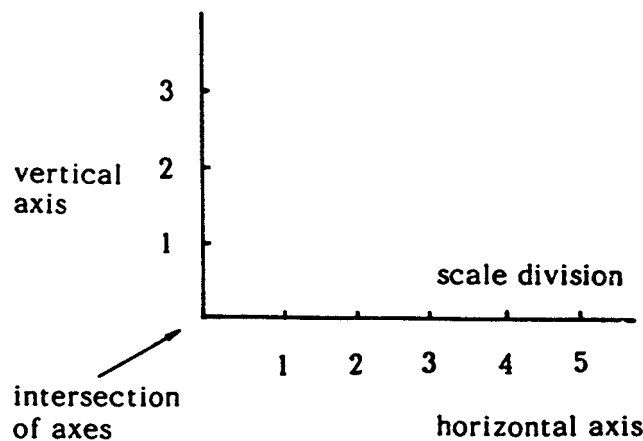
Beside the axes you write the variables which you use, together with the units in which they are expressed.

Example:

Suppose that you make a graph of the average daily temperature during one month. How would you name and place the variables on the axes? What units would you use?

'Time' is an independent variable, it should be on the horizontal axis and expressed in days.

'Temperature' often depends on the time of the year, it is a dependent variable, it should be on the vertical axis and expressed in degrees centigrade (Celsius).



On the axes you make graduations. The axes can have different graduations.

Often the graduation starts with 0, at the intersection of the axis, but this is not a rule.

The graduations have to be chosen in such a way that you can plot all the values you have.

When the graph has to be very accurate you should use special graph paper (with squares).

When you have drawn the axes and named and graduated them, you can fill in the data which you have. The last thing is to connect the marks on the graph by a line.

Now an example:

In this table a woman has noted every month how much her baby weighs.

Table 3: Baby weight increase in time

weight in kg	age in months
4	2
4.5	3
5.2	4
5.7	5
6.1	6
6.4	7
6.8	8
7.1	9
7.4	10
7.7	11
7.9	12

For a better display of the growth of the child we can make a graph from the data.

First the axes. The variables we use are age and weight. 'Age' is an independent variable, so it will be placed on the horizontal axis.

The weight depends on the age and will be placed on the vertical axis.

'Age' is expressed in months, 'weight' in kg.

Now we can start filling in the data.

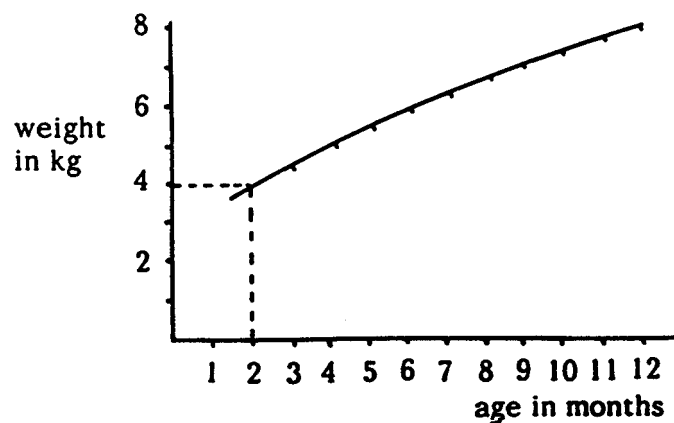
The first independent variable is 2 months.

The corresponding weight is 4 kg. We plot this on the graph.

The second variable on the horizontal axis is 3 months; the corresponding weight is 4.5 kg. We plot this on the graph.

And so we go on, plotting all the available data.

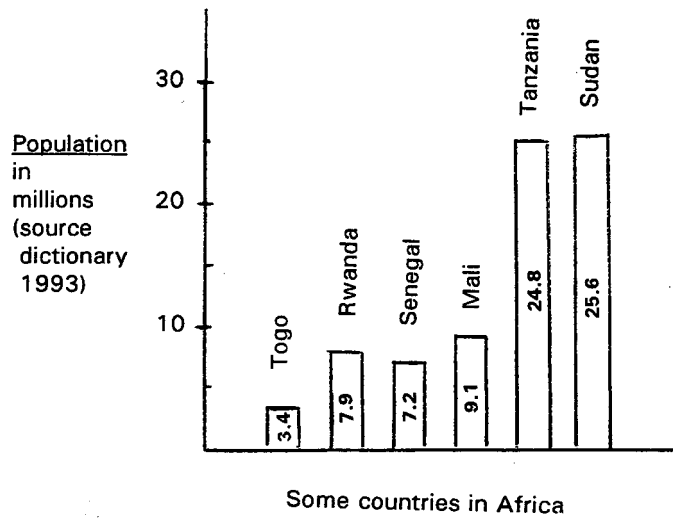
The last thing we have to do is to draw a line connecting all the marks. This line should be smooth without sharp corners.



Is a weight of 7.9 kg normal for a child of 12 months?

10.3 Other ways to display data

Columnar diagram

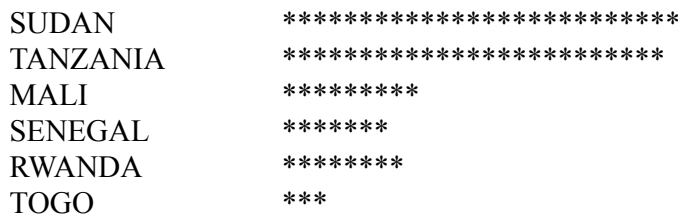


Questions:

- a How many inhabitants does Tanzania have in this diagram?
- b Niger has 7.5 million inhabitants; where would you place it in this diagram?
- c The data are from a dictionary printed in 1993; how many inhabitants are there by now (= early 21st century)?

Picture graph

In this picture graph the same data are represented as in the columnar diagram on the previous page.

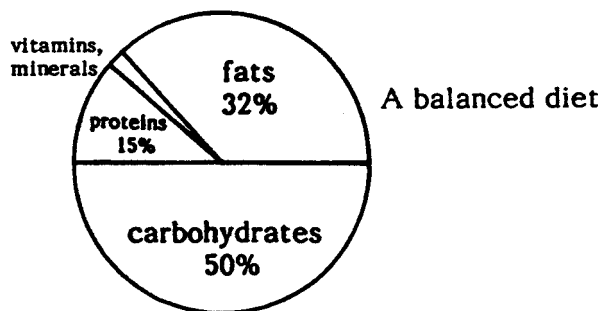


Questions:

Each * in the picture graph represents how many inhabitants? How could this picture graph be made more accurate?

Circular diagram

A survey of percentages is often expressed in a circular diagram.



Questions:

- a What kind of food is eaten most in a balanced diet?
- b What is the percentage of minerals and vitamins in a balanced diet?

Application

1 Maize meal consists of:

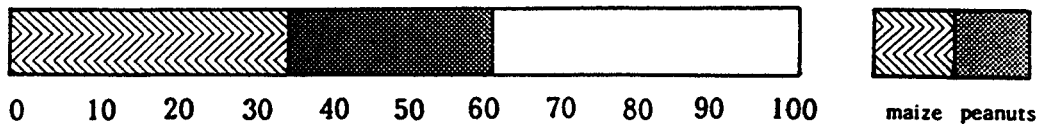
carbohydrates	75 %
proteins	9 %
fats	4 %
water	11 %
minerals and vitamins	1 %
	----- +
total	100 %

Make a circular diagram using these data.

If someone only eats maize meal, which food constituents are then in short supply?

Rectangular diagram

Percentages can also be expressed in a rectangular diagram.



A farmer has planted his land with:

maize	35 %
peanuts	25 %
sweet potatoes	25 %
cowpeas	15 %
	----- +
total	100 %

Question: can you finish this diagram by adding sweet potatoes and cowpeas?

Application

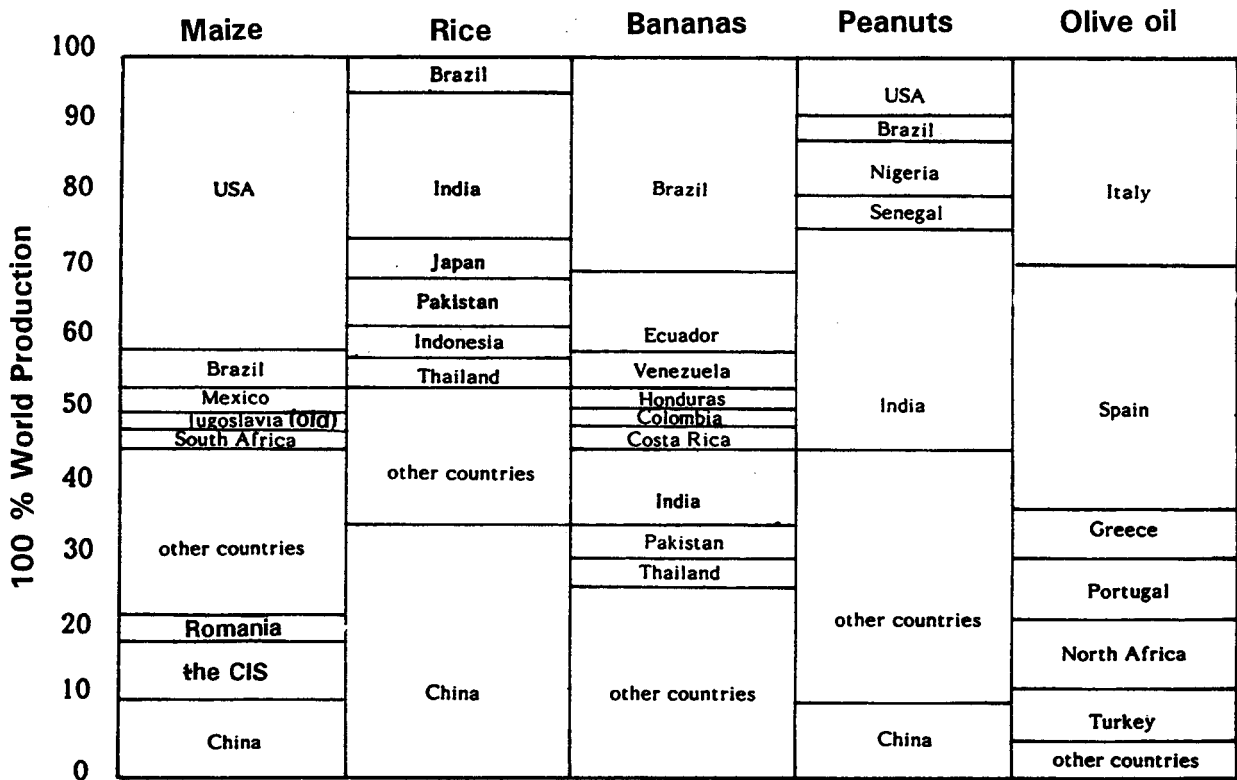
- 2 Sorghum, variety Lintel

Table 4: Fertilizer application and sorghum yield

Nitrogen application in kg/ha	Sorghum yield in kg/ha
0	1,220
50	1,780
100	2,110
150	2,320
200	2,530

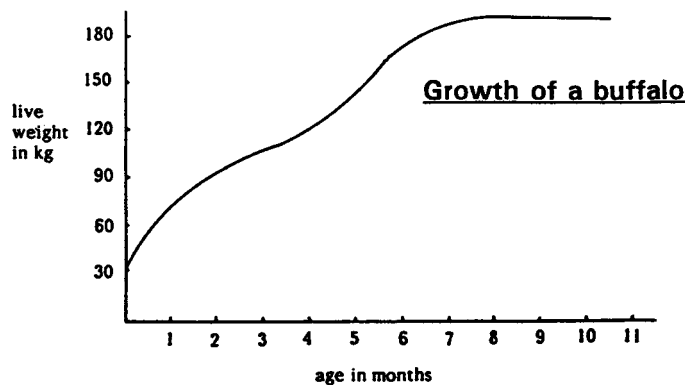
- a Make a graph of the above data.
 - b Do you start both axes at zero?
 - c Could you make a rough estimation of the yield if 75 kg of nitrogen were applied?
 - d How much costs 1 kg nitrogen and what is the value of 1 kg sorghum (enquire locally). How much fertilizer would you apply in this case if you had the money?
- 3 Try to find the data of a crop fertilizer trial that has been carried out locally. Make a graph of the data.

4 The diagram shows the 'major production areas' of certain important crops. On the vertical axis is 'world production' and on the horizontal axis are the 'major production areas'. This gives an idea (the data have indicative value only).



Questions:

- How much rice does India produce (expressed as a percentage of world production)?
- What does it mean if a country produces 100% of the world production?
- Which product is not produced in Brazil (ignore 'other countries')?
- Which products does China produce?
- Which countries have the biggest share in the world production of the products shown in the table?



Questions:

- How much did the buffalo weigh when it was 4 months' old?
- How much did the buffalo weigh when it was born?
- During which period did the buffalo grow most? How can you see that in the graph?

- d* During which period did the buffalo grow least? How can you see that in the graph?
- e* What was the average growth of the buffalo in the first half year?
- f* Is this a realistic growth curve for a buffalo?

5 In a village all the land is owned by 5 farmers:

- farmer A has 0.5 ha
- farmer B has 1.5 ha
- farmer C has 4.0 ha
- farmer D has 2.5 ha
- farmer E has 1.5 ha

Altogether they have ... ha; this we call 100%

- a* Make a circular diagram to show the division of land in the village.
- b* What other medium is suitable for showing the division of land between these farmers?

6 A millet crop in India.

Table 5: Crop treatment in millet

Treatment after sowing	Yield in kg/ha
no weeding during 10 days	1,417
no weeding during 20 days	1,379
no weeding during 30 days	568
no weeding during 40 days	538
no weeding during 50 days	229

- a* Make a graph using the data which are given above.
- b* Which variable do you use for the horizontal axis?
- c* In this experiment there was also a control treatment: no weeding at all. The yield of this control was 131 kg/ha. Can you include this datum in the graph?

11 Time

Purpose: to learn to cope with time (in the 'Western' way)

Say you have a ewe (sheep) and she is mated on 15 July; you know that she will lamb in 145 days. When will be the day she lambs?

Answer: July has 31 days and so has August, but September has 30 days, October 31 days and November 30 days.

From 15 July until the end of July is 16 days, add 31 days of August, 30 days of September, 31 days of October and 30 days of November. Altogether this gives 138 days.

The difference between 145 and 138 days is 7 days. So the 7th day of the next month, December, will be the (expected) day of lambing.

A rule of thumb is that pregnancy with sheep lasts 5 months less 5 days.

11.1 Rules for counting time

Every week has 7 days.

Months have different numbers of days:

January	31	July	31
February	28 or 29	August	31
March	31	September	30
April	30	October	31
May	31	November	30
June	30	December	31

A year has 365 days if February has 28 days and 366 days if February has 29 days. February normally has 28 days but every four years February has 29 days. We call these years leap years. A leap year occurs every four years, when the year is divisible by 4.

Example: 1994 is not divisible by 4 so it was a normal year. But 1996 and 2000 are divisible by 4, so these years have been leap years. The year 2000 had 366 days and February in that year had 29 days.

Application

- 1 From the first day of May until the end of November is how many months? And how many days?
- 2 Which date is it 5 weeks from now? Which date was it two weeks ago?
- 3 Today is 25 March. Your hen begins to brood her eggs. After 21 days the eggs will hatch. Which date will that be?
- 4 How many days is it from the 16th of August until the 4th of September?

A century consists of 100 years. Now we live in the 21st century. 1566 was in the 16th century.

Every day consists of 24 hours; one hour has 60 minutes and one minute has 60 seconds.

Question: how many seconds make one day?

In the middle of the night the first hour begins and the day ends in the middle of the next night (after 24 hours). Then the next day begins.

When it is half past ten we write this as 10.30 h. Before the point we write the hours and after the point the minutes. So in this case 10 hours and 30 minutes.

The middle of the day is at 12.00 h. Two o'clock in the afternoon we write as 14.00 h or 2 h p.m. (or PM).

p.m. means 'post meridium' = after mid day; the opposite is a.m. which means 'ante meridium' = before mid day.

Question: when it is 11.45 h and in 40 minutes you have an appointment, at what time will that be?

Answer: $11.45 + 40 \text{ minutes} = 11.85 \text{ h}$. But one hour has only 60 minutes so $11.85 \text{ h} = 11.60 + 25 \text{ minutes}$. That is 12 h and 25 minutes = 12.25 h.

Application

- 5 School begins at 14.00h; now it is 7.30 h. How much time is there before school begins?
- 6 It is now 8.40 a.m. and you have one and a half hour to finish your exam. At what time does the exam end?
- 7 You earn one coin per hour for your work.

You worked

Monday from 7.00 a.m. until 6.00 p.m.

Tuesday from 6.30 a.m. until 6.00 p.m.

Wednesday from 7.00 a.m. until 5.00 p.m.

Thursday from 6.00 a.m. until 1.00 p.m.

Every day you rested from 1.00 until 3.00 in the afternoon, without pay.

How much did you earn?

12 Unusual measurements

Purpose: to learn to measure without the use of special measuring instruments

Materials needed: tape measure, measuring glass (litre measure), rope or piece of string, scales, various tin cans and buckets.

12.1 Introduction

Sometimes you find yourself in a situation in which you have to measure certain things without having measuring instruments.

Examples:

- You want to know the approximate area of a farmer's land and you do not have a tape measure on hand.
- You want to plant potatoes 50 cm apart and you have nothing to measure this distance with.
- You bought 50 m of rope. At home you want to check whether you got the right length. How can you check the length of a rope quickly?

The way to deal with such situations is to learn to know your body measurements and to use them whenever necessary.

The stride

Exercise:

- Mark a length of ten metres.
- Go and walk this length taking your usual strides (repeat this).
- How many of your strides are there in 10 m?
- And how many in 25 m (if you can walk this)?

Retain these numbers!

You can also use your feet by placing one foot right in front of the other.

How long is your foot?

How many of your feet do you need for one metre?

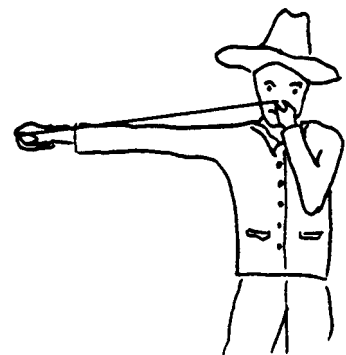


The hand

The hand is very useful for making small measurements.

Exercise:

- Stretch your hand to measure your fingerspan, the distance between the tips of your little finger and your thumb.
- Measure the distance between the thumb and forefinger. Both are stretched.
- Measure the distance between middle finger and thumb. Both are stretched.
- Do you have a finger that measures exactly 5 cm?



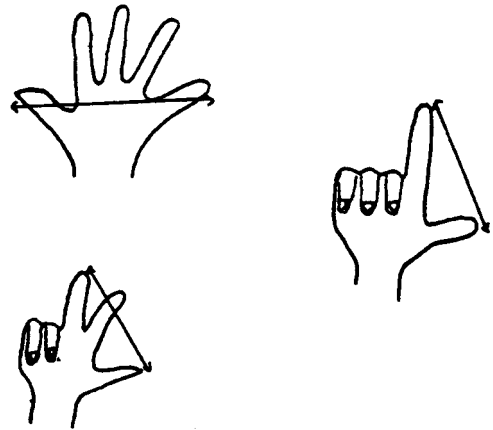
If any of the distances you measured so far measures 5 cm or a multiple of 5 cm, this can be useful for measuring small distances such as seed placement, planting distances within and between rows.

The arm

Your forearm can be useful too as it measures about 40 cm (try this). Ropes and strings can be measured as shown.

Exercise:

- Take a piece of string of 1 metre.
- Take one end between thumb and forefinger of one hand. Take the other end in the same way in your other hand.
- Stretch one arm and find a spot on your body which the other end of the string reaches when you keep it stretched. This could be your nose or shoulder.
- Now try to measure a string or rope in the same way. Check the results that you got by measuring the string with a tape measure.



Volumes

Volumes can be measured accurately with a measuring glass.

Not everybody has a measuring glass all the time and that is why it is useful to learn to use tins and buckets, which are everywhere, to measure volumes accurately.

Exercise:

- Measure the volume of various containers, including beer tins, buckets, oil drums or whatever containers you may have on hand.

Weights

Fertilizers, herbicides and insecticides are usually measured in kg, lb and g.

If there are no scales to measure with, we must invent another way to measure the amount we want.

This can be very useful in:

- The feeding of animals. Especially if you feed a concentrate it is necessary to feed the right amount as concentrates are expensive.
If you know how much to feed you should try to find a tin or can that holds exactly the amount that must be fed.
- The application of organic fertilizers (manure, for instance). Probably you need a bucket or wheelbarrow for this purpose.
- The application of chemical fertilizers. Especially when you fertilize each plant individually it is important not to give too much. Fertilizers applied in too great a quantity can do harm!
So before you apply fertilizer to an individual plant, try to find the right container. This can be a spoon or crown cap or
- The preparation of a solution. Herbicides or insecticides are often applied as solutions. These solutions usually consist of some grams or powder dissolved in water. It is very important to use the exact amount of pesticide. If not, money may be wasted, or the result may not be what it should be, or you may unnecessarily pollute the environment.

Question: do you know any other applications of the use of tins, buckets and spoons?

Some volumes which are handy to know:

tea spoon =	1.5 to 3 ml
table spoon =	12 to 15 ml
dessert spoon =	about 8 ml
one drop of water =	about 0.04 ml

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13 Conversion of units

Purpose: to convert units from one measurement system into another for countries where the metric system is not the only one in use

13.1 Introduction

Two systems of units are commonly used worldwide: the old 'imperial' (British) system and the metric (S.I. or International) system. The metric system is the officially adopted system almost everywhere. But for historic reasons the 'imperial' system is still quite popular in certain countries.

In both systems three basic units – length, mass and time – are in use, from which all other units are derived.

Both systems use the second as unit of time.

However, they differ in the units of length and mass; the imperial system uses feet and pounds whereas the metric system uses metres and kilograms.

Besides the units mentioned, other units exist, such as gallons, acres, inches, miles and pints, which also belong to the imperial system.

Other differing units can be found in the U.S.A. (for instance, US gallons) and locally, in almost every country.

In **table I** you will find **conversion factors** for the conversion of units from the imperial system into the metric system and vice versa.

As you will have already noticed, in this guide we generally use the metric system units.

Example: to convert 2 litres into pints, multiply by 1.8

$$1.8 \times 2 = 3.6 \text{ pints}$$

Application

1	2	metre	= ... × ... = ...	feet
	3	mile	= ... × ... = ...	kilometre
	3.1	sq.mile	= ... × ... = ...	sq.kilometre
	6	imp.gallon	= ... × ... = ...	litre
	10	long ton	= ... × ... = ...	metric ton
	0.1	hectare	= ... × ... = ...	acre
	8.3	inch	= ... × ... = ...	centimetre

If you want to convert miles into yards, you will find that there is no conversion factor in the table. In this case you will have to use several conversion factors to find the answer.

Example: to convert 6 miles into yards

$$\begin{aligned} 6 \text{ miles} &= 6 \times 1.6 \text{ km} = 9.6 \text{ km} = 1000 \times 9.6 \text{ m} = 9600 \text{ m} \\ &= 1.1 \times 9600 \text{ metres} = 11\,000 \text{ yards or} \\ 6 \text{ miles} &= 6 \times 1.6 \times 1000 \times 1.1 = 11\,000 \text{ yards} \end{aligned}$$

Application

2	0.6 sq.m	= ... sq in	0.1 km	= ... in
	5 acre	= ... sq m	100 sq yd	= ... acre
	5 ft	= ... cm	0.01 long ton	= ... kg

When applying chemicals or fertilizers it is often necessary to change pounds per acre (lb/acre) into kilograms per ha (kg/ha) or ounces per square yard (oz/yd²) into grams per square metre (g/m²) or the other way round.

Example: to convert 100 lb/acre into kg/ha

first change lb into kg by multiplying by 0.45
 then change acre into ha by multiplying by 0.40
 so 100 lb/acre = $100 \times 0.45 / 0.40 = 100 \times 1.1 = 110$ kg/ha

Application

3 lb/acre = 0.45/0.40 kg/ha	0.1 lb/acre = ... kg/ha
oz/yd ² = ... g/m ²	0.3 oz/yd ² = ... g/m ²
kg/ha = ... lb/acre	330 g/m ² = ... oz/yd ²
g/m ² = ... oz/yd ²	10 kg/ha = ... lb/acre

In **table II** you will find the most frequently used units of the metric system and their relationships.

Examples:

a 1 hm = ... cm
 in the table you see that it takes 4 steps to go from hm to cm
 each step means that you have to multiply by 10
 so 1 hm = $10 \times 10 \times 10 \times 10 = 10^4 = 10\,000$ cm

b 0.2 m² = ... km²
 in the table you see that it takes 6 steps to go from m² to km²
 each step means that you have to divide by 10
 so $0.2 \text{ m}^2 = \frac{0.2}{10 \times 10 \times 10 \times 10 \times 10 \times 10} = \frac{0.2}{10^6} = 0.2 \times 10^{-6} = 2 \times 10^{-7} \text{ km}^2$

Application

4 1100 mm = ... dm	1 m ² = ... cm ²
0.5 kg = ... g	600 dm ³ = ... m ³
60 ha = ... hm ²	0.06 ha = ... m ²
500 m ² = ... are	0.3 m ³ = ... litre
50 cm ³ = ... cl	300 dl = ... dm ³

The **temperature** is expressed in 3 different units: degrees Fahrenheit (°F), degrees Celsius (°C; centigrades) and degrees Kelvin. Centigrades are officially adopted almost everywhere.

To change F into C: $C = \frac{5}{9} \times (F - 32)$

To change C into F: $F = \frac{9}{5} \times (C + 32)$

The ‘Kelvin’ is a unit not used in daily life, it is a ‘scientific’ unit.

To change C into K: add 273

To change K into C: subtract 273

In this guide we generally use ‘degrees centigrade’ (°C).

Examples:

$$50\text{ }^{\circ}\text{F} = \dots\text{ }^{\circ}\text{C}$$

$$50\text{ }^{\circ}\text{F} = \frac{5}{9} \times (50 - 32) = 10\text{ }^{\circ}\text{C}$$

$$50\text{ }^{\circ}\text{C} = \dots\text{ }^{\circ}\text{K}$$

$$50\text{ }^{\circ}\text{C} = 50 + 273 = 323\text{ K}$$

Application

$$5\quad 45\text{ }^{\circ}\text{F} = \dots\text{ }^{\circ}\text{C}$$

$$85\text{ }^{\circ}\text{C} = \dots\text{ }^{\circ}\text{F}$$

$$290\text{ K} = \dots\text{ }^{\circ}\text{C}$$

$$315.5\text{ K} = \dots\text{ }^{\circ}\text{C}$$

$$99\text{ }^{\circ}\text{F} = \dots\text{ }^{\circ}\text{C}$$

- 6 What is the volume in m^3 of:
4 acres \times 2 inches
2 acres \times 4 inches
10 sq feet \times 5 inches
- 7 A farmer has got 6 lambs. The weight of the lambs is respectively: 20 lb; 500 oz; 19 lb; 22 lb; 550 oz; 11 kg.
How much do all lambs weigh together, expressed in the metric system (in kg)?
What is the average weight, expressed in the imperial system (lb)?
- 8 A farmer applied urea to her land.
She used 100 lb for her 2 acres.
An extension agent came to visit her and asked her how many kg of urea she had used and how much that would have been per hectare. What did the farmer answer (she is super in arithmetic and units!)?
- 9 Mr Ali has a field A measuring $20 \times 50\text{ m}$ and it produces 120 kg of groundnuts. Mr Benjedid has a field B $50 \times 50\text{ m}$ and it produces 250 kg groundnuts. Which field is the most fertile, i.e. has the highest yield per unit of area?
We take the 'are' as unit of area; 1 are = 100 m^2 .

Table 6: Some conversion factors

metric system	multiplied by .. gives (conv.factor)	imperial system	imperial system	multiplied by .. gives	metric system
Length			length		
centimetre (cm)	0.40	inches (in)	in	2.5	cm
metre (m)	39	inches (in)	in	0.025	m
metre (m)	3.3	feet (ft)	ft	0.30	m
metre (m)	1.1	yards (yd)	yd	0.91	m
kilometre (km)	0.62	miles	mile	1.6	km
Area and square (sq) measure			area and square (sq) measure		
sq cm	0.15	sq in	sq in	6.5	sq cm
sq m	11	sq ft	sq ft	0.093	sq m
sq m	1.2	sq yd	sq yd	0.84	sq m
sq km	0.39	sq miles	sq mile	2.6	sq km
hectare	2.5	acres (a)	a	0.40	hectare
Volume			volume		
litre (l)	0.26	US gallons	US gallon	3.8	l
litre (l)	0.22	Imp gallons	Imp gallon	4.5	l
litre (l)	1.8	pints	pint	0.58	l
litre (l)	0.9	quarts	quart	1.1	l
Weight			weight		
gram (g)	0.035	ounces (oz)	oz	29	g
kilogram (kg)	35	ounces (oz)	oz	0.029	kg
kilogram (kg)	2.2	pounds (lb)	lb	0.45	kg
metric ton (= 1000 kg)	0.98	long tons	long ton	1.02	metric ton

NOTE:

The figures in the table have been rounded off for the sake of convenience; for instance, it is more accurate to write 1 cm = 0.39 inch (instead of 0.40).

Table 7: The Metric System

10	km	*	hm	*	dam	*	m	*	dm	*	cm	*	mm
10	kg	*	hg	*	dag	*	G	*	dg	*	cg	*	mg
10	kl	*	hl	*	dal	*	l	*	dl	*	cl	*	ml
100	km ²	**	hm ²	**	dam ²	**	m ²	**	dm ²	**	cm ²	**	mm ²
1000	m ³		***		dm ³		***		cm ³		***		mm ³
	kl	*	hl	*	dal	*	litre	*	dl	*	cl	*	ml

Something to always remember:

1 sq km = 1,000 × 1,000 m
 1 sq hm = 1 hectare = 100 × 100 m
 1 sq dam = 1 are = 10 × 10 m

1 ha = 100 are
 1 are = 100 m²

Application

10 Insight with regard to measures (metric system).

Fill in the right measure:

- the height of our classroom is about 30
- the volume of a coca cola tin is about 3
- the weight of a bread is about 0.8
- the surface area of a student classroom table is about 35
- the volume of a bucket is about 7000

An empty page for more examples and applications:

14 Specific weight

Purpose: to note the difference in weight of various kinds of material

14.1 Introduction

The weight of a bag filled with feathers is much less than the weight of the same bag filled with soil. Every kind of material has a different weight per cubic metre (in general: unit of volume). This we call the **specific weight** of one cubic metre of a material. It is applied in all kinds of calculations.

For example:

You have a bin measuring 1 metre by 0.70 by 1.50. It is filled with maize (grains). The specific weight of maize (grains) is about 810 kg/m³ (if not spoiled by insects). How many kg of maize do you have?

The bin has a volume of $1 \times 0.70 \times 1.50 = 1.05 \text{ m}^3$. Maize weighs about 810 kg/m³.

So you have 810×1.05 kg of maize. This is about 850 kg.

The specific weight of one cubic metre of a harvested product is not always the same. It depends on the product and its moisture content. Often the moisture content is given together with the specific weight.

If a woman harvests maize at a moisture content of 40% and she dries it to a moisture content of 20%, how many kg of maize will there be left if she harvested 500 kg of maize?

Here we use the following formula:

kg of harvested maize $\times \frac{100 - \text{moisture content when harvested}}{100 - \text{moisture content after drying}} = \text{weight of dried maize in kg}$

This gives $500 \times \frac{100 - 40}{100 - 20} = 375$ kg of dried maize.

Application

- 1 You have a circular bin (a silo) with maize grains. The bin measures 1.5 m across (so the radius is ...). The height is 3 m.
What is the volume of this bin (in m³)?
How many kg of maize can it contain? The specific weight of maize is 810 kg/m³.
- 2 Dave harvests 1000 kg of grain at 25% moisture. For this grain he can receive 1 coin per kg. If he dries it to a moisture content of 10% he will receive 1.10 coins per kg.
What will be the best thing for Dave to do? (do not consider drying expenses and trouble).
- 3 You have a box which measures $1.5 \times 2 \times 1$ m. It is filled with seed with a moisture content of 20%. The seed weighs 900 kg.
How much does it weigh at a moisture content of 10% (in kg)?
What is the specific weight (in kg/m³) of the seed at a moisture content of 20%? And what at a moisture content of 10%?

The same applies to **liquids**.

The specific weight of water is 1 kg/litre, so 1 litre of water weighs 1 kg.

Five cubic metres (m³) of water weigh 5000 kg, because 1 cubic metre is 1000 litres.

Every liquid has its own specific weight.

For example, petrol has a specific weight of 0.75 kg/l.

If you have 5 one litre bottles each filled with petrol, how much does this petrol weigh? Answer: 5 litres weigh $5 \times 0.75 = 3.75$ kg.

Petrol is therefore lighter than water; we knew this already because petrol (or diesel oil) floats on water.

As soon as a liquid or other material has a specific weight of more than 1, it sinks in water.

Application

4 Which of the following materials will have a specific weight greater than 1:

lead, wood, leaves, stone, feathers

5 You have a tank of $2 \times 3 \times 2$ metres filled with petrol.

What is the weight of the petrol (in kg)?

How many litres of petrol can be put in this tank and how many litres of water?

If the tank had been filled with water, what would then have been the weight of the water (in kg)?

15 Irrigation

Purpose: Irrigation requires insight into units and time and the ability to make calculations. This chapter is basic knowledge; to understand this chapter you need the background information of chapters 3, 6, 8, 11 and 13.

15.1 Units

The discharge of a canal (stream, river) is the quantity or volume of water that passes per unit of time. It is expressed in l(itres) per s(econd) = l/s **or** in cubic metres per hour = m³/h **or** in cubic metres per day = m³/day.

- 1 l/s is the same as 3.6 m³/h because 1 litre = 1 dm³ = 0.001 m³
one hour has 3600 seconds (60 seconds in one minute and 60 minutes in one hour, 60 × 60 = 3600)
so 1 l/s = 3600 × 0.001 m³/h = 3.6 m³/h
1 l/s = 24 × 3600 × 0.001 m³/day = 86.4 m³/day.
- 1 mm/ha = 10 m³ because 1 mm = 0.001 m; 1 ha = 10 000 m²
so 1 mm/ha = 0.001 × 10 000 m² = 10 m³.

Application

1	1 m ³ /h	= ... m ³ /day	3 l/s	= ... m ³ /h
	5 m ³ /s	= ... m ³ /day	5 mm/ha	= ... m ³ /ha
	1 l/s	= ... m ³ /s	1 m ³ /ha	= ... mm/ha
	1 l/s	= ... m ³ /h	18 mm/ha	= ... m ³ /ha
	7.2 m ³ /h	= ... l/s	4 inches/ha	= ... m ³ /ha
	1728 m ³ /day	= ... l/s	750 m ³ /ha	= ... inches/ha

Combinations are also possible, for example:

$$3 \text{ l/s/ha} = ?? \text{ mm/day}$$

$$3 \text{ l/s/ha} = \frac{3 \times 3600 \times 24}{1000} \text{ m}^3/\text{day/ha} = 259.2 \text{ m}^3/\text{day/ha} = 259.2 \text{ m}^3 \times 0.1 \text{ mm/day} = 25.92 \text{ mm/day}.$$

Rounded off 3 l/s/ha = 26 mm/day.

Application

2	1 l/s/ha	= ... mm/day
	39 mm/day	= ... l/s/ha
	4 l/s/ha	= ... mm/day

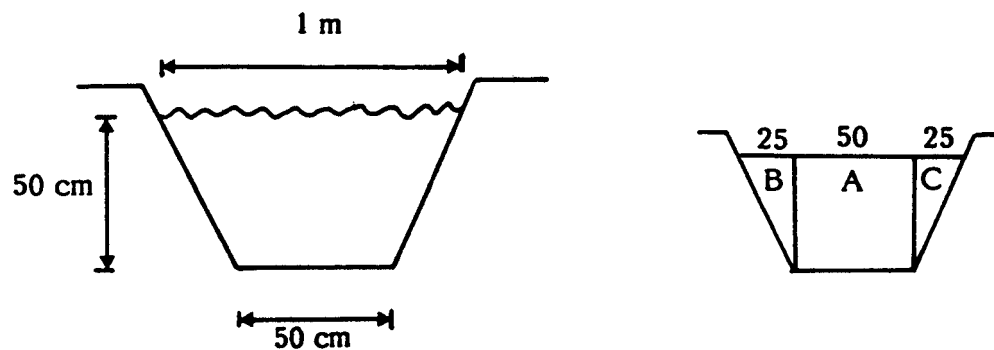
15.2 Areas

A stream flows through a canal and you want to know the quantity of water which passes. First you need to know the cross-sectional area of the canal. How do you find the cross-sectional area?

- measure the sides of the canal
- draw a diagram of the cross section
- calculate the cross-sectional area of the canal

Example:

You made the following measurements and made a diagram. Surface width is 1 m; bottom width is 50 cm and depth is 50 cm.



Calculation of the area:

You divide the cross section into parts from which you can calculate the area.

$$\text{area A} = 50 \times 50 \text{ cm} = 2500 \text{ cm}^2$$

$$\text{area B} = \frac{1}{2} \times 25 \times 50 = 625 \text{ cm}^2$$

$$\text{area C} = \frac{1}{2} \times 25 \times 50 = 625 \text{ cm}^2$$

The total area is area A + area B + area C = 2500 + 625 + 625 = 3750 cm².

Make the measurements at several places in the canal and from these data calculate the average cross-sectional area.

Now you know that the area is 3750 cm². But you still don't know the quantity of water that flows through the canal. To calculate this you have to know the velocity of flow. The velocity of flow can be measured in the following way. This can best be done by two people:

- Measure 25 m along the canal. One person stands at the beginning of the line and the other at the end.
- Then you need a watch with a seconds hand and a floating fruit or piece of wood; the person who stands upstream places this in the water, in the middle of the flow.
- The person downstream notes exactly how many seconds it takes for the object to float 25 m downstream.

Suppose that it takes 10 seconds to cover 25 m. Velocity is expressed in m/s.

So 25 m in 10 sec = 2.5 m/s.

As the velocity of the object floating on the surface of the water is greater than the average velocity of the stream, it is necessary to correct the measurement by multiplying by a coefficient, usually 0.80.

Here 2.5 m/s \times 0.80 = 2 m/s.

Make several trials to get the average time taken.

Together with the average cross-sectional area you can calculate the quantity of water flowing.

Area = 3750 cm² = 0.375 m²; velocity = 2 m/s

Through an area of 0.375 m² water flows with a velocity of 2 m/s.

So the quantity of water flowing is 0.375 m² \times 2 m/s = 0.75 m³/s.

This is called the **discharge** of the flow.

Question: Can you make a formula for this calculation?

Application

- 3 A canal has the following dimensions:
depth = 40 cm; bottom width = 30 cm and surface width = 90 cm.
What is the cross-sectional area (in cm^2) of this canal?
If the velocity of flow is 0.5 m/s, what is the discharge (in m^3/s)?
- 4 A small canal has the following dimensions:
depth = 30 cm; bottom width = 30 cm and surface width = 80 cm.
What is the cross-sectional area (in cm^2) of this canal? If we want a discharge of $0.33 \text{ m}^3/\text{s}$, what must then be the velocity of flow (in m/s)?

Sometimes you cannot measure the sides of the canal and you only have some data.

Normally the dimensions are given as follows:

depth = 40 cm; bottom width = 35 cm and side slope 1 : 0.75

What does 'side slope' mean?

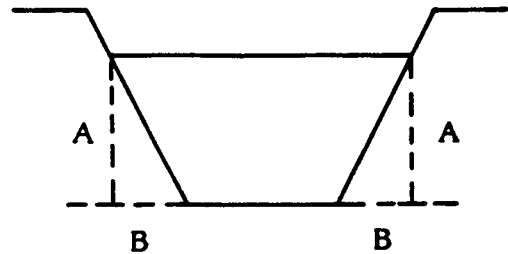
The side slope says something about the slope. If the side slope is 1 : 0.75 this means that the lengths of the imaginary vertical and horizontal sides of the slope are in the proportion of 1 : 0.75.

What does that mean in our example?

Look at the figure.

If we draw the dotted lines we see a vertical side (A) and a horizontal side (B). We know that the depth is 40 cm = A (vertical side) and that $A : B = 1 : 0.75$ so $40 : B = 1 : 0.75$; $B = 40 \times 0.75 = 30 \text{ cm}$

Now we can easily calculate the cross-sectional area.



Application

- 5 You have the following data on a canal:
depth = 50 cm; bottom width = 30 cm and side slope 1 : 0.50
What is the cross-sectional area (in cm^2)?
If the velocity of flow is 2 m/s, what is then the discharge of the flow (in m^3/s)?
- 6 Calculate the cross-sectional area (in cm^2) of a canal with the following dimensions: depth = 60 cm; bottom width = 40 cm and side slope 1 : 0.50.

15.3 Irrigation depth

Another important issue in irrigation is 'irrigation depth'.

Irrigation water coming into a field from a canal penetrates into the soil everywhere (if all goes well). A (theoretical) layer of water of 75 mm depth uniformly covering the whole field normally supplies an amount of water to the plants that ensures optimum growth, until the next irrigation application.

So a farmer can say 'I need an irrigation application of 75 mm'. This is a standard irrigation application.

As we have seen in the section about units, we can convert millimetres into m^3/ha . Written as a formula this gives:

$$\text{depth} = \frac{\text{volume}}{\text{area}}$$

Now to obtain the right irrigation depth, we have to calculate how much water should be applied.

Example 1:

Suppose that the area of your farm plot is 2 ha and the irrigation depth is 75 mm; how much water must be applied?

depth = volume/area; 75 mm = volume/area

Convert all measurements into metres; this gives $0.075 = \frac{\text{volume}}{20\,000}$

Hence the volume is $0.075 \times 20\,000 = 1500 \text{ m}^3$.

All this water is given in one session. The duration of the session is 10 hours in our case. So 1500 m^3 of water is given in 10 hours, this is $150 \text{ m}^3/\text{h}$.

$$150 \text{ m}^3/\text{h} = \frac{150 \times 1000}{3600} \text{ l/s} = 41.7 \text{ l/s}.$$

So you need a flow of 41.7 l/s for 10 hours to irrigate a farm plot of 2 ha. In your imagination you may think that a layer of 75 mm of water covers the entire area after 10 hours of irrigation.

In reality the water sinks into the soil; the depth to which the water sinks is not the same everywhere in the plot.

And in reality there are **water losses**; think of evaporation on a hot and windy day. In our calculation we have not considered possible losses.

Example 2:

You have a flow of 20 l/s and your farm plot measures 1 ha. The irrigation time is $4\frac{1}{2}$ hours. Will this provide enough water for the plot?

Answer:

$$20 \text{ l/s} = \frac{20 \times 3600}{1000} \text{ m}^3/\text{h} = 72 \text{ m}^3/\text{h}. \text{ During } 4\frac{1}{2} \text{ hours this is } 324 \text{ m}^3.$$

324 m^3 over 1 ha gives a water layer of which the depth is 32.4 mm.

This is only 43% of the standard depth.

The best solution here will be to reduce the area to be irrigated. To 0.4 ha, for example, so that the depth becomes about 75 mm.

Application

- 7 The area of a farm plot is 1.32 ha. The duration of the irrigation application is 5 hours and 30 minutes. The application depth is 75 mm.
What is the discharge of the flow (in l/s)?
- 8 A flow of 20 l/s has been running into a field of 5 ha for 20 hours.
What is the application depth (in mm)?
- 9 It takes 50 hours to irrigate an area of $50\,000 \text{ m}^2$ to a depth of 4 inches. What is the discharge of the flow (in l/s)?
- 10 A piece of land needs 108 mm irrigation water every 10 days. There is a pump which supplies 250 l/s. The pump works continuously. How many hectares can be served by this pump?
- 11 An imaginary case, for the sake of a calculation.
There is an area of 1200 ha that receives a rainfall of 75 mm in one day. The area has an irrigation system of which the main canal has a discharge capacity of 5 l/s. We assume that there are no water losses.
How long would it take for this irrigation system to supply the same amount of water as the rain does (in days)? The irrigation water is applied all day long (24 hours).

15.4 Slope of the canal

Owing to the contour of the land, one side of a field may be higher than the other. The simplest example of a sloping field would be one on the side of a hill. Slope is expressed as a percentage and is calculated by dividing the vertical distance by the horizontal distance and then multiplying by 100.

Example:

A field to be irrigated has a head ditch 200 m long running down the slope.

The difference in elevation between the two ends of the ditch is 4 m. What is the percentage of slope?

Answer:

$$\text{slope} = 4 \div 200 \times 100\% = 2\%$$

This means that the land falls 2 m per 100 m distance.

There are several ways of expressing the slope.

You can say that a slope is 0.005. This means that the land falls 5 m every 1000 m distance, $5 \text{ m} \div 1000 \text{ m}$.

Expressed in percentages: $0.005 \times 100\% = 0.5\%$

Slight slopes may be expressed in per mil (‰).

For example: 1‰ means that the land falls 1 m every 1000 m distance, or the slope is 0.001.

Application

12 A main irrigation canal enters a farm plot at the highest part of the plot, at 355.0 m level. The canal leaves at the lowest part, at 351.8 level.

The length of the canal is 160.0 m. What is the slope as a percentage?

13 Another irrigation canal enters a farm plot at 160 m level and leaves at 159 m level. The length of this canal is 500 m. What is the slope of this canal as a percentage?

14 The top of a hill lies at 750 m level. One kilometre down the level is only 630 m. What is the slope of the hill?

You make this measurement four more times and you find different slopes, namely 10%, 11%, 12.5% and 11.5%. What is the average slope of this hill?

Note that the slope has different values at different positions. So you must always calculate an average slope for accuracy. The average becomes more accurate as you make more observations.

NOTE

In the AgroSource series there are guides on irrigation with many more calculations on irrigation, in the classroom as well as in the field:

a AgroSource 9 and 10: Training elements in smallholder irrigation schemes (basin irrigation)

2 volumes, about 200 pages in all

b AgroSource 11: Practicals for basic land surveying and irrigation

150 pages; 9 indoor practicals and 36 field practicals

16 Crop growing

Purpose: calculations in agricultural operations

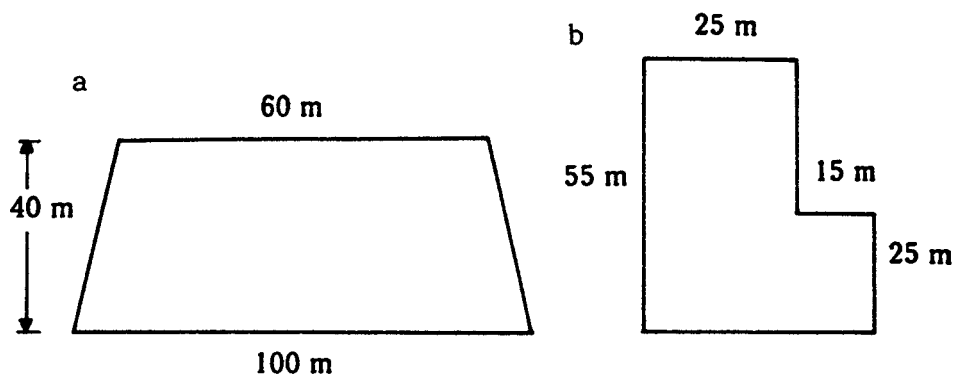
16.1 Area

When you grow a crop you start by calculating the area of land that you will use. We already did this in chapter 8.

As a reminder we calculate the following areas.

Application

1



Remember that, if the field does not have a simple shape:

- divide it into pieces of simple shape
- calculate the area of each piece
- add the areas of the pieces to get the total area of the field

16.2 Seed rate

The amount of planting material which is needed depends on the area of land that you have and on the amount of planting material you need per unit of area.

The amount of planting material = total area \times required amount per unit area.

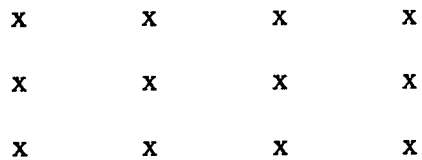
Example:

If you plant lemon trees 6 m \times 6 m apart, how many seedlings do you need for 400 sq metres? Answer: each seedling occupies 6 \times 6 m² = 36 m². The total area is 400 m². You need 400 \div 36 = 11 plants (approximately).

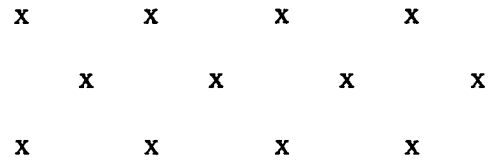
Guavas are planted 8 m apart.

To calculate the number of guavas you can plant on one hectare, you must first consider the spacing pattern of the trees.

The spacing pattern can be rectangular or triangular:



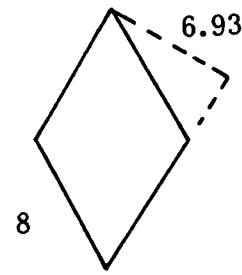
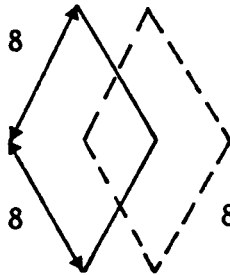
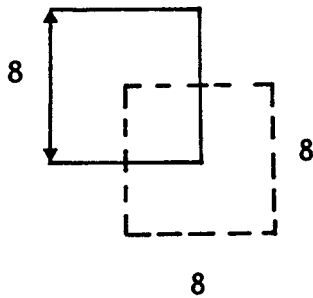
rectangular spacing



triangular spacing

With rectangular spacing every guava tree occupies $8 \times 8 = 64 \text{ m}^2$.

With triangular spacing the area needed is smaller. The area of a parallelogram is $L \times H$ (see chapter 8). In this case the height is 6.93. This gives $8 \times 6.93 = 55.4 \text{ m}^2$.



Application

- 2 How many guavas can you plant on 1 ha if the trees must be planted 8 m apart (rectangular spacing)?
- 3 Mrs.Sanchez wants to plant rows of tomatoes starting from a base line of which the length is 20 m. The distance between the rows is 90 cm. How many rows of tomatoes can Mrs.Sanchez plant?
- 4 Mr.Kale is planting apple trees, 5 m apart. He plants 20 trees. How much land will these trees occupy, in m^2 ? (give two possibilities).

16.3 Thousand grain weight

Seeds are often small and it is therefore impossible to count the exact number of seeds you have to sow. Therefore the amount of seed required is expressed in grams or kilograms. But you know that seeds differ in weight; so 1 kg of mango seeds consists of far less seeds than 1 kg of onion seeds. To make things easier we use the 'thousand grain weight' TGW which is the weight of 1000 seeds of a certain crop.

Example: How much does 1 seed weigh if the TGW is 25 g? Answer: 1000 seeds weigh 25 g so 1 seed weighs $25 \div 1000 = 0.025 \text{ g}$.

Application

- 5 The TGW of a barley variety is 45 g and the seed rate is 360 seeds per square metre. How many kg do you need to sow 2 hectares?
- 6 The TGW of a bulrush millet is 5 g and the seed rate is 4000 seeds per 100 m^2 . How many kg do you need for 1 acre?

16.4 Seed losses

The number of seeds sown is usually more than the number of plants harvested. This is due to losses:

- seeds which do not germinate (say, 10%)
- seedlings which die soon after germination (say, 5%)

Even if high quality seeds are used, at least 5% will not germinate. Later on more seedlings will die even if circumstances are good. In general, losses depend on factors such as:

- the quality of the seeds (whether fresh or old; the way the seeds were stored)
- the way the seedbed has been prepared
- the weather
- pest and disease damage, weeds

A small experiment could be carried out to determine the total losses; as follows (this experiment has no practical value):

- Mark 1 m² inside the field you are going to sow. Count the number of seeds you sow in this square metre. Treat this square metre in the same way as the rest of your field (application of fertilizer, for instance).
- At harvest time, count the number of plants in this square metre. The difference between the number of plants harvested and the number of seeds sown is the **total field loss**.

Example: in the square metre you sowed 25 soya seeds. Only 20 plants could be harvested.

The total loss is $\frac{25 - 20}{25} \times 100\% = 20\%$

A simple **germination trial** will not give the total losses, but will at least inform the farmer about the viability of a certain seed lot (viability = ability to germinate normally). A germination trial prior to actual sowing is of practical value, but it says nothing about possible field losses, for instance due to insects, birds or drought.

For a germination trial follow these steps:

- count 100 seeds
- put them on a moist piece of tissue and keep this moist
- count the normal, germinated seeds, after about one week (count only once!)
- say there are 85 normal seedlings
- now the loss is $(100 - 85) \div 100 \times 100\% = 15\%$.

The above germination trial can also be carried out in the field; in that case the trial can take place under more or less normal sowing conditions.

Application

- 7 A woman needs 250 tomato plants. The total losses will be 20%. How many seeds does she have to sow?
- 8 The planting distance for lettuce is 30 cm × 30 cm (rectangular). The area to be planted is 100 m². The total losses will be 20%. How many seeds do you have to sow to get enough plants?

16.5 Fertilizer calculations

Plants need nitrogen, phosphoric acid and potash for their growth. These substances are called **plant nutrients** and written as follows:

nitrogen

N

phosphoric acid	P ₂ O ₅ or, simplified, NPK
potash	K ₂ O

There are other plant nutrients but the above are the most important ones.

In the following we deal with (chemical) fertilizers only. Farmyard manure, compost, green manure and crop residues also contain N, P₂O₅ and K₂O together with other nutrients and they may be cheaper and better than (chemical) fertilizers.

The fertilizers on the market contain one (example urea) or more of the above nutrients. The contents of a bag of fertilizer are specified on the outside; for example ammophos 16-20-0. This means that this fertilizer contains 16% N, 20% P₂O₅ and 0% K₂O, so the first number indicates the amount of nitrogen, the second the amount of phosphoric acid and the third the amount of potash (always in that order).

You can see that a fertilizer contains more than just N, P and K, because if you add up the percentages you find 16 + 20 + 0 = 36%. The rest (64%) is not of use as fertilizer, it is called carrier material.

Now back to farming. If you want to apply fertilizer on your farm the first question is : which fertilizers are available on the market and in which proportions do they contain nitrogen, phosphoric acid and potash. The second point is the fertilizer rate which is recommended in your case: how much to apply to one hectare.

Say that the recommended rate is 90-60-30. This means that you need 90 kg N, 60 kg P₂O₅ and 30 kg K₂O per hectare.

The proportion 90-60-30 can be simplified to 3-2-1, so you can see that you need a fertilizer which contains nitrogen, phosphoric acid and potash in the proportion 3 : 2 : 1.

Example:

In a certain area the fertilizer recommendation for maize is 60-55-65. To make up this recommendation we can use a fertilizer which contains N P K in the proportion 1 : 1 :1 (for practical reasons we do some rounding off). So in this case the (complete) fertilizer 14-14-14, for instance, can be used. If it is not possible to find a fertilizer which makes up the recommended rate, we can add another fertilizer which only contains nitrogen (or only phosphoric acid or only potash).

How many kg of fertilizer do you need?

Here we use the following formula:

$$\text{weight of fertilizer} = \frac{\text{weight of nutrient recommended}}{\% \text{ nutrient in fertilizer material}}$$

Take for instance the fertilizer recommendation of 90 60 30 and ammophos 16 20 0 as fertilizer. We need 90 kg of N. Our ammophos contains 16% N.

Using the formula we get:

$$\text{weight of ammophos} = \frac{90}{16/100} = 562.5 \text{ kg ammophos.}$$

The amount of P₂O₅ we need is 60 kg; ammophos contains 20% P₂O₅ , hence

$$\text{weight of ammophos} = \frac{60}{20/100} = 300 \text{ kg ammophos.}$$

Ammophos does not contain K_2O .

If we give 562.5 kg ammophos, we give just the right amount of N but we give too much P_2O_5 . It is better to use 300 kg ammophos (just the right amount of P_2O_5) and then to add another fertilizer in order to get enough N and K_2O .

For nitrogen we can use ammonium sulphate 20% N, or urea 45% N.

The amount of nitrogen in 300 kg ammophos is $300 \times 16/100 = 48.0$ kg N. The recommendation calls for 90 kg N, so $90 - 48 = 42$ kg N has to be added. If we fill this gap with ammonium sulphate:

$$\text{weight of ammonium sulphate} = \frac{42 \text{ kg N}}{20/100} = 210 \text{ kg ammonium sulphate.}$$

Or with urea:

$$\text{weight of urea} = \frac{42 \text{ kg N}}{45/100} = 93 \text{ kg urea.}$$

As you see, less urea is needed than ammonium sulphate; this is because of the higher concentration of N in urea.

To add potash we use muriate of potash, 60% K_2O .

$$\text{weight of muriate of potash} = \frac{30 \text{ kg } K_2O}{60/100} = 50 \text{ kg muriate of potash.}$$

So finally we take 300 kg ammophos, 210 kg ammonium sulphate (or 93 kg urea) and 50 kg muriate of potash, for 1 hectare. This corresponds exactly with what is recommended.

Application

- 9 Calculate how much ammonium sulphate (20% N) is needed to supply 100 kg/ha of N to an area of 2500 m² (in kg).
- 10 Say you have fertilizer 20-14-14. The recommendation for your crop is 80-53-28. You can add phosphoric acid by using single superphosphate 20% P_2O_5 , and nitrogen by using ammonium sulphate 20% N (or urea 45% N). How much do you need of each fertilizer, per hectare?

As we saw in the above example, in order to give the same amount of nitrogen we need many more kg ammonium sulphate than urea. Even if urea is more expensive per kg than ammonium sulphate it can be much cheaper to use urea.

Say one bag of 50 kg urea costs 50 coins and one bag of 50 kg ammonium sulphate costs 40 coins. In our example 2 bags of urea costing 100 coins or 5 bags of ammonium sulphate costing 200 coins were needed.

Application

- 11 Which of the two fertilizers is the cheapest as far as N is concerned: urea that costs 60 coins per bag of 50 kg or ammonium sulphate that costs 35 coins per bag of 50 kg? Use the data given before.
- 12 Mr. Ling needs 110 kg urea or 245 kg ammonium sulphate. One bag of 50 kg urea costs 50 coins and one bag of 50 kg of ammonium sulphate costs 30 coins. Which fertilizer will Mr. Ling prefer (from a money point of view) and why?

What matters is **the price per kg of plant nutrient** (N, P_2O_5 and K_2O), not the price per kg of fertilizer material that is on the market.

NOTE: In our guide ‘physiology of crop growth’ there is also a chapter on fertilizer calculations; basically the same calculations but the presentation is somewhat different. That guide has also a practical on how to apply fertilizer by hand, together with many other practical lessons.

16.6 Use of pesticides

Certain chemicals used in crop production are herbicides, insecticides and fungicides; they are called ‘pesticides’. Generally speaking the use of pesticides should be restricted as much as possible. If you do decide to use them, make every possible effort to use them effectively: always apply pesticides **at the right time** and **in the right dosage**; and apply them **uniformly** over the crop.

Pesticides are usually bought and applied in a **formulation**. A formulation consists of an ‘active ingredient’ (a.i.) and other material (so called carrier material). This ‘other material’ may be water, oil, an organic solvent, clay or sand.

Recommendation rates for pesticides are often expressed as kilograms of active ingredient per hectare (kg a.i./ha).

These rates have been carefully determined to give optimum results at the lowest cost possible and/or with minimum health risks to the farmer. Therefore use pesticides at the recommended rate only!

To arrive at the correct rate of active ingredient, you must calculate the amount of the formulation needed to obtain a given amount of active ingredient.

How do you calculate the amount of formulation required? There are many different formulas listed in various books. Obviously you cannot remember all these formulas or carry all these books around with you. Therefore you must know how to make the calculation equations yourself. As follows.

Pesticide calculations are often expressed in the following form:

$$X = A / B$$

X is the answer we try to find; usually the required weight or volume of a formulation. A/B is a fraction. You already know that as the numerator (A) becomes larger, X becomes larger too.

On the other hand, as the denominator becomes larger, X becomes smaller. Using these simple relationships you can make your own equation in a logical way.

Example: Suppose that you want to apply a herbicide in a wettable powder formulation. How do you determine how much formulation you need? To do this you must know:

- the area of your field
- the recommended rate of a.i. (ask extension agent or supplier)
- the percentage of a.i. in the wettable powder

The percentage of a.i. in the wettable powder is printed on the container of the herbicide. Remember the equation $X = A/B$; X is kg of wettable powder herbicide needed. Obviously the larger our field the more herbicide we need; so ‘field area’ must be part of the numerator (A). Also, if the recommended rate increases, the amount of wettable powder you need will increase. So the recommended rate must also be part of the numerator (A). If the percentage a.i. increases, the necessary amount of wettable powder decreases. For example, if the recommended rate is 4 kg a.i./ha, then with WP (wettable powder) 25% a.i. you will need 16 kg of the formulation and with WP 50% a.i. you will only need 8 kg of the formulation. Hence ‘percentage concentration of active ingredient’ must be part of the denominator (B).

So $X = \frac{A}{B}$ gives

$$\text{amount in kg of wettable powder herbicide} = \frac{\text{recommended rate} \times \text{field area}}{\% \text{ concentration of a.i. in the WP}}$$

Before you can proceed to solve your equation, you must make sure that all areas, volumes and weights are expressed in the same way! Express the concentration of active ingredient as a decimal (50% as 0.50 or 35% as 0.35).

Example: To apply 2 kg a.i./ha of PCP-WP 50% herbicide to a 2500 sq metre field, how many PCP-WP do you need?

$$2500 \text{ m}^2 = \frac{2500}{10\,000} = 0.25 \text{ ha}$$

$$\text{kg of PCP-WP 50\%} = \frac{2 \text{ kg a.i./ha} \times 0.25 \text{ ha}}{0.50} = 1$$

If you are not sure whether your equation is right, you can check it by comparing the units on the two sides of the 'equal' sign. The units on the two sides of the equal sign should be of the same order!

Application

- 13 You have a granular insecticide formulation with 6% active ingredient. The recommended rate is 1.75 kg a.i./ha. You have a 3.5 ha field. How many kg of the granule do you have to apply?
- 14 How many litres of MCPA EC 4 lb/imperial gallon are required to spray a 500 m² plot at the rate of 0.8 kg a.i./ha?
Note: here you must first calculate the % a.i. of the formulation.
EC = emulsifiable concentrate.
- 15 To control rice stem borers 3 kg/ha of r-BHC is needed (3 kg a.i./ha).
How many kg of dolgranule containing 6% r-BHC (6% a.i.) is needed to treat 2 ha of rice field?
- 16 To control leaf hoppers you must prepare 2500 litres of 0.09% Sevin. The wettable powder you use contains 90% Sevin. How many kg of wettable powder do you need to make the solution?
Note: first make the equation, as it differs from the ones you used before!

16.7 Sprayers

Chemicals in liquid form are often applied with sprayers.

If a (knapsack) sprayer does not have any specifications it can be calibrated by the following procedure:

- First determine the nozzle delivery.
- Fill the sprayer with water and spray the water during 1 minute into a suitable container. If the amount of water is, say, 2 litres, the nozzle delivery of the sprayer is 2 litres per minute.
- Determine the width that is covered in one swath (m).
- Determine the speed of walking while you spray (m/min).
- The area that can be covered in 1 minute = width of 1 swath × the speed of walking (m²).
- The time necessary to spray 1 ha = 10 000 divided by the area that can be covered in 1 minute.
- The amount of spray solution applied to 1 ha = time necessary to spray 1 ha × nozzle delivery.

Example:

It takes one minute to spray 1 litre of spray solution.
The width of one swath is 1 metre.

The speed of walking is 25 m per minute.

The area that can be covered in 1 minute is $1 \times 25 = 25 \text{ m}^2$.

The time necessary to spray 1 hectare is $10\,000/25 = 400$ minutes.

The amount of spray solution applied to 1 ha is $400 \times 1 = 400$ litres.

Application

17 Three persons calibrate a knapsack sprayer. The results are as follows:

Table 8: Pesticide spraying measurement

Person n°	Nozzle delivery (l/min)	Speed (m/min)	Swath (m)
1	1.11	23.00	2.10
2	1.04	26.50	1.98
3	1.15	25.50	2.00
Average

(in reality the trial results would be rounded off figures)

- Calculate the average delivery per ha (in litres).
- Determine how many times the tank must be refilled if the capacity of the tank is 20 litres.
- Suppose that a herbicide 45% a.i. is to be applied uniformly to 1 ha.
The recommended rate is 2 kg a.i./ha.
Calculate the amount of herbicide needed for 1 ha (in g).
Calculate the amount of herbicide in each sprayer load.

An empty page for more examples and applications:

17 Animal husbandry

Purpose: some calculations about livestock units, productivity and feeding

Required background information: chapters 2, 3, 6 and 11.

17.1 Livestock units

Say you have a herd consisting of three cows older than 3 years, one cow of two years and two calves. You let them graze on your own pasture.

Your neighbour has a herd consisting of two cows older than 3 years, one calf and eleven sheep. He lets them graze on a pasture of the same size and quality as yours. In both cases the animals have just enough to eat although the number of animals is not the same.

This is possible because sheep are smaller than cows and eat less than cows do.

It is difficult to compare different animals (and animals of different ages) with each other with regard to feeding and grazing. To make comparison possible we convert different animals to the same common unit.

This unit is called LIVESTOCK UNIT, abbreviated to LU. One LU denotes the feed requirement of a standard animal of a certain live weight (usually a dairy cow of 550 kg).

We can say that, with the introduction of the livestock unit, we can compare the feed needs of sheep, goats, calves and other animals with those of dairy cows.

To express different animals and animals of different ages in LUs we use a conversion table.

Table 9: Conversion table of livestock units (LUs)

Type of livestock	LU per head
1 (dairy) cow	1
cow between 1 and 2 years of age	0.7
calf under 1 year of age	0.3
bullock	0.8
donkey	0.7
sheep or goat	0.1
horse, buffalo, mule	1.0
camel	1.1

Examples of the use of LUs:

A farmer can say 'I have a herd of 6 LUs'; or when you have feed in stock you can say 'I have enough feed for 4 LUs for 4 months'.

LUs help us to calculate and to plan the quantity of feed needed for a herd during a certain period.

It also helps us to determine how many animals of a certain type we can put on a certain field or farm plot.

Application

- 1 A farmer has four cows; one of 2 years, two of 4 years and one of 5 years. He also has a calf. How many LUs does this farmer have to feed?
- 2 Another farmer has five cows of 4 years, two heifers and one calf. He also has a bullock. How many LUs does this farmer have to feed?
- 3 Mr. Kasim has two donkeys, one horse and thirteen goats. How many LUs does Mr. Kasim have to feed?
- 4 You have enough pasture for a herd of 6 LUs. Compose an imaginary flock of animals to your liking; use the conversion table.

17.2 Feed conversion

Domestic animals eat feed (grasses, shrubs, hay and silage, concentrates) and this enables them to grow and to give milk or eggs.

So because of the feed animals can give us milk, eggs and meat.

We can say 'an animal produces', and to produce it needs 'raw material'.

Domestic animals generally produce more 'economically' than other types of animals.

Some types of animals need a lot of feed to produce only a little meat.

To express how many kg of a certain feed a domestic animal needs to give 1 kg of meat (or another product, eggs for instance) we use the feed conversion rate abbreviated to FCR or f.c.r.

For example: say that a broiler chicken has a feed conversion of 2.2 This means that the broiler needs 2.2 kg of a certain feed to grow 1 kg.

To calculate the feed conversion rate in chickens we need to make the following measurements:

- a We weigh 100 one day old chicks and write down their weight and the date of weighing. Say that they weigh 4 kg in all (the average weight is 40 g).
- b We feed the chickens and we write down every kg they eat.
- c This is possible in the case of caged poultry and rabbits; also in the case of pigs or larger animals kept in pens or the like.
- d Say that our chickens eat 456 kg during the growing period.
- e After this growing period we weigh the chickens again. The chickens weigh 190 kg (all chickens survived).
- f Now we have all the data we need for the calculation:
 - How many kg did the chickens grow?
Normally we subtract the starting weight from the end weight, but in practice with one day old chicks we neglect the starting weight (like here). So here the end weight is 190 kg.
 - How much did they eat? 456 kg
 - The chickens needed 456 kg feed to grow 190 kg.
So to grow 1 kg they needed $456/190 = 2.4$ kg of feed.

In the above case the feed conversion rate is 2.4

Another flock of broilers needed 559 kg of feed to grow 215 kg. Here the conversion rate is 2.6 (namely $559/215 = 2.6$).

What can we say about the two flocks?

One has a FCR of 2.6 and the other of 2.4. The flock with a FCR of 2.4 is better, economically speaking. The flock with a FCR of 2.6 needs more feed per kg of meat produced than the other flock.

A low feed conversion rate points to economic use of the feed

The same calculation can be made for egg laying.

All domestic animals use their feed for maintenance and production.

The part they use for maintenance is for each type of animal more or less the same but the part for production depends on the productivity of the animal.

With the productivity we can calculate the feed conversion rate.

Let us consider a layer (hen)

A layer needs 70 g of feed per day for maintenance.

For every egg it lays it needs 50 g of feed extra.

A certain hen produces 1 egg/week. So it needs 7×70 (for maintenance) plus 1×50 (for eggs) = 540 g of feed per week.

One egg weighs 50 g. The FCR (for eggs) is $\frac{540}{50} = 10.8$

Another hen produces 6 eggs/week.

This hen needs 7×70 plus $6 \times 50 = 490 + 300 = 790$ g of feed per week.

In this case the FCR = $790 \div (6 \times 50) = 2.7$

So we see that the productivity has a very strong influence on the feed conversion rate and so on the price of the end product.

You can take this into account when you must decide whether or not to slaughter a certain hen.

Application

- 5 An animal weighs 15 kg. Two months later it weighs 45 kg. It ate 75 kg of feed. What is its FCR?
- 6 A young chicken has an average feed uptake of 60 g per day. In two weeks it has grown 420 g. What is its FCR?
- 7 A hen lays 5 eggs per week. It eats 105 g of feed a day. One egg weighs 50 g. What is its FCR for laying eggs in this period?

17.3 Killing out percentage

If you slaughter an animal you do not get as much carcass weight as the animal weighs alive, because the head, the skin, the digestive organs and some other parts are separated from the carcass.

The killing out percentage is the percentage that indicates how much the carcass weight of the animal is in relation to its live weight.

For example: you have an animal which has a killing out percentage of 75%. Its live weight is 95 kg. How much is the carcass weight?

Answer 75% of 95 kg; this is $\frac{75}{100} \times \frac{95}{1} = \frac{7125}{100} = 71.25$ kg

Application

- 8 A farmer wants to slaughter a cow. A very similar cow recently slaughtered had a killing out percentage of 55%.
The cow weighs 400 kg. What can the farmer expect to be the carcass weight?
- 9 A sheep weighs 78 kg. The killing out percentage for a similar sheep was 55%. What will be its carcass weight?

There are tables that indicate the killing out percentages of animals under different conditions, because animals have different killing out percentages. For example, a chicken has a higher killing out percentage than a sheep, because a sheep has a relatively bigger digestive tract.

Animals in good condition have a higher killing out percentage than animals in poor condition.

Say you want to know the killing out percentage of chickens:

- weigh a chicken; say it weighs 2.40 kg
- slaughter the chicken; separate all the parts that you do not eat
- weigh the carcass of the chicken; say it weighs 1.80 kg
- calculate the killing out percentage

Here $\frac{1.80}{2.40} \times 100\% = \frac{3}{4} \times 100\% = 75\%$

So the killing out percentage of this (type of) chicken is 75%.

Application

10 Calculate the killing out percentage of rabbits. The live weight of a rabbit is 4.0 kg and its carcass weight 2.4 kg.

11 You have chickens and you sell them alive, or slaughtered without feathers, head and digestive organs (with a killing out percentage of 75%).

Alive you sell them for 200 M/kg and slaughtered for 300 M/kg.

In which case do you earn more if you do not count the time you need to slaughter and to prepare the chicken.

How much more do you earn per kg?

If you do not know how to cope with this sum, just imagine a weight for a chicken and use this in your calculation.

17.4 Dry matter in feedstuffs

The percentage of dry matter in a feedstuff is a determining factor for the composition of a ration. You have to give more feed when this contains more water; the feed is then less 'concentrated'.

If you know the percentage of dry matter in a feedstuff you can calculate how many kg of dry matter the animal obtains from this feedstuff (and how many kg concentrate you have to give as a supplement according to the norms for the production level).

Example 1:

A stall fed cow gets fresh grass as much as it can eat.

This grass has been analysed and the dry matter (DM) content was 22%.

You yourself are weighing the grass and the cow eats about 50 kg of this grass each day.

How many kg of DM does the cow get by eating this grass?

Answer:

50 kg = 100%; 1% = 0.50 kg

22% of 50 kg is $22 \times 0.50 = 11$ kg DM

This is enough for a cow.

Example 2:

We want to feed a sheep with sweet potato vines. The sheep has an estimated DM intake of 1 kg per day. Sweet potato vines contain 25% DM.

How many kg of sweet potato vines do we have to feed this sheep?

Answer:

1 kg of sweet potato vines contains 0.25 kg DM ($1 \times \frac{25}{100}$).

The sheep needs 1 kg DM.

So we have to give $1 \div 0.25 = 4.0$ kg of sweet potato vines.

Example 3:

You have a dairy cow that is stall fed.

We know that from good quality roughage this cow can eat 11 kg of DM each day.

You have limited sweet potato vines, 10 kg a day with a DM content of 25%.

Besides this you have good elephant grass with a DM content of 20%.

How many kg of elephant grass do you have to cut each day?

Answer:

10 kg of sweet potato vines = 100%; 1% = 0.1 kg.

25% of 10 kg is $25 \times 0.1 = 2.5$ kg DM.

The cow can eat 11 kg DM each day, so if you give 10 kg sweet potato vines, you give 2.5 kg DM.

This is not enough; the cow needs another

$11 - 2.5 = 8.5$ kg DM.

Elephant grass has a DM content of 20%; 1 kg contains 0.20 kg DM.

The cow can have 8.5 kg DM. This is $8.5 \div 0.20 = 42.5$ kg elephant grass.

So you have to cut 42.5 kg elephant grass each day (say about 40 kg).

Note:

In the above examples we have only considered the **dry matter aspect of feeding animals**. In reality feeding is (much) more complicated; think of energy and protein for instance. See volume 1 of our **dairy farming series** for more information.

Application

12 A farmer has a young cow which is given 20 kg fresh forage maize (plants) each day (DM 25%). How many kg DM does the cow get by eating the maize?

13 Dairy goats have a dry matter intake of about 3% of their live weight.

A farmer tells you that her goat, with a live weight of 50 kg, eats every day 1 kg of rice straw (80% DM) and 10 kg of kudzu (19% DM; kudzu is a leguminous creeper plant). Do you think that this is possible?

14 A heifer has a DM intake of 6 kg. It eats 15 kg alfalfa (22% DM) each day. We want to supplement this with elephant grass.

How many kg of elephant grass do we have to cut each day?

17.5 Animal productivity

Different animals are kept for different purposes because they produce different products. The **productivity** of a type of animal is expressed in terms of what it produces. Some animals and their products will be discussed below.

Growth

For all animals growth is expressed in kg/day. So what matters is the number of kg they grow per unit of time, related to body weight and feed quality.

Example 1:

A beef cow gains 485 kg in 100 weeks. It grows at an average rate of $485 \div 100 = 4.85$ kg/week or 0.69 kg/day.

Example 2:

Young chickens of two weeks weigh 200 g each. When they are eight weeks old they weigh 2 kg. What is their productivity in the period between 2 and 8 weeks? They produced $2 \text{ kg} - 200 \text{ g} = 2000 - 200 = 1800$ g each. The time needed was $8 - 2$ weeks = 6 weeks. The productivity is $1800 \text{ g} / 6 \text{ weeks} = 300 \text{ g/week}$, or $300 \text{ g} / 7 \text{ days} = 43 \text{ g/day}$.

Example 3:

Other young chickens of 5 weeks weigh 800 g each. When they are 90 days old they weigh 2.2 kg. What is their productivity in the period between 5 weeks and 90 days? They produced $2.2 \text{ kg} - 800 \text{ g} = 2200 - 800 = 1400$ g each. The growing period was $90 - 35$ days = 55 days. The productivity is $1400 \div 55 = 25.4 \text{ g/day}$ or $25.4 \times 7 = 177.8 \text{ g/week}$.

Sheep

The productivity of sheep is often expressed in lambs born per year.

Example 1:

A ewe gave birth to one lamb in March and in November the same year she gave birth to two lambs. Next August she will give birth again. So between March and August of the following year she had 3 lambs. That is 3 lambs in 18 months. One year has 12 months; the ewe gave 3 lambs/18 months = 2 lambs/12 months = 2 lambs per year.

Example 2:

You have a flock of 12 ewes which are bred once a year and they give birth to 20 lambs. What is the lambing percentage?

The lambing percentage is $\frac{20}{12} \times 100\% = 166\%$

Hens

Hens produce eggs. A good way to express the productivity of hens is the number of eggs produced per week and during the whole laying period.

Rabbits

The productivity of does (female rabbits) is expressed in kindles (young rabbits) per year.

Say your doe delivered 4 litters in one year with respectively 8, 6, 9 and 5 live kindles. How much did the doe produce that year?

Answer: $8 + 6 + 9 + 5 = 28$ kindles. Another way to express the productivity of a doe is litters per year and average number of kindles per litter.

Cows

Cows produce several products such as milk, calves and meat. If a cow produces milk we can express its productivity in litres of milk per day, per lactation period and per year.

For example: A cow gives 3 litres of milk every morning and 4 litres in the evening. How much does it give per day?

Answer: In one day it gives $3 + 4 = 7$ litres, so 7 litres/day.

Milk production during a lactation period depends on the average production per day. When the lactation period is 300 days and the average production is 7 litres/day, this gives $300 \text{ days} \times 7 \text{ litres} = 2100$ litres in the lactation period.

If a cow produces a calf each year, then the milk production during one lactation period is the same as the milk production per year.

Milk itself has several constituents. Milk of Friesian cows contains

water	87.5%	protein	3.3%
fat	3.75%	milk sugar	4.6%
salts	0.85%		

Make a circle diagram of the above data.

Local cows often give milk with a higher fat percentage.

Application

15 A hen lays 12 eggs in two weeks. What is the productivity of this hen?

16 In $1\frac{1}{2}$ years your rabbit gave birth to resp. 9, 7, 8, 4, 6 and 6 kindles. How many kindles did your rabbit produce per year? And how many litters per year?

- 17 A cow produced 70 litres of milk in 10 days. How much milk did it produce per week?
- 18 When you drink $\frac{1}{4}$ kg of milk from Friesian cows, how many grams of fat and protein do you consume?

17.6 Using calendars

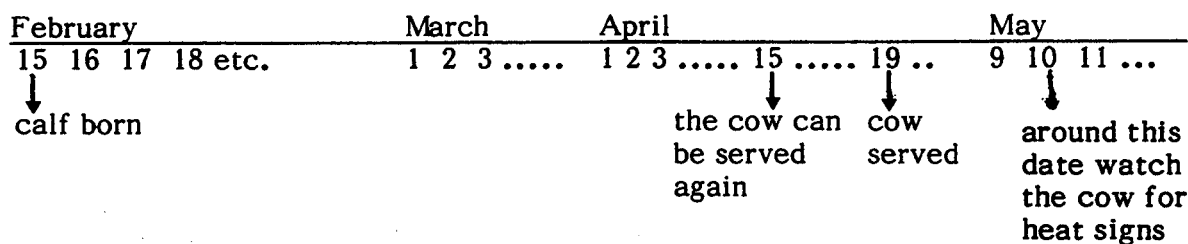
It is important to note events (that we should not forget) on a calendar.

Let us look at a dairy cow.

A cow is pregnant for 9 months. Two months after the date she had a calf, a cow can be served again. With cows the intervals are so long that the dates can easily get muddled. For example, we forget when the cow was served, so that when the cow gives birth we are not expecting it and are not there. We also have to watch out three weeks after the cow has been served. If she is in heat she has to be served again; if not, we may expect a calf nine months after the date of service if all goes well. Or we do not remember when the cow calved, with the result that she is served too late, say 4 months after calving. This will decrease the milk yield and we will have fewer calves.

To overcome these problems we can make a calendar.

For example:

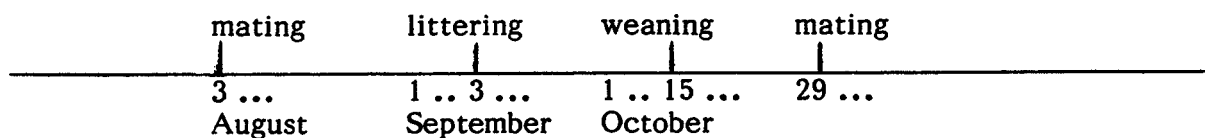


Another example:

Rabbits are pregnant for 31 days. The young rabbits stay with the mother for 6 weeks. If we want as many litters as possible the female has to be mated as soon as possible after weaning. Mating is possible 2 weeks after weaning.

In order to do everything at the right time we make a calendar. The rabbit will be mated on August 3rd.

Schedule for breeding rabbits:



Question: can you complete this schedule up to the next weaning?

18 Answers to the problems

Chapter 1

1. $\frac{8}{4}$ $\frac{4}{3}$ $\frac{3}{6}$ $\frac{1}{9}$
2. $1\frac{3}{5}$ $1\frac{1}{2}$ 1
 $5\frac{1}{2}$ $2\frac{1}{4}$ $1\frac{1}{4}$
3. $\frac{1}{4}$ $\frac{1}{5}$
4. $\frac{1}{6}$
- 5a. $\frac{1}{4}$ $\frac{1}{4}$ $\frac{1}{4}$ $\frac{1}{4}$
- 5b. $\frac{1}{2}$ $\frac{1}{4}$ $\frac{1}{4}$
- 5c. $\frac{1}{8}$ $\frac{1}{8}$ $\frac{1}{4}$ $\frac{1}{2}$
- 5d. $\frac{1}{2}$ $\frac{1}{8}$ $\frac{1}{8}$ $\frac{1}{4}$
6. $\frac{4}{5}$ $\frac{1}{3}$ $1\frac{3}{4}$
 1 $\frac{2}{5}$ 3
 $\frac{3}{4}$ $\frac{3}{12}$ $4\frac{1}{5}$
 1 $\frac{4}{9}$ $3\frac{3}{4}$
 $\frac{6}{10}$ $4\frac{7}{10}$
 $\frac{5}{9}$ $7\frac{2}{5}$
7. $1\frac{3}{4}$ $2\frac{4}{5}$
 $2\frac{1}{3}$ $5\frac{4}{6}$
 $4\frac{2}{5}$ $8\frac{3}{4}$
 $2\frac{5}{7}$ $11\frac{8}{9}$
8. $\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{3}$
9. $\frac{1}{2}$ $\frac{1}{3}$ $\frac{1}{4}$ $\frac{1}{7}$ $\frac{1}{10}$ $\frac{1}{22}$
10. $\frac{3}{6}$ $\frac{1}{4}$
 $\frac{3}{10}$ $\frac{3}{6}$
 $\frac{4}{6}$ $\frac{3}{8}$
 $\frac{5}{6}$ $\frac{6}{10}$
11. $\frac{2}{8}$ $\frac{5}{6}$ $\frac{7}{20}$
 $\frac{2}{10}$ $1\frac{1}{12}$ $\frac{3}{10}$
 $\frac{6}{12}$ $\frac{2}{5}$ $\frac{2}{12}$
 $\frac{4}{8}$ $\frac{16}{30}$ $\frac{5}{24}$
12. $\frac{2}{5}$ $\frac{1}{2}$ $\frac{3}{4}$
 $\frac{5}{6}$ $\frac{1}{5}$
- 13a. $\frac{19}{20}$ $\frac{9}{10}$ $\frac{3}{4}$ $\frac{3}{5}$ $\frac{1}{2}$ $\frac{4}{10}$
- 13b. $\frac{5}{6}$ $\frac{3}{4}$ $\frac{2}{3}$ $\frac{5}{8}$ $\frac{1}{2}$ $\frac{1}{6}$ $\frac{1}{8}$
14. $\frac{1}{18}$ $\frac{1}{40}$ $\frac{1}{9}$
 $\frac{3}{16}$ $\frac{1}{6}$ $\frac{1}{4}$
15. $3\frac{3}{4}$ 1
 $2\frac{1}{3} + 2\frac{1}{3} = 4\frac{2}{3}$ $\frac{2}{3}$

- | | | |
|-----|----------------|------------------|
| | $5\frac{1}{3}$ | 2 |
| | | $6\frac{2}{5}$ |
| 16. | $\frac{2}{20}$ | 2 |
| | $\frac{6}{21}$ | $2\frac{2}{3}$ |
| | $\frac{2}{5}$ | $\frac{8}{9}$ |
| | $\frac{1}{10}$ | $\frac{15}{14}$ |
| | $\frac{1}{6}$ | $1\frac{1}{4}$ |
| 17. | $\frac{9}{4}$ | $1\frac{1}{24}$ |
| | $\frac{17}{5}$ | $1\frac{9}{21}$ |
| | $\frac{10}{4}$ | $1\frac{1}{2}$ |
| | $\frac{13}{7}$ | $1\frac{3}{5}$ |
| | $\frac{16}{6}$ | $1\frac{17}{35}$ |
| 18. | $3\frac{5}{6}$ | |

Chapter 2

1. 50 35
8 124
68 33
108 43
2. 60
3. 220 kg extra, total 770 kg
4. 1568
5. 40 91
33 33
6. 5
7. 16000

Chapter 3

1. 0.8 0.58 0.945
0.5 0.64 0.421
0.6 0.25 0.125
2. $\frac{75}{100} = 0.75$ 1.25
 $\frac{40}{100} = 0.40$ 2.6
 $\frac{20}{100} = 0.20$ 1.25
 $\frac{4}{100} = 0.04$ 3.16
3. 1.5 2.2 2.4
1.2 1.8 3.2
6.5 7.4 0.3
3.4 1.9 0.9
3.2 1.9 2.4
18.8 0.5 0.902
4. 0.3
5. 28%

Chapter 4

1. 10^7 5.33×10^2 2.5×10^6
 1.4×10 9×10^3
2. 50 15 500 000 000

3. 3600 $30\ 000$
 10^{-4} 6×10^{-10}
 3.65×10^{-2} 6×10^{11}
 1.5×10^{-1}
4. $0.00\ 000\ 006$ 5500
 0.035 0.3371
5. $0.001 = 10^{-3}$
 $350\ 000 = 3.5 \times 10^5$
 $10\ 000 = 10^4$
 $3300 = 3.3 \times 10^3$
 $0.001 = 10^{-3}$
 $0.000\ 001 = 10^{-6}$
 $6\ 000\ 000 = 6 \times 10^6$
 $3600 = 3.6 \times 10^3$
6. 10^{10} 10^{-5}
 10^{-5} $10^0 = 1$
 $10^1 (= 10)$ $10^0 = 1$
7. 2×10^3 101×10^4
 10^2 4.8×10^{-3}
 10^{11} 6.91×10^8
 6×10^{-2} 34003
8. 15×10^5 $2 \times 10^0 = 2$
 3.6×10^1 $1 \times 10^1 = 10$
 5×10^1 8000

Chapter 5

1. $3\frac{2}{3}$
2. 0.17
3. $164/600$
4. weekly average of daily maxima: February 24.3; March 29.1
 weekly average of daily minima: February 19.6; March 19.3
 (coldest week: March)
 average temperature on March 4: 27..5
 table of daily averages:

date	February	March
1	23.3	21.5
2	23.0	24.0
3	22.5	25.0
4	22.0	27.5
5	21.0	23.8
6	21.0	23.5
7	21.0	25.3

 weekly average: February 21.9 ; March 24.4
 (lowest average temperature: February)

Chapter 7

1. 7.8 41.5
 7.9 41.5
 7.9 120.5
2. 20.7 6.0
 1.2 1.0
3. 4 9 3 54 or 54.0 122 or 120

4. $223,6 \times 52,125$ is rounded off at $200 \times 50 = 10.000$ and $89,25$ at 90 ; $10000 + 90 = 10.090$, thus the comma should be placed at $11744,4$

Chapter 8

- 1a. area 45
 1b. circ. 24, area 35
 1c. area 36
 1d. circ. 25.12, area 50.24
 1e. circ. 8, area 4
 2a. 126
 2b. 160
 2c. 120
 2d. 502.4
 2e. 27
 3. 226000 m^2 (rounded off) = 22.6 ha
 4.

14	28	87.9
3.5	7	22
6	12	37.7

 5. 0.98 m^3
 6. 38 m^2 requiring 10 tins
 7. $6 \text{ m}^3 = 6\ 000$ litres
 8. 88 m^2 ; $22 \times 0.01 = 0.22 \text{ kg}$
 9. $63 \text{ m}^3 = 63\ 000$ litres

Chapter 9

1.

3 cm	4 cm	3 : 4	12	3	3 : 9
9 : 3	9 : 12				

 2.

3 : 4	3 : 1	22 : 7
7 : 1	4 : 1	1 : 4

 3. 15
 200
 0.005
 4. $2 : 3\frac{1}{2} = \text{son} : 1.75$ son = 1.0 m
 5. 10 litres 210 km 3 times
 10 litres
 6. 0.2 48 0.3 litres oil
 7.2 litres petrol
 7. 0.09 kg
 8. 320
 9. 1, 2, 3
 10a. when A turns once, B turns twice
 10b. A 40 B 20
 10c. 80
 10d. B = 31.4 whole wheel = 219.8
 10e. $176 \text{ m/min} = 10.6 \text{ km/h}$
 11. 4 m 2 cm 30 m 9.65 cm
 12. $3 : 10\ 000\ 000$ $1 : 10\ 000\ 000$
 1 : 600
 14a. 6.5 km (approx.)
 14b. 30 km (approx.)
 15a. 25 km (approx.)
 15b. 4000 ha (approx.)

Chapter 10

1. proteins, fats, vitamins
2. about 1925 kg/ha; ? ? ?
4. about 20%
the crop is only grown in that country
olive oil
maize, rice, peanuts
-
5. about 115 kg
about 30 kg
first 2 months, greatest slope in the graph
between 6 and 10 months
about 25 kg/month
6. 10 ha; rectangular diagram
7. -

Chapter 11

1. 7 months 214 days
3. 15 April
4. 18 days
5. 6.30 h
6. 10.10 h a.m.
7. 33-34 coins

Chapter 13

1. $2 \times 3.3 = 6.6$
 $3 \times 1.6 = 4.8$
 $3.1 \times 2.6 = 8.06$
 $6 \times 4.5 = 27$
 $10 \times 1.02 = 10.2$
 $0.1 \times 2.5 = 0.25$
 $8.3 \times 2.5 = 20.75$
2. $0.6 \times 10\,000 \times 0.15 = 900$
 $5 \times 0.4 \times 10\,000 = 2 \times 10^4$
 $5 \times 0.3 \times 100 = 150$
 $0.1 \times 1000 \times 39 = 3900$
 $100 \times 0.84 \times 10^{-4} \times 2.5 = 2.1 \times 10^2$
 $0.01 \times 1000 \times 1.02 = 10.2$
3. 1.1 0.11
34.5 10.3
0.88 9.57
0.029 8.8
4. 11 10 000
500 0.6
60 600
0.125 300
5 30
5. 7.2 211
17 42.5
37.2
6. in cubic metres:
800 800 0.12
7. 68.9 kg

- mean 25 lb
8. ??
 9. A = 12 kg/are
B = 10 kg/are
 10. respectively dm, dl, kg, dm², ml

Chapter 14

1. 0.75 m 5.3 m³ 4293 kg
2. sell it at 25% moisture
3. 800 kg 300 kg/m³ 266 kg/m³
4. lead, stone
5. 9 000 kg
12 000 litres of petrol
12 000 litres of water
12 000 kg

Chapter 15

1. 24 10.8
432000 50
0.001 0.1
3.6 180
2 1000
20 3
2. 8.6 4.5 35
3. 2400 cm² 0.12 m³/s
4. 1650 cm² 2 m/s
5. 2750 cm² 0.55 m³/s
6. 4200 cm²
7. 50 l/s
8. 28.8 mm
9. 27.8 l/s
10. 200 ha
11. 2083 days
12. 2%
13. 0.2% or 2‰
14. 12%
11.4%

Chapter 16

- 1a. 3200 m²
- 1b. 1750 m²
2. 156
3. 22
4. rectangular: 500 m²
triangular: 425 m²
5. 324 kg
6. 0.8 kg
7. 313 seeds
8. 1389 seeds
9. 125 kg
10. 200 kg fertilizer 20 14-14
125 kg superphosphate
200 kg ammonium sulphate or

- 88.8 kg urea
- 11. amm.sulphate: 1 kg N costs 3.50 coins
urea: 1 kg N costs 2.66 coins
- 12. urea is cheaper, namely 110 against 147 coins
- 13. 102 kg
- 14. 0.1 litre
- 15. 100 kg
- 16. 2.5 kg
- 17a. 220 litres
- 17b. 11 times
- 17c. 4 kg approx. 365 g

Chapter 17

- 1. 4.3 LU
- 2. 7.5 LU
- 3. 3.7 LU
- 4. many possibilities
- 5. 2.5
- 6. 2.0
- 7. 2.9
- 8. 220 kg
- 9. 42.9 kg
- 10. 60%
- 11. slaughtered chickens 25 M/kg extra
- 12. 5 kg DM
- 13. unlikely: too much (1.2 kg DM)
- 14. about 13-14 kg
- 15. 6 eggs/week or 85%
- 16. 28 rabbits/year
4 litters/year
- 17. 49 l/week
- 18. 0.009 kg or 9 g fat
0.008 kg or 8 g protein