

## Scientific notation

### Introduction

In engineering calculations numbers are often very small or very large, for example 0.00000345 and 870,000,000. To avoid writing lengthy strings of numbers a notation has been developed, known as **scientific notation** which enables us to write numbers much more concisely.

### 1. Scientific notation

In scientific notation each number is written in the form

$$a \times 10^n$$

where  $a$  is a number between 1 and 10 and  $n$  is a positive or negative whole number.

Some numbers in scientific notation are

$$5 \times 10^3, \quad 2.67 \times 10^4, \quad 7.90 \times 10^{-3}$$

To understand scientific notation you need to be aware that

$$10^1 = 10, \quad 10^2 = 100, \quad 10^3 = 1000, \quad 10^4 = 10000, \quad \text{and so on,}$$

and also that

$$10^{-1} = \frac{1}{10} = 0.1, \quad 10^{-2} = \frac{1}{100} = 0.01, \quad 10^{-3} = \frac{1}{1000} = 0.001, \quad \text{and so on.}$$

You also need to remember how simple it is to multiply a number by powers of 10. For example to multiply 3.45 by 10, the decimal point is moved one place to the right to give 34.5. To multiply 29.65 by 100, the decimal point is moved two places to the right to give 2965. In general, to multiply a number by  $10^n$  the decimal place is moved  $n$  places to the right if  $n$  is a positive whole number and  $n$  places to the left if  $n$  is a negative whole number. It may be necessary to insert additional zeros to make up the required number of digits.

### Example

The following numbers are given in scientific notation. Write them out fully.

a)  $5 \times 10^3$ ,    b)  $2.67 \times 10^4$ ,    c)  $7.90 \times 10^{-3}$ .

### Solution

a)  $5 \times 10^3 = 5 \times 1000 = 5000$ .

- b)  $2.67 \times 10^4 = 26700$ .  
 c)  $7.90 \times 10^{-3} = 0.00790$ .

**Example**

Express each of the following numbers in scientific notation.

- a) 5670000,      b) 0.0098.

**Solution**

- a)  $5670000 = 5.67 \times 10^6$ .  
 b)  $0.0098 = 9.8 \times 10^{-3}$ .

**Exercises**

1. Express each of the following in scientific notation.  
 a) 0.00254,      b) 82,      c)  $-0.342$ ,      d) 1000000.

**Answers**

1. a)  $2.54 \times 10^{-3}$ ,      b)  $8.2 \times 10$ ,      c)  $-3.42 \times 10^{-1}$ ,      d)  $1 \times 10^6$  or simply  $10^6$ .

## 2. Using a calculator

Students often have difficulty using a calculator to deal with scientific notation. You may need to refer to your calculator manual to ensure that you are entering numbers correctly. You should also be aware that your calculator can display a number in lots of different forms including scientific notation. Usually a MODE button is used to select the appropriate format.

Commonly the EXP button is used to enter numbers in scientific notation. (EXP stands for exponent which is another name for a power). A number like  $3.45 \times 10^7$  is entered as 3.45EXP 7 and might appear in the calculator window as  $3.45^{07}$ . Alternatively your calculator may require you to enter the number as 3.45E7 and it may be displayed in the same way. You should seek help if in doubt.

Computer programming languages use similar notation. For example

$$8.25 \times 10^7 \quad \text{may be programmed as} \quad 8.25E7$$

and

$$9.1 \times 10^{-3} \quad \text{may be programmed as} \quad 9.1E - 3$$

Again, you need to take care and check the required syntax carefully.

A common error is to enter incorrectly numbers which are simply powers of 10. For example, the number  $10^7$  is erroneously entered as 10E7 which means  $10 \times 10^7$ , that is  $10^8$ . The number  $10^7$ , meaning  $1 \times 10^7$ , should be entered as 1E7.

Check that you are using your calculator correctly by verifying that

$$(3 \times 10^7) \times (2.76 \times 10^{-4}) \times (10^5) = 8.28 \times 10^8$$