Using SI units

Specification references

- *3.1.1 Use of SI units and their prefixes*
- *M0.1 Recognise and make use of appropriate units in calculations*

Maths Skills for Physics references

- *1.1 Units and dimensions*

Learning objectives

After completing the worksheet you should be able to:

- show knowledge and understanding of base and derived SI units
- use equations to work out derived units
- use base units to check homogeneity of equations.

Introduction

Base quantities are measured in base units. These are units that are not based on other units. For example, mass is measured in kilograms and length is measured in metres. Other quantities have units which are derived from the base quantities. For example, the unit of density ($kg\ m^{-3}$) is derived from the kilogram and the metre.

The first example shows you how to use an equation to work out the unit of a derived quantity. The second example shows you how to check that an equation is homogeneous or, in other words, that its units are balanced.

Worked example

Question

What is the SI unit of speed?

Answer

Step 1

Identify the equation to use.

Speed is defined as: $\dfrac{\text{distance travelled}}{\text{time taken}}$

Step 2

Write the equation in terms of units.

The SI unit of speed is defined as: $\dfrac{\text{unit of distance travelled}}{\text{unit of time taken}}$

Step 3

Select the appropriate SI base units.

SI unit of distance = metre (m)

SI unit of time = second (s)

Step 4

Insert the SI base units into the equation.

SI unit of speed = $\frac{\text{metre (m)}}{\text{time taken (s)}}$ = metre per second = m s^{-1}

Question

1 Work out the missing units, unit symbols and names, equations, and quantities in this table. (*1 mark* for each correct answer)

Physical quantity	**Equation used**	**Unit**	**Derived unit symbol and name**
frequency	$\frac{1}{\text{time period}}$	**a**	Hz hertz
volume	length^3	**b**	–
acceleration	$\frac{\text{velocity}}{\text{time}}$	**c**	–
force	mass × acceleration	kg m s^{-2}	**d**
work and energy	force × distance	**e**	J joule
potential difference	$\frac{\text{energy}}{\text{electric charge}}$	J C^{-1}	**f**
electrical resistance	**g**	V A^{-1}	**h**
momentum	mass × velocity	**i**	–
impulse	force × time	**j**	–
k	$\frac{\text{force}}{\text{area}}$	**l**	Pa pascal
m	**n**	kg m^{-3}	–

Worked example

Question

Check that the equation: kinetic energy = $\frac{1}{2} m v^2$ is homogeneous.

Answer

Make sure you always state which side of the equation you are working on, left-hand side (LHS) or right-hand side (RHS).

Step 1

Start with the LHS. The unit of kinetic energy is the joule. Change this to base units.

LHS: $\text{J} = \text{N m} = \text{kg m s}^{-2} \times \text{m} = \text{kg m}^2\ \text{s}^{-2}$

Step 2

Repeat Step 1 for the RHS.

RHS: units of $\frac{1}{2} m v^2$ are $\text{kg} \times (\text{m s}^{-1})^2 = \text{kg m}^2\ \text{s}^{-2}$

(The constant, $\frac{1}{2}$, is a number with no units.)

Step 3

Don't forget to write your conclusion.

LHS = RHS so the equation is homogeneous.

We can't tell that there is a $\frac{1}{2}$ in the equation, so we cannot say that the equation is correct, only that it is homogeneous.

Questions

2 Use base units to show the equation $Q = I\,t$ for electric charge passing a point in time t, when the electric current is I, is homogeneous. (*1 mark*)

3 Use base units to show that the equation $P = I\,V$ is homogeneous, where I is electric current, V is voltage, and P is power measured in watts (W). (Hint: $1\ \text{W} = 1\ \text{J s}^{-1}$) (*2 marks*)

4 The Earth's gravitational field strength, $g = 9.81\ \text{N kg}^{-1}$, is also sometimes given as the acceleration due to gravity, $g = 9.81\ \text{m s}^{-2}$. Show that these units are equivalent. (*1 mark*)

Maths skills links to other areas

You may also need to check equations are homogeneous wherever they are used in the specification – examples can be found in Chapter 7 *On the move*, and Topic 11.1 *Density*.

You can also use this method to help you decide whether you have remembered an equation correctly.