

Powers of 10 and standard form revision

10^5 means 'ten to the power of five' – the small number is called 'the power'. It is a convenient way to write very large or very small numbers.

$$10^1 = 10$$

$$10^2 = 100$$

$$10^3 = 1000$$

$$10^4 = 10000 \text{ and so on}$$

$$10^{-1} = 1/10 = 0.1$$

$$10^{-2} = 1/100 = 0.01$$

$$10^{-3} = 1/1000 = 0.001$$

$$10^{-4} = 1/10000 = 0.0001 \text{ and so on}$$

Powers of 10 can be combined with other numbers

e.g. $3 \times 10^4 = 30000$

With negative powers of 10, the zero before the decimal point counts as one of the zeros.

e.g. $6 \times 10^{-7} = 0.0000006$

If the number multiplying the power of 10 is a decimal greater than 1 and less than 10, the numbers to the right of the decimal point replace the first zeros. This is called 'standard form' as opposed to 'expanded form' when the full number is written.

e.g. $4.2 \times 10^5 = 420000$

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Size of a typical bacteria = $2 \times 10^{-6} \text{ m} = 0.000002 \text{ m}$



Amount of profit Tesco makes every minute = $\text{£ } 7 \times 10^3 = \text{£ } 7000$



Distance between Norwich and Hollywood = $8.7 \times 10^6 \text{ m} = 8700000 \text{ m}$



Amount of energy stored in 1 tonne of coal = $32000000000 \text{ J} = 3.2 \times 10^{10} \text{ J}$



Questions:

- 1) Write 4000000 m in standard form
- 2) Write 86000 Hz in standard form
- 3) What is $9.1 \times 10^8 \text{ J}$ written in expanded form

Answers:

1) 4.0×10^6 m

2) 8.6×10^4 Hz

3) 910000000 J

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Physics calculations often require you to multiply or divide powers of 10. Errors are often made during division calculations involving negative powers of 10, so take care.

To multiply powers of 10 together, you add the powers. e.g. $10^2 \times 10^7 = 10^9$

To divide powers of 10, you subtract the powers. e.g. $10^{12} / 10^4 = 10^8$
- be careful with negative powers in the denominator

Questions:

1) $10^6 \times 10^8 = ?$

2) $2.1 \times 10^3 \times 4 \times 10^7 = ?$

3) $3 \times 10^{-8} \times 2 \times 10^{-3} = ?$

4) $10^{12} / 10^9 = ?$

5) $10^{-6} / 10^7 = ?$

6) $(5 \times 10^2) / (2 \times 10^{-5}) = ?$

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Answers:

1) $10^6 \times 10^8 = 10^{14}$

2) $2.1 \times 10^3 \times 4 \times 10^7 = 8.4 \times 10^{10}$

3) $3 \times 10^{-8} \times 2 \times 10^{-3} = 6 \times 10^{-11}$

4) $10^{12} / 10^9 = 10^3$

5) $10^{-6} / 10^7 = 10^{-13}$

6) $(5 \times 10^2) / (2 \times 10^{-5}) = 2.5 \times 10^7$

Powers of 10 and the scale of the universe

Watch the following short video – note down as many powers of 10 prefixes as you can

e.g. m (milli), k (kilo), M (Mega), G (Giga)

https://www.youtube.com/watch?v=5AAR7bNSM_s

Powers of 10 prefixes

Certain powers of 10 have their own prefixes, some of which you have met before. You need to be able to recall and interconvert between the following powers of 10 for the A Level course:

<i>PREFIX</i>	<i>SYMBOL</i>	<i>VALUE</i>
<i>pico</i>	<i>p</i>	10^{-12}
<i>nano</i>	<i>n</i>	10^{-9}
<i>micro</i>	μ	10^{-6}
<i>milli</i>	<i>m</i>	10^{-3}
<i>centi</i>	<i>c</i>	10^{-2}
<i>kilo</i>	<i>k</i>	10^3
<i>mega</i>	<i>M</i>	10^6
<i>giga</i>	<i>G</i>	10^9
<i>tera</i>	<i>T</i>	10^{12}

Example: How many nanometres are there in a kilometre?

Answer: $10^3 / 10^{-9} = 10^{12}$

Complete the following questions

1. How many micrometres are there in a gigametre?
2. How many kilograms are there in a teragram?
3. Calculate $1 \text{ pm} \times 1 \text{ Mm}$ (give your answer using a power of 10 prefix)
4. Calculate $10 \text{ kg} / 0.1 \text{ }\mu\text{g}$ (give your answer using a power of 10 prefix)
5. A grain of stardust travels 2.3 km in 8.1 ms. Calculate its average speed in m/s using standard form. Round your answer to 1 decimal place.

Answers

1. How many micrometres are there in a gigametre? $10^9 / 10^{-6} = 10^{15}$
2. How many kilograms are there in a teragram? $10^{12} / 10^3 = 10^9$
3. Calculate 1 pm x 1 Mm (answer using a power of 10 prefix) $10^{-12} \times 10^6 = 10^{-6} = 1\mu\text{m}$
4. Calculate 10 kg / 0.1 μg (answer using a power of 10 prefix) $10^4 / 10^{-7} = 10^{11} = 100 \text{ Gg}$
5. A grain of stardust travels 2.3 km in 8.1 ms. Calculate its average speed in m/s using standard form. Round your answer to 1 decimal place.

$$\text{average speed} = (2.3 \times 1000) / (8.1 \times 10^{-3}) = 2.8 \times 10^6 \text{ m/s}$$