

Orders of Magnitude

Ages 11-16 | KS3-KS4 | 25-35 minutes | Pairs or small groups

Estimate first. Reveal second. Write an exponent or prediction before checking the interactive journey or entity pages.

Name / pair: _____

Class: _____

Date: _____

CORE IDEA

One order of magnitude is a factor of ten.

The exponent difference tells you the number of 10x steps. A difference of 3 means $10^3 = 1,000$ times.

ACTIVITIES 1-3**1**

Which power of ten?

Choose the nearest power of ten in metres for: human, human hair, bacterium, football pitch, Mount Everest, Earth and Sun. Example: 1.75 m is nearest to 10^0 m.

A nearest power is an estimate of scale, not an exact measurement.

2

Put them in order

Place these from smallest to largest: virus, bacterium, human hair, human, blue whale, Mount Everest, Earth, Sun. Circle one pair whose spacing surprised you.

3

Count the orders of magnitude

Use nearest exponents for DNA and hair; Earth and Sun; Burj Khalifa and Everest. For each pair: subtract the exponents, then write the approximate multiplier. Example: $5 - 2 = 3$ orders, so $10^3 = 1,000$ times.

Exponent difference and multiplicative difference are related, but they are not the same statement.

Orders of Magnitude

Continue with standard form, estimation and reasoning. Keep units beside every value.

ACTIVITIES 4-6

4 Scientific notation / standard form

Rewrite in metres using a number from 1 up to (but not including) 10, multiplied by a power of ten: hair 0.00007 m; bacterium 0.000002 m; football pitch 105 m; Everest 8,848.86 m; Earth 12,742,016.8 m; Sun 1,391,400,000 m.

Example: 450,000 m = 4.5×10^5 m.

5 Estimate before revealing

Predict the nearest order of magnitude for DNA width, a virus, blue whale length, Saturn diameter, Mount Everest height and the mean Earth-Sun distance. Add one reason for each estimate, then check the web activity.

6 Big question

Why can a difference of only 6 in the exponent describe objects that feel unimaginably different in size? Which was harder to estimate: microscopic or astronomical scales? Explain your reasoning.

POWERS-OF-TEN REFERENCE

10^{-9} nanometres | 10^{-6} micrometres | 10^{-3} millimetres | 10^0 metres | 10^3 kilometres

Every +1 exponent step is x10. Every -1 step is /10. Negative exponents still describe positive lengths.

<https://justhowbig.com/education/orders-of-magnitude/>

Teaching Orders of Magnitude

A practical companion to the two-page student worksheet and interactive powers-of-ten journey.

Age / level	Ages 11-16 / KS3-KS4. Adaptable for maths, physics and general science.
Time	25-35 minutes.
Set-up	One worksheet per student; one connected device per pair where available.
Core ideas	Orders of magnitude; powers of ten; standard form; exponent differences; multiplicative reasoning; dimensional intuition.

LEARNING OBJECTIVES

- Recognise that one order of magnitude is specifically a factor of ten.
- Compare and order real lengths written in scientific notation.
- Estimate a nearest power of ten and explain the estimate.
- Convert an exponent difference into an approximate multiplier.

SUGGESTED LESSON FLOW

5 min Model one whole 10x step. Contrast exponent difference with multiplier.	10 min Students estimate and order before opening any links.	10 min Complete exponent and standard-form tasks; check with the journey.	5-10 min Discuss errors, measurement choices and the big question.
--	--	---	--

KEY TEACHING POINTS

- An order of magnitude is not a synonym for "much bigger"; it is a 10x change.
- A difference of 3 orders means about $10^3 = 1,000$ times, not 3 times.
- Negative exponents do not mean negative size: 10^{-6} m is a positive length smaller than 10^{-3} m.
- Scientific notation states magnitude compactly; the coefficient must be at least 1 and less than 10.
- Width, height, diameter and distance can place the same subject in different orders of magnitude.

Answers, differentiation and discussion

Accept sensible rounding where students state their chosen measurement and work consistently.

ANSWER GUIDANCE

1. Nearest powers	Human 10^0 ; Human hair 10^{-4} ; Bacterium 10^{-6} ; Football pitch 10^2 ; Mount Everest 10^4 ; Earth 10^7 ; Sun 10^9 . Boundary answers may vary when a value lies near the geometric midpoint.
2. Order	Virus < Bacterium < Human hair < Human < Blue whale < Mount Everest < Earth < Sun.
3. Orders and multipliers	DNA (10^{-9}) to hair (10^{-4}): 5 orders, about 100,000x. Earth (10^7) to Sun (10^9): 2 orders, about 100x. Burj Khalifa (10^3) to Everest (10^4): 1 order, about 10x. Actual ratios need not equal the rounded power exactly.
4. Standard form	70 μm hair: 7×10^{-5} m; 2 μm bacterium: 2×10^{-6} m; Football pitch: 1.05×10^2 m; Mount Everest: 8.849×10^3 m; Earth: 1.274×10^7 m; Sun: 1.391×10^9 m.
5. Estimates	DNA 10^{-9} m; virus 10^{-7} m; blue whale 10^1 m; Saturn 10^8 m; Everest 10^4 m; Earth-Sun distance 10^{11} m. Credit reasoning and an adjacent power where justified.
6. Big question	Six exponent steps represent $10^6 = 1,000,000$ times. Strong answers discuss repeated multiplication and why direct experience is limited at microscopic and astronomical scales.

DIFFERENTIATION

Support Provide the powers-of-ten reference, unit prefixes and a number line. Let students compare only exponent parts first. Use three objects before expanding to eight.	Stretch Convert units before comparing; estimate actual ratios from coefficients; introduce $\log_{10}$ as the exponent; explain why logarithmic scales make wide ranges readable.
--	--

DISCUSSION PROMPTS

- Which scale was hardest to estimate, and what reference could improve the estimate?
- Why can two objects in the same order of magnitude still differ substantially?
- When would diameter be more useful than height or length?
- Why are logarithmic scales useful when values span many powers of ten?

MEASUREMENT CAUTIONS

Examples use selected dimensions from Just How Big?. DNA is helix diameter; Everest is elevation above mean sea level; Solar System is the diameter of Neptune's orbit. Cells, viruses, people and galaxies vary, so answers describe representative values and approximate orders.