# Mathematical shorthand continued

Students investigate the width of atoms and other very small objects to discover the need for, and learn about scientific notation for very small numbers.

## Visible learning

### Learning intention

* To be able to express very small numbers in scientific notation.

### Success criteria

* I can convert very small numbers in decimal form to scientific notation.
* I can convert very small numbers in scientific notation to decimal form.
* I can order numbers represented in scientific notation.

### Syllabus outcomes

A student:

* develops understanding and fluency in mathematics through exploring and connecting mathematical concepts, choosing and applying mathematical techniques to solve problems, and communicating their thinking and reasoning coherently and clearly **MAO-WM-01**
* solves measurement problems by using scientific notation to represent numbers and rounding to a given number of significant figures **MA5-MAG-C-01**

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## Activity structure

### Launch

1. Open the video ‘Voyage into the world of atoms’ (2:01) (<https://bit.ly/VoyageAtoms>) without playing.
2. Ask students to pay attention to the line at the bottom of the screen.
3. Play the first 8 seconds and pause the video.
4. Have students conduct a Think-Pair-Share ([bit.ly/DLSthinkpairshare](https://bit.ly/DLSthinkpairshare)) answering the 2 questions below.
5. What do you believe is happening in the video?
6. What are the units on the number line at the bottom of the screen?
7. Play the remainder of the video. Teachers may choose to play the remainder at high speed.
8. Explain to students that atoms make up all matter, including each of us.
9. Use a Pause-Pose-Pounce-Bounce question strategy [PDF 200KB] ([bit.ly/pausepouncebounce](https://bit.ly/pausepouncebounce)) to ask students to describe how wide an atom might be?

If required, prompt students with a frame of reference. For example, the door is 1 metre wide. What number of metres do you believe we could use to describe how wide an atom might be?

### Explore

1. Display Table 1 to students below.

Table 1 – very small objects

|  |  |
| --- | --- |
| Width of a sand particle | 0.000 063 metres |
| Width of a carbon atom | 0.000 000 000 154 metres |
| Mass of an electron | 0.000 000 000 000 000 000 000 000 000 9 grams |

1. Conduct a Think-Pair-Share where students discuss with a partner what they notice, what they wonder and which number they think is the largest in Table 1.
2. Hand all students a copy of Appendix A ‘Converting powers of 10’. Have students use a calculator and evaluate each of the powers of 10 in the table.
3. Students are to again engage in a Think-Pair-Share to consider the following questions.
4. What do you notice and what do you wonder?
5. How would you express each of the decimals in the table as fractions?
6. What would be a power of ten that is closest to each of the measurements in Table 1?

Teachers should consider drawing attention to the relationship between powers of 10 with equal magnitude, such as $10^{5}$ and $10^{-5}$.

### Summarise

1. Use slides 1–14 from the Mathematical shorthand continued PowerPoint for explicit teaching of the skills required for interpreting and representing very small numbers in scientific notation.

The explicit teaching technique used in the PowerPoint is ‘Your turn.’ The first slide is a worked example which should be displayed for the students and then use the following steps.

1. Reveal the question to students and its solution.
2. Students read in silence.
3. Students individually think and explain to themselves what is happening in each step.
4. Students hold up a thumbs up to the teacher when they have finished reading and have some sort of understanding.
5. Think-Pair-Share. Students explain the solution to their partner.
6. In pairs, students then answer the self-explanation questions.
7. Finally, randomly select students to share their answers with the whole class.
8. Demonstrate to students how to use their calculator to express small numbers in scientific notation.
9. Have students complete Appendix B ‘Converting small numbers’. This activity allows students to convert between scientific notation and decimal form and vice versa, as well as calculate some examples from Biology and Physics.

These questions have been designed to progress from easy to hard and then into problem solving activities.

### Apply

#### Equipment

* Class set of Appendix C ‘Ordering numbers’, printed.
* A device with internet access between pairs of students.

#### Method

1. Hand students Appendix C and ask students to order the objects in the table, in descending order, based on their own estimates.
2. Have students complete a basic internet search to identify each of the lengths in the table and record them in scientific notation.
3. Instruct students to use the values they have found to create an accurate descending list of the measurements.
4. Have students engage in a Think-Pair-Share to discuss the following questions.
5. Was your original order accurate?
6. What object was surprisingly longer or shorter than you expected?
7. How do you know which measurement is larger when comparing numbers in scientific notation?

## Assessment and differentiation

### Suggested opportunities for differentiation

**Launch**

* Teachers can replace discussions of the size of atoms with things that can be seen, such as considering a number that might describe the width of a piece of paper or the weight of a speck of dust.

**Summarise**

* Students are challenged to use negative indices to consider their application to index laws.

### Suggested opportunities for assessment

**Explore**

* The Think-Pair-Share activity is an opportunity for students to show their depth of understanding of connections between negative-integer indices, fractions and decimals.

**Summarise and apply**

* Both Appendix B and C can be collected as evidence of students’ ability to represent and use very small numbers expressed in scientific notation.

## **Appendix A**

### Converting powers of 10

By entering each number into your calculator or using your own methods, write each number without index notation. Two have been completed for you.

|  |  |
| --- | --- |
| Index form | Basic numeral |
| $$10^{5}$$ | 100 000 |
| $$10^{4}$$ |  |
| $$10^{3}$$ |  |
| $$10^{2}$$ |  |
| $$10^{1}$$ |  |
| $$10^{0}$$ |  |
| $$10^{-1}$$ | 0.1 |
| $$10^{-2}$$ |  |
| $$10^{-3}$$ |  |
| $$10^{-4}$$ |  |
| $$10^{-5}$$ |  |

## **Appendix B**

### Converting small numbers

Complete the table below. Questions 1 to 7 should be completed without a calculator.

|  |  |  |
| --- | --- | --- |
| Item | Decimal form | Scientific notation |
| **1.** | **0.02** |  |
| **2.** |  | **4 x 10-3** |
| **3.** |  | **6.48 x 10-7** |
| **4.** | **0.000 004 980** |  |
| **5.** | **0.000 000 0213** |  |
| **6.** |  | **1.6 x 10-1** |
| **7.** |  | **7.77 x 100** |
| **8.** |  | **8 x 10-2 + 1.5 x 10-3** |
| **9.** |  | **(6 x 10-4) x (5.4 x 10-2)** |
| **10.** | **(5.1 x 10-3) x (2.6 x 10-4)** |  |
| **11.** | **7.9 x 105 ÷ 4.3 x 10-2** |  |
| **12.** | **4 microns (in meters)** |  |

**Answer the following questions leaving your answer in scientific notation.**

1. There are approximately $3×10^{5}$ platelets in a mL of human blood. How big is a platelet? Have you made any assumptions? If so, what were they?
2. The volume of 1 molecule of water is 9.8 × 10- 23 cm3. How many water molecules in a mL of water? (Note: 1mL = 1 cm3)

**Challenge:**

**What is the smallest number you can enter into your calculator in scientific notation?**Appendix C

## Ordering numbers

Below is a list of very small items.

1. Research their lengths and write them in scientific notation (correct to 2 significant figures)?

|  |  |  |
| --- | --- | --- |
| Item | Objects | Value in scientific notation |
| A | Diameter of a water molecule |  |
| B | Length of a fly |  |
| C | Diameter of smallest bacterium |  |
| D | Diameter of a red blood cell |  |
| E | Diameter of a human hair |  |
| F | Diameter of cat whisker |  |
| G | Diameter of DNA helix |  |

1. List the lengths in descending order by writing their corresponding letters A, B, C and so on.

## Sample solutions

### **Appendix A – converting powers of 10**

|  |  |
| --- | --- |
| Index form | Basic numeral |
| $$10^{5}$$ | $$100 000$$ |
| $$10^{4}$$ | $$10 000$$ |
| $$10^{3}$$ | $$1000$$ |
| $$10^{2}$$ | $$100$$ |
| $$10^{1}$$ | $$10$$ |
| $$10^{0}$$ | $$1$$ |
| $$10^{-1}$$ | $$0.1$$ |
| $$10^{-2}$$ | $$0.01$$ |
| $$10^{-3}$$ | $$0.001$$ |
| $$10^{-4}$$ | $$0.0001$$ |
| $$10^{-5}$$ | $$0.00001$$ |

### Appendix B – converting small numbers

|  |  |  |
| --- | --- | --- |
| Item | Standard form | Scientific notation |
| **1.** | **0.02** | **2 x 10-2** |
| **2.** | **0.004** | **4 x 10-3** |
| **3.** | **0.000 000 648** | **6.48 x 10-7** |
| **4.** | **0.000 004 980** | **4.98 x 10-6** |
| **5.** | **0.000 000 0213** | **2.13 x 10-8** |
| **6.** | **0.16** | **1.6 x 10-1** |
| **7.** | **7.77** | **7.77 x 100** |
| **8.** | **0.0815** | **8 x 10-2 + 1.5 x 10-3** |
| **9.** | **0.0000324** | **(6 x 10-4) x (5.4 x 10-2)** |
| **10.** | **(5.1 x 10-3) x (2.6 x 10-4)** | **1.33 x 10-6** |
| **11.** | **7.9 x 105 ÷ 4.3 x 10-2** | **1.84 x 107** |
| **12.** | **4 microns (in meters)** | **4 x 10-6** |

1. 3.3 x 10-6 mL. I have assumed that platelets are measured in millilitres.
2. 1.02 x 1022

### Appendix C – ordering numbers

|  |  |  |
| --- | --- | --- |
| Item | Objects | Value in scientific notation |
| A | Diameter of a water molecule | $1.51×10^{-10}$ metres |
| B | Length of a fly | $6×10^{-3}$ metres |
| C | Diameter of smallest bacterium | $2×10^{-7}$ metres |
| D | Diameter of a red blood cell | $7×10^{-6}$ metres |
| E | Diameter of a human hair | $5×10^{-6} $metres |
| F | Diameter of cat whisker | $5×10^{-5}$ metres |
| G | Diameter of DNA helix | $2×10^{-9}$metres |

1. B, F, D, E, C, G, A

## References

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