TUNNELWORKS
KS3 MATHS LESSON 4 (ESSENTIALS)
TEACHERS' NOTES

About this lesson

This lesson explores percentages and ratios. Students complete a table which models how rainfall across London drains into four Combined Sewer Overfl ows (CSOs) that will be connected to the Thames Tideway Tunnel. They use their results to explore how the rain passes over London and how the rainwater from each CSO's catchment area contributes to wastewater flow through the Tunnel over time.

Learning outcomes

Students can:
- Explain how percentages, ratios and fractions can each represent parts of a whole
- Calculate and work with percentages
- Identify ratios between values

Curriculum links

KS3 Maths
- Use ratio and scale factor notation and methods involving conversion, mixing, measuring, scaling, comparing quantities and concentrations
- Calculate missing quantities and totals using given ratios, including reduction to simplest form
- Solve problems involving percentage change, including: percentage increase and decrease

What you will need

- KS3 Maths Lesson 4 presentation
- Lesson 4 worksheet

Students are likely to need calculators for the worksheet challenges.

Preparation

Review the KS3 Maths Lesson 4 presentation. Adapt the content to suit your students' ability. Note that the table / model simplifi es the rainfall by assuming each hour's rainfall falls as a single volume of rain. You may want to discuss other ways in which maths models simplify the real world but still provide useful insights.

Time (60mins)	Teaching activity	Learning activity	Assessment for learning
5 mins	**Starter:** Ask students to discuss ratios, percentages and fractions in their table groups and come up with a definition or explanation of each one, and to identify what all have in common.	Students discuss and share their definitions or explanations and identify that ratios, percentages and fractions all describe parts of a whole or contributions to a total.	Discussion, questioning.
15 mins	**Whole class:** To begin with, you may wish to show the intro video about the Thames Tideway Tunnel project if the class have not seen it before, otherwise start with screen 1. Watch the video in screen 1 and find out what students must do. Review screen 2 to help students understand the link between the table and the locations of the CSOs. Screen 3 shows how rainfall runoff from the surrounding catchment area enters the existing sewerage network system. The Thames Tideway Tunnel will be connected to each CSO to capture and divert wastewater during heavy rainfall, for treatment at Abbey Mills Pumping Station. Read the note at the top of the worksheet and review the data table at screen 4. Ask students to explain what the table can tell them, once completed.	Students identify that each row represents the wastewater flow volume through one CSO into the Tunnel, and the total of each column represents the total wastewater flow volume through all four CSOs into the Tunnel during a one hour period. They identify that the table can tell them each hour or CSO's contribution to the total wastewater flow volume and show how this changes over time.	Discussion. Verbal answers.
15 mins	**Individuals:** Students complete tasks 1 and 2. If necessary review how to convert each hour or CSO's total into a percentage of the overall total. **Answer:** Overall total = 25,000m^3 of water.	Students add up the hourly totals (columns) and totals for each CSO (rows) and then calculate the total flow volume caused by the rainfall.	Written work.

15 mins	**Whole class:** Review answers as a class. Review the questions in task 3. **Individuals:** Students complete task 3.	Students share answers to complete the table. Students calculate the answers to questions 1 – 8.	Verbal answers. Written work.
10 mins	**Plenary:** Share answers, asking students to explain how they completed each question. Discuss how each way of communicating a part of a whole (ratio, percentage, fraction) has strengths and weaknesses. Watch the answers video on screen 5.	Students share answers and working methods. Students discuss strengths and weaknesses of ratios, percentages and fractions and when each one might be most helpful to use.	Discussion, questioning.

Differentiation

Easier	Harder
Ask less able students to work together to complete their table, assigning one or more rows or columns according to ability. Convert each CSO's total flow volume to a percentage of the overall total as a class, before asking students to convert each hour's total flow volume (again students could complete together). Omit selected questions from task 3.	Use the ideas in Dig Deeper.

Answers to Task 3

1. West to East
2. CSO C, between 12pm and 2pm
3. Between 12pm and 2pm
4. CSO D
5. CSOs D and B
6. 9 and 10am, and 1 and 2pm
7. 600%
8. 5:1

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Modelling with ratios and percentages

- Ask students to identify the % contribution per 500m^3 water (2%) and then to convert this into a fraction (1/50th). Students can then convert each percentage contribution into 50ths of the whole and simplify where possible.

- Students could create volume / time graphs for each CSO and for the Tunnel as a whole, manually or by creating the table in a spreadsheet and using the chart function.

- The table on the student activity sheet simplifies the contribution of wastewater flowing from each CSO into the Tunnel over time because it does not account for the time taken for water to flow through the Tunnel, for example to get from CSO A to CSO B.

The table below provides fictitious data for the distance separating each CSO from the point at which the total flow volume is calculated, which is just downstream of CSO D:

CSO	Distance from measurement point (m)
A	4,000
B	2,500
C	1,000
D	500

Assume that water flows through the Tunnel at 4m/s.

Can students calculate how long it takes for water flowing from each CSO into the Tunnel to reach the measurement point? (To simplify a much more complex situation, students should assume that each hour's volume of wastewater flows all at once at the beginning of each hour. For example, 1,500m^3 flows through CSO B into the Tunnel at 12pm.)

Students can then create a new table showing when wastewater caused by the rain first passes the measurement point, increases over time and finally returns to zero once the rain has fallen and flowed through the Tunnel.

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Modelling with Algebra

- Students could enter their model into a spreadsheet, creating cells into which they can enter values for each variable, and see how this changes the total distance bored under different conditions.

- Challenge students to create a formula that can account for any shift length or working period, eg

  d = 1.188 x (t – b) x f

  Where ***t*** represents the total time for the shift and as before, ***b*** represents stoppage time.

- Students could calculate the speed through different soils by multiplying the maximum speed of 1.188 m/hr by each soil factor ***f***. They could then plot distance – time graphs to represent a range of scenarios (moving though different soil types, moving from one type to another, and including different periods of downtime), and challenge other students to interpret the graph's gradients and shape to identify the soil type and what happened during each fictional shift.

- Each ring of concrete lining is made of seven segments and lines 1.5m of tunnel. Can students add to their formula to work out how many rings or segments will be needed in a specific time? (In fact, the tunnel comprises seven segments and a keystone but we have ignored this in order to keep the maths age appropriate.)

- Each ring of segments costs £600 and the TBM costs £4,500 to operate for one hour. Can students use this information to calculate the total running cost per shift? They should remember that the running costs remain even if the TBM is not moving, but segments are only required when being added to newly-bored Tunnel.