TUNNELWORKS
KS3 MATHS LESSON 2 (ESSENTIALS)
TEACHERS' NOTES

About this lesson

This lesson explores co-ordinates by challenging students to create an approximate map of the Thames Tideway Tunnel and one branch. It uses Ordnance Survey fourfigure grid references to do this. Students can then use co-ordinates to identify areas of sub-maps and as time permits, use Pythagoras Theorem (building on Lesson 1) to estimate some or all distances.

Learning outcomes

Students can:

- Recall how to use the co-ordinate system in one quadrant
- Plot co-ordinates
- Calculate areas bounded by co-ordinates
- Calculate distances between points.

Curriculum links

KS3 Maths

• Key concepts	1.1a-c; 1.2b; 1.4a
• Key processes	2.1a, c, d; 2.2a-c, h, j-n; 2.4a-b
• Range and content	3.2a, c, f

What you will need

- KS3 Maths Lesson 2 presentation
- Lesson 2 worksheet
- OS mapping of London (optional)

Preparation

Review the KS3 Maths Lesson 2 presentation and presenter's notes, and the lesson 2 worksheet. Decide on which content you will include in your teaching, and adjust the timings below to suit your own lesson length, or to spread the content across two lessons.

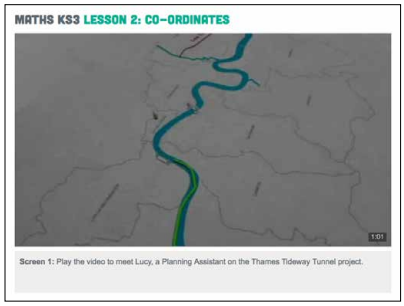
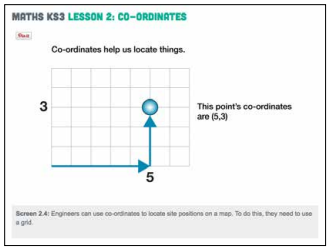
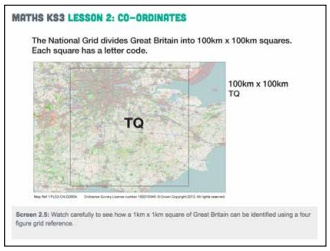
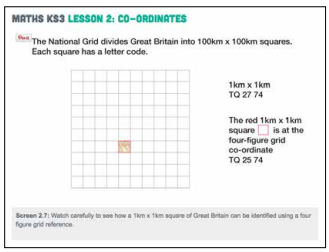
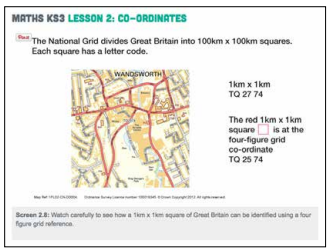
Time (60mins)	Teaching activity	Learning activity	Assessment for learning
5 mins	**Starter:** Ask students to think of different ways to describe a location in London. How many ways can they think of?	Students discuss ideas in pairs/ groups and share as a class.	Discussion, questioning.
15 mins	**Whole-class:** Optional: Show the intro video and explore the map and site in screens 1.1 - 1.3 of Lesson 1 if you wish. Watch the video in screen 1 and find out what students must do. Work through the interactives in screens 2.1 - 2.9 (but not 2.10 - 2.11) and answer each question. Discuss how increasing the number of figures in the grid reference system adds accuracy.	Students review coordinates and answer on-screen questions . Students could identify the accuracy of 6 – 10 figure grid references (100m – 1cm).	Verbal answers. Discussion, verbal answers.
15 mins	**Pairs/groups:** Read the engineer's note on the worksheet and review the mapping challenge. Explore screen 3.1 without showing the completed map.	Students plot each location to create their map, working in pairs/groups as appropriate.	Written work.
5 mins	**Whole-class:** Review students' maps and compare to the completed map on screen 3.2. Read the challenge to find the boundary co-ordinates of the sub-maps.	Students discuss how their maps' accuracy depend on the accuracy of using the four-figure grid system.	Discussion, questioning.
5 mins	**Individuals:** Ask students to plot and write down the corner coordinates for each sub-map.	Students plot submaps and share corner co-ordinates.	Written work.

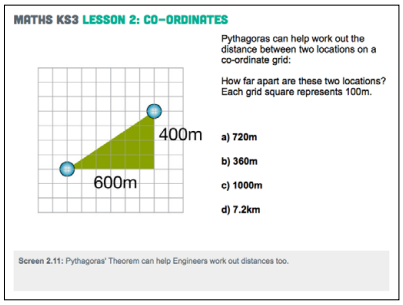
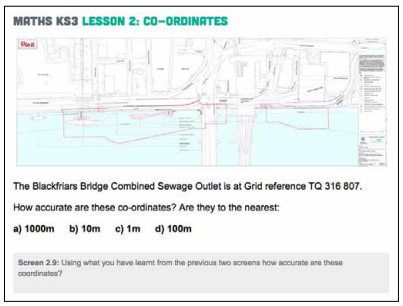
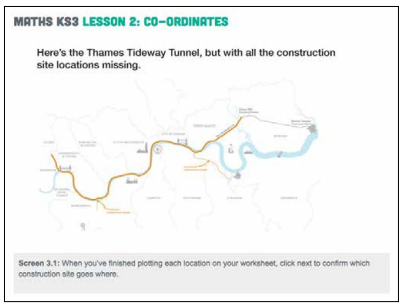
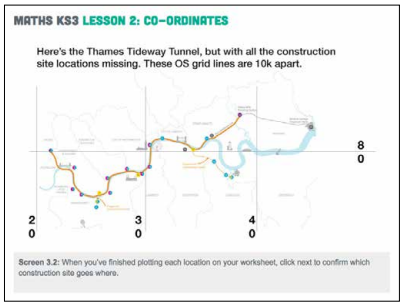
15 mins	**Plenary:** Review students' answers. If time permits, complete challenge 3. Optional: Review the last challenge on screens 2.10 - 2.11. Challenge students to calculate approximate distances between points using Pythagoras' theorem.	Share answers. Students calculate distances between points.	Verbal answers Written work, verbal answers.
5 mins	Watch the video on screen 4.	Discussion	Discussion, questioning.

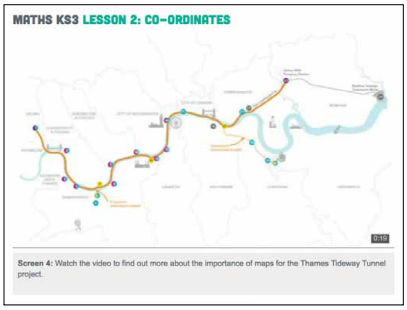
Differentiation

Easier	Harder
Use mixed-ability groups and share out locations. Omit the Pythagoras challenge and discussions of increasingly accurate grid reference systems.	Include all CSO site locations – see 'Dig Deeper' for the complete list. Include the challenge to calculate approximate distances using Pythagoras' Theorem. Ask students to calculate the area in square km of the whole map and the submaps. Make Blackfriars Bridge the central origin (0,0) of a four-quadrant grid. Challenge students to calculate the co-ordinates of selected locations using this revised grid system.

Presentation Notes
Lesson 2

Screen	Notes
1  Screen 1: Play the video to meet Lucy, a Planning Assistant on the Thames Tideway Tunnel project.	Use this video to set the scene and introduce the challenge for KS3 Maths Lesson 2.
2.1 to 2.8  Screen 2.4: Engineers can use co-ordinates to locate site positions on a map. To do this, they need to use a grid.  Screen 2.6: Watch carefully to see how a 1km x 1km square of Great Britain can be identified using a four figure grid reference.  Screen 2.7: Watch carefully to see how a 1km x 1km square of Great Britain can be identified using a four figure grid reference.  Screen 2.8: Watch carefully to see how a 1km x 1km square of Great Britain can be identified using a four figure grid reference.	Use this screen to review the basics of co-ordinates. Remind students that they always go along the x axis and up the y axis. OS map terms for this are 'eastings' then' northings', or as many are taught: 'along the ground then up the tree'. This simple example raises the question of how to locate something that's in the square that has the point at its bottom left-hand corner. OS grid references deal with this as shown on the next stage. Explain how the Ordnance Survey (OS) split the country into 100 x 100km squares, each of which has a two letter designation. London falls within TQ which is approximately as shown. In this there is a grid of 100 10 x 10km squares that provide a 1-figure grid reference, eg 2 7. And within each of these 10 x 10km squares there are another 100 squares, each now 1km x 1km. This provides a four figure reference. Ask students what a six figure reference will show them. This is what's most often used with OS maps when people are exploring the outdoors – for most purposes it's a good balance between accuracy and difficulty. The Armed forces often use eight-figure grid references and the detailed mapping that engineering companies can use for planning can go down even more than this. See also screen 3. Use this stage if you are going to estimate the distances between points along the tunnel and to estimate the total length. It's a good way to again discuss the limitations of a four-figure grid, since the accuracy of the estimate depends on the accuracy of the locations of each point (and also on the exact route of the tunnel between them, which aren't perfectly straight lines, as the tunnel needs to avoid going under buildings and avoid existing underground features).

Screen	Notes
2.9 to 2.11  	Use this screen to set the scene for lessons 1 and 2 in KS3 Maths. Victoria Embankment is a typical CSO site, where they will link an existing sewer to the new Thames Tideway Tunnel. Under all but the most exceptional conditions, the modified CSOs will divert rainwater and sewage down into the Tunnel rather than letting it discharge into the river Thames. At the moment, the outfall at Victoria Embankment discharges about 94,000 m3 into the river each year. That's about as much as in 38 Olympic-sized swimming pools. This is a good example of why building the Thames Tideway Tunnel is so important. The drop shaft takes the diverted water and sewage down to the same level as the main tunnel. It's important to design each part of the CSO correctly so water will flow easily through it, but not so fast that the flow may damage the new structure.
3.1 and 3.2  	Show this map briefly before students start their challenge. It's then best not to have it showing. Once the class has completed their challenge, click on the arrows to reveal the locations students have been plotting. The challenge locates each point in a four figure grid reference which covers a square 1km x 1km, so students' maps will be an approximation. Use this as a way to discuss why in real life, people need six or eight-figure grid references. If you are able, show students an area of your school grounds that is 100 x 100 m (the accuracy of a six foguire reference) and 10 x 10m (the accuracy of an eight figure reference). If a GPS can locate someone to within 1m, what figure of grid reference is this equivalent to. What about 'professional' GPS that can locate to 1cm? Ordnance Survey provide a fantastic, free guide to using grid references. Download the PDF at: www.ordnancesurvey.co.uk/gi/nationalgrid/nationalgrid.pdf or watch the online presentation at: http://www.ordnancesurvey.co.uk/oswebsite/education-and-research/teaching-resources/usingthe-national-grid/index.html You might like to use OS mapping for this exercise or to discuss OS grid references further. OS Landranger series maps 176 and 177 are ideal.

Screen	Notes
4  **Screen 4:** Watch the video to find out more about the importance of maps for the Thames Tideway Tunnel project.	Use this 4 to provide feedback and answers for KS3 Maths Lesson 2.

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KS3 MATHS DIG DEEPER
EXTENSION IDEAS

Pythagoras and triangles

Challenge students to manually construct triangles. While engineers rely on sophisticated software to create engineering drawings, a good engineer can always create drawings by hand.

Using a protractor and ruler:

Two sides and the included angle

10cm	21°	13.5cm
10cm	60°	6.1cm

Two sides and the included angle

45°	8cm	10cm
67°	9.5cm	6.4cm

Using compasses and ruler:

Three sides

6cm	8cm	10cm
8.5cm	9.5cm	6.4cm

Modify these dimensions to suit your students. Ask students to measure the remaining sides and angles. Add complexity to either task by challenging students to work to a scale, such as 1cm = 10m.

Using compasses and ruler:

Use these co-ordinates to create a complete map of every construction site location:

38 83	Abbey Mills Pumping Station	37 77	Deptford Church Street
21 79	Acton Storm Tanks	36 78	Earl Pumping Station
30 78	Albert Embankment foreshore	27 75	Falconbrook Pumping Station
23 76	Barn Elms	38 77	Greenwich Pumping Station
44 81	Beckton Sewage Treatment Wks	22 78	Hammersmith Pumping Station
31 80	Blackfriars Bridge Foreshore	29 77	Heathwall Pumping Station
26 75	Carnwath Road Riverside	35 80	King Edward Memorial Park Foreshore
34 79	Chambers Wharf	29 77	Battersea
28 78	Chelsea Embankment Foreshore	24 75	Putney Bridge Foreshore
27 77	Cremorne Wharf Depot	30 78	Victoria Embankment Foreshore

Rotations and reflections

Challenge students to use their knowledge of rotations and reflections to reposition a CSO.

Use a four-quadrant grid from -10 to +10 on each axis. These co-ordinates describe the main parts of a very simple CSO diagram:

Existing sewer: (1,8) to (9,8)
Connecting pipe: (4,8) to (5,6)
CSO: Circle of radius 1 unit, centred on (5,6)
Culvert: (5,6) to (5,3)
Main Tunnel: (1,4) to (9,2) and (0,2) to (8,0)

Start by asking students to plot and join these pairs of points.

What are the co-ordinates for all or some parts of the CSO if it is:

- Reflected through the X-axis?
- Reflected through the X-axis and then the Y-axis?
- Rotated 90° anti-clockwise?
- Rotated 270° clockwise?

See what other combinations students can think up and give to each other.

Bearings

Using their maps, challenge students to calculate the bearings between selected locations. You could:

- Ask them to list the bearings so someone can follow the route by helicopter, starting at Acton Storm Tanks
- Ask for the bearings to different locations from one central point, such as Blackfriars Bridge
- Ask for bearings to other locations from the CSO that's nearest your school or community.

You could combine this with students' work to calculate the approximate distances between each location (or selected ones) to give a bearing and distance in each case.