TUNNELWORKS
KS3 SCIENCE LESSON 1 (ESSENTIALS)
TEACHERS' NOTES

About this lesson

This lesson explores the relationship between force, area and pressure using the example of cranes on a Thames Tideway Tunnel construction site. Students consider how adding a load to the crane, or using stabilising pads, changes the pressure a crane exerts on the ground as the force or area changes.

Learning outcomes

Students can:
- Describe pressure as the force acting on an area.
- Calculate pressure using the correct units.
- Solve simple problems to find the pressure, force or area.

Curriculum links

KS3 Science

• Key concepts	1.1a; 1.2a
• Key processes	2.3a
• Range and content	3.1b, 3.4c

What you will need

- KS3 Science Lesson 1 presentation
- Lesson 1 worksheet

Students are likely to need calculators for the worksheet challenges.

Preparation

Review the KS3 Science Lesson 1 presentation and its presenter's notes, and the student 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. Think of other examples you may wish to use to explore pressure, such as pressing on a drawing pin.

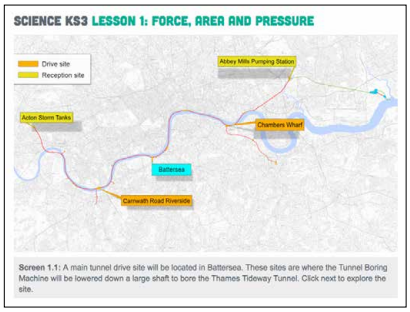
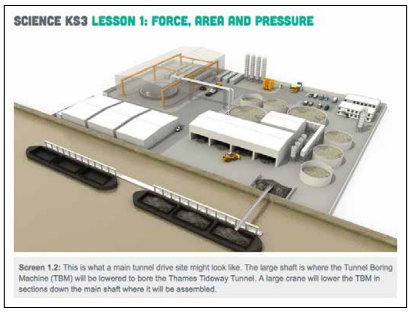
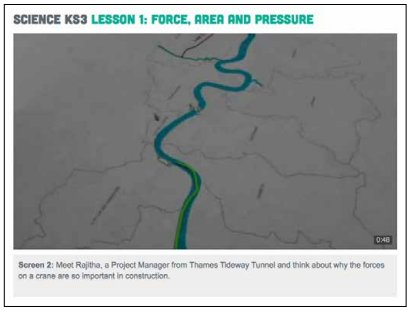
Time (60mins)	Teaching activity	Learning activity	Assessment for learning
5 mins	**Starter:** Students share their ideas about pressure in pairs and then discuss as a class. Ask for reallife examples of where pressure matters.	Students share ideas.	Verbal answers, discussion, questioning.
15 mins	**Whole-class:** 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. Explore the map and site in screens 1.1 and 1.2. Watch the video in screen 2 to find out what students must do. Work through the interactives in screens 3.1 to 3.4 and answer each question.	Students discuss why thinking about the pressure on the ground might be important for safety. (You could link this also to buildings and foundations on different soils.) Answer on screen questions.	Discussion. Verbal answers.
15 mins	**Individuals or pairs:** Read the site report on the worksheet and the first two questions. Identify key data to use. Students complete challenge 1 on the worksheet, remembering to convert each kg of mass into 10N of force.	Students identify key data and answer top two questions on worksheet. Discuss as a class. Students calculate pressure under each crane using information provided.	Written work. Written work.
20 mins	**Plenary:** Review students' answers and briefly explore transposing the pressure equation to find the force or area.	Practice transposing to solve for F or A, remembering 1kg force is 10N)	Discussion, questioning.
5 mins	Students complete challenge 2 to apply their ideas. Watch the answers video on screen 4	Complete challenge 2. Discussion.	Written work. Discussion, questioning.

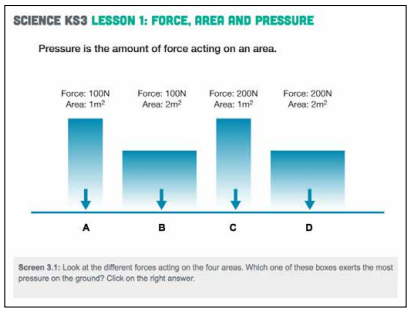
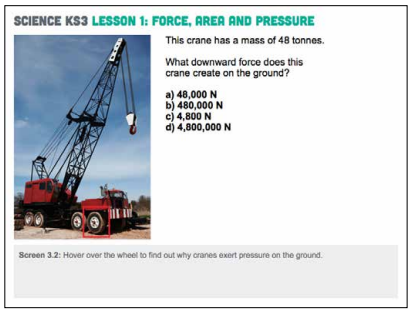
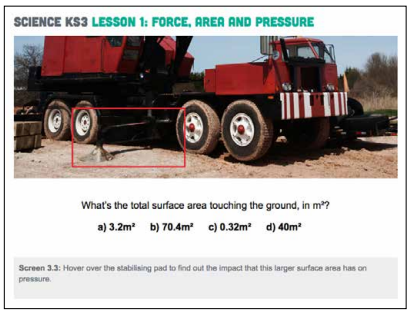
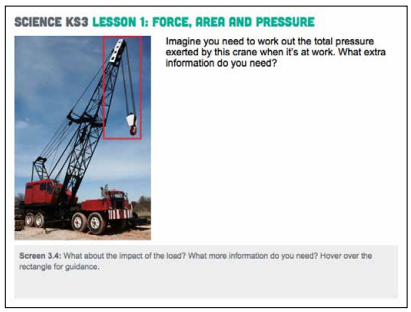
Differentiation

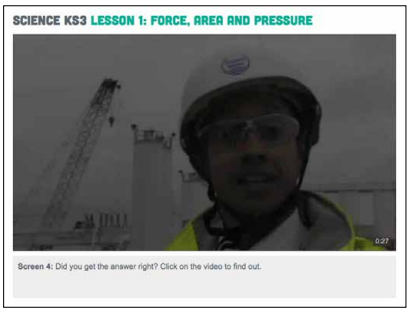
Easier	Harder
Calculate the pressures under the four loads in screen 3.1. Calculate the pressure under crane A as a whole-class example. Omit challenge 3.	Use challenge 2 while less able student complete challenge 1. Use the ideas in Dig Deeper.

Presentation Notes
Lesson 1

Screen	Notes
Intro  	This short video at the top of the Lessons column introduces the Thames Tideway Tunnel. It is just under 3 minutes long. Use the video at the start of KS3 Science Lesson 1 (and Lesson 2 as well is you wish) to set the overall scene for your students. **About the Thames Tideway Tunnel:** 39 million tonnes of untreated sewage overflows into the River Thames each year from London's Victorian sewerage system. The Thames Tideway Tunnel is a major new sewer that will tackle this problem, protect the River Thames from increasing pollution for at least the next 100 years, and enable the UK to meet European environmental standards. Though built to last and in good condition, the existing sewerage network is now too small to transfer all London's sewage to our treatment works for processing (after rainfall). London's sewerage system dates from the 19th Century and was designed as a combined system. This means that a single pipe carries both foul water (from homes and businesses) and rainwater run-off (from streets, roofs and parks) to sewage works for processing before being discharged into the River Thames. Increasingly, when it rains in London there is not enough capacity in the sewerage network to convey all the rainwater as well as foul flows. The system was designed to overflow into the River Thames so that peoples' homes and streets are not flooded with untreated sewage. The system does this through combined sewer overflows (CSOs) on the banks of the River Thames. Thames Water have worked with the Environment Agency to identify the most polluting CSOs – the ones that cause unacceptable environmental impacts because of the frequency or volume of the overflow, or because they discharge into an environmentally sensitive part of the river. The Thames Tideway Tunnel Project will address the overflows from these CSOs, either by directly connecting them to the tunnel, or by making other alterations to the sewerage system which will utilise the existing capacity more effectively. The flows diverted into the Thames Tideway Tunnel will be stored in the tunnel and pumped out for treatment at Beckton Sewage Treatment Works in east London. The CSOs will still be needed after the Thames Tideway Tunnel has been built to direct flows to the River Thames in exceptional circumstances when the new tunnel system is full. This is only expected to occur very occasionally. The Thames Tideway Tunnel will also bring wider social and economic benefits: A cleaner, healthier River Thames is essential for the wellbeing of the city as a whole. There will be less pollution and more dissolved oxygen in the water. The Thames Tideway Tunnel will ensure the country's capital remains a flourishing business centre and tourist destination, protecting the city's reputation around the world. The river is a great, under-used asset for the capital that must be protected.

Screen	Notes
1.1  **Screen 1.1:** A main tunnel drive site will be located in Battersea. These sites are where the Tunnel Boring Machine will be lowered down a large shaft to bore the Thames Tideway Tunnel. Click next to explore the site. **1.2**  **Screen 1.2:** This is what a main tunnel drive site might look like. The large shaft is where the Tunnel Boring Machine (TBM) will be lowered to bore the Thames Tideway Tunnel. A large crane will lower the TBM in sections down the main shaft where it will be assembled.	Use this slide to set the scene for KS3 science Lesson 1. The main drive sites are where the Tunnel Boring Machine (TBM) will be lowered deep in the ground. At the end of each 'run' the TBM will be raised back to the surface at a reception site with a similar shaft. Click on the next arrow to open a 3D diagram of a typical main drive site. Hover over the main drive shaft. This will be a shaft 25-30m wide and 40-60m deep, into which the TBM will be lowered in sections by a large crane. The TBM will be assembled at the bottom of the shaft. After this, a warehouse-style shed (an Acoustic Enclosure) will be built over the shaft to keep out the elements, reduce the impact of noise on local communities, store the concrete segments that will line the excavated tunnel to create the Thames Tideway Tunnel, and install a permanent gantry crane for lowering segments down to the TBM where they will be fitted in place.
2  **Screen 2:** Meet Rajitha, a Project Manager from Thames Tideway Tunnel and think about why the forces on a crane are so important in construction.	Show this short video clip to introduce the challenges in KS3 Science Lesson 1.

Screen	Notes
3.1  	Consider each box qualitatively: which has the largest area touching the ground? How will increasing the area change the pressure? Which exerts the largest force? What happens to pressure when you increase the force? Help students look for the largest force over the smallest area. What can students say about the pressure exerted by boxes A and D? (It is the same: the force has doubled, but so has the area.) Depending on the group, introduce the idea that the force is the box's weight: the force created when gravity acts on the box's mass. These examples use g=10 to simplify the calculations. Ask students for the name of this downward force: weight. You might want to discuss this in the context of how people talk about their weight in kg and identify that the word weight is used more specifically in science than it is in general. What students are really talking about is their mass. But interestingly, scales work by measuring the downward force they exert when they step on the scales, which is indeed their weight: the force acting on their mass due to gravity. Students need to remember that mass is measured in kg and that there are 1000 kg in one metric tonne. The pressure depends on area. Ask students what parts of the crane are touching the ground? They should identify the types and the pads. The stabilising pads help the crane stay level when moving heavy loads. They also increase the surface are of the crane on the ground. (Explore this qualitatively by asking students what they think will happen to the pressure exerted by the crane before and after the pads are lowered to the ground. Since they increase the area, the pressure should decrease.) Students should remember that area is measured in m^2. Pads: 0.55 x 0.55 x 8 = 2.42 m^2 Tyres: 0.25 x 0.40 x 8 = 0.8 m^2 The total surface area touching the ground is 3.2m^2 when the pads are lowered. Bring the two ideas of force and surface area together to create the equation for pressure. You can work out the pressure exerted by the example crane using the information in previous slides: 480,000N / 3.2m2 = 150,000 Pa. That's why big cranes have such heavy-duty tyres! (The author exerts a pressure of about 45,000 Pa standing in his shoes.) The missing information is the LOAD the crane must carry. This too will exert a force through the crane's tyres and stabilising pads, so the load mass should be added to the crane mass when it's at work.
3.2  	
3.3  	
3.4  	

4  	Use this video to provide feedback and the answers to the problems at the end of KS3 Science Lesson 1.