

IMAGINEERING ENGINEERING

KS4 STEM LESSON 5 WORKSHEET

HYDRAULIC RAMS: HYDRAULICS & PRESSURE

Specification

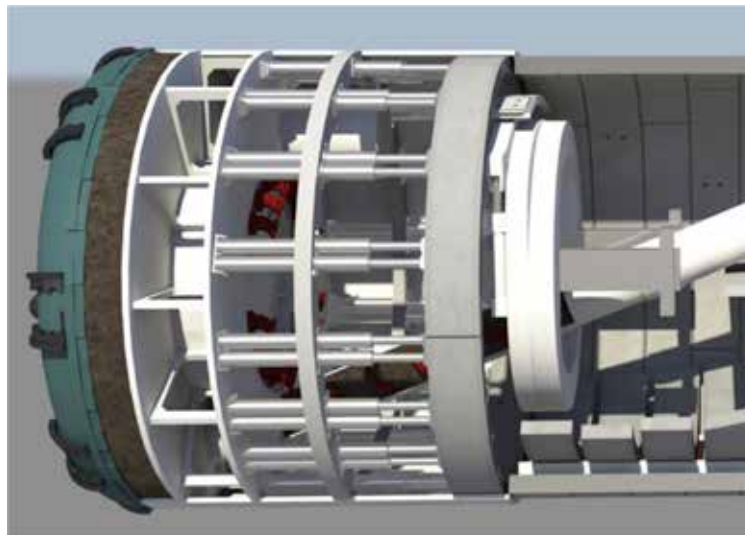
The hydraulic rams are the main driving force of the tunnel boring machine (TBM), pushing the cutter head forward into the earth with tremendous force and pressure. This pressure is provided by a central pumping system which provides pressure for several of the machines hydraulically operated parts.

In this activity, you will learn to:

- describe the functioning of the hydraulic rams
- understand Pascal's principle and apply it to the TBM
- understand the wider potential of hydraulic systems.

Explore the Imagineering Engineering app or use your teacher's guidance to help complete the challenges below. You may also need to use your wider research skills.

Challenge 1: The Hydraulic Rams



Using the *Tunnelworks* AR App, describe below the purpose and functioning of the hydraulic rams. Make sure that you include at least two purposes.

Challenge 2: Pressure Calculations

To understand how the hydraulic rams of the TBM work, we can use hydraulic cylinders in the classroom in a practical demo. Cylinder A represents the input pressure from the machine's hydraulic pumping system, whilst cylinders B and C represent a hydraulic ram.

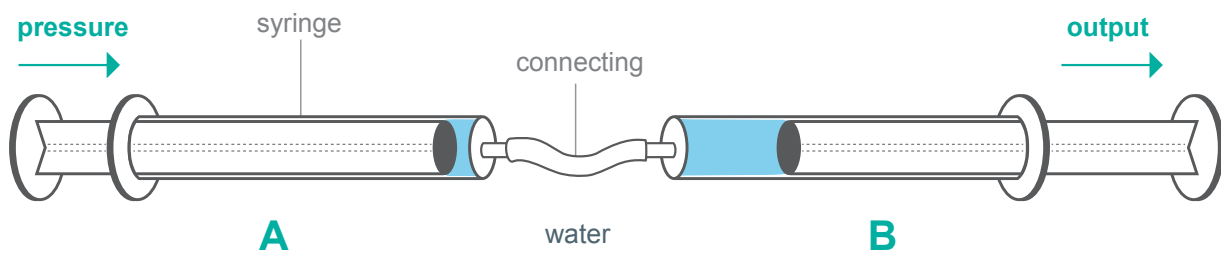


Fig 1. The hydraulic pumping system of the TBM

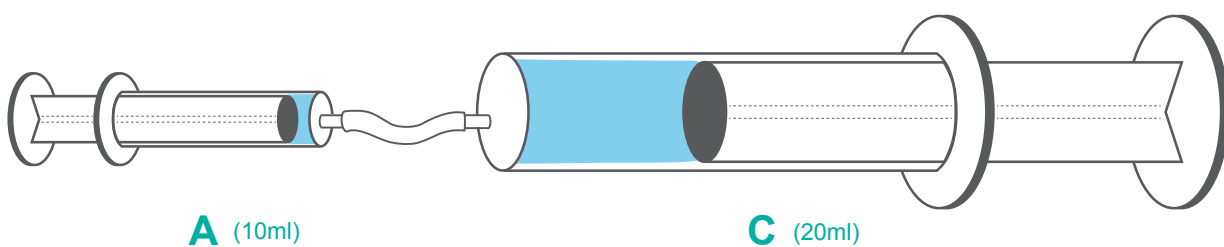
Challenge 1: Predicting Movement

The most important principle of hydraulic systems is Pascal's principle.

A pressure change occurring anywhere within a confined incompressible fluid will be transferred through the fluid so that the change occurs everywhere.



This means that if cylinder A is pushed inwards by 2cm, cylinder B will be pushed out by 2cm.



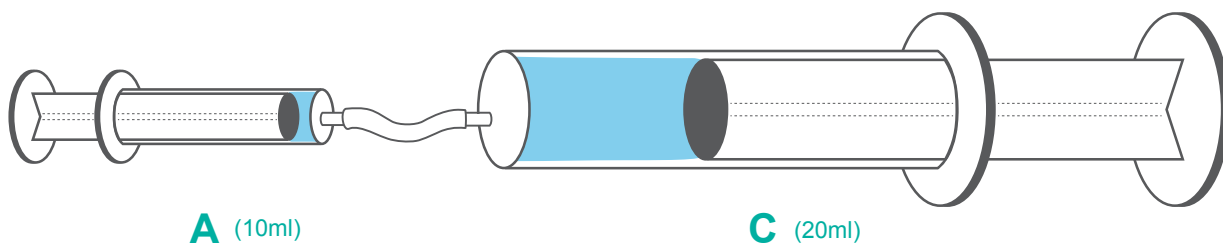
Cylinder C has twice the area of cylinder A, and so will only be pushed out half as far.

Calculate the different movement lengths for the following:

	Area of A (cm ²)	Area of C (cm ²)	Distance moved at A (cm)	Distance moved at C (cm)
a)	2	4	2	
b)	3	9	6	
c)	4	2	1	
d)	4	6	1	
e)	3	4	1	
f)		2	2	4
g)		4	2	1

Challenge 3: Calculating Force & Pressure

Hydraulics are pressure systems, meaning that they rely on an understanding that pressure is a combination of force divided by the area, measured in Pascals (pA). So far, we have only considered the movement of the pistons. We must also consider the force and pressure by which the pistons move.



If the plunger of cylinder A has an area of 1cm² and the plunger of cylinder C has an area of 2cm² and 3N of force is applied to A, how much force would be transferred to C?

$$\text{The pressure put into the system} = \frac{\text{the force at A (N)}}{\text{Area of A (m}^2\text{)}} = \frac{3}{0.01} = 300 \text{ Pa}$$

This pressure would then be transferred to the larger surface area of cylinder C.

$$\text{The force at cylinder C would therefore} = \text{pressure at C (Pa)} \times \text{area of C (m}^2\text{)} = 3 \times 0.02 = 600\text{N}$$

The force has therefore been doubled. This is called **force multiplication**, and provides **mechanical advantage**.

Cylinder C however will still only move half the distance of cylinder A.

Calculate the following, using different dimensions for cylinder A and C.

	Area of A (cm ²)	Area of C (cm ²)	Distance moved at A (cm)	Distance moved at C (cm)	Input force at A (N)	Output force at C (N)
a)	2	5	2		4	
b)	10	5	2		4	
c)	8	10	5		6	
d)	1	0.5	1			6
e)	3	4	0.5		0.5	
f)	4		2	4	2	
g)		4	2	1		2

Which of the systems above experienced force multiplication?

EXTENSION:

Engineering careers presentation poster

Specification

You should now be an expert on tunnel boring machines and the Thames Tideway Tunnel, and have a good understanding of the engineering concepts that inform tunnel building. It is now time to discover the types of engineering careers available, and the education pathways that will help you to get there.

In this activity, you will learn to:

- understand the difference between civil, electrical and mechanical engineering and name examples of their work
- describe the education pathway to each type of engineering.

Explore the Tunnelworks AR app or use your teacher's guidance to help complete the challenges below. You may also need to use your wider research skills.

Challenge: Engineering Classroom Display

In your groups you must produce an A1 sized presentation poster, detailing the three different engineering pathways: civil engineering, electrical engineering and mechanical engineering. For each you must include:

- what each type of engineer does in their day to day work
- the types of projects that each type of engineer works upon
- the degree courses relevant to each type of engineering
- the GCSEs and A-Levels and other courses that can lead to each engineering career.
- The personal skills needed for each engineering pathway.

You could use the Thames Tideway Tunnel and the TBM as examples, explaining which type of engineer would design the tunnel or each component of the machine.

Make sure that you use your skills of communication, teamwork and creativity to create an informative, exciting design. For presentation tips, ask your teacher for guidance.