TUNNELWORKS
KS3 MATHS LESSON 3 WORKSHEET
MODELLING WITH ALGEBRA

Project Planning Request: Tunnel Boring Machine (TBM)
We need to develop a simple maths model of how quickly the TBM can bore and line the tunnel. This will depend on a number of factors including the soil type and any 'downtime' for maintenance or repairs. Can you develop a simple formula to show how much tunnel the TBM can create per hour or shift?

Key facts
- The TBM bores through the ground using a rotating cutting head. Then, rings of concrete segments are put in place to line the Tunnel.
- A ring of concrete segments will line 1.5m of Tunnel.
- The TBM can bore a maximum of 28.5m in 24 hours if working constantly.
- There are three equal shifts in 24 hours.
- The TBM bores through clay, sand or chalk soils at different rates.
- Clay: the TBM can work at its maximum rate.
- Chalk: the TBM can work at 0.9 times its maximum.
- Sand and gravel: the TBM can work at 0.8 times its maximum.

Task 1: Create a basic formula and find the answer.
How far can the TBM bore in one shift? Write a simple formula to work this out. Assume the TBM can bore at its maximum rate. Use **d** to represent the distance and **s** to represent the speed.

Enter the right numbers into your formula to calculate the distance the TBM can bore in a shift.

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Task 2: Allow for stoppage time.
There may be times when the TBM must stop during a shift. Modify your formula so it can allow for any hours stopped. Use **b** to represent this stoppage time.

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Task 3: Allow for different types of soil

The different types of soil deep under London affect how fast the TBM can bore, due to different hardness, stability, and the ease with which the spoil (waste soil and rock) can be removed. Modify your formula so you can allow for the effect of different soils on the TBM's distance per shift. Use **f** to represent the effect of the soil type.

Task 4: Calculate some sample data for the Project Planning Team

Use your formula, and the key facts, to work out the following:

1. Assuming no stoppage time, how far can the TBM bore in 24 hours though sand?

2. The TBM is boring through chalk and must stop for one hour each shift.
How far can it bore in 24 hours?

3. The TBM is boring through chalk with no stoppage time.
How many rings of tunnel segments are required every 48 hours?

4. Halfway through a shift the TBM will pass from sand to chalk.
How far will it bore in this shift, assuming no stoppages?