# Bridging the Gaps

## Purpose:

The purpose of this multi-level task is to engage students in using their knowledge of place value, standard form and rounding, to solve a problem involving a range of orders of magnitude.

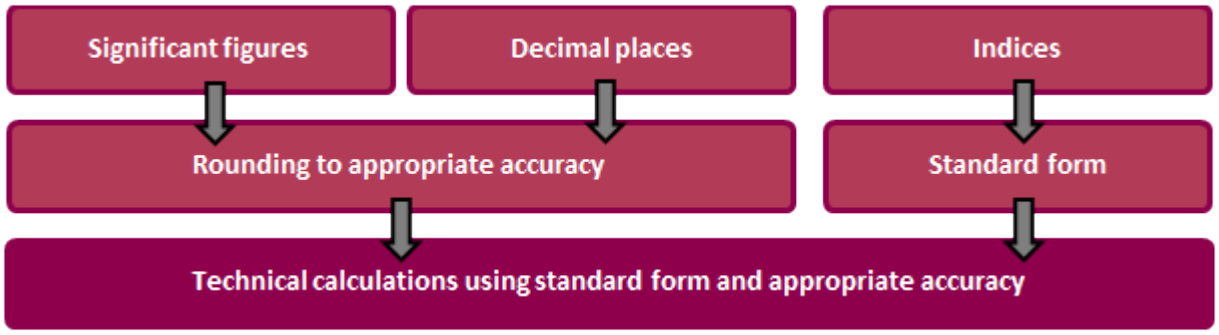
## Achievement Objectives:

S5-4: Calculate probabilities, using fractions, percentages, and ratios.

S5-3: Compare and describe the variation between theoretical and experimental distributions in situations that involve elements of chance.

## Description of mathematics:

This background knowledge and skills that need to be established before and/or during this task are outlined in the diagram below:




This task may be solved following with guidance as to the steps to take and rounding decisions to make, or with greater independence, encourage the students to make decisions around appropriate accuracy. The approach should be chosen in sympathy with their skills and depth of understanding.

## Activity:

Task: An engineer is designing a bridge that is to stretch 2.434 km. She wants the bridge to be constructed from aluminium or from steel. Metals expand or contract with a change in temperature.

The rule to find the total length a metal will expand by is the product:

**original length x change in temperature x expansion constant**

where the expansion constant for Aluminium is 2.22 x 10-5 per °C and for steel it is 1.30 x 10-5per °C.

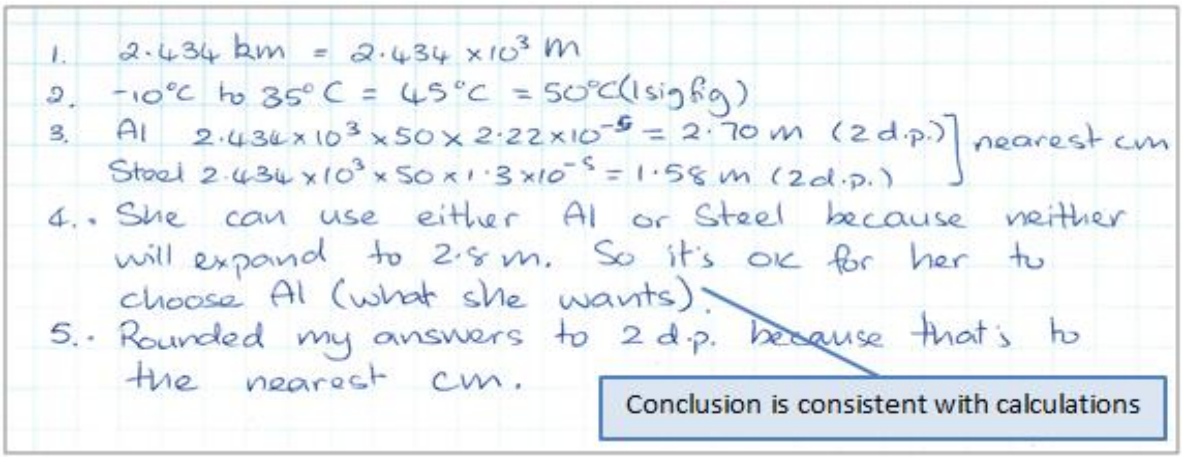
While she would prefer to use Aluminium because it is much lighter, her design can only allow for up to 2.8 m of expansion for the full length of the bridge. If the local climate experiences temperatures that range from an average of -10 °C (winter nights) to mid 30's of °C (midday summer), which material should the engineer choose for the bridge? Comment on any rounding decisions you made.

## The procedural approach

The student is able to calculate, with guidance, values in standard form, giving an answer to an appropriate degree of accuracy.

Prompts from the teacher could be:

1. Convert the length of the bridge design to metres, leaving the value in standard form.
2. Find the range of temperatures, to just 1 significant figure, that the bridge is expected to tolerate.
3. Use the rule given, to calculate the expected expansion of the bridge if it was to be made from steel and if it was to be made from aluminium.
4. Decide on which material the engineer should use for her design.
5. Comment on how you rounded your calculated values.



1. $2.434\ km = 2.434 \times 10^3\ m$
2. $-10°C$ to $35°C = 45°C = 50°C$ (1 sig fig)
3. Al $2.434 \times 10^3 \times 50 \times 2.22 \times 10^{-5} = 2.70\ m$ (2 d.p.)
   Steel $2.434 \times 10^3 \times 50 \times 1.3 \times 10^{-5} = 1.58\ m$ (2 d.p.)
   nearest cm
4. She can use either Al or Steel because neither will expand to 2.8 m. So it's ok for her to choose Al (what she wants).
5. Rounded my answers to 2 d.p. because that's to the nearest cm.

Conclusion is consistent with calculations

## The conceptual approach

The student is able to calculate values in standard form, giving an answer to an appropriate degree of accuracy. The student is able to incorporate wider aspects of the context to make a valued judgement.

Prompts from the teacher could be:

1. Estimate a range of temperatures that the bridge could be expected to tolerate.
2. Use the rule given, to calculate the expected expansion (in m) of the bridge for the different materials.
3. Decide which material the engineer should choose for the bridge.
4. Comment on any rounding decisions you made.

T: Tell me about the 55 degrees.

S: Well the temperatures given are probably average temperatures. There are sometimes really freakish hot or cold days, so I expanded the range 5 degrees each way.

Temp Range −10 to mid 30's
allow −15 to 40 °C (extreme days)
So 55 °C

Bridge is $2.434$ km $= 2.434 \times 10^3$ m

Expansion length × temp Range × constant

Aluminium $\underbrace{2.434}_{4\text{ sig figs}} \times 10^3 \times \underbrace{55}_{2\text{ sig figs}} \times \underbrace{2.22}_{3\text{ sig figs}} \times 10^{-5} = 2.971914$
$= \cancel{2.97}\ 3.0$ m.

Steel $2.434 \times 10^3 \times 55 \times 1.30 \times 10^{-5} = 1.74031$
$= \cancel{1.74}\ 1.7$ m

Conclusion: Aluminium expands too much (allowing for extreme temperatures to occurr) so she needs to use Steel

Comment: Rounding to only 2 sig figs because Temp Range only " " ".
But this is only 1 d.p. in m, which is to the nearest 10 cm. (Same as the 2.8 m I had to compare with)

Conclusion is consistent with calculations **and** shows understanding of the context

Understanding of decimal place value and appropriate rounding shown throughout