

Synchrotron Investigations

7.1 Metric units trail

Summary

Students often have a theoretical understanding of metric units, but also have limited ability to estimate. Through a 'Metric Trail' containing physical objects, most of which the students can pick up and use to make estimates, students will develop a better intuitive understanding of metric units. The units included in the following activities are those commonly used in daily life also included are less encountered units.

The methodology followed in most of these activities is to:

- Present the student with objects from which to estimate.
- Have the student measure the objects using the equipment provided.
- Present the student with a second set of objects from which to estimate.
- Have the student evaluate their estimation skills.

Organisation of the 'Trail'

It is up to each individual teacher as to how they organise the 'Trail'. Activities are flexible and can be altered to suit available preparation and execution time, and the number of students involved.

The 'Trail' also lends itself to different situations. Teachers may be able to have a single class for one or two periods, using only the activities for *Mass*, *Time* and *Length* and largely contained in one classroom. Other teachers who have combined classes may create a 'Trail' where students move to a variety of rooms around the school while encompassing all the metric categories outlined in the *Assumed Skills* section.

The worksheets supplied with the activities are basic outlines that require varying degrees of adaptation to suit the requirements of your chosen 'Trail'. Outline worksheets have been supplied for *Mass*, *Time* and *Length*. Teachers covering more measurement units can easily alter the worksheets to suit their situation.

Once you have chosen the items being measured in *Mass* and *Length* the worksheets will require editing accordingly. Adaptation is also required for post-measurement evaluation, which begins at the level of an average first year high school student and progresses through to using statistical skills learned in middle high school years. Teachers will need to adapt activities to suit the class performing the analysis.

The activities in this section can also be used as a basis for any additional metric unit activities, for example capacity or temperature.

Using mass as an example, the students:

1. Estimate the weights of five to six objects. The examples used in this sample activity are:
 - half a brick or a rock
 - a litre of milk
 - a TV remote control
 - a drawing pin
 - the head of a match.

Teachers supply reference weights to allow students to compare the objects with known values. In the case above, providing weights of 1 kg, 100 g, 10 g and 1 g would be ideal.

2. Accurately measure the objects. Scales need to be provided to allow students to accurately measure weights. For the example weights mentioned you would need:
 - bathroom scales to measure the brick/rock
 - kitchen scales to measure the litre of milk
 - Science Department scales to measure the drawing pin and match head.
3. Estimate and then measure the weight of three more objects. For example:
 - a bottle of water
 - an A4 sheet of paper
 - a calculator.
4. Draw conclusions. For example:
 - When making estimates, in what range are you most/least accurate?
 - Did you make a good choice of which units and prefixes to use?
 - Do you tend to under or over estimate?
 - Was your accuracy in the second set of estimates better after feedback from the first set of estimates and measurements?

Teacher Preparation

The worksheets supplied are a model only and will need to be altered to suit your particular class. Objects selected for the *Mass* worksheet and *Length* worksheet need to be based on what you have available in your school.

Each worksheet requires particular tools for measurement. These will need to be organised, based on student numbers, prior to running the activity.

See the first point in the *Assumed Skills* section.

Assumed Skills

1. The *Length* activity assumes that students have previously been exposed to the techniques involved with laser interference patterns, used to measure very small distances. Experiments developing these techniques are included in this resource. If teachers do not want to use these techniques then the *Length* activity will require editing to remove any references. Two different objects will be required to substitute for the objects linked to laser interference patterns.
2. It is assumed that students have already been exposed to the metric system and all the units which are covered in the 'Trail' you have chosen to create. These might include:

mass (grams)	length (metres)	energy (joules)
time (seconds)	sound (decibels)	temperature (degrees Celsius)
capacity (litres)		

Students should also be familiar with metric prefixes. Listed below are those normally covered in the mathematics classroom, plus others. In order to facilitate overlap with units and techniques used in science, as well as those in daily life, students should be familiar with the list below.

pico (p, 10^{-12})	milli (m, 10^{-3})	kilo (k, 10^3)
nano (n, 10^{-9})	centi (c, 10^{-2})	mega (M, 10^6)
micro (μ , 10^{-6})	deci (d, 10^{-1})	giga (G, 10^9)

3. Students should be able to calculate percentage error using

$$\% \text{ error} = \frac{\text{estimate} - \text{true}}{\text{true}} \times 100 \%$$

4. Students should be familiar with calculating the mean and standard deviation for ungrouped discrete data.
5. Students should be able to calculate/measure heights by using a clinometer and trigonometry or by using similar triangles.
6. Students should be able to measure very small separations and thicknesses using a laser pointer via interference effects. See the following page for information on this process.

