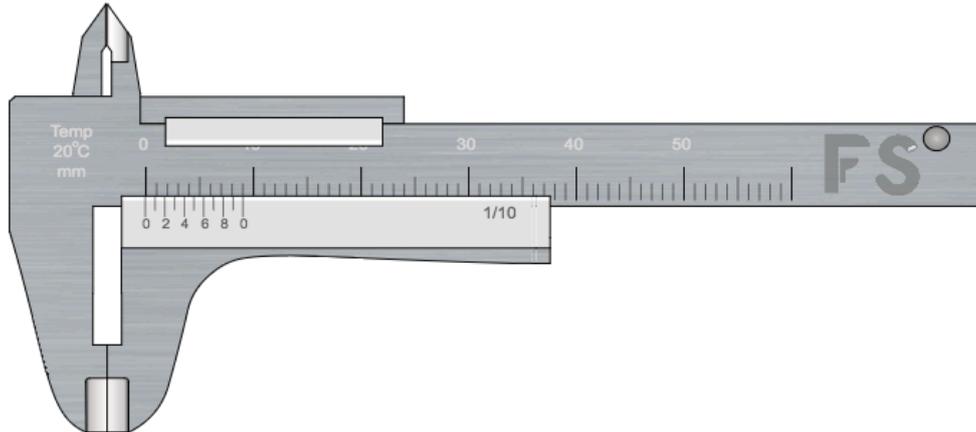


FLASHY SCIENCE

Vernier callipers experiment User guide

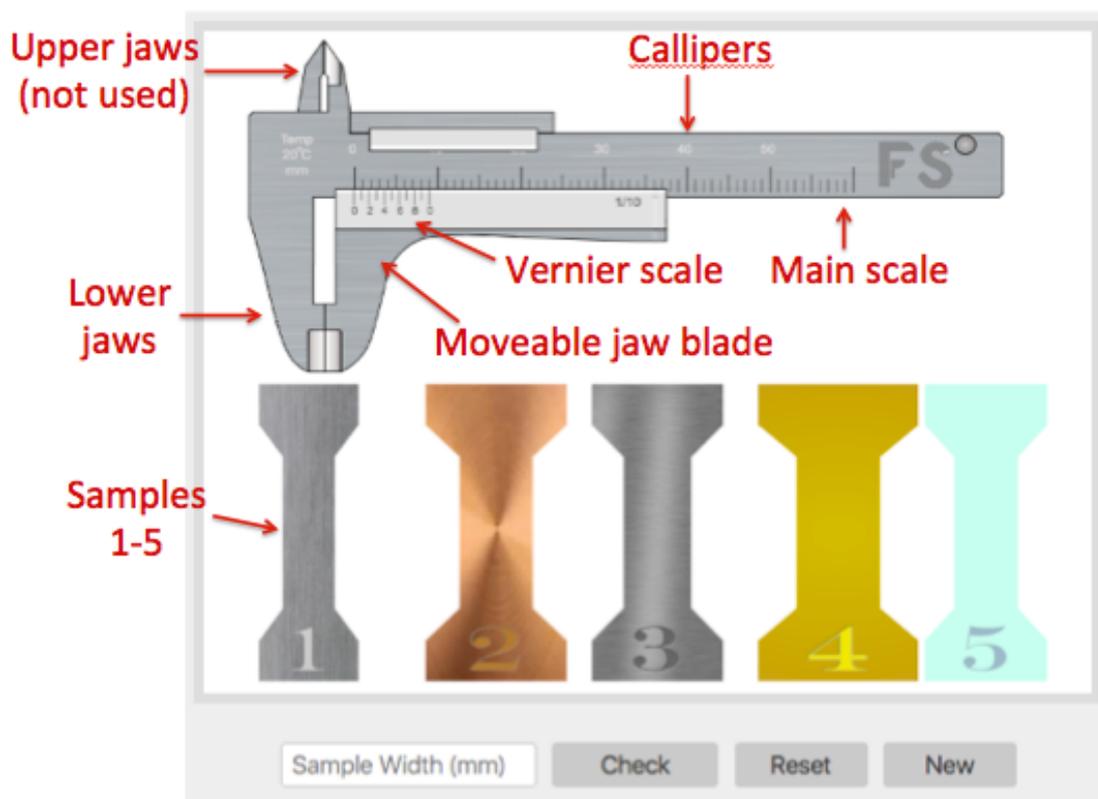


QUICK GUIDE:

1. Drag moveable part of lower jaw to make jaw separation larger than sample width.
2. Drag sample into lower jaws. Sample will snap into place.
3. Drag moveable jaw blade to close jaws around sample.
4. Read width from scale (see below for how to do this).
5. Type width into 'Sample Width' text box and click 'Check' to see if you were right (green = correct, red = incorrect).
6. Drag a sample out of the jaws (or press 'Reset') to return it to its original place and select a new sample.
7. Click 'New' for a new set of samples with different widths.

To read the caliper scale (see full instructions for more details):

- Find the tick mark on the main scale (upper scale) that is just below the 'zero' mark on the Vernier scale (lower scale). This gives a whole number of millimetres for sample width.
- Locate the tick mark on the Vernier scale that is most closely aligned with any tick mark on the main scale. This gives the number of tenths of a millimetre in the sample width.
- Add the values from the above steps to find the overall sample width.



Real world relevance

Measurement is the starting point of meaningful scientific understanding. Callipers are common pieces of equipment used across science and engineering that allow object dimensions to be measured with a high degree of accuracy and precision. This can be vital for designing mechanical components or for experiments in which sample dimensions affect the outcomes, e.g. resistance or stress.

Callipers have one set of fixed jaw blades and one set of moveable jaw blades, which are positioned to the edges of the sample to be measured. The sample dimensions can be shown in different ways. **Digital callipers** use a display to indicate sample width, although the display often needs zeroing before use. **Linear callipers** have a mark on the moveable section that indicates the sample width on a scale on the main arm of the callipers. **Vernier callipers** keep the linear scale on the main arm but include another scale on the moveable section to give a precise measurement of sample dimensions. This simulation allows you to learn how to use Vernier callipers.

FlashyScience Instructions – Vernier Callipers

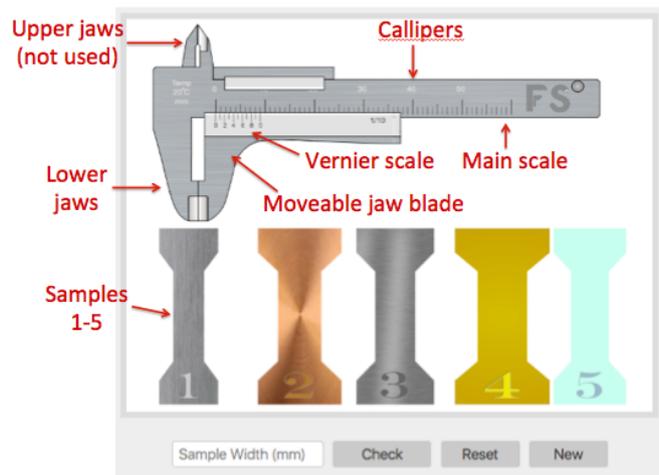
Callipers are common pieces of equipment that allow object dimensions to be measured with a high degree of accuracy and precision. This can be vital for specifying new component sizes or for calculating important dimensions for experiments.

All callipers have ‘jaws’ with a separation that can be adjusted to fit the sample being measured. The ‘Vernier callipers’ used in this experiment displays the jaw separation by the intersection of two linear scales.

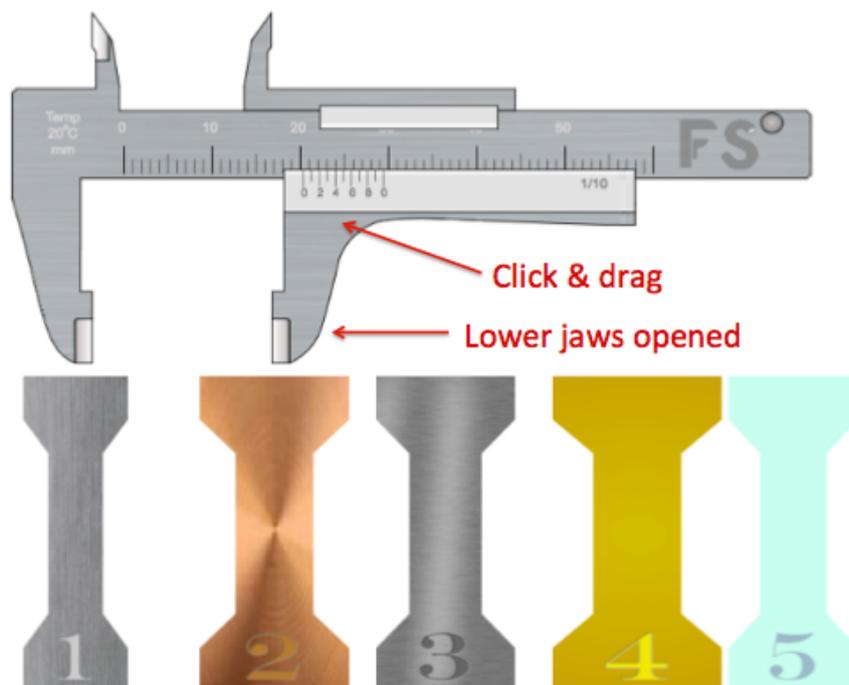
Operating the Experiment

1. When you start the Vernier Callipers experiment you will see:

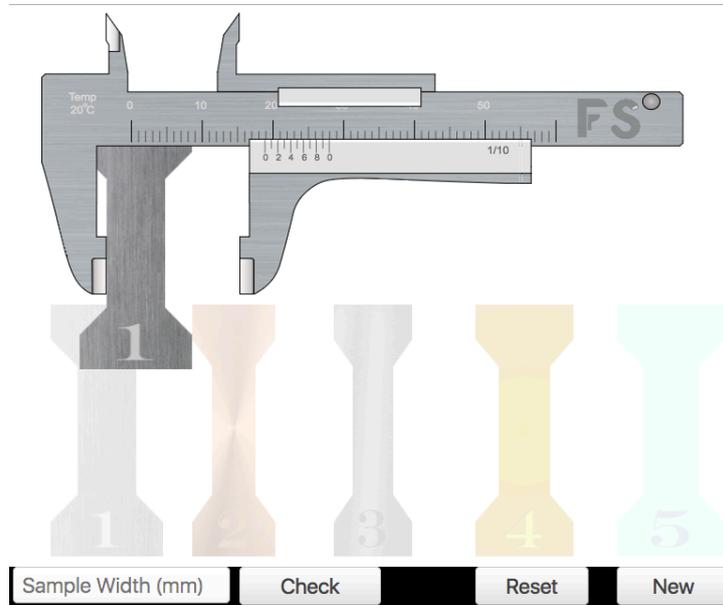
- The callipers (main scale, a Vernier scale, lower and upper jaws)
- Five samples made of different materials
- A ‘Width check’ textbox and button
- ‘Reset’ and ‘New’ buttons



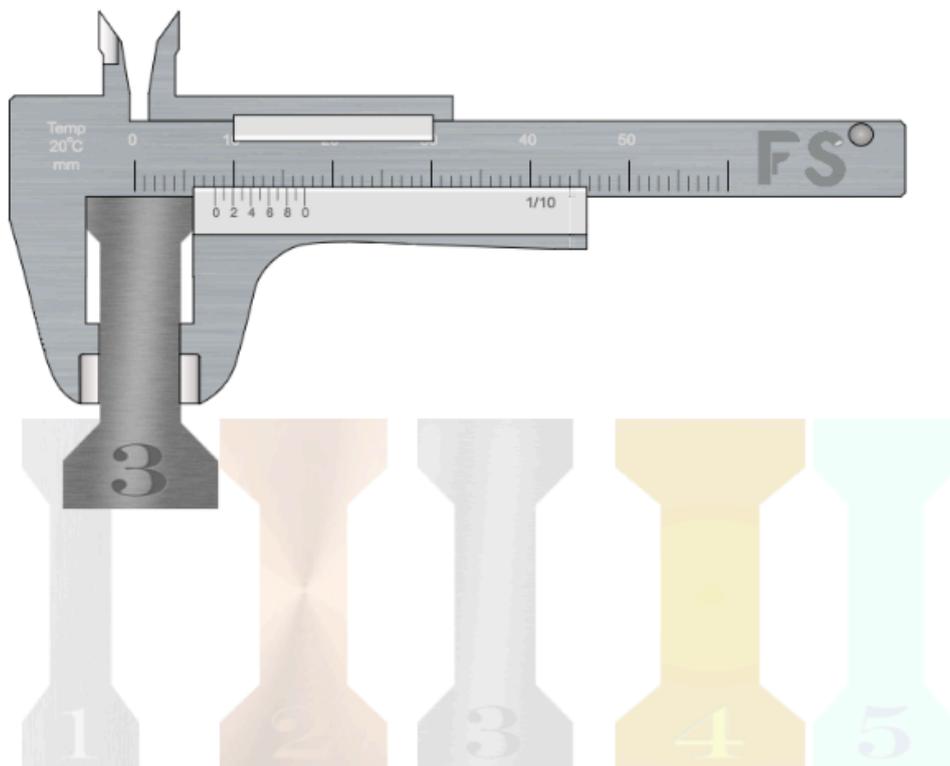
2. Click and drag the *moveable jaw blade* to open the caliper jaws.



3. Click and drag a sample so that it snaps into place between the lower jaws.

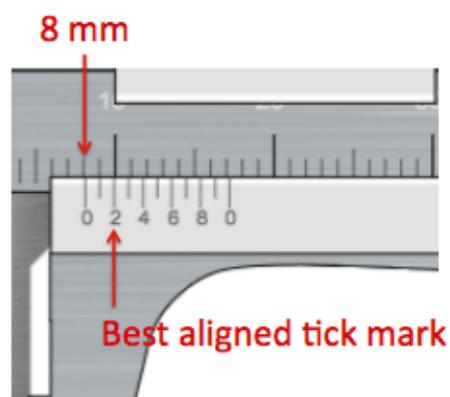


4. Click and drag the moveable jaw plate to close the lower jaws around the sample.

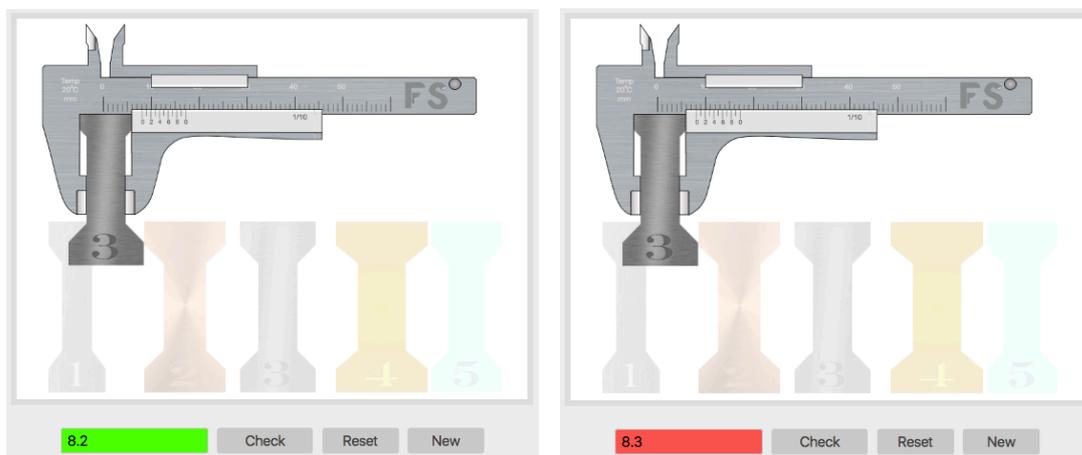


5. Read separation using the two scales. To do this:

- Find the tick mark on the main scale (upper scale) that is just below the 'zero' mark on the Vernier scale (lower scale). This gives a whole number of millimetres for sample width. In the example here, this is 8 mm.
- Locate the tick mark on the Vernier scale that is most closely aligned with any tick mark on the main scale. This gives the number of tenths of a millimetre in the sample width. In the example here, this is the tick mark '2' on the Vernier scale, corresponding to 0.2 mm.
- Add the values from the above steps to find the overall sample width. Here, this would be $8 + 0.2 \text{ mm} = 8.2 \text{ mm}$.



6. Check your measurement by typing it into the 'Sample Width' text box and pressing 'Click'. The text box will become green if you have a correct measurement and red if your measurement is different to the sample width.



Correct sample width entered

Incorrect sample width entered

7. Drag the sample out of the caliper jaws or click 'Reset' to return the sample to its original place. You can then choose a new sample.

8. You can click on 'New' at any time to create a new set of samples with different widths.

Experiments

1. Measure the width of ten samples. Check to see how many you measure correctly and give yourself a mark out of ten. Repeat this until you get 10/10 every time!
2. *Error analysis:*
 - a. Measure and record the width of ten or more sample.
 - b. Use the width data to calculate the cross-sectional area of each sample.
 - c. Determine the *absolute error* and *fractional error* for each width measurement.
 - d. Determine the *absolute error* and *fractional error* for each cross-sectional area value.
3. *Statistical analysis:*
 - a. Measure and record the width of ten or more samples.
 - b. Calculate the mean and standard deviation of the width measurements.
 - c. (Advanced experiment) Calculate the *standard error* of the width measurements and from this determine the confidence level of the mean.