Using Tracker – defining variables (Soap bubble example)

This document assumes you have worked through *Analysing linear motion using Tracker* and can set axes, change the quantities displayed on graphs etc.

There is an experiment to find the viscosity of air that involves measuring the radius *r* of a soap bubble at the end of a capillary tube as it deflates. We will not go into the full theory here. Get in touch if you want to know more, or consult *Tyler – A Laboratory Manual of Physics*. This venerable book describes a method that uses a travelling microscope to find the bubble radius. We will be using video analysis but the theory is the same.

Our focus here will be to use Tracker to produce a graph of r^4 versus time t. This should be a straight line with a negative gradient. It is a step in the process to determine the viscosity.

A capillary tube was dipped in a soap solution and a bubble blown. The end of the tube was closed with a finger to maintain the bubble and then clamped in front of a black background, with a ruler secured in the same plane.

A Veho USB microscope connected to a laptop was used to capture the deflating bubble.

Note that our capillary tube had a diameter of about 4 mm. To do this experiment with a travelling microscope, a very much narrower tube would be required so that deflation occurred slowly. There could be a very large uncertainty in the measurement of this diameter.

The bubble was susceptible to bursting due to air currents, so we lowered it into a glass beaker to protect it.

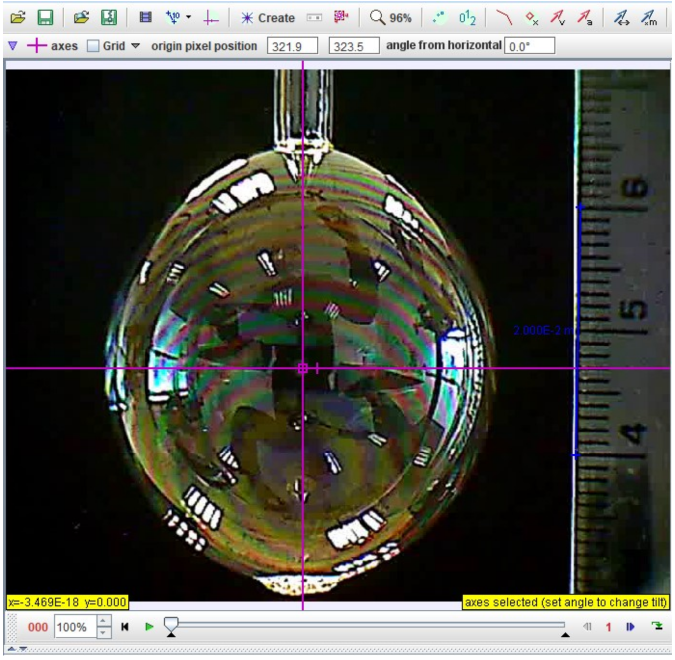
The beautiful coloured bands on the bubble, due to thin film interference, could form the basis of another project!

Launch Tracker and import the video **bubble.wmv**.

Place the axes at the centre of the bubble. Calibrate the image in the usual way.

Create a **Point Mass** and track the edge of the bubble as it deflates.

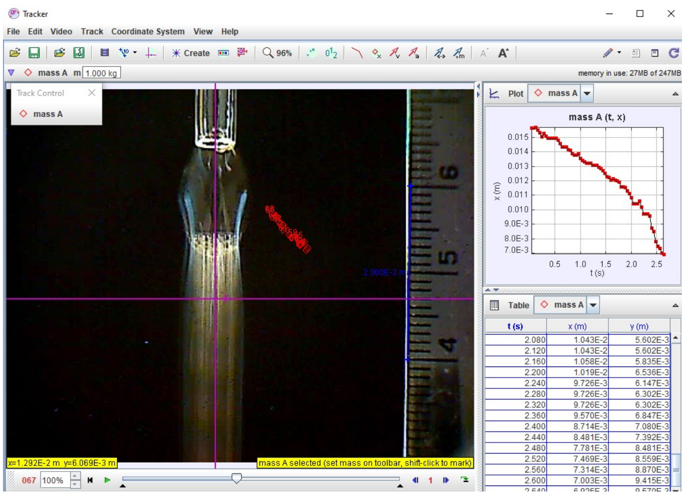
Of course, as the bubble deflates, its centre moves upwards. This isn't a problem. Always track the edge of the bubble at its widest point and the *x* measurement will then be its radius.



Note how our tracking point moves inwards and upwards. Keep tracking until the bubble bursts.

It's clear from the graph that the relationship between *x* (i.e. radius) and *t* is not linear.

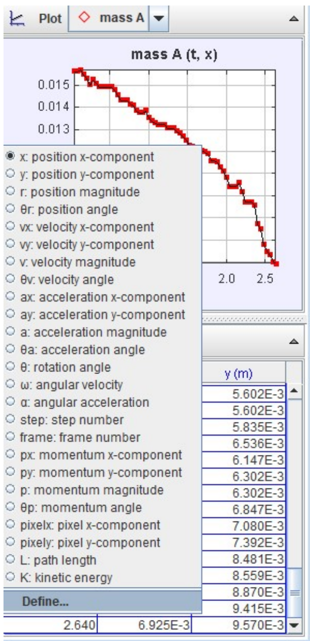
We think that the relationship is such that a graph of r^4 versus *t* would be a straight line. Can we show this?



If we click the y-axis quantity to try to change it, not surprisingly, x^4 or r^4 is not an option.

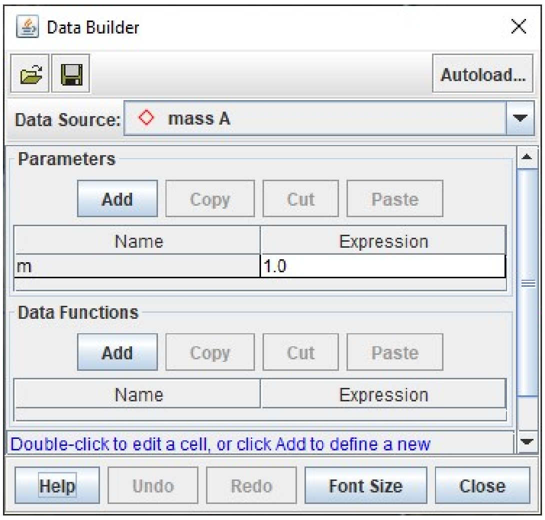
However, Tracker gives us an opportunity to define a new variable in terms of existing quantities, so that's what we'll do.

Click **Define...**

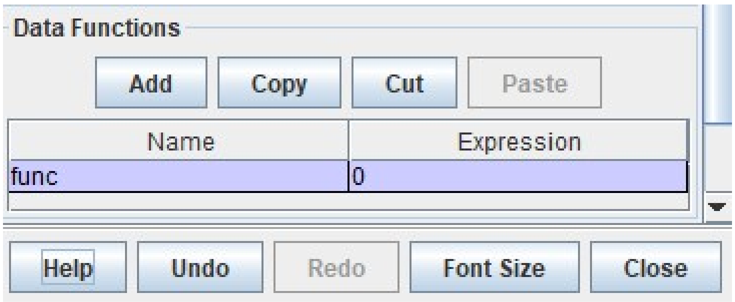


This is what should appear.

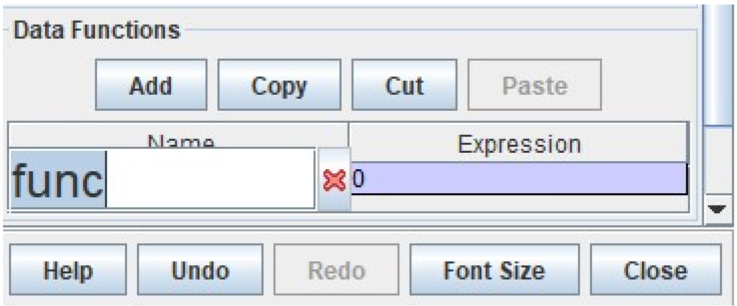
Click the **Add** button in the **lower** part of the box, below where it says **Data Functions**.



This should appear:



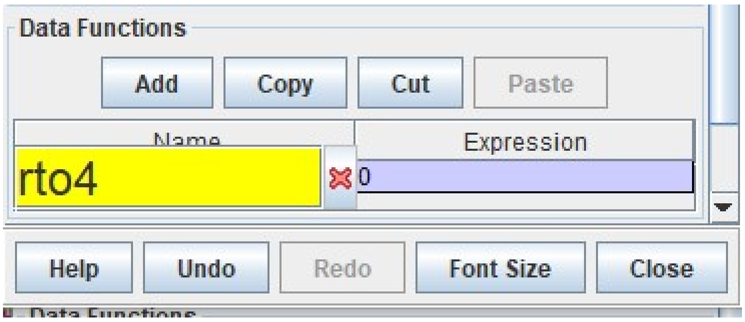
Double click in the cell that says **func.**



Change **func** to **rto4**.

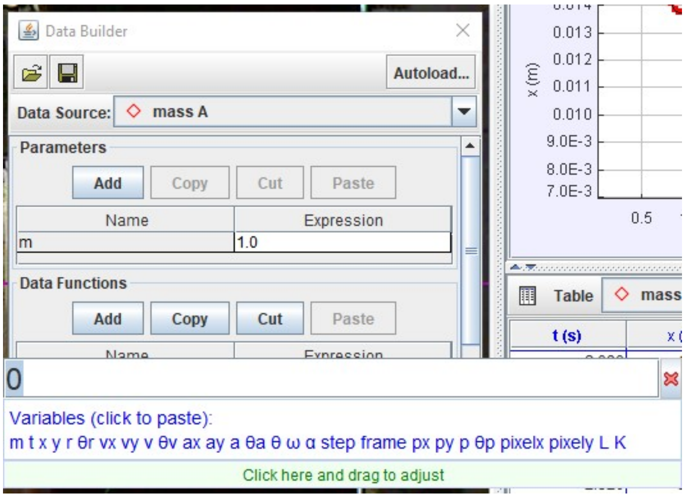
What you can enter here is quite limited, hence the clumsy variable name and lack of units. At this point, exporting data to a spreadsheet probably seems like a better idea.

Press the **Enter** key.



Now double click on the expression cell. You should see this:

We're going to tell Tracker how to calculate a new variable we've named 'rto4'.

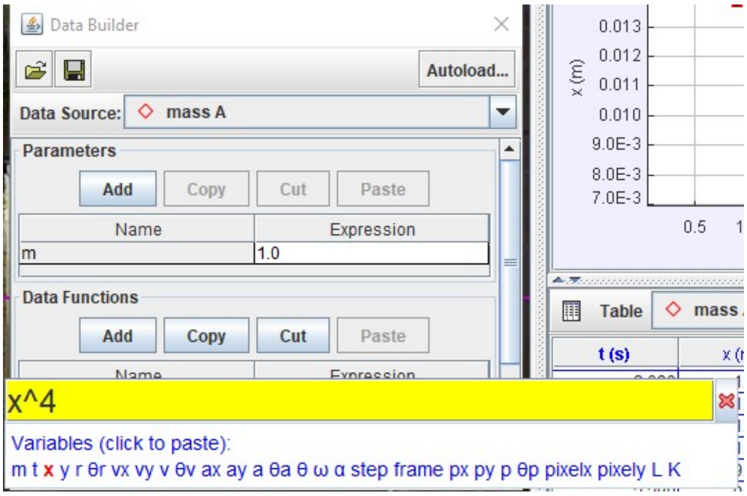


From the list of Variables, click *x* and type *^4* after it as shown.

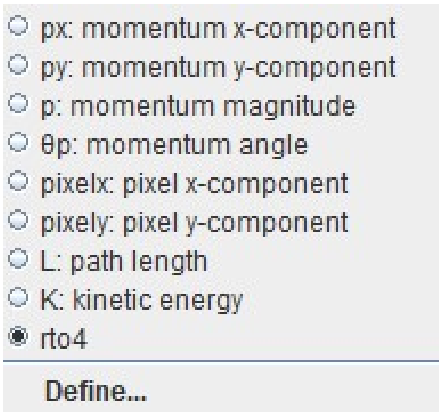
Press **Return**.

Click **Close on** the box.

We've now defined a new variable *rto4* as *x* raised to the power of 4.



If we click the y-axis quantity, we see that rto4 is now listed and we can select it.



...and here's our graph of r^4 versus t.

As before, we double clicked the graph to make it bigger.

For proper analysis, it would be best to go to **File... Export... Data file** and export measurements into Excel where much more detailed analysis can take place, but this facility is good for showing whether or not you're on the right... err... track.