Discussion

Interpreting Graphs, Errors, Uncertainty, Limitations

In the discussion, the findings of the investigation need to be analysed and interpreted. This is where you write in detail about what your analysis shows.

Refer to graphs and tables by number. i.e. Graph 2 shows .....

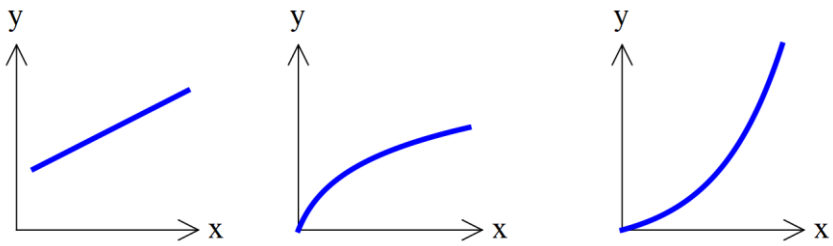
The errors involved in your investigation.

Identification of limitations in data and methods, and suggested improvements.

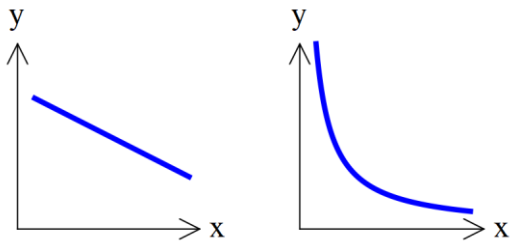
Interpreting and Using Graphs

Graphs are drawn to show the relationship, or trend, between two variables.
There could be many specific relationships, however, they fit into three main groups.

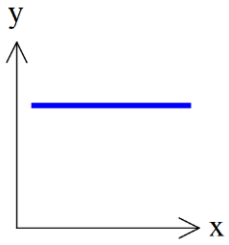
- Variables where the increase in one corresponds to an increase in the other.



- Variables where the increase in one corresponds to an decrease in the other.

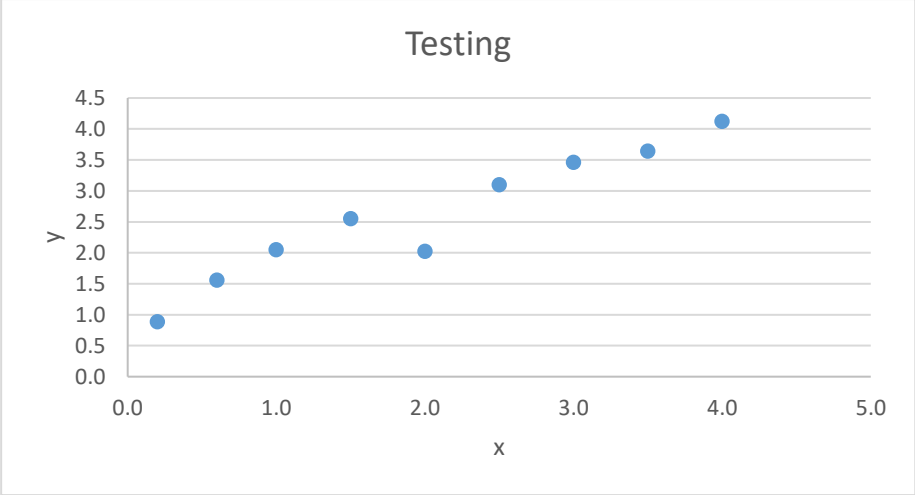


- Variable where one increases and the other stays the same.



Let's look at an example and how we might use the graph as evidence to support our findings.

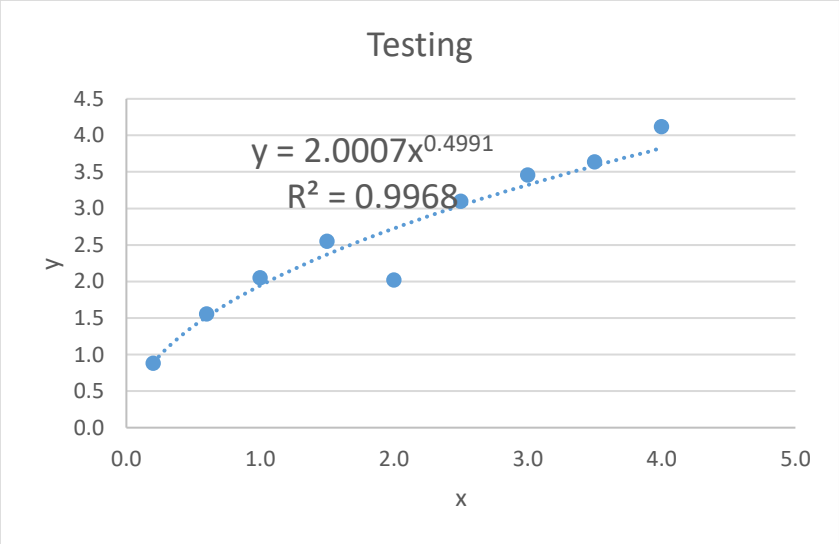
x	y
0.20	0.89
0.60	1.55
1.00	2.00
1.50	2.45
2.00	2.83
2.50	3.16
3.00	3.46
3.50	3.74
4.00	4.00



From our graph we can say

- as *x* increases, *y* increases.
- The data point for *x* = 2 looks out of place. Perhaps we should repeat that measurement.

To be more precise with the relationship we could insert a 'Trendline' and find an equation. Excel has this capability.
For the example above the 'Trendline' and equation are shown below.



This information supports what we had already determined and gives extra information.

In particular:

- The equation has $x^{0.4991}$, which is close to $x^{0.5}$ or $\sqrt{x}$
- The R^2 value is 0.9968. Without going into the specific details on *R* and R^2, essentially it indicates how well the 'Trendline" fits the data. Closer to 1 being better.

Thus for this data we could say that the graph, 'Trendline' and R^2 value indicate that *y* varies with the square root of *x*.

Errors

All equipment has an error/uncertainty. This could be:

- Due to its manufacture
- Its precision
- Its use

Manufacturing errors are unavoidable, if the equipment is faulty then use a new one.

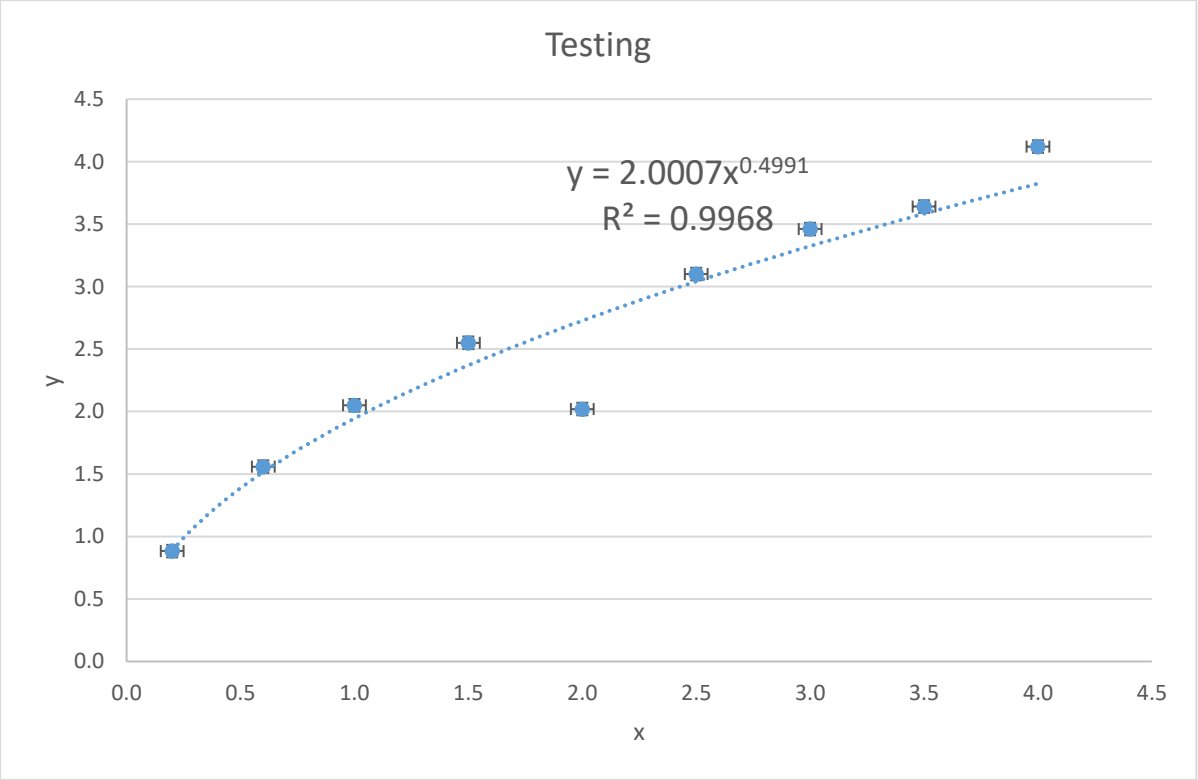
Precision is determined by the equipment. A 30cm rule might be divided into 1mm divisions, whereas a micrometer might be able to measure down to 0.001 of a mm.

The use error comes down to how you use the equipment. Ensuring that you take measurements in the same way every time will reduce this effect.

A Few notes on errors:

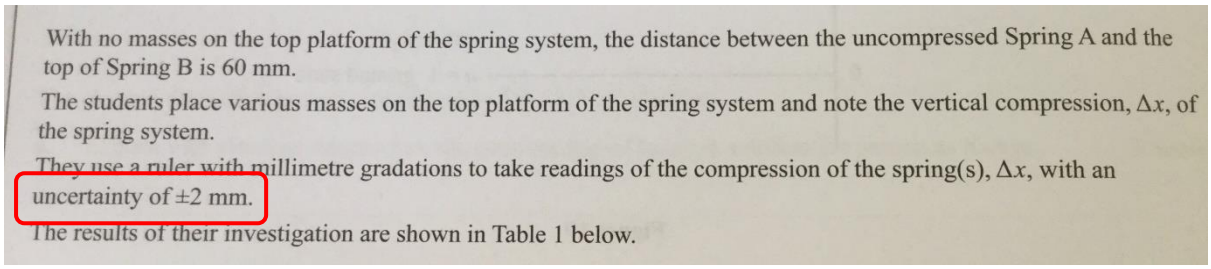
- As a rule of thumb, the error in equipment is ± half the smallest division. This is referred to as the **uncertainty** in the measurement.
- Human error is not an accepted scientific error.
- Mistakes are just that. The data should be discarded and the experiment repeated.
- Poor equipment handling should be rectified with practice

Excel can put in error bars for you. The instruction video shows you how.
https://www.youtube.com/watch?v=ppSzIvIrsh0



On the 2019 Year 12 VCAA Exam – Section B Question 19, asked you to put error bars on a graph.

The information was



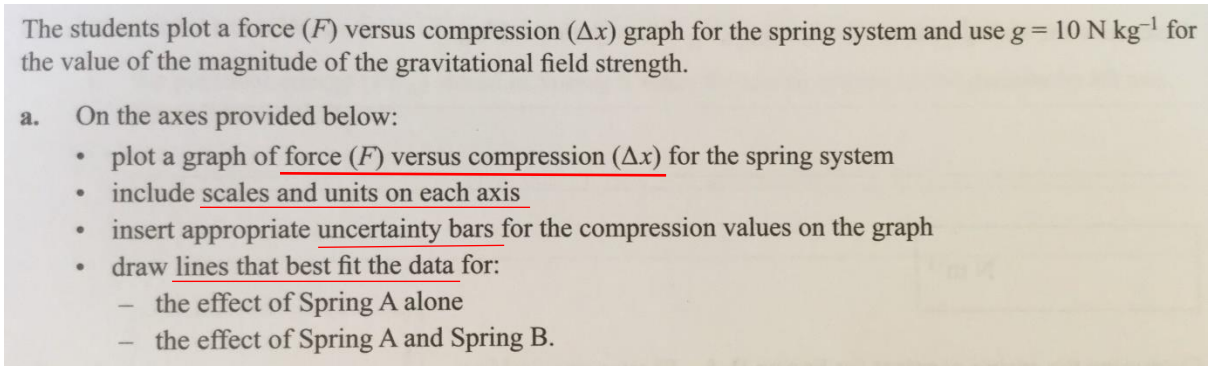
With no masses on the top platform of the spring system, the distance between the uncompressed Spring A and the top of Spring B is 60 mm.

The students place various masses on the top platform of the spring system and note the vertical compression, Δx, of the spring system.

They use a ruler with millimetre gradations to take readings of the compression of the spring(s), Δx, with an uncertainty of ±2 mm.

The results of their investigation are shown in Table 1 below.

The task was



The students plot a force (F) versus compression (Δx) graph for the spring system and use $g = 10$ N kg^{-1} for the value of the magnitude of the gravitational field strength.

a. On the axes provided below:

- plot a graph of force (F) versus compression (Δx) for the spring system
- include scales and units on each axis
- insert appropriate uncertainty bars for the compression values on the graph
- draw lines that best fit the data for:
  - the effect of Spring A alone
  - the effect of Spring A and Spring B.

Limitations

In all experiments there are limitations. There are all sorts of things that limit the accuracy/precision of you measurements.

An example being if you are using a stop watch for timing. The precision of you measurements are limited by your reaction time.

In conclusion your discussion will:

- State whether your results support or contradict your question, and reference your evidence.
- If appropriate, state the relationship between the independent and dependent variable.
- Detail any errors, Limitations and difficulties.
- Evaluate your experimental procedure, making comments about its success and effectiveness.
- Suggest changes in the experimental procedure (or design) and/or possibilities for further study.

Resources

A Level Physics Online, https://www.alevelphysicsonline.com/practical-skills has a series of short Youtube videos on uncertainty, percentage uncertainty, variables and graphing. https://www.youtube.com/watch?v=T78cXi-72Eg An 11 min Youtube video on uncertainties, hand written, but a good description. It is UK production for A level and is part of the Science Shorts series of 18 videos. There are also videos on Standard form, and Proportionality and Graphs. https://www.youtube.com/watch?v=6XZsfV5FCwc An 18 min Youtube video that effectively covers the material in this appendix and also appendix 6. It is also UK based and refers to the IB. https://www.youtube.com/watch?v=KFzN4CYjtoI This 13 minute Youtube video features a person talking to camera explaining data analysis with large hand held cards. It is simple, effective and covers the topic.

Using Excel to analyse data
https://www.mtholyoke.edu/courses/mpeterso/phys103/labs/ExcelHandout.pdf An 8 page pdf guide to using Excel in a Physics Lab. An impressive resource.
Youtube videos:
https://www.youtube.com/watch?v=5O00O8CqVQ4 Calculations, graphing and trendlines (10 min) https://www.youtube.com/watch?v=alTdv8LG6Xk Physics 101: Lab 1 Data analysis and presentation. 28 min