3.1 Overview: 5 Credits of Pure Fun

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Aim:
To determine the relationship between A and B

Method:
Numbered steps with diagrams. Can use things like “repeat step 4 two more times” or “repeat step 3-5 with 2, 3, 4, and 5 masses.”
Include things you controlled at each point.

Controlled Variables:
List 5 things you kept the same and a sentence for each saying how.

Independent Variable:
A - The thing that we changed.
Reason: We wanted to observe the effect of changing A on B

Dependent Variable:
B - The thing that we measured.
Reason: We wanted to observe how B changes as we change A

Accuracy Improving Techniques – what you did right:
List 5 things you did that helped improve the accuracy. (Merit: What you did.)
Explain each with a sentence. (Excellence: How and why did it impact the results?)

Eg: 3 repeated trials at each value, measuring several things together for each trial and dividing (eg. Pendulum swings). Why?

Problematic areas of method can be discussed in the Evaluation Section.

More Examples:
Swinging with pendulum

- Parallax – look horizontally at scale, scale close to object being measured
- Initial velocity, let swing a couple of times first
- Keep amplitude small - low swing height (keeps period constant)
- Care to have complete swings – start timing at “0” not “1”
- Reliability – take time for 10 swings and divide by 10 for average

Timing with stopwatch

- Multisampling – Repeat and average - Reduces errors from random variation
- Random variation and limits of accuracy - measure several at once
- Reaction time error will be systematic skewing of results in one direction.
- If prediction is possible then averaging several trials will reduce error.
- Record answer to same decimal place as the measuring device. Eg. A stopwatch measuring 10 swings: 10.41 sec/10 = 1.041s per swing
- Human reaction time is about 0.1 second. This uncertainty can be added to the experiments uncertainty which otherwise would just be from trial differences.

Results with example table:

	Trials (seconds for 10 swings)					First graph	Second Graph		
Y axis	T1	T2	T3	T4	T5	Average time per swing (s)	Average^2	Min^2	Max^2
0.3	7.18	7.22	7.35	7.40	7.24	.7278	0.5297	0.5156	0.5476

1. Time 10 swings. Repeat this over at least 5 trials.
2. Average the trials and divide by 10 to get the average time per swing.
3. Plot initial curvy graph – error bars not required
4. Transform the data (average, max, min values)
5. Plot averages on a straight line graph
6. Draw LOBF with equal points above and below line
7. Plot *error bars* on at least *one* axis by using the transformed min and max values
8. Draw min and max gradients based on error bars

Note: If all trials are perfectly the same then there will be no error bars! In this case take the accuracy of the measuring device as the uncertainty.

Conversely, if there is too much variation the error bars will be too big and gradient uncertainty too large. There is a happy medium that accurately reflects the error in taking readings.

Error bars **only** on transformed graph in order to get the extreme lines.

Just plot the values straight from the data table. Uncertainty is simply calculated from the slopes of the final graph.

Trial values need to be divided by 10 if each trial is measuring 10 swings. This needs to be noted in table headings.

Graphs x 2:
A over B (Line of Best Fit Curve)
A over B^2 (Line of Best Fit Straight Line and Two Extreme Gradients)
Extreme gradients NOT defined by error bars primarily, they are determined by the points on the end of the bars.

LoBF for Achieved, one extreme line for Merit. Do **both** extreme lines as backup.
There is no rule for putting the dependent variable on any particular axis in physics. The idea is what ever makes the maths easier when using the gradient in an equation for the relationship, eg. V/I = R so current would always go on the x axis even if it was the thing being measured.

Calculations:
Line of Best Fit Gradient ± [(max grad – min grad)÷2]
Uncertainty is rounded to 1sf
Data is then rounded to same decimal places as uncertainty
Eg. 2.053 ± 0.1605 becomes 2.1 ± 0.2

y intercept: Your best fit line (the average gradient) should project across the y axis.

Rearrange the given formula to follow the general equation. Example: $y = mx^2 + c$ (m is gradient)
The gradient may include a constant, eg. Plotting kinetic energy over velocity squared.

- $E_k = \frac{1}{2} mv^2$

- gradient = ½ mass
- gradient x 2 = mass. Uncertainty x2 = uncertainty of mass
- Compare determined mass with known value. Within uncertainty? How far out as %?
- Discuss the significance of this in the evaluation

Conclusion:
Our aim was _______ and we found out that there is a ___________ relationship between A and B. Our result was _____ ± _____ (a number with units) which allowed us to calculate the constant for ________ to a value of ______ ± ______ and this compares with the accepted value of _____ from _______ (give reference).

Evaluation – what didn't go well:
List 5 things that did improve accuracy. (Merit: What did/didn't you do)
Explain each with a sentence or paragraph. (Excellence: How and why did it impact the results?)

2010 Tips from Students

Method

- Mention your dependent, independent (with range) and control variables in your method to save time (but you **must** state these somewhere).
- Try and include at least 5 accuracy techniques in your method too.

Conclusion

- You **must** give your mathematical relationship, ie. $L = 0.5T^2$ where 0.5 = m = 0.3 x sinθ

Graphs

- Same number of points above and under the line of best fit.
- Label everything, eg. Axis (units) or axis^2 (units^2)
- Do not break graph axis. Use even scales.
- When finding gradient choose 2 points which are spread out.
- Gradient triangle taken *from graph line* not points.
- Gradient triangle needs to be as big as the graph, not a small triangle.
- Do error bars correctly. Your best fit line must partially cut at least 3 error bars.
- If there is an outlier that is not used then say so, and why, in the discussion. If there are no outliers then talk about that instead.

Evaluation

- You **must** have **at least two** fully detailed (well explained) physics theory points to get excellence, eg. Rotational inertia and the systematic effects on the experiment.
- You must state how these physics *theories* affect, and are related to, your *real life* gradient and therefore your final calculated value.
- Discussion of just random errors is not sufficient.
- Compare your experimental value (eg. 4.5 ± 0.4 m/s compared to 4.6 m/s)
- Final value must be expressed to correct sf and dp, eg. **Not** 4.56 ± 0.4, or 4.5 ± 0.46. The uncertainty is to **one** sf, and the value is to the **same dp** as the uncertainty.
- If your uncertainty is too small either add some error (eg. 0.1s can be added for human reaction time when using a stopwatch) some people can spend too long on taking readings and making them so accurate you don't end up with any error bars. "Repeat the trial."
- Do well and good luck ☺ (past yr 13's)