Physics 1.1

EducationPerfect

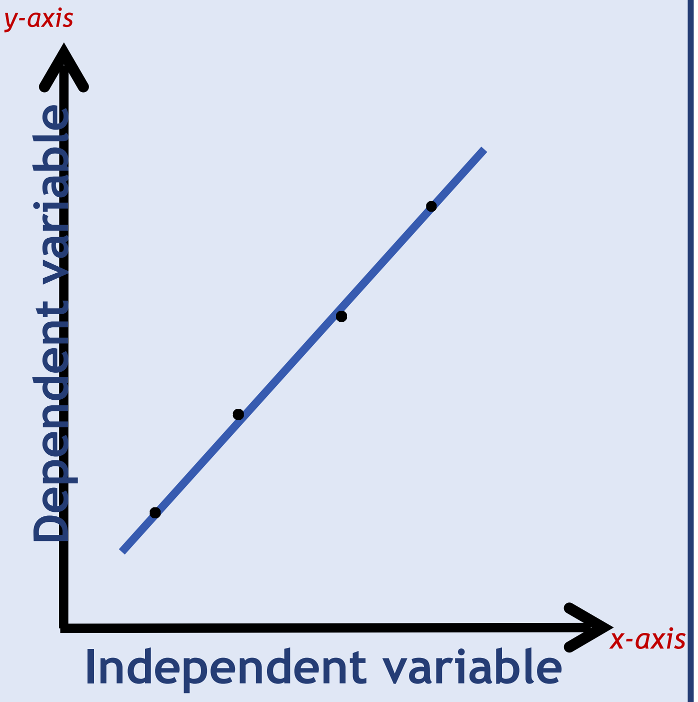
Physics 1.1 - Internal (4 Credits)

Your task is to carry out a practical physics **investigation** that leads to a **linear** mathematical relationship, with **direction**.

There are three key words in the above statement:

1. Investigation
2. Linear
3. Direction

Lets look at what each of these words means for this internal assessment.



1. Investigation

What's involved in carrying out a practical physics investigation??

Put the following steps in the most logical order.

Evaluating the investigation

Writing a conclusion

Developing a method

Writing an aim/hypothesis

Collecting primary data

Processing the data (calculating averages)

Drawing a graph

Identifying the trend

1. Investigation - answer

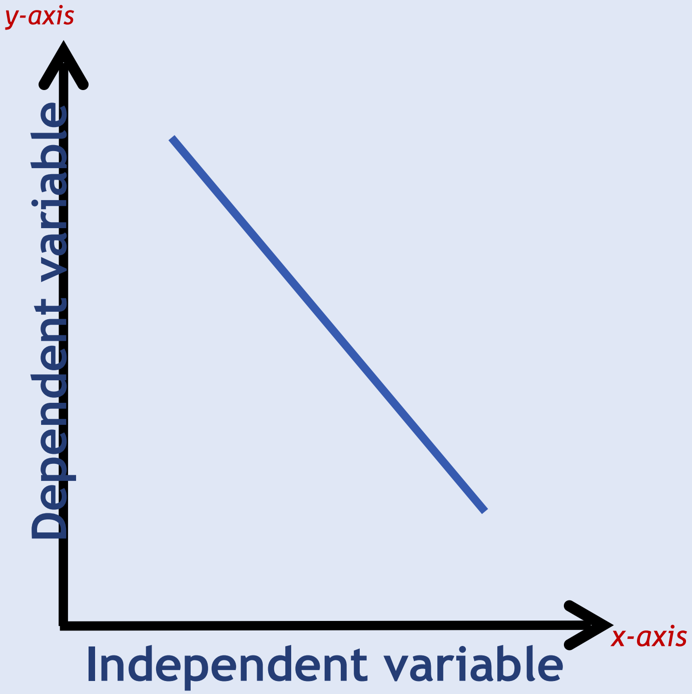
The report template that you will be provided with will help you structure your report however an understanding of proper procedures is important in any investigation.

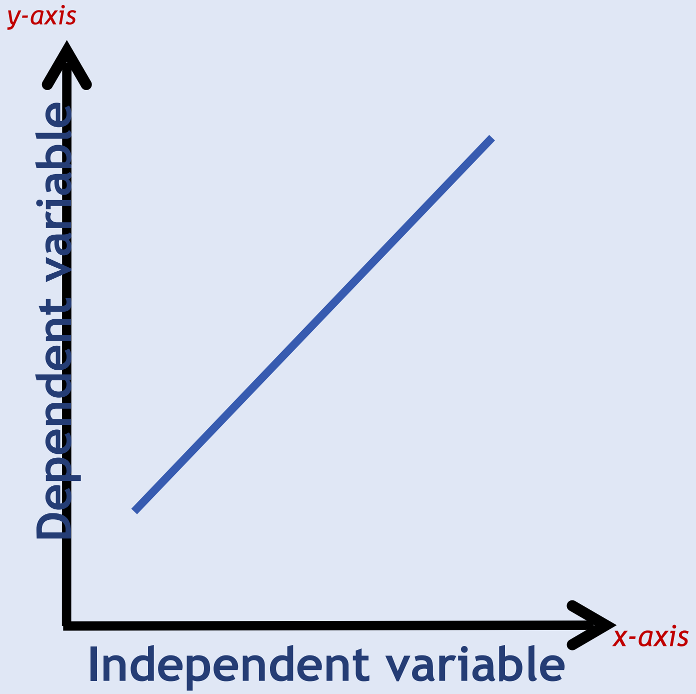
1. **Writing an aim/hypothesis**
2. **Developing a method**
3. **Collecting primary data**
4. **Processing the data (calculating averages)**
5. **Drawing a graph**
6. **Identifying the trend**
7. **Writing a conclusion**
8. **Evaluating the investigation**

In this investigation you need to do one more step which is to write a linear mathematical equation in words.
Where would this step go?

2. Linear

Linear effectively means straight line. Therefore, a **linear** mathematical relationship will be displayed on a graph as a straight line. This means that your graph should end up looking like either of the following:

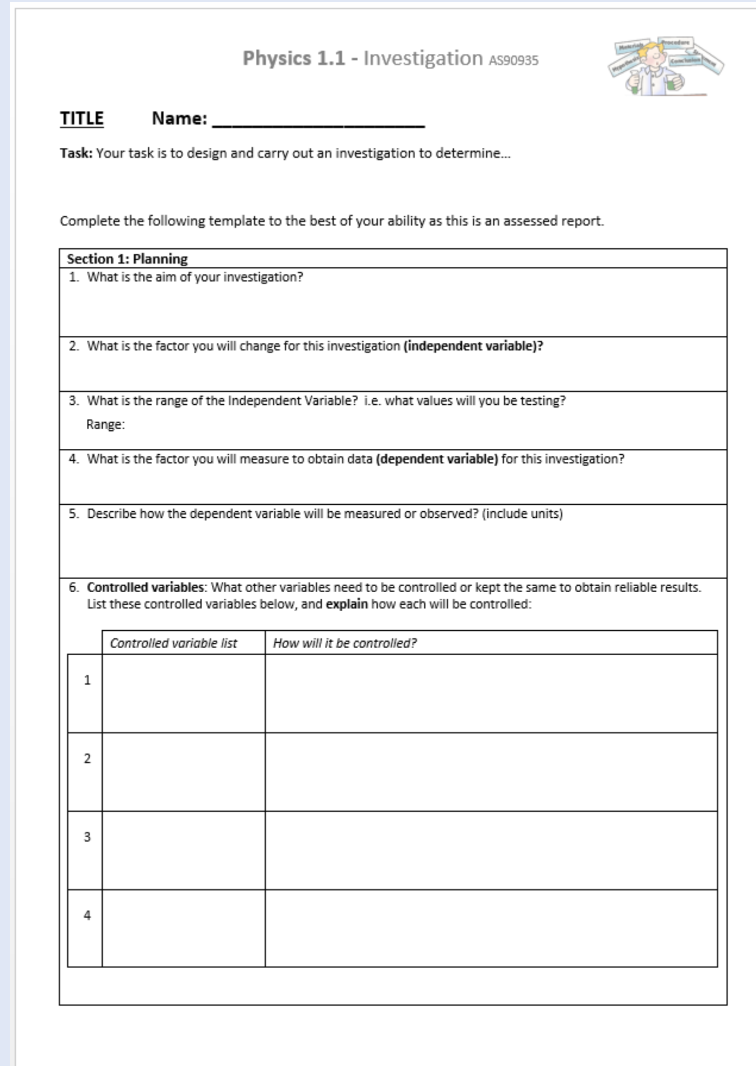




3. Direction

With direction means that general instructions for the investigation will be specified in writing and direction will be given in the form of a purpose, an outline of the method, and the equipment and/or materials from which to choose.

A template or suitable format for planning the investigation will be provided for you to use like the one pictured to the right.



Physics 1.1 - Investigation AS90935

TITLE **Name:** ____________________

Task: Your task is to design and carry out an investigation to determine…

Complete the following template to the best of your ability as this is an assessed report.

Section 1: Planning

1. What is the aim of your investigation?
2. What is the factor you will change for this investigation **(independent variable)?**
3. What is the range of the Independent Variable? i.e. what values will you be testing?
   Range:
4. What is the factor you will measure to obtain data **(dependent variable)** for this investigation?
5. Describe how the dependent variable will be measured or observed? (include units)
6. **Controlled variables**: What other variables need to be controlled or kept the same to obtain reliable results. List these controlled variables below, and **explain** how each will be controlled:

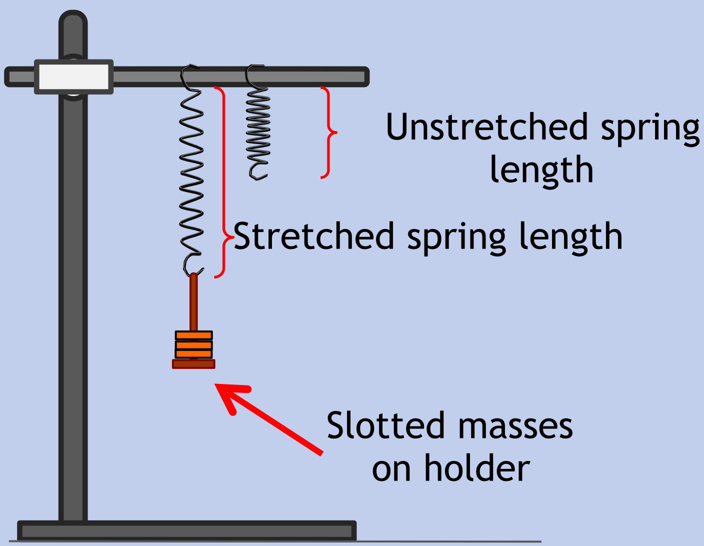
	Controlled variable list	*How will it be controlled?*
1		
2		
3		
4		

Two examples

Throughout this presentation two examples will be used to highlight important aspects associated with carrying out a comprehensive practical investigation. These two examples are:

Spring experiment

Mass versus spring extension



Mini Cooper experiment

Mass versus braking distance

Getting started - key variables

As part of the assessment you will be given a task statement. When you read the task statement you should be able to identify the two main variables in the experiment. These are the:

- **Independent variable:** the one factor you will be changing.
- **Dependent variable:** the factor you will be measuring.

Task Statement: *This assessment activity requires you to find the mathematical relationship between the* ***mass suspended from the spring*** *and the* ***spring extension***.

independent variable

dependent variable

Note: You should use the exact same underlined wording throughout your report e.g in your hypothesis, table headings, graph axis labels, conclusion etc.

Getting started - Aim and hypothesis

To start your investigation you need to reword the task statement into an **aim** and a **hypothesis.**

Lets have a look at these two aspects:

Aim: *Hint: take the key phrase directly from the task statement.*

*Your **aim** should start with "The aim of this investigation is to find the mathematical relationship between____[insert key phrase] ____".*

Hypothesis: *Hint: choose increase **or** decrease depending on what you think will happen in the experiment.*

*Your **hypothesis** is a testable prediction and should be written like this "If ___[insert independent variable]____ increases/decreases then ___[insert dependent variable]___ will increase/decrease at a constant rate."*

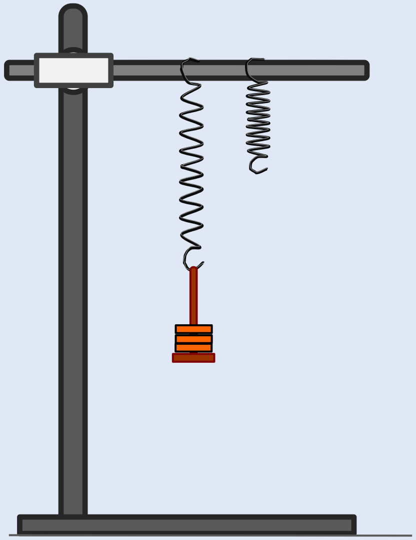
Write an aim and hypothesis

Using the following task statement as a guide, have a go at writing an aim and hypothesis for this classic spring experiment. As you read the statement underline the independent and dependent variables.

Task statement: *This assessment activity requires you to find the mathematical relationship between the mass suspended from the spring and the spring extension.*

Aim

The aim of this investigation is to find the mathematical relationship between *the mass suspended from the spring* and *the spring extension*.



Hypothesis

If the *mass suspended from the spring* ***increases*** then *the spring extension will* ***increase*** at a constant rate.

Independent variable (I.V)

The independent variable for an experiment is the factor that is intentionally changed to observe its effect on the dependent variable. For Achieved you need to test at least four different values over a ‘reasonable range’.

To decide on what is a reasonable range you need to carry out some trials using the equipment provided. Things to consider when doing the trials are:

- What range does the equipment allow for?
- What range gives results that you can accurately measure?
- What range spreads the data enough so that a trend can be established with no overlapping values?

Range for the I.V

BMW are wanting you to design an experiment to determine how the mass of a Mini Cooper affects its braking distance.

Note: A Mini Cooper with no driver or passengers has a mass of 1150kg.

What is the independent variable for this experiment?

The mass of the Mini Cooper

What would be a reasonable range for the I.V?

1200kg, 1250kg, 1300kg, 1350kg, 1400kg

Dependent variable (D.V)

As you change the independent variable, you will observe, measure and record the change in the dependent variable.

You will be required to measure the dependent variable accurately with the use of scientific equipment such as measuring tapes, stopwatches, voltmeters or thermometers.

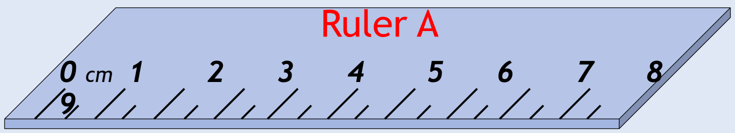
To increase the accuracy of your measured values you need to remove the following **sources of error**:

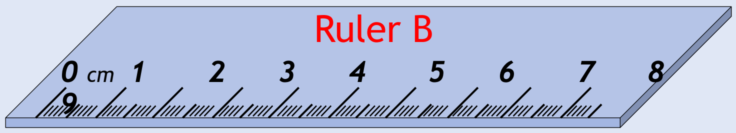
- Precision
- Parallax error
- Zero error

These sources of error will be explained on the next three slides.

Precision

The precision of your measurements depends on your measuring equipment. Which ruler below is more precise? Explain why.





Answer

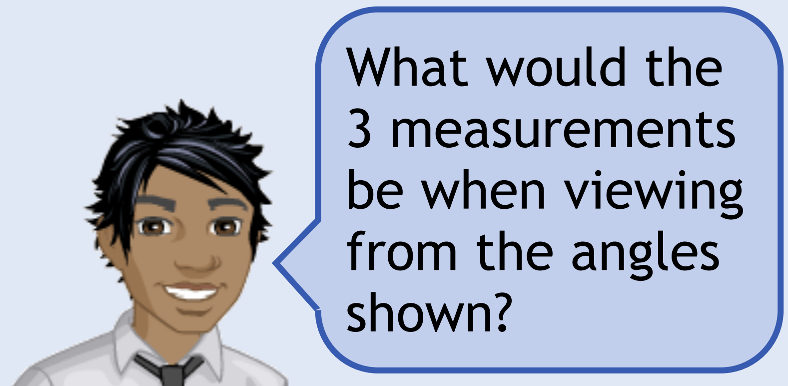
Ruler A has 0.5cm increments whereas Ruler B has 0.1cm

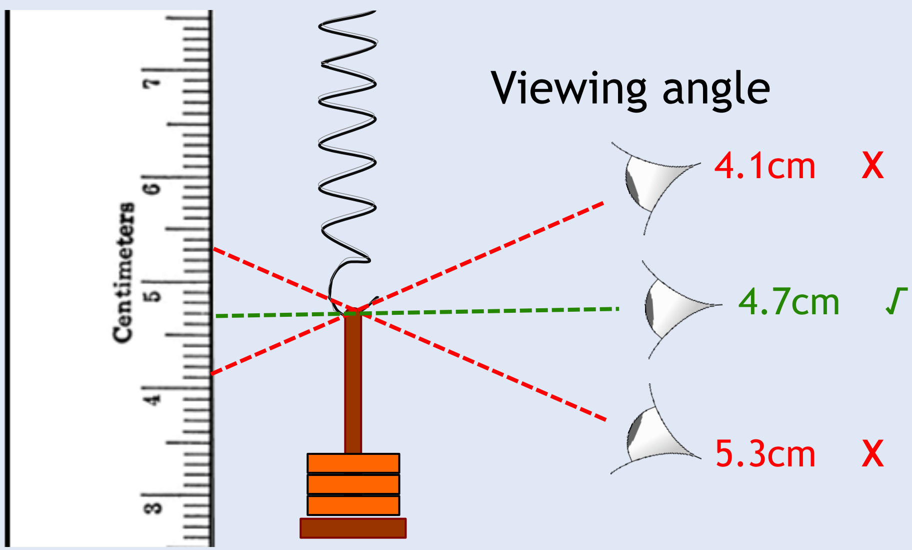
Note: Record your data to the highest degree of precision possible and then you can comment on this in your evaluation.

Parallax error

Parallax error occurs when a measurement is **more or less** than the **true value** because of your eye being positioned at the wrong angle to the measurement markings.

To avoid parallax error you should always **make sure that your eye is 90 degrees to the measuring scale.** The diagram below shows how parallax error can reduce the accuracy of your measurements.





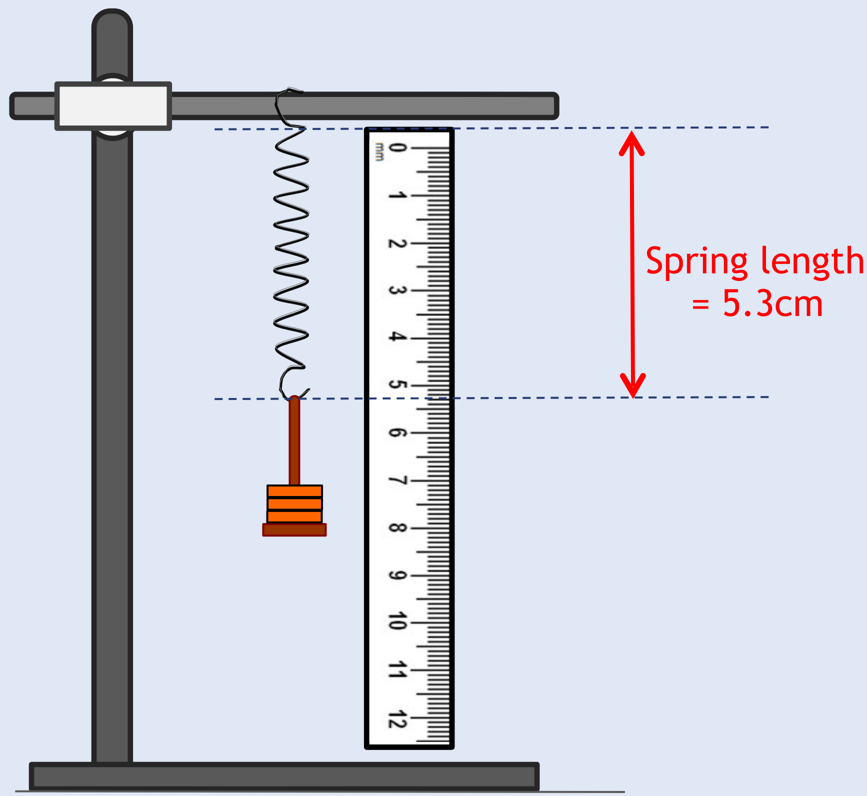
Zero error

Zero error can occur when the measuring equipment is not calibrated to zero correctly or when the person measuring doesn't account for the area at the end of a ruler.

What is wrong with the measurement in the diagram to the right?

Estimate the actual length of the spring in this example?

How does zero error effect the accuracy of the results?



Controlled variables

For any experiment there are numerous variables/factors that MUST be controlled/kept the same. If these variables are not controlled then the reliability of the data is reduced.

List all the variables that would need to be controlled in the Mini Cooper experiment and give examples of HOW you would keep them constant.

Controlled variables

- Speed of the car prior to braking e.g 50km/hr.
- Condition of the brake pads e.g replace with new pads after each trial.
- Condition of the tyres e.g replace with new tyre after each trial.
- Type of surface used e.g always use the same section of dry tarmac.
- Environmental conditions e.g test indoors (no wind).
- Pressure put on the brakes e.g press brakes down fully for all trials.

Remember: The aim is to find the mathematical relationship between the mass of the Mini Cooper and its braking distance.

Method

For any investigation you need to develop a detailed **step-by-step** method for collecting data. Below is a method written for the spring experiment by a Year 10 student. How could it be improved?

1. Measure the initial length of the spring.
2. Hang the spring from a clamp stand
3. Apply the first mass to the spring.
4. Measure the final length of the spring.
5. Subtract the initial spring length from the final spring length to give you the spring extension.
6. Record this value in the table.
7. Repeat steps 1-6 three times.

Note: Try rewriting this method and add in any extra detail you can think of. Also, try to draw a diagram of how you would measure the dependent variable.

Improved Method

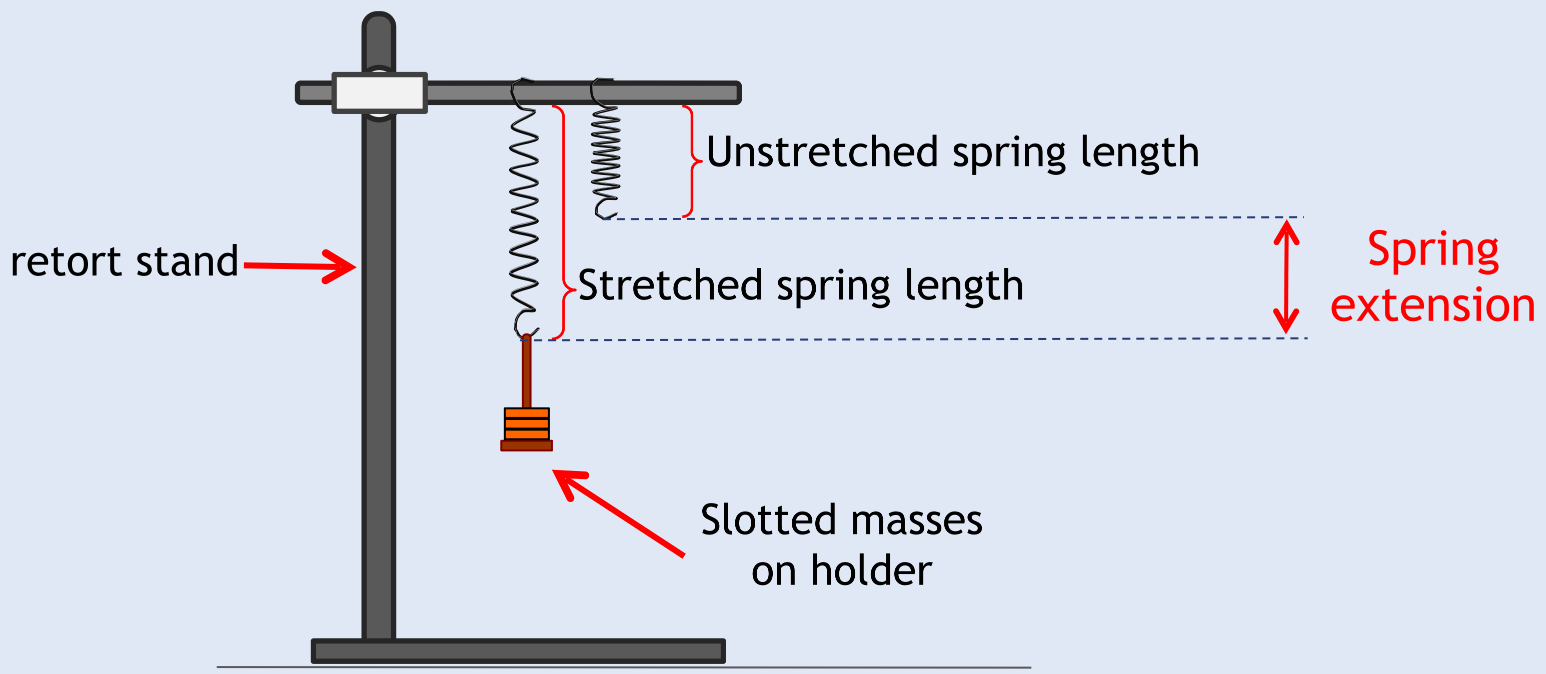
1. Using a 15cm ruler measure the initial length of the spring at eye level from the top coil to the bottom coil.
2. Hang the spring from a clamp stand
3. Apply the first mass to the spring which is 100g (stand + one 50g mass).
4. Measure the final length of the spring from the top coil to the bottom coil Using a 15cm ruler at eye level.
5. Subtract the initial spring length from the final spring length to give you the spring extension.
6. Record this value in the table.
7. Repeat steps 1-6 three times.
8. Repeat steps 1-7 for the following masses: 200g, 300g, 400g, 500g.

Note: Each step is numbered and they are written without using ‘I’, ‘me’ or ‘we’.
The last two steps are very important and can always be written this way.

Diagram of measurement

A good diagram is needed to show how you measured the dependent variable. Diagrams should be drawn in 2-D and clearly labelled.

Remember: The dependent variable is ‘spring extension’.



Tabulation

The table format below will work for most experiments that you need to carry out at school.

Note: Depending on time you may only do 3 trials.

Your **independent** variable and **units** go here.

The **range** for your I.V goes here.

Your **dependent** variable and **units** go here.

7 lines

	Trial 1	Trial 2	Trial 3	Trial 4	Average

Practice drawing out this table for the Spring experiment.

Table example

Mass suspended from the spring (g)	Spring extension (cm)				
	Trial 1	Trial 2	Trial 3	Trial 4	Average
100					
200					
300					
400					
500					

Copy and complete this table.

To calculate an average add the data for each trial then hit the equals button **before** dividing by the number of trials.

e.g. 2.1 + 2.0 + 2.2 + 2.3 = 8.6

8.6/4 = 2.1666.. (2.2 1.d.p)

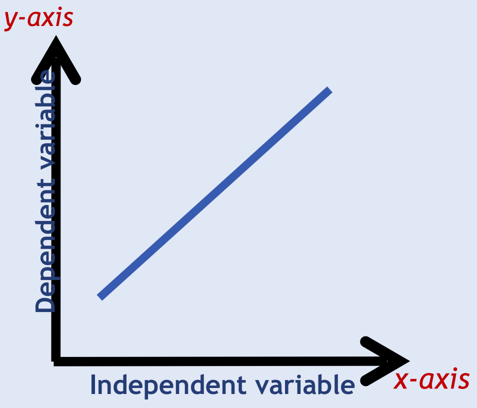
Note: round the averages to the same accuracy as the raw data. Remove any outliers/anomalies before calculating the average.

Now have a go at graphing this data. Use the same labels that are in the table for your graph. Also, only graph the averages.

Graphing checklist

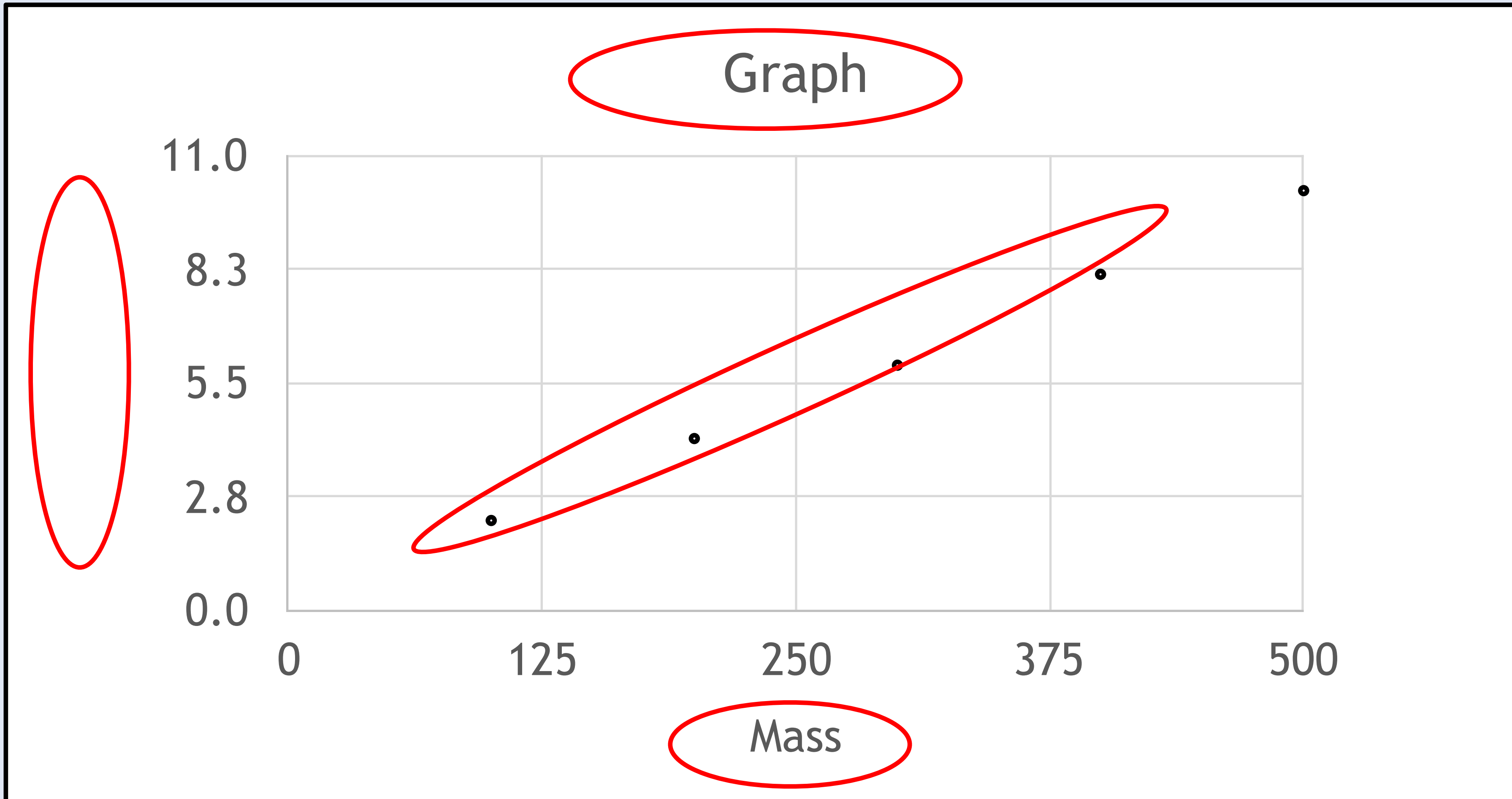
Below are some of the most important things to remember when drawing your graph.

- Use graph paper.
- Make it large (at least ¾ page).
- Give your graph a descriptive title.
- Label your **x-axis** with your **independent** variable (include units).
- Label your **y-axis** with the **dependent** variable (include units).
- Make sure your scale is **even** on both axes.
- Only plot your **averages**.
- Plot your points accurately using a **cross** (x).
- Draw a **straight** line of best fit using a ruler.

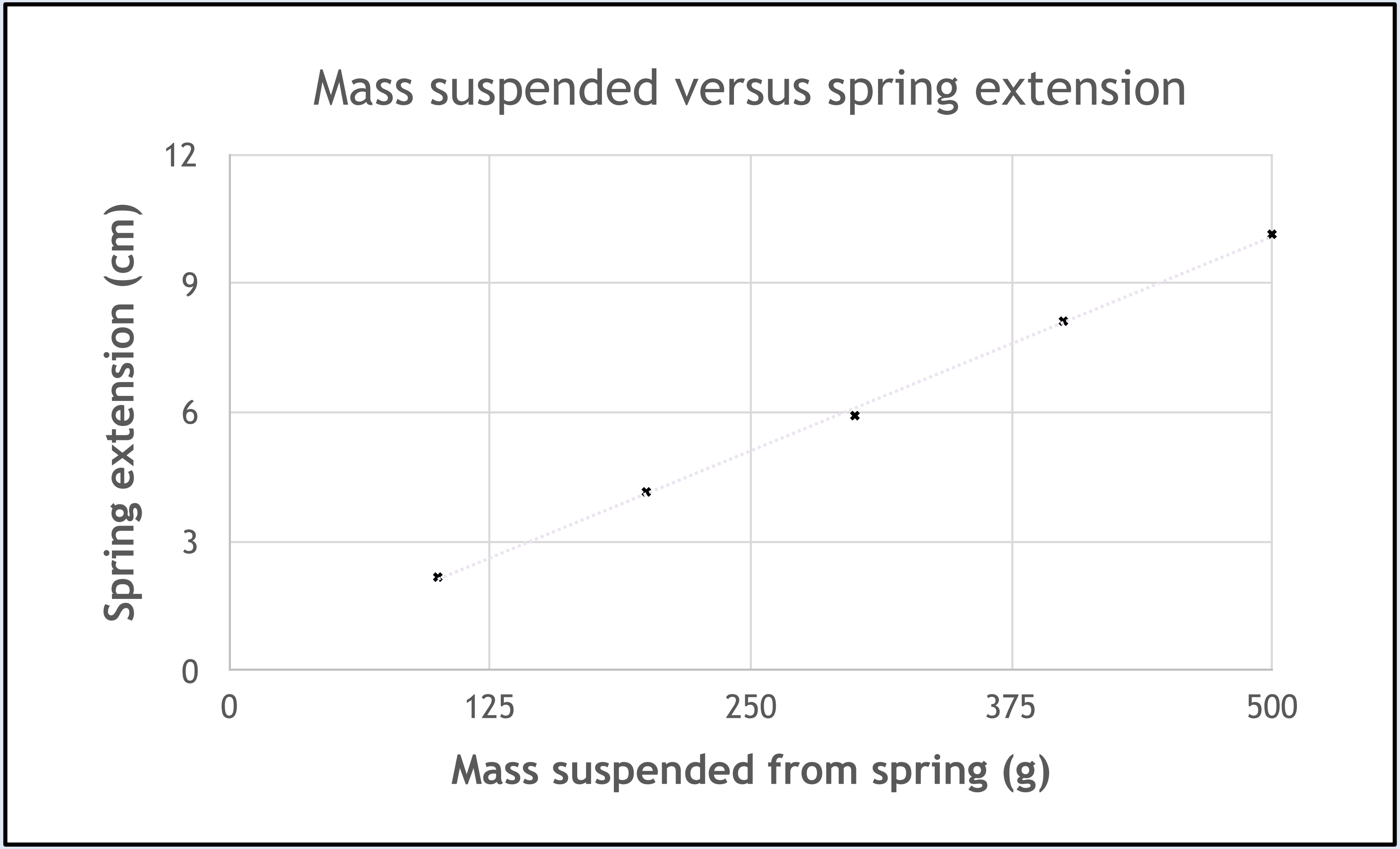


Graphing example - errors

The graph below is NOT perfect. What changes would you make?



Graphing example - improved



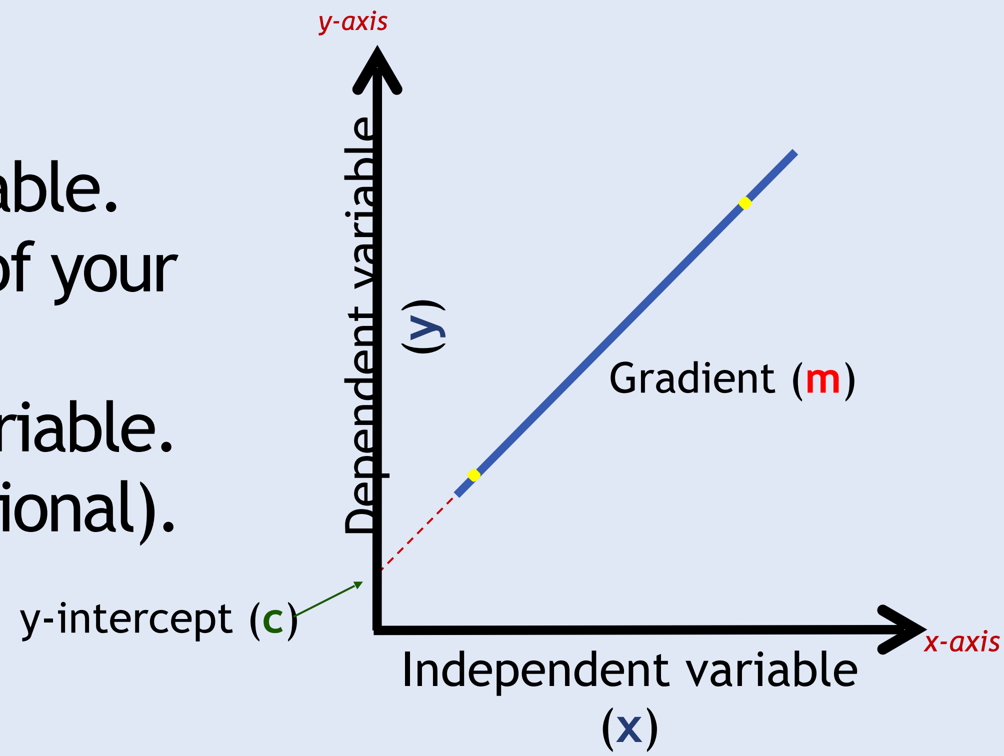
Linear relationship

After constructing your graph and drawing a line of best fit with a ruler you will be able to calculate the gradient of the line and then write a mathematical relationship using the general equation: $y = mx + c$

In this equation:

- y is your dependent variable.
- **m** is the slope/gradient of your line of best fit.
- *x* is your independent variable.
- *c* is your y-intercept (optional).

More on this later…



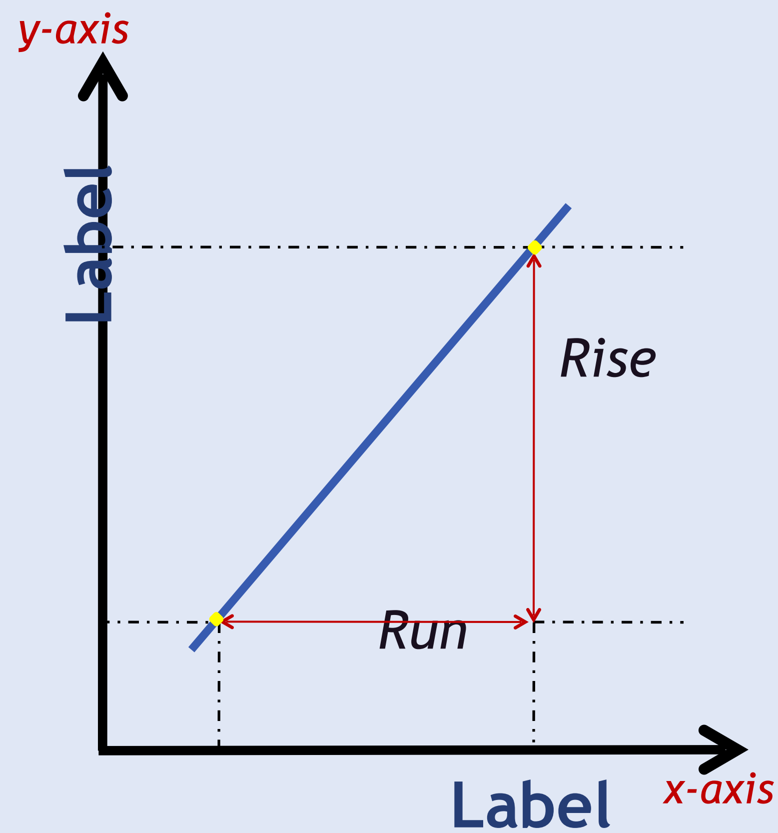
Calculating the gradient/slope

To work out the gradient/slope of your line graph use the following equation:

Slop e (m) = Run

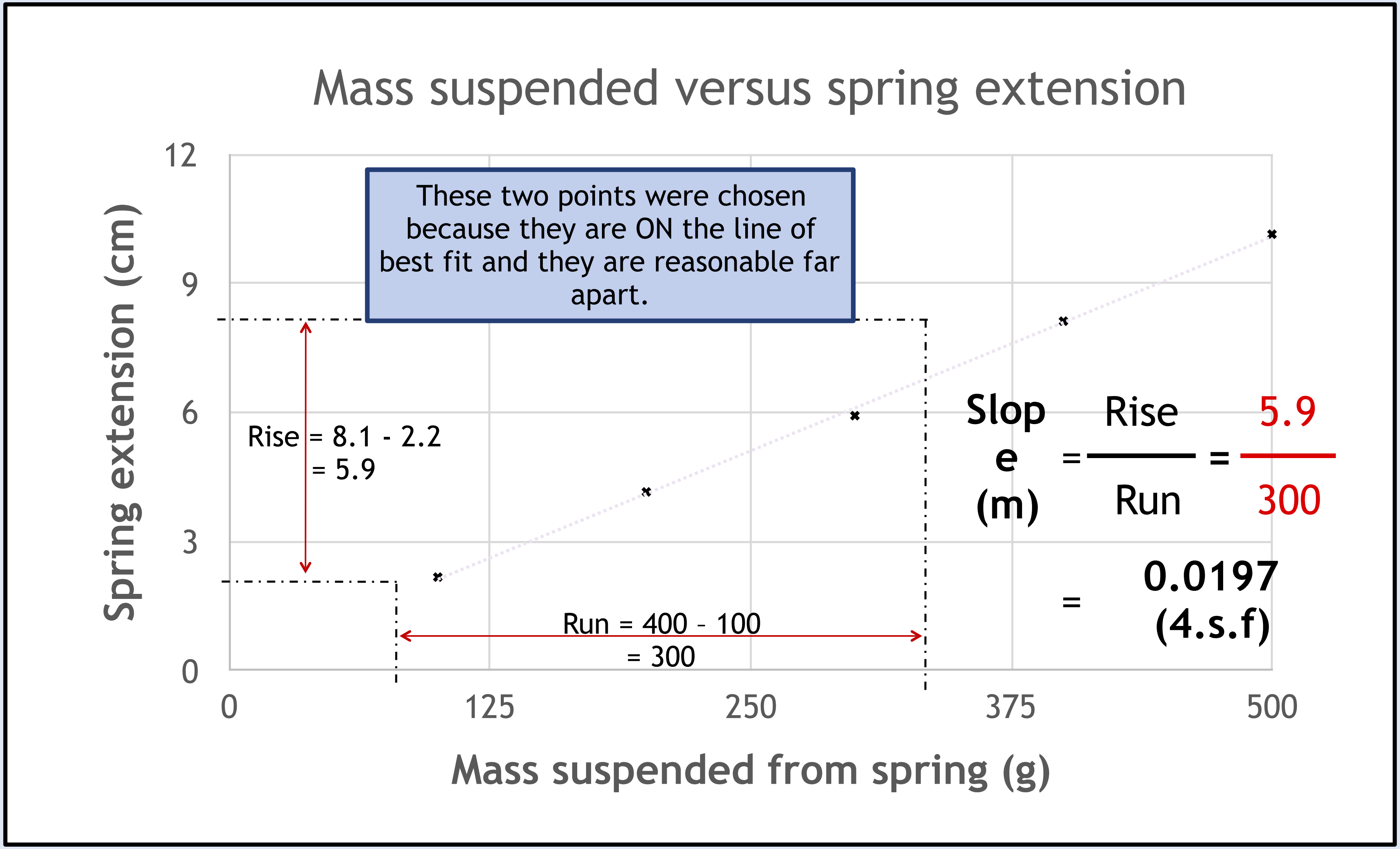
axis

To calculate the rise and the run you MUST use two points that are ON your line of best fit and you should draw construction lines as shown.



Lets have a go at calculating the slope (m) for the previous graph.

Calculating the slope (m)



Linear mathematical equation

The value that was calculated for m (0.0197) now needs to go into the equation ***y*** = **m*x***.

y and ***x*** need to be replaced by the axis labels from your graph.

Therefore, the linear mathematical relationship for the spring investigation would be:

Spring extension = 0.0197 x Mass suspended from the spring

Conclusion

When writing your conclusion do the following:

- Restate the aim of your investigation

The aim of this investigation is to find the mathematical relationship between____[insert key phrase] ____.

- State the trend shown by the graph.

The graph shows that as the _[independent variable]__ increased the __[dependent variable]__ ***increased/decreased*** at a constant rate.

- State whether your hypothesis was proven correct or incorrect.

My hypothesis which was proven correct/incorrect (remove one).

- Compare two averages as proof.

For example: on average …. <u>whereas</u> …. which is a greater/less.

Conclusion example

Write a conclusion for the Spring experiment using the structure on the previous slide.

The aim of this investigation was to find the mathematical relationship between the mass suspended from the spring and the spring extension.

It was found that as the mass **increased** then the spring extension also **increased** at a constant rate of 0.0197.

The hypothesis was therefore proven correct.

For example: on average a mass of 100g extended the spring by 2.2 cm whereas a mass of 400g extended the spring by 8.1cm which is a lot greater.

Evaluation

In your evaluation you need to discuss the Science ideas linked to your investigation and you have to **convince** the reader/marker that your investigation was comprehensive.

Split your evaluation into the following six separate paragraphs:

Physics ideas - explain your results with relevant physics principles.

Accuracy – explain each accuracy improving technique you used.

Range of I.V – explain why you chose the range you did.

Controlled variables – justify how + why you controlled these factors.

Reliability of data – explain why your data was reliable.

Relevance - explain how the investigation relates to the real world.

Evaluation - science ideas

To start your evaluation you should explain your trend using relevant Physics ideas.

Have a go at explaining the Physics behind the Spring experiment. Why did the spring extension increase as the mass increased?

When a mass is suspended from the spring a downwards force is applied to the spring and it stretches until it provides an equal but opposite support/restoring force. The greater the force applied the greater the spring extension.

For example, when 400g was suspended from the spring a 0.4N downwards weight force was applied to the spring causing it to extend by 8.1cm. At this point the forces became balanced and the mass was motionless.

In this experiment, for every 100g of mass added to the spring it extended by roughly 2cm. This follows Hooke's Law which states that the extension of an elastic object like a spring is directly proportional to the force added.

Evaluation - accuracy

In this paragraph you need to explain why the particular accuracy improving techniques you used were necessary.

As discussed earlier you should focus on: how precise your measuring equipment was; how you avoided parallax error and how you avoided zero error.

Key statements you should adapt and use are below:

- To increase **precision** a ruler with **small increments** (0.1cm) was used so that the measured values were as close to their true value as possible.
- To avoid parallax error (measurement errors due to viewing angle) all measurements were read at an angle 90 degrees to the measuring scale on the ruler.
- To avoid zero error the 0cm mark of the ruler was lined up at start point rather than the end of the ruler, if this was not done every measurement would have been 0.5cm smaller than the true value.

Evaluation - range of your I.V

In this paragraph there are three key things that you must do. Firstly, state how many different values you tested and why this was important, then justify the lowest and highest values of your range.

Have a go at doing this for the Spring experiment.

Answer

I think that the range for the independent variable was valid because five different masses were tested which allowed for a trend to be established.

The lowest mass of 100g was enough to stretch the spring and allow for an accurate measurement. The highest value of 500g was the maximum mass the spring could handle without being stretched beyond its limit/damaged.

Evaluation - controlled variables

In this paragraph you need to choose 2-3 of your controlled variables and discuss why you kept each one constant. Also, explain how the results would have differed if you hadn't.

For example: "*In the Spring experiment it was important to use the same spring for every trial as different springs would stretch different amounts under the same load/mass and therefore the results would not be reliable or consistent.*"

Have a go at explaining why the speed of the car prior to braking was important to keep **constant** in the Mini Cooper experiment.

Answer: *$E_k = \frac{1}{2} mv^2$. The kinetic energy of a car is dependent on its mass and its velocity. During the experiment the velocity of the car was kept constant (50km/hr) so that the only factor affecting the braking distance was the mass. If velocity had increased the kinetic energy of the car would increase and more work would need to be done to bring the car to a stop therefore the braking distance would increase.*

Evaluation - reliability of data

In this paragraph, state how many times you repeated the experiment and give an example of consistent data. Then explain why repetition is important in terms of identifying anomalies and allowing you to average your results.

The example below is for the Spring experiment.

*The data gathered was reliable because the experiment was repeated four times for each different mass and they got **consistent results** except for their second trial at 400g.*

*By repeating the experiment four times it allowed **an average to be calculated** which **<u>reduces</u> the effect of random errors** made when collecting the data, **for example** not reading the measurement at exactly eye level each time.*

*It also allowed me to **identify an anomalous result** (67) and remove it from the data before I calculated the average. If they had not repeated this trial 3 more times an incorrect relationship would have been found.*

Evaluation - relevance

The final paragraph in your report should try to explain why or how the experiment is relevant to everyday life.

This requires you to think about the context of the investigation and link the Physics ideas to examples in everyday life and/or discuss whether the experiment could be scaled up to the real-life scenario.

For the Mini Cooper experiment choose one of the following statements and write a paragraph that links the ideas to the findings of the investigation.

1. Following distance should be adjusted when you have a car full of passengers.
2. Trucks over 3500kg have a speed limit of 90km/hr.

Practice investigation

The link below will open a practice investigation template for you to complete. It is based on the Mini Cooper experiment that has been used as an example in this slideshow.

Complete investigation to the best of your ability and then grade it using the exemplar provided.

Lets get a move on…

Mini Cooper Investigation Template

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