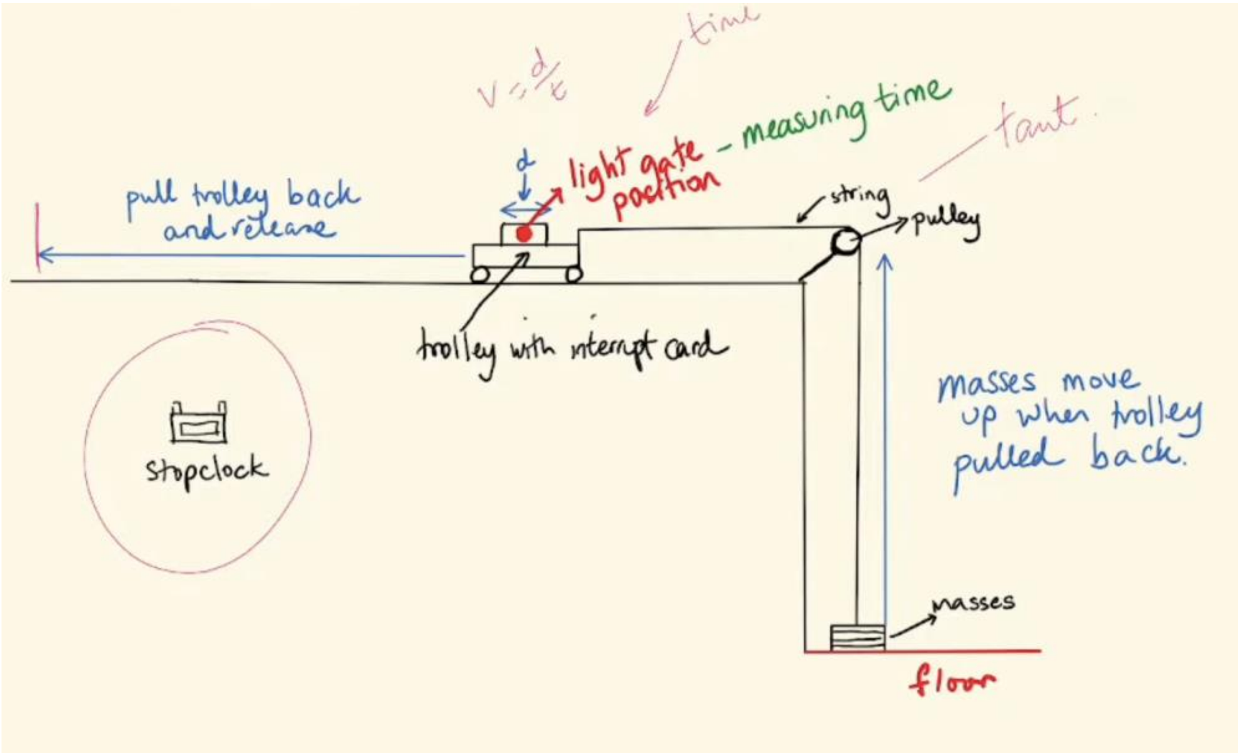
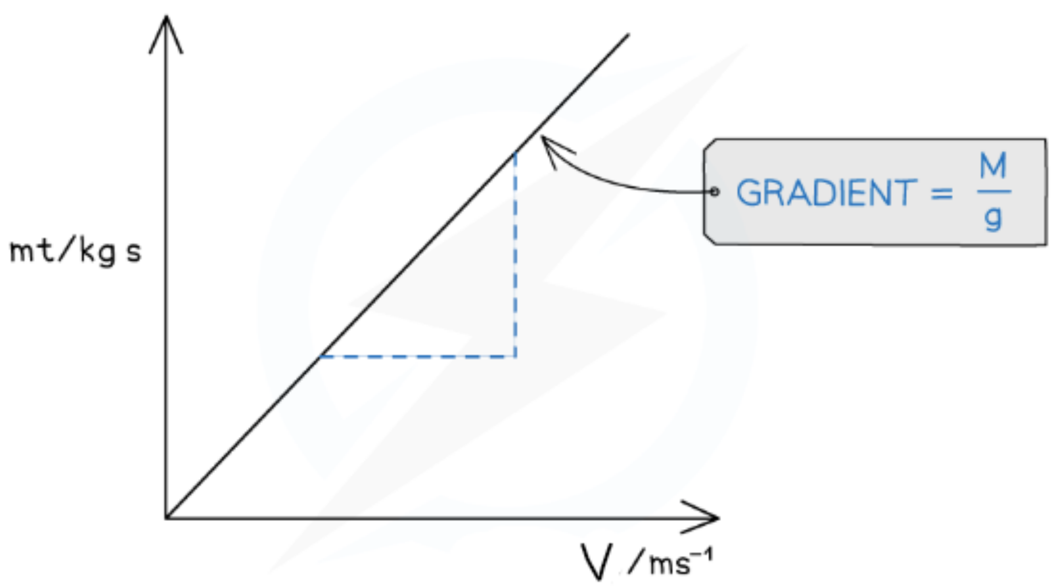
Core Practical 9: Investigating Impulse

Aim – Determine the change in momentum of a trolley due to a force acting on it/general investigation



Graph



Method

1. At first, take the string and attach masses to it, put the masses on the floor and pull the trolley with the interrupt card as far back as possible as to ensure the string is taught

2. Place the light gate at the position where the trolley is when the string is taut, well why do this? Its to ensure we take the speed of the trolley after the masses have accelerated it

3. Now we can derive some relationships between the variables we are testing

   The forces accelerating the trolley are the weights, and so

$$F = mg$$

   The Time, we measure using the stop clock which is the time taken to go from the release point to the light gate. This is the time in which the force acts

$$T$$

   The Final Velocity of the trolley can we found using the interrupt card and the light gate, t is the time to pass through light gate and we use the length of the card

$$\frac{\text{length of card}}{t}$$

   The impulse of the trolley, which is the change of its momentum can be found by doing Mv, where M is the mass of the trolley and v is its final velocity, so Mv is the final momentum but since the trolley starts from rest its initial momentum is 0 and so impulse is Mv

$$Mv$$

   The impulse of the trolley is also the force acting on the trolley over a time period, since mg is the force accelerating it which acts over a time T (reading on stopwatch) impulse is also equal to

$$mgT$$

   And so, finally

$$mgT = Mv$$

   From this, if we rearrange

$$mT = \left(\frac{M}{g}\right)v$$

If we now compare this to y = mx, we can see a graph of mT to v would give us a gradient of M/g

4. Plot the required graph, and the straight line confirms the linear relationship between the variables

Evaluation

Systematic errors:

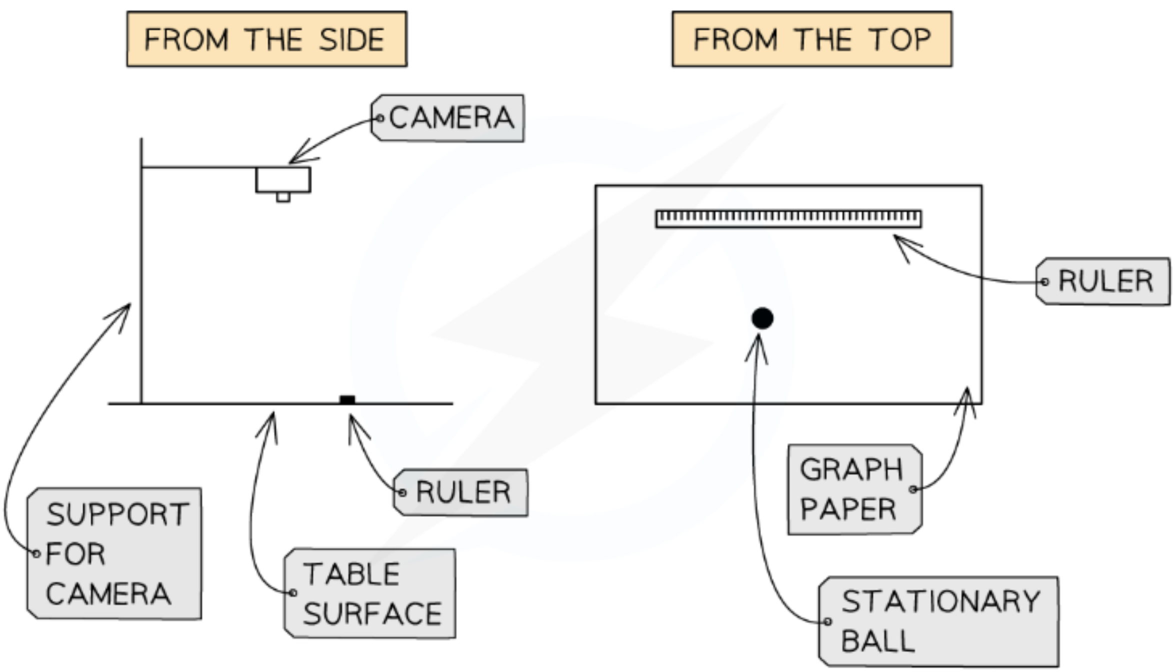
- The interrupt card may be a different width to that recorded in the data logger
  - Measure it three times and calculate an average value
- The interrupt card may not be of sufficient height to trigger the light gate
  - Move the light gates down, or use a taller card
- Mass of the system, *M*, may not be measured correctly
  - Measure it three times and calculate an average value
- The overall mass, *M*, of the system may not be kept constant
  - Ensure each hanging mass, *m*, which is removed is transferred to the trolley so the overall mass of the system (trolley + hanging masses) stays the same

Random errors:

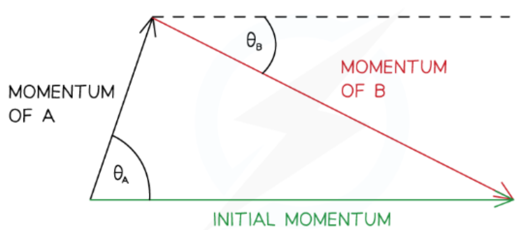
- The trolley may not travel in a straight line
  - Discard this result
- The trolley may hit one of the light gates when passing through
  - Discard this result

Core Practical 10: Investigating Collisions using ICT

Aim – General Investigation



Graph (Vector Diagram Not Graph)



Method

1. We will have two spheres, ideally of equal mass, and we would want to measure their diameter using a Micrometre

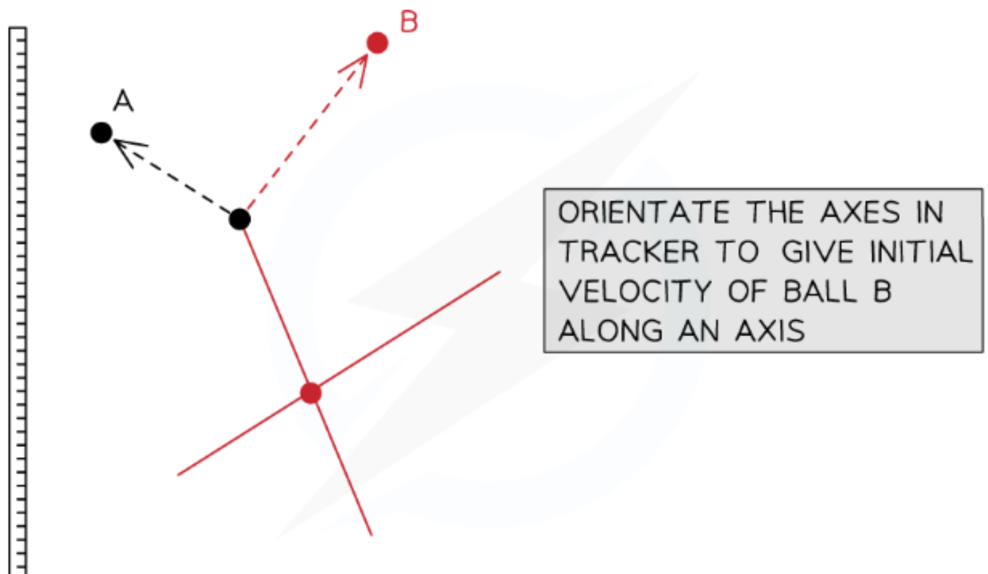
2. As stated before mark the centre point of the graphing paper, and place one of the balls there. The ball placed there will be stationary

3. Start recording on the camera, and in the view of the camera and the paper, roll a sphere into the stationary one

4. Download the video software and load it into some video analysis/collision analysis software (Edexcel uses Tracker)

Tracker App Analysis

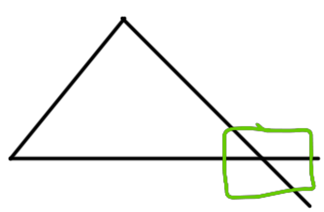
5. Use Tracker to analyse the video clips and record the momentum of each ball



6. Plot the vector diagram from the results as provided in the graph section

Graph Analysis

- If the triangle fully closes properly, then momentum was conserved, but there may be other outcomes, here we will go over an example



X – You can see the horizontal lines does not reach the end, this tells us that momentum in the X direction was not fully conserved

Y – in the Y direction you can see the line is too long, this tells us that there way have been some external force acting.

Evaluation

Systematic errors:

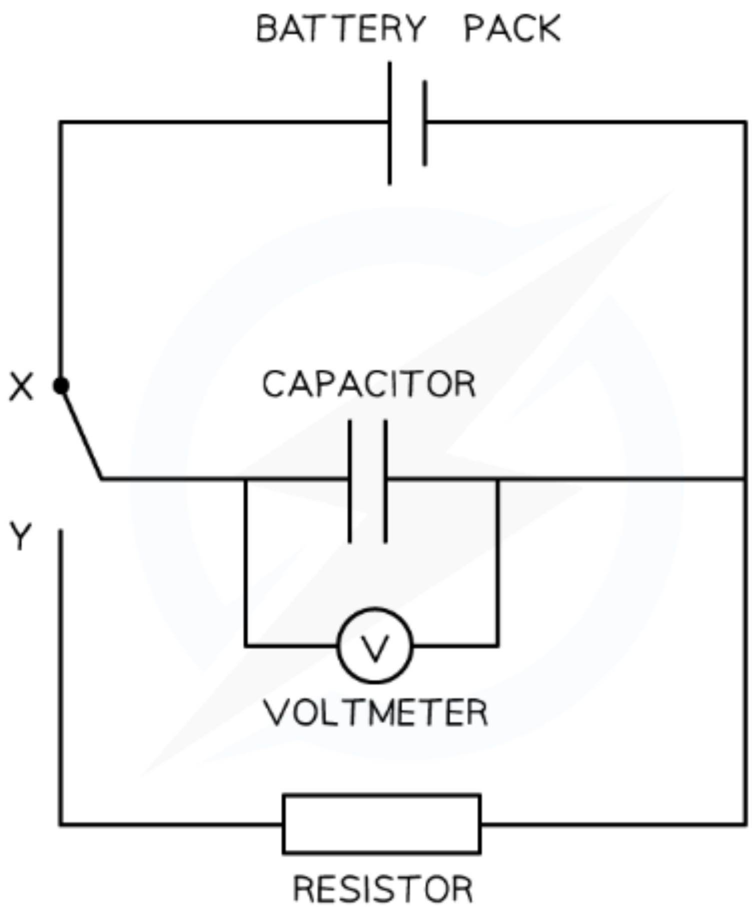
- Parallax error from camera to the table
- The precision of the balance may give a wide range of possible values for mass
  - If possible use a more precise balance
- The spheres may have damage
  - Check there is no damage to the surface of each sphere before using
- The *Tracker* axes may not be correctly aligned when analysing

Random errors:

- The collision event may happen between frames
- From variations in the table surface
  - This could cause loss or gain of kinetic energy due to friction or slopes
- The sphere may not travel far enough to hit the second stationary sphere
  - Discard this result and release with greater initial velocity

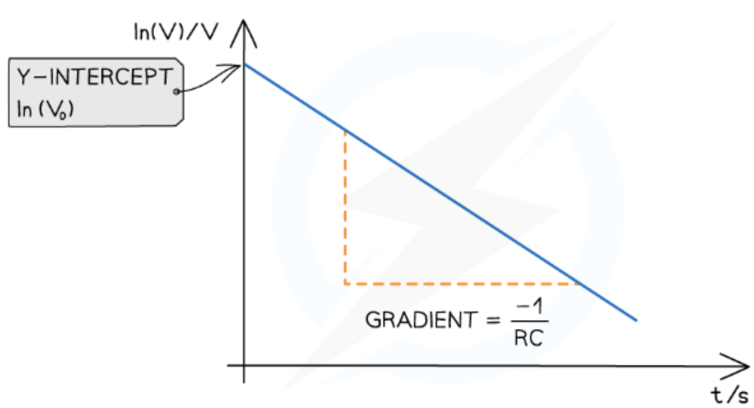
Core Practical 11: Investigating Capacitors

Aim - The overall aim of this experiment is to calculate the capacitance of a capacitor



Graph

A Graph of ln(V) to time is plotted, it is derived from the discharge of a capacitor equation



Method

1. Setup apparatus like in the image (typical discharge of a capacitor circuit)

2. Connect a resistor to the circuit, **knowing its resistance**

3. Close the switch and allow the capacitor to start discharging

4. Measure the voltage in continuous increments, for example every 5 seconds

5. Once you collected the given results, plot the given graph

Graph Analysis

1. Calculating the capacitance using $C = -\frac{1}{R \cdot \text{Gradient}}$

Evaluation

Systematic Errors:

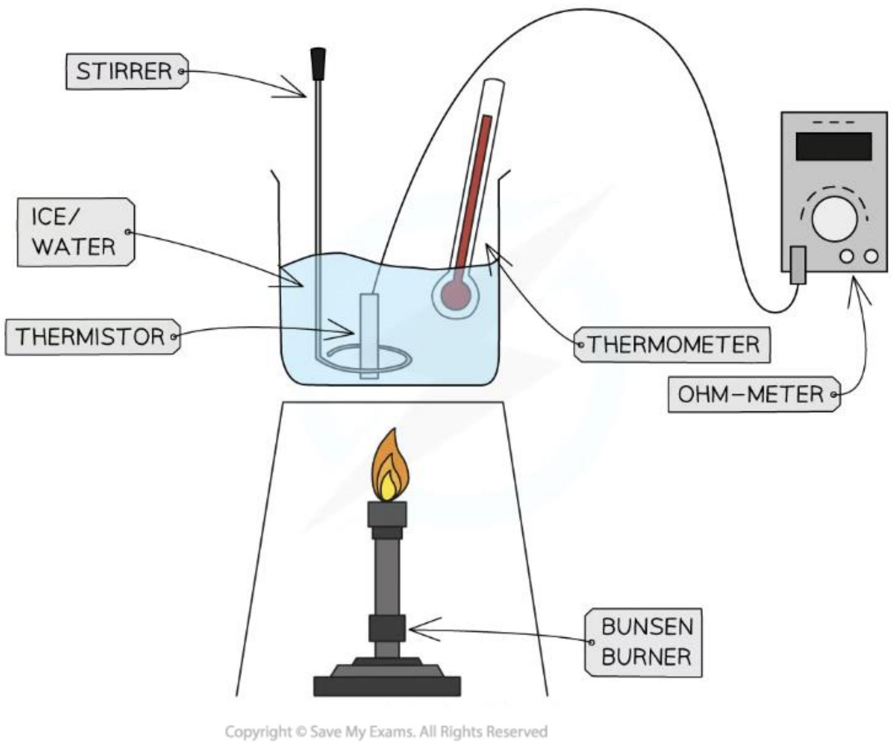
- If a digital voltmeter is used, wait until the reading is settled on a value if it is switching between two
- If an analogue voltmeter is used, reduce parallax error by reading the p.d at eye level to the meter
- Make sure the voltmeter starts at zero to avoid a zero error

Random Errors:

- Use a resistor with a large resistance so the capacitor discharges slowly enough for the time to be taken accurately at p.d intervals
- Using a datalogger will provide more accurate results for the p.d at a certain time. This will reduce the error in the speed of the reflex needed to stop the stopwatch at a certain p.d
- The experiment could be repeated by measuring the time for the capacitor to charge instead

Core Practical 12: Calibrating a Thermistor

Aim – the overall aim of this experiment is to be able to deduce the temperature of a fluid, solely from the resistance of a resistor (that resistor being the thermistor) and so we must calibrate the resistor in a way which would allow us to do this



Graph

A Graph of resistance to temperature should be plotted, the graph will follow a relationship of $R = R_0 e^{\frac{B}{T}}$, where T is the temperature, and B is some material dependant constant. This graph is called a **calibration curve**

Method

Note – Initially, we start with ice, ideally below 0 degrees which will melt into water

1. Place the Thermistor into the ice

2. Ensure everything is in place, and place the beaker onto the tripod

3. When everything is in place, turn on the Bunsen Burner which will slowly heat the ice

4. When the thermometer gets to a reading of 0 Celsius, using the multi-meter take a reading of the resistance

5. Record the temperature and the corresponding resistance on a results table

6. Ensure while doing all of this, using a stirrer, you are stirring the solution to maintain an even distribution of the temperature

7. Take readings of the resistance every 5 Celsius, from 0 – 100

8. After all your readings are taken plot a graph of Resistance to temperature, now we can use almost any reading of resistance in a suitable range and deduce the temperature of the water from it (We have calibrated the thermistor by establishing a relationship between its resistance readings and the corresponding temperatures measured using a thermometer in our experiment.)

9. You may be asked to use logarithms to deduce a linear relationship between these two variables, you can do that using the exponential equation we had found above and forming $\ln R = \frac{b}{T} + \ln R_0$, this tells us that a graph of lnR to 1/T gives a gradient of b, and since that is a material **constant** it will be a linear graph

Taxonomy - A **calibration curve** is a graph that shows how an instrument's output (resistance) relates to the actual physical quantity being measured (temperature).

Evaluation

Systematic Errors:

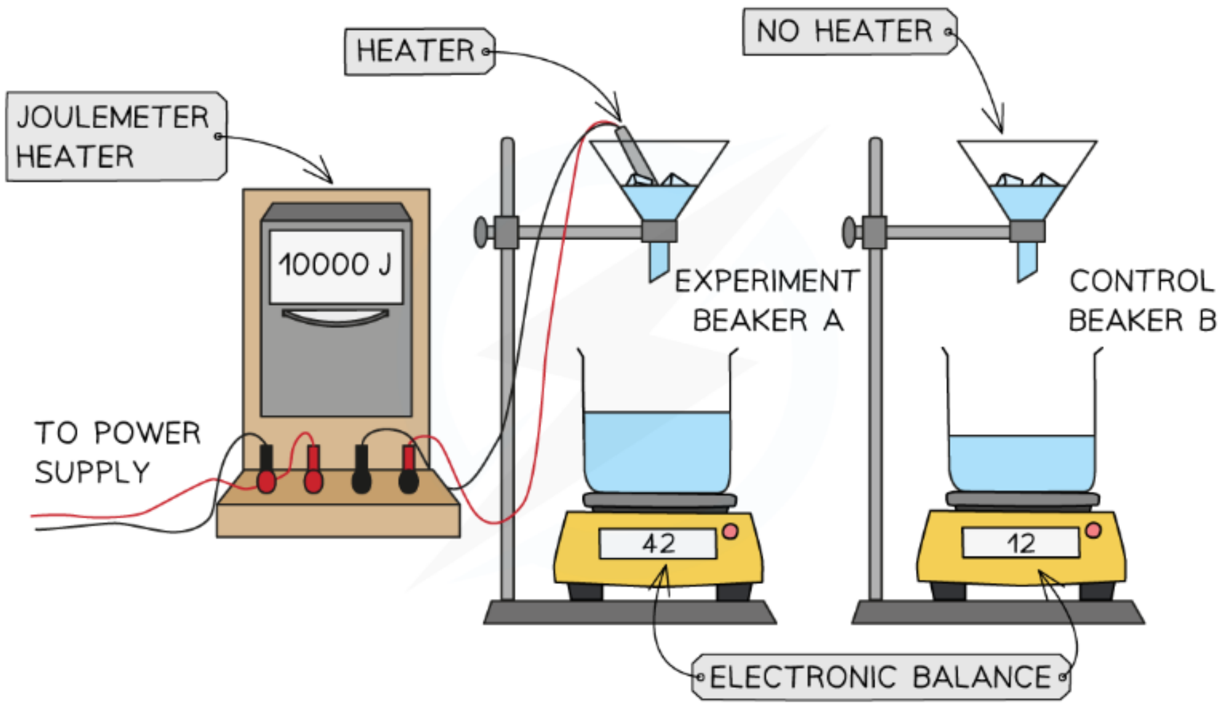
- Read the thermometer at eye level
- Check the zero error on the ohm-meter by connecting the leads across the terminals

Random Errors:

- Allow time for the temperature to reach equilibrium
- Stir the water before readings
- Ensure thermometer bulb is completely submerged in the water and level with the thermisto
- Turn off current between readings to avoid heating in the wires

Core Practical 13: Investigating Specific Latent Heat

Aim – To determine the specific latent (of fusion) heat of ice



Method

1. Get two funnels, attach them both to retort stands and place filter paper inside the funnels. Within one of the funnels take a heater and using a retort stand place it around the middle of the funnel, the setup will look something like this (heater on the left, held up by stand).

2. Use a spoon and an electronic balance to measure out 50g of crushed ice into a beaker and pour into each funnel (each funnel should receive the same amount of ice)

3. Add a beaker below each funnel and place it on an electronic balance (same setup as first image)

4. When the ice in both beakers start to melt, and they should start melting around the same time, set the heater in the funnel with the heater to supply 10,000 Joules in total and it should start heating (supplying energy) to the ice

5. Wait until the reading on the Joulemeter says 10,000 Joules and turn the heater off

6. Read and record the mass of each beaker of water on each electronic balance (the beaker below the funnel with the heater will most likely have a higher mass of water)

7. Repeat the experiment at least 3 times and calculate the average mass m (in kg) for the water in each beaker

8. Find the increase in the amount of melted ice by doing $M_{\text{Beaker with Heater}} - M_{\text{Control}}$

9. To find the latent heat of fusion, we do $L = \frac{\Delta E}{m}$, where E is 10,000 J and m is the value we will calculate from the calculation in step 8. **The difference in mass of water collected in the two beakers represents the extra ice melted due to the supplied energy**, this is the fundamental idea of this experiment.

Evaluation

Systematic Errors:

- Make sure you zero the electronic balances when the beakers are empty
- Always check that the ice has reached 0 °C by reading the thermometer at eye level
- This experiment requires accurate determination of energy transfers
  - To improve the accuracy, consider applying lagging or insulation to the funnels and beakers - this will reduce the amount of energy lost to the surroundings

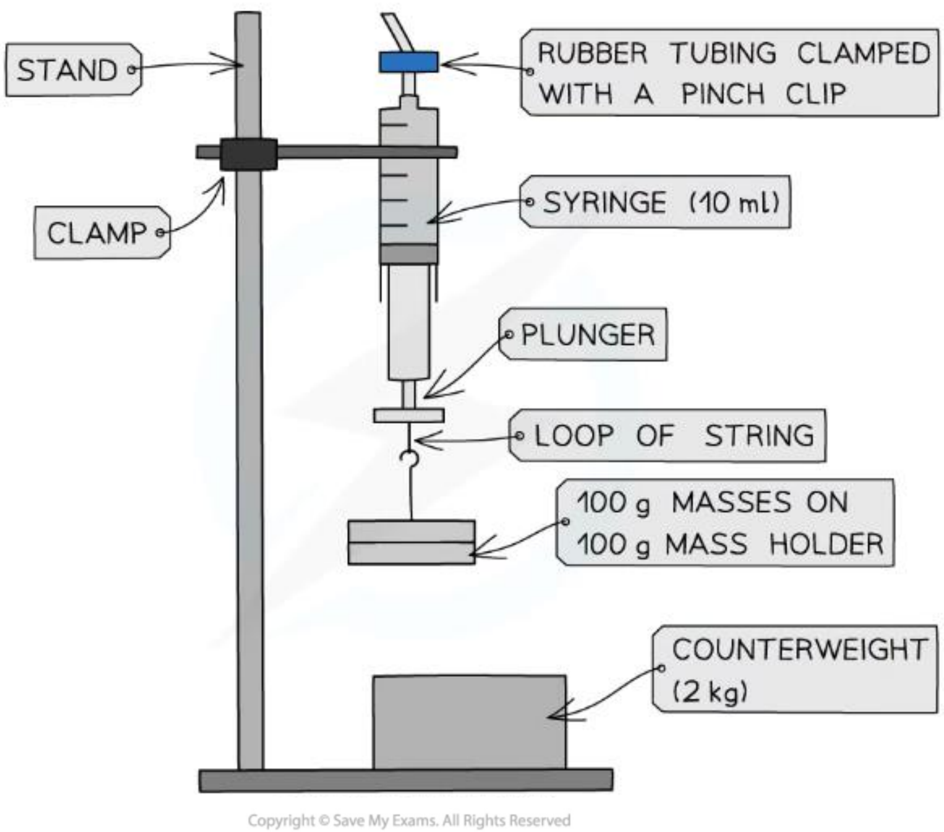
Random Errors:

- The heater should be switched off and allowed to cool between readings
  - So the rate of heating and the starting temperature of the heater is the same

- Calculate the average mass of the water
  - This will reduce random errors in the reading
  - Repeat the experiment at least 3 times

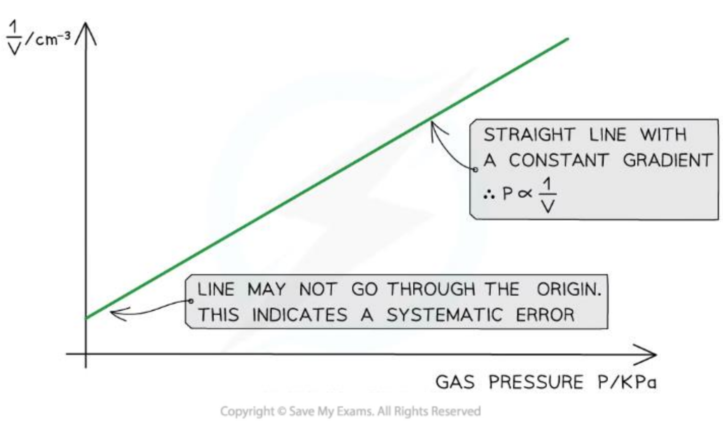
Core Practical 14: Investigating Gas Pressure & Volume

Aim – investigating and in some way confirming Boyles Law (The inverse relation of Volume and Pressure). It may seem counterintuitive, but in this CP our method is rather than increasing the pressure we decrease it (it will have the same effect)



Graph

A Graph of 1/V to Pressure should be plotted, considering we are dealing with Boyles law, this makes sense.



Method

1. With the plunger removed from the syringe, measure the inside diameter of the syringe using a vernier calliper, this will be used later to find its Area which we will use to compute the pressure

2. Place the plunger back and the rubber tubing should be fit over the nozzle and clamped with a pinch clip as close to the nozzle as possible

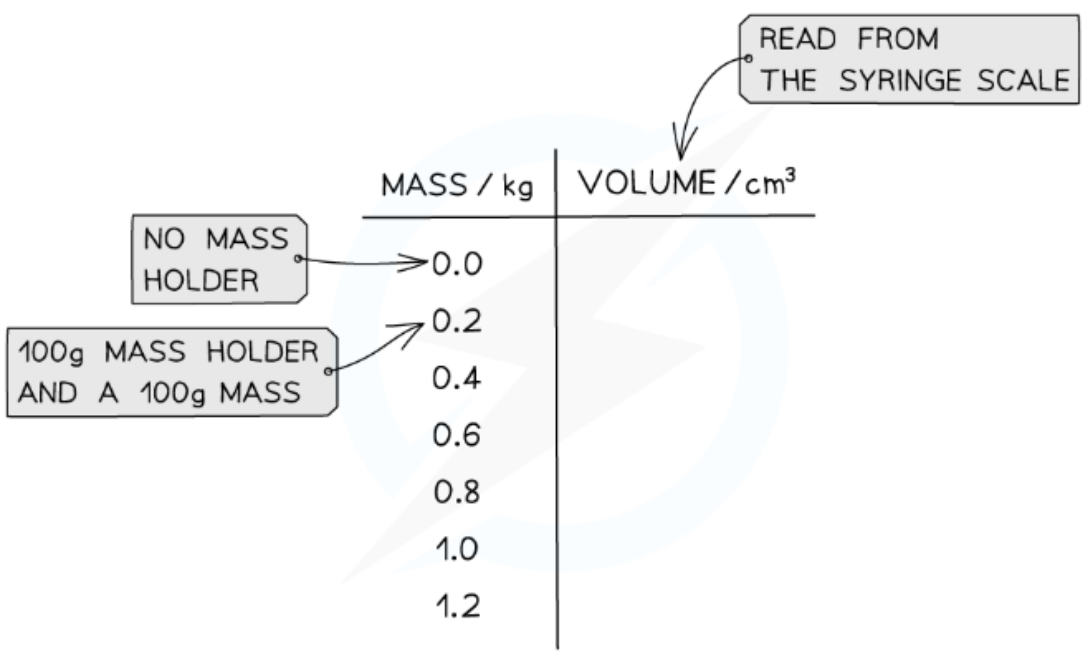
3. Set up apparatus as shown in diagram (like always)

4. Push the syringe upwards until it reads the lowest volume of air visible, record this volume.

5. Add the 100g mass holder to the loop of the string, which will pull down on the plunger a little bit. You must wait a bit after doing this as this will affect the temperature which affects the volume.

6. Record the value of the new syringe scale

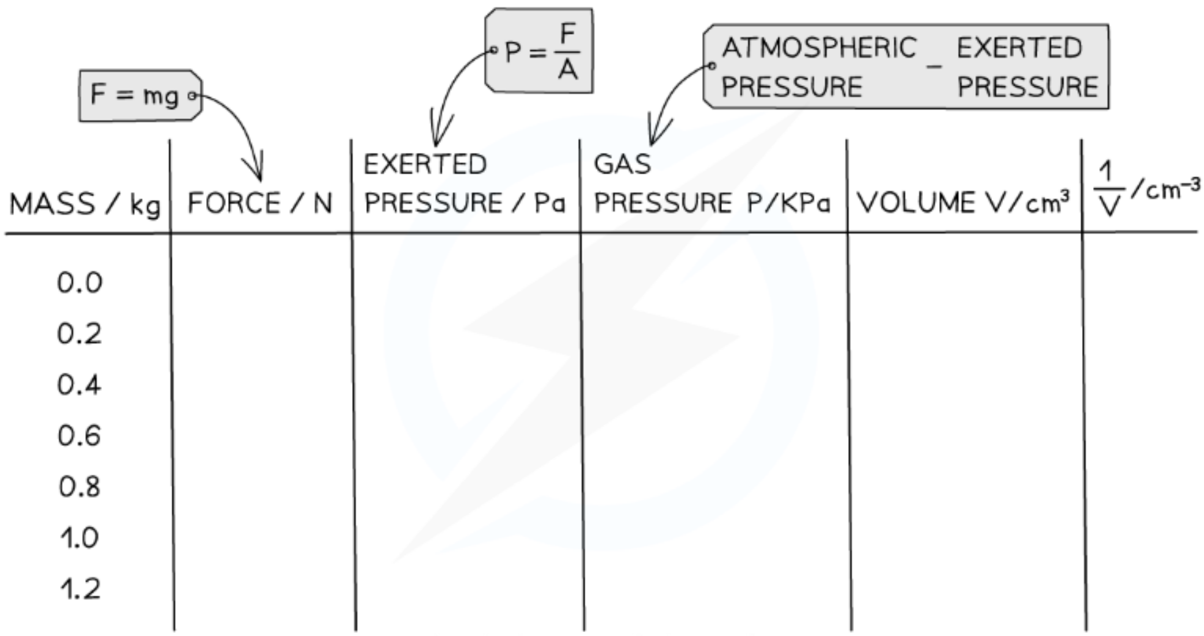
7. Repeat this by adding 100g masses until you added 1kg worth of masses and create some sort of results table



8. When you took results, find the cross-sectional area of the syringe using $A = \frac{\pi d^2}{4}$, d is the value of diameter we found before using the Vernier Callipers

9. To calculate the pressure of the gas first use $P = \frac{F}{A}$, where F is the force from the weights and P is the pressure exerted by the weights. To find the gas pressure (what we want) then do $P_{\text{gas}} = P_{\text{atm}} - P_{\text{weights}}$

10. Then plot a graph of 1 / V to Gas Pressure and it should give us a straight line, confirming Boyles Law



MASS / kg	FORCE / N	EXERTED PRESSURE / Pa	GAS PRESSURE P/KPa	VOLUME V/cm³	$\frac{1}{V}$/cm^{-3}
0.0					
0.2					
0.4					
0.6					
0.8					
1.0					
1.2					

At the end, you should have another table of results that looks like this. Each reading of volume had its own mass so force value, which we then use to find the gas pressure.

Evaluation

Systematic Errors:

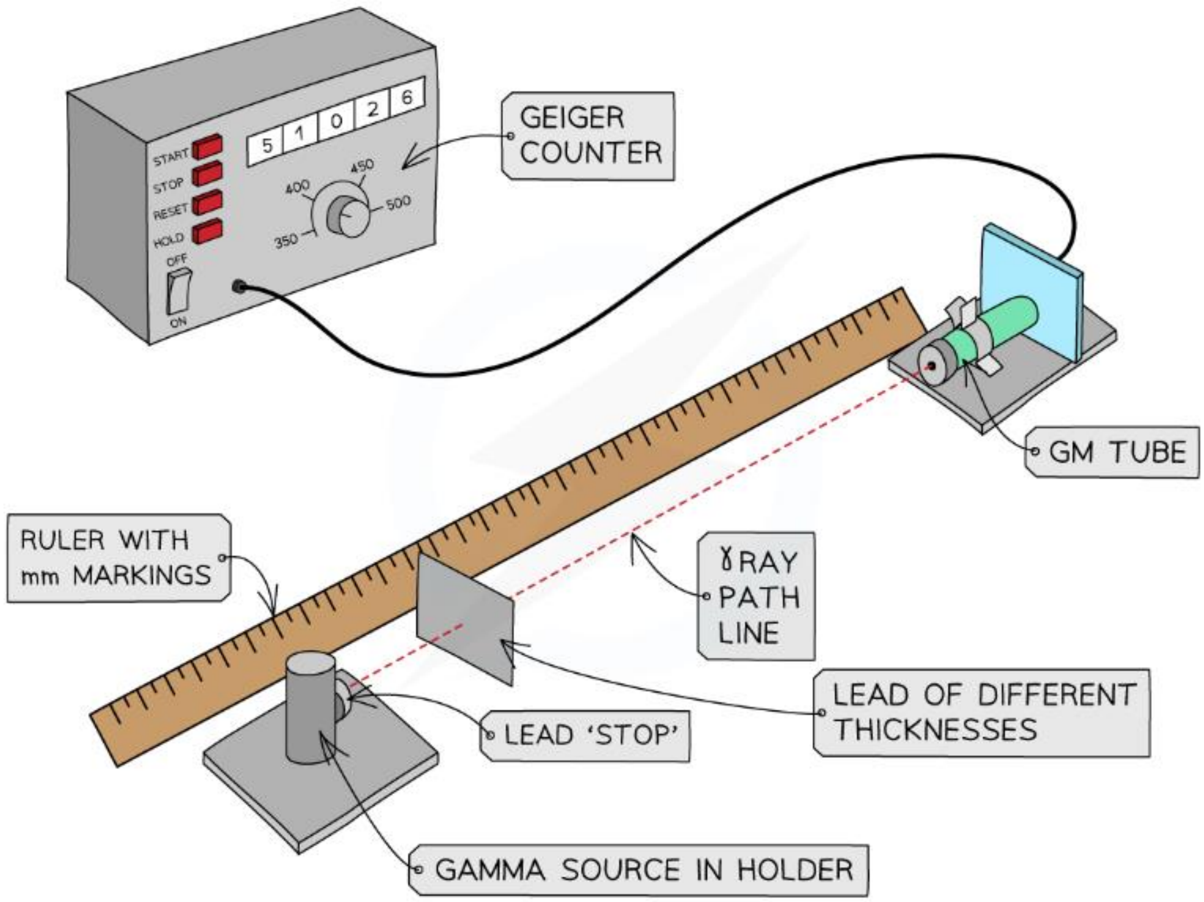
- There may be friction in the syringe which causes a systematic error
  - Use a syringe that has very little friction or lubricated it, so the only force is from the weights pulling the syringe downwards

Random Errors:

- The reading of the volume should be taken a few seconds after the mass has been added to the holder to allow temperature changes to equilibrate
- Room temperature must be kept constant

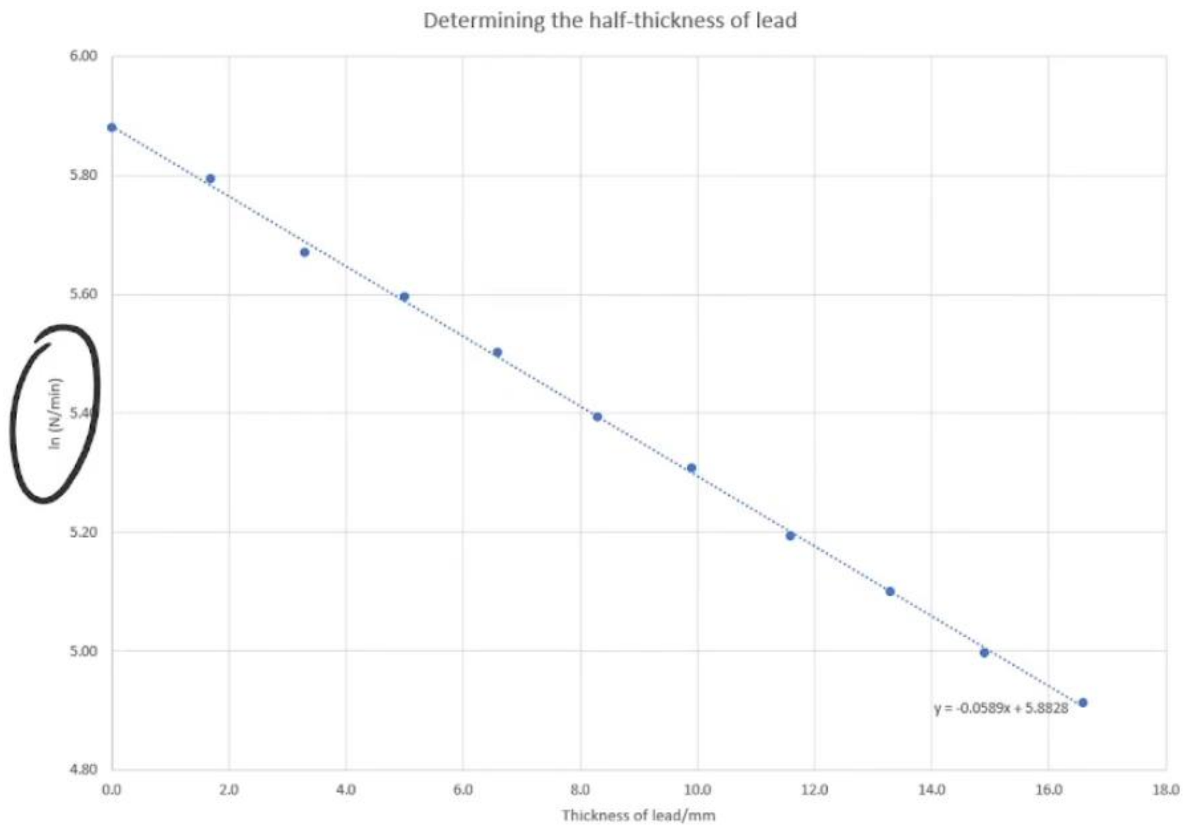
Core Practical 15: Investigating Gamma Radiation Absorption

Aim – To investigate the absorption of gamma rays by different thickness of lead, and potentially find the half thickness



Graph

A graph of ln(N) where N is the corrected counts per minute, to the thickness of lead will be plotted



Method

1. Connect the Geiger-Muller to the counter and, without any sources present measure the **Background Radiation** over a five-minute period, find the average background rate per minute

2. Measure the thickness of the lead absorbers using Vernier Callipers at three points on each sheet, and for each sheet record the average thickness

3. Place the radioactive source a fixed distance of 10cm away from the tube, its very important that the distance is a control variable

4. Place each sample of lead between the source and the GM tube and measure the radiation, find a corrected count (corrected count accounts for the background radiation) by doing $Corrected\ Count(N) = Measured\ Radiation - BG\ Radiation$, **all of the counts should be measured in the form of Counts per Minute**

5. The count rate and thickness of lead will follow an exponential decay relationship, dictated by the formula $N = N_0 e^{-\mu x}$, where N is the count rate, x is the thickness and mew is just some material dependant constant

6. Using the exponential relationship we discovered above, we know that if we plot a graph of ln(N) to x, then we will get a gradient of a negative of the material constant and a Y intercept of the natural logarithm of the initial count rate, this is dictated by $\ln N = \ln N_0 - \mu x$. Using this information we know the graph would be a straight line of negative gradient

7. Plot the required graph, we can also find the half-thickness of lead, which is the thickness of lead required to bring the count rate to a half of its original value. We can do this by simply using the exponential decay relationship we found before and saying that $N/N0 \ = \ 1/2$

Evaluation

Systematic Errors:

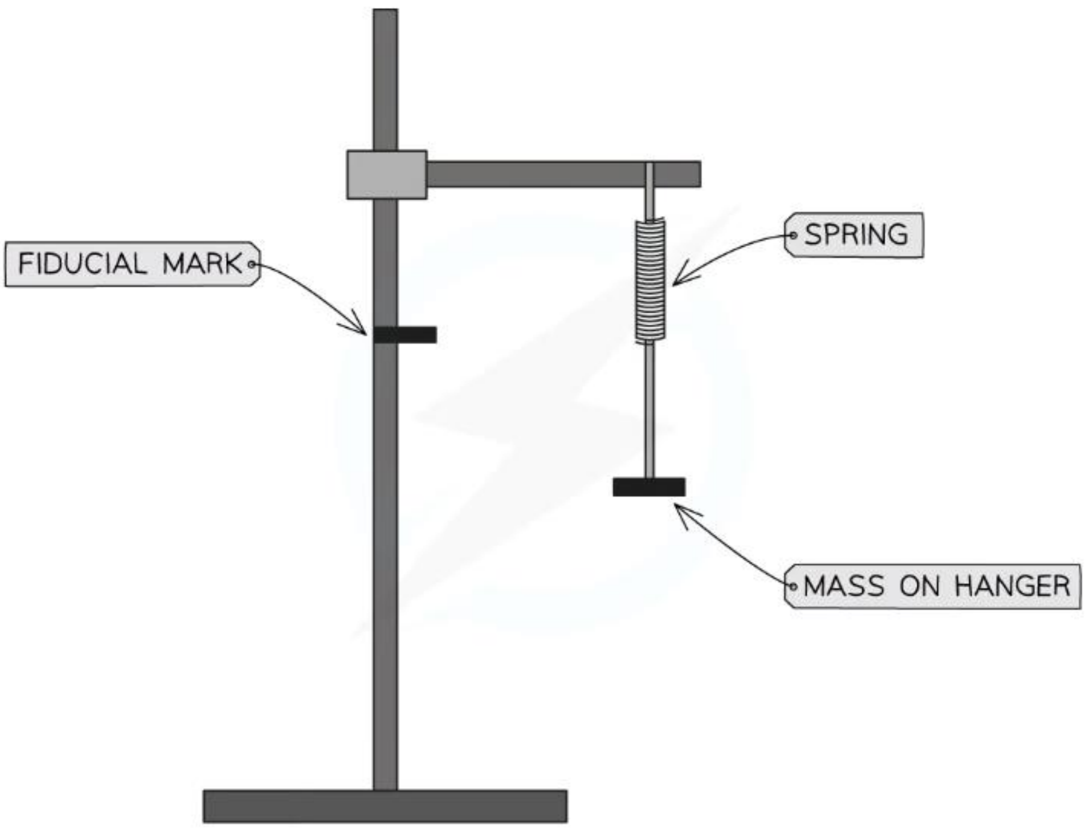
- Make sure that the source is stored well away from the counter during the experiment
- Conduct all runs of the experiment in the same location to avoid changes in background radiation levels

Random Errors:

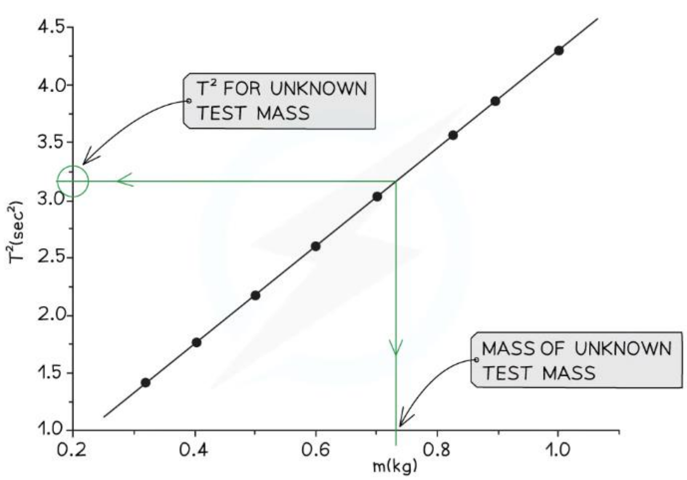
- The accuracy of such an experiment is improved with using a reliable source of radiation with a long half-life and an activity well above the natural background level

Core Practical 16: Investigating Resonance

Aim – Determine the value of an unknown mass by a graphical method, by observing the relationship between Time Period and Mass of a mass-spring system. The Practical does not directly incorporate resonance, but we are using the **natural frequency** which is related to resonance.



Graph



Method

Note – The Fiducial Marker helps us find the Time Period, placing it at springs lowest position (when the spring is extended) makes the experiment easiest, as the spring going up and coming back down to the same place as the Fiducial Marker would be 1 time period

1. Set up the spring with 100g mass attached
2. On the stand make a clear fiducial mark about 5cm below the bottom of the spring
3. Extend the spring so that the bottom is level with the fiducial marker, release and start timing
4. Measure time for 10 oscillations **(its important you do around 10 oscillations as this reduces the effect random error has on the accuracy of the results)**
5. Repeat with the same mass two more times
6. Find the average time period of one oscillation
7. Add 100g and find the average time period for that as well, you may need to move the fiducial marker downwards slightly as the mass is a bit heavier
8. Repeat until you have tested a range of masses, around 5-6

mass/kg	Average 20T/s	T/s	T^2/s^2
0.100	7.94	0.40	0.16
0.200	9.54	0.48	0.23
0.300	11.02	0.55	0.30
0.400	12.38	0.62	0.38
0.500	13.52	0.68	0.46
0.600	14.58	0.73	0.53
0.700	15.52	0.78	0.60

You should now have a table looking like this, (we would have the avg for 10 Time Periods), to find the time for 1 time period divide the total time by the number of oscillations, and find the T^2 values for each mass

9. Plot the graph of T^2 to m and now you have a linear relationship for Time and Mass

10. Find the time period of the unknown mass, calculate T^2 and use the graph to find its mass

Further Analysis

Q – Why did we use a graph of T^2 instead of just T? using the formula for a Mass – Spring system which is in the formula book, and finding a relationship for T^2 we get

$$T^2 = \frac{4\pi^2}{k} \cdot m$$

If you compare this to y = mx + c, you can see that a graph of T^2 to m would give us a linear gradient, which is must easier to analyse to find our unknown mass

Note on Fiducial Marker – you can also align it with the mass on the hangar and place the initial position of the marker at the lowest position of the mass, or you can do the spring (which is what I wrote down). As long as it helps measure 1 Time Period it doesn't really matter.