Paper 6 notes

Measuring tools	*Quantity measured*	*Measuring tools*	*Quantity measured*
Meter rule **Measure tape**	Length	**Ammeter**	Electric current
Electronic balance	Mass	**Voltmeter**	Voltage
Micrometer **Vernier caliper**	Thickness of small length	**Barometer**	Atmospheric Pressure
Stopwatch	Time	**Nanometer**	Gaseous pressure
Measuring Cylinder	Volume of water Or irregular shape	**Newton meter**	Force

☛ *1-Pendulum Experiments* :-

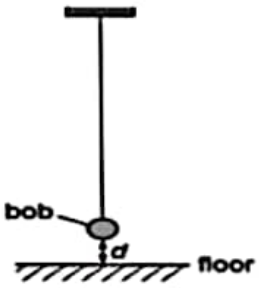
precautions might be taken to measure the height of spring

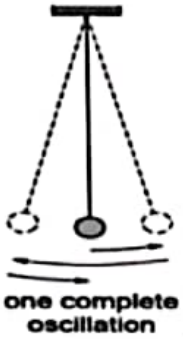
1- use set square

2- put the ruler vertically very close to the bob

3- Look perpendicular to the scale to avoid parallax

4 –Measure the length from the centre of mass of bob.





Explain why measuring time of 20 swing (oscillation)rather than 1 swing is more accurate

1- To reduce the effect of reaction time 2- to reduce error

3- Time of one swing is too small to be measured

Why measuring the time of 200 oscillation isn`t suitable

1- Pendulum may stop 2- student loses counting

Suggest a practical reason why the result obtained from experiment is different

1- student didn`t react quickly when the pendulum start

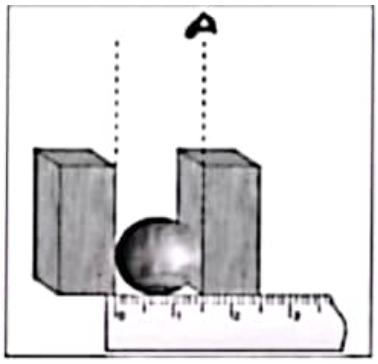
2- difficulty to measure the length from the centre of bob

Suggest improvements for experiment

1- Repeat and take average 2-use different length

3- Use fiducial mark 4) Draw a graph for the results to find the anomalous results

How you would use 2 rectangular blocks and ruler to measure the diameter of pop



use meter ruler ,place two wooden blocks just to fit the ball

read the distance between the two blocks.

Precautions for this investigation

1-No air current in the place.

2- Take suitable number of oscillation from 20 to 50. Don't use too much oscillation because this leads to miscounting and the pendulum will stop

3- Take the time for number of swings then divide the time measured by the number of sings

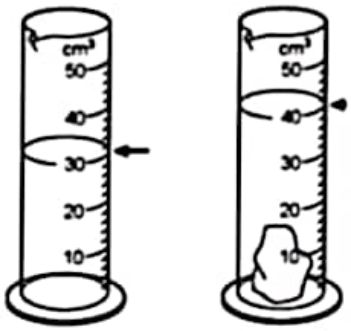
4- Repeat and take average.

5- Release the bob from small distance.

6- Look perpendicular to the ruler while measuring the height.

2- Displacement method experiment

Reasons of inaccuracy:-



1- Parallax error.

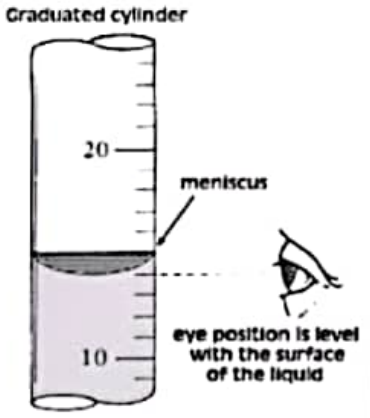
2- The reading didn't taken from the bottom of meniscus.

3- Splashing water during put the object.

4- Air bubbles in the clay.

5- The volume of string.

Precautions while using cylinder



1- Thin string used.

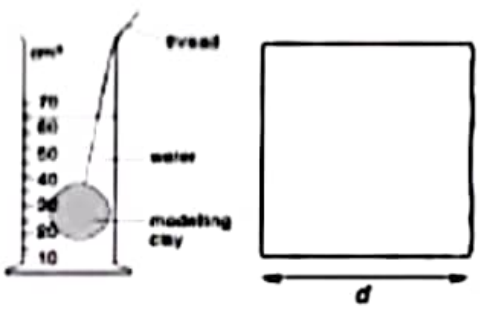
2- Look perpendicular to the scale of the cylinder.

3- Look from the meniscus.

4- Put the rock gently.

5- Put the measuring cylinder on horizontal bench

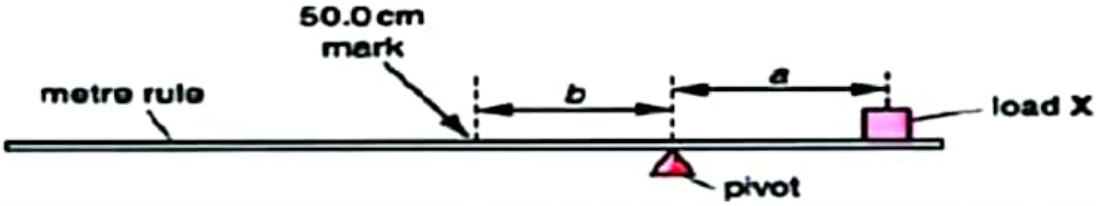
Using modeling clay



Inaccuracy:

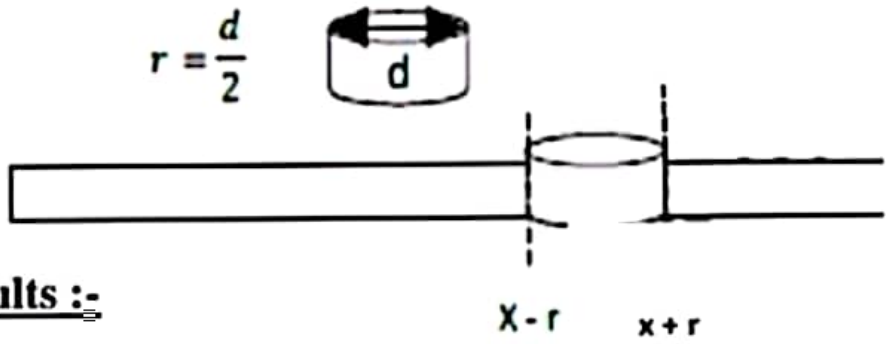
1- The modeling clay has lost during cutting.
2- Modeling clay might not have uniform density.
3- The clay may absorb water.
4- Air bubbles in the clay.
5- Difficult to make perfect shapes with clay.

3-Balancing experiment



Difficulty	Way to overcome
Balancing the ruler above the pivot	move load x toward the pivot until the ruler just tip, read the position , then the load x away of pivot until just tip take the reading , then get average
The mass slips over the ruler:	Stick the mass with the ruler
How to make the center of mass above a certain mark on the meter rule? The center of mass of the cylinder may not above the correct mark (X)	- Measure the diameter of the cylinder. - Adjust the cylinder above the correct mark (X) so that one side of cylinder at mark X-r and the other side at mark X+r Or Take the reading on both sides of the cube and find means $\frac{R_1+R_2}{2}$ = the desired position

Illustrated Diagram



Precautions to get reliable results :-

1-Repeat and take average.

2- Look perpendicular to the scale of the ruler while taking the reading to avoid parallax error.

3-Use range of masses.

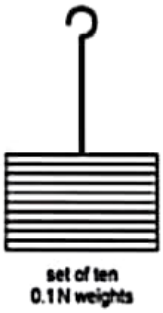
Position of Center of Mass:

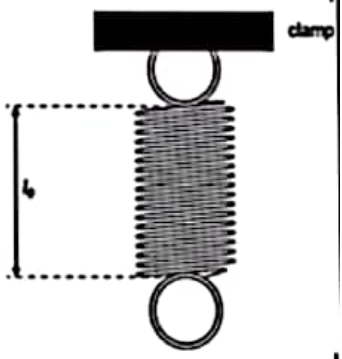
1-The point at which the meter rule is balanced above the pivot.

2- At 50 cm mark for the meter rule.

4-Spring Experiment

To make a fair comparison between springs of different materials, some variables should be kept constant

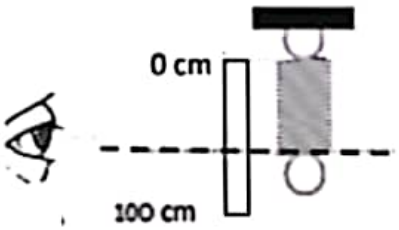




1- Same diameter Same Thickness of spring.
2- Same range of loads.
3- Same Length of wire. 4- Same thickness of wire.

Position of meter rule

- Put the meter rule vertical to the bench; parallel to the spring while looking perpendicular to the scale of the meter rule.
- The rings are not involved in the length because they don't stretch.



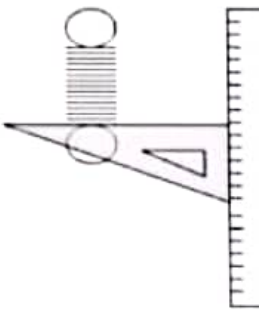
Reasons of Inaccuracy:

1- Spring extension isn't uniform with load.
2- Spring exceeds the limit of proportionality.

Precautions while measuring the distance between bench and spring

1- Always measure from the same point of spring
2- Wait until the spring stops vibration
3-Ensure ruler is vertical / use horizontal aid
4- Bench surface must be horizontal

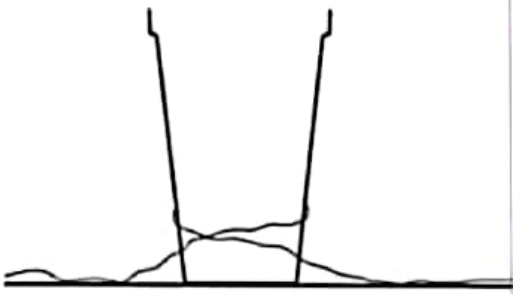
improve the accuracy of their measurements



1- clamping the metre ruler in place and then using the set square to make the length/extension measurement.
2- use the set square to make sure that the clamped ruler is vertical in relation to the bench.
3-set the clamped ruler at 0 cm when no masses are added and so read the extension directly.

5- Measuring the Circumference of Cylindrical Object

Describe how you would use the length of string and ruler to get the circumference of cylindrical shape



1-Wind 5 revolutions of the string on many position of the cup
2 Mark the start and the end of the string.
3- Measure the distance between the two marks.
4- Divide the distance by the number of turns

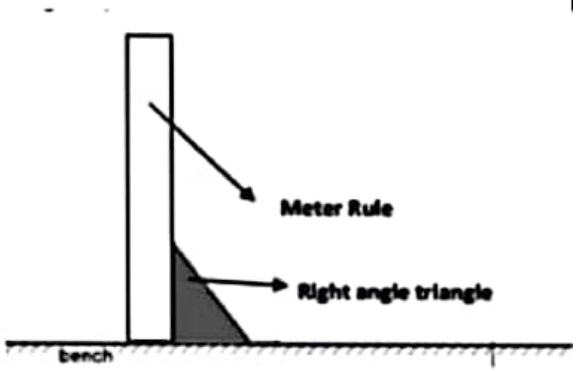
Reasons of inaccuracy:-

1- Using Thick string.
2- The marks are thick
3- Leaving Space between turns.
4- Winding the turns at angles.
5- Stretching of the string.

Precautions

1- Thin string used.
2- Thin marks.
3- Tangent turns without spaces.
4- Take more number of turns.
5- Make sure that the string isn`t stretched.

How to check that the ruler is vertical to the bench?



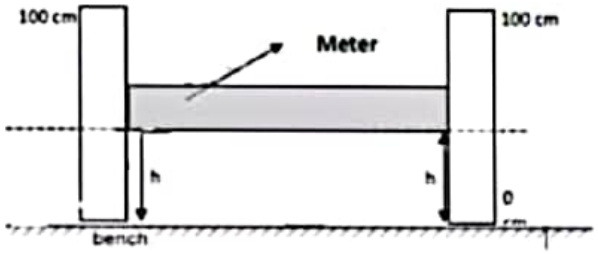
1- Set square

Put the set square (right angle triangle) so that one side of the right angle is parallel to the bench, while the other side of the right angle is parallel to the meter rule.

2- use protractor

How to check that the ruler is horizontal to the bench?

Measure the height of the meter rule above the bench from both sides that are must be equal.



Thermal Experiment

Precautions to increase the reliability of measurement:-

1-Look perpendicular to the scale of the thermometer while taking the reading to avoid parallax error.
2- Wait for the mercury in thermometer reading to stop rising.
3- Stirring gently to be sure the water temperature is the same .
4- Do not make the thermometer touching to the walls of beaker.

Conditions that should be kept constant when this experiment is repeated

1-Room temperature 2-Starting temperature.
3-Same volume of water 4-Same beaker.
5-Same thermometer. 6- Draught
7-Same amount of stirring!(In case of mixing hot water with cold water)

Inaccuracy of this type of experiments :- Heat lost to surrounds.

Overcoming heat lost;

1- Lag container with insulator.
2- Cover the container with lid to prevent heat loss by evaporation.
3- Raise the temperature to a value near to the room temperature.

Rate of Cooling

1- The rate of cooling decrease by time, the initial rate of cooling is greater than the final rate of cooling. Because the liquid temperature becomes near to the room temperature.

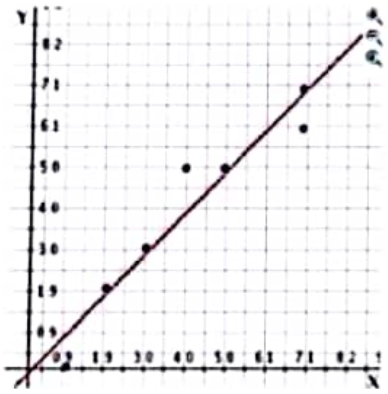
Justification

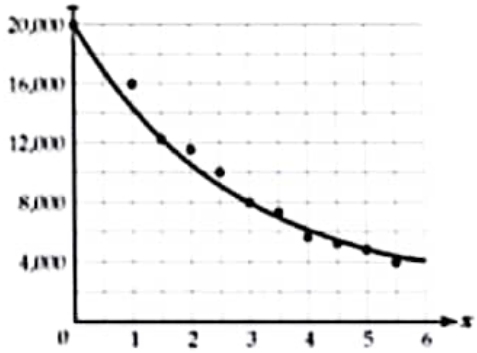
If you have a two tables in the questions, and you want to justify the statement.
Calculate the difference in temperature in a given time interval in each table then compare between the results within the limit of experimental accuracy.

Examples of insulators Glass- wool – Cotton-wool.–Plastic–Rubber.

Graphs:-

1- Correct labels axes
2- Suitable scale (you don't have start from origin if he didn't ask)
3-Graph should be least more than half of work sheet
4- plot point correctly (x) or ⊙
5- Draw best fit line or curve .
6- continuous line.

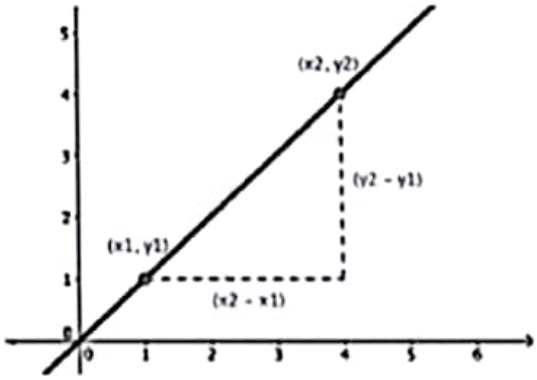




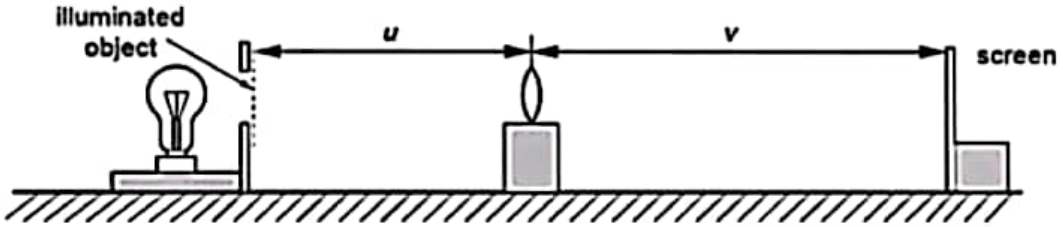
Best fit curve

Gradient Calculation

1-Choose two points from the line the distance between them more than half of the graph
2- show the taken points by triangle method
3- Use the equation $\frac{Y_2-Y_1}{X_2-X_1}$



Lens Experiment



The distance between the illuminated body and the screen is about from 30cm up to 100 cm.

Precautions

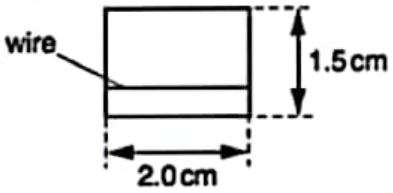
1- Dark room.
2- Object and lens at same height from bench.
3- Mark on lens holder to show the position of lens center.
4- Look perpendicular while taking reading . repeat and take average.
5- move the lens forward and backward slowly till get focused image

Image formed on the screen

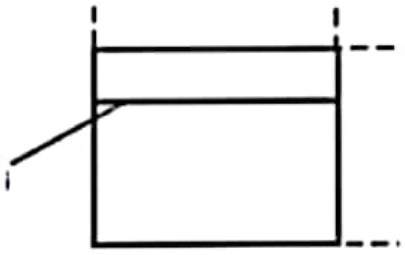
1-The image is received on screen.
2- The image is inverted
3- Magnified, when the distance between image and lens > between object and lens
4- Smaller. when the distance between image and lens < between object and lens

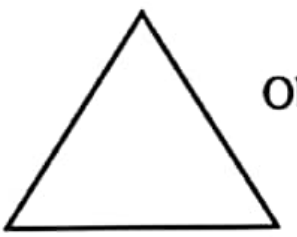
the image:-

Object

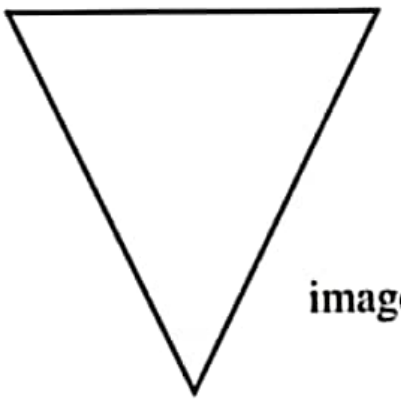


Draw a diagram of the image, actual size, for a magnification $m = 2.0$.





Object



image

Mirror/Glass Block Experiment

Reasons of this inaccuracy

1-Thickness of lines. 2-Thickness of pins.
3- Pin holes may be thick. 4- Thickness of mirror.
5- Glass in front of mirror causes double refraction

Precaution

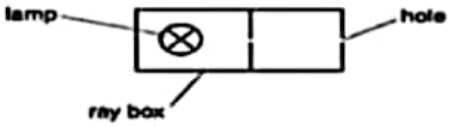
1-Draw the lines so that they are as thin as possible.
2- Use thin protractor.
3- Look perpendicular while taking readings to avoid parallax error.
4- Look from the base of the pins: Explain
a. No concern about pins being vertical. b. Base of the pin lie on the rays.
c. The Base is always perpendicular to the plane.

Precaution when placing the pins:

1- Place the pins as far apart as possible. (not less than 5 Cm)
2- Place the pins vertical.

Ray box

it is a source of a light beam in this type of experiment.



precaution when using ray box

1- small slit in the ray box.
2- Mark the rays at the center of beam.
3- Don't look through the lamp (Safety precaution)

Inaccuracy when using ray box Thick ray – lamp isn't bright enough

Electricity Experiment

Cell	Store of chemical energy. The longer line shows the positive terminal of the cell, the shorter line is the negative terminal.
Battery	Two or more cells in series.
Diode	Only allows the current to flow in one direction – the direction of the arrow.
Fixed Resistor	The value of the resistor affects the size of the current.
Variable Resistor	Allows the current to varied.
Fuse	Melts (blows) when the current is greater then the fuse's current rating.
Voltmeter	Measures the size of the potential difference.
Ammeter	Measures the current
Thermistor	The resistance changes with temperature. Resistance is low at high temperatures and high at lowo temperatures.
Light Dependent Resistor (LDR)	The resistance changes with light low i Resource author: Martyn_Inglis when the light intensity is low.

Inaccuracy

1- Heating effect of the current. 2- Battery used up.

3- It is difficult to put the sliding contact at the correct position.

Precautions to overcome heat in the wire:-

1- Use a battery of lower electromotive force.

2- Switch on and off between readings.

Precautions in General

1-Tap on the voltmeter and ammeter to check that pointer free to move.

2- Take several reading then take overall average.

Note

The resistance of the lamp changes by temperature So brightness of the lamp changes

June 2017 /61

A student is investigating whether the resistance of a wire depends on the material from which the wire is made.

Resistance R is given by the equation $R = \frac{V}{I}$.

The following apparatus is available to the student:

ammeter
voltmeter
micrometer screw gauge
power supply (0–3 V)
variable resistor
switch
connecting leads
wires of different materials.

Plan an experiment to investigate whether the resistance of a wire depends on the material from which it is made.

You should:

- draw a diagram of the circuit you would use to determine the resistance of each wire
- explain briefly how you would carry out the investigation, including the measurements you would take
- state the key variables that you would control
- draw a suitable table, with column headings, to show how you would display your readings (you are **not** required to enter any readings in the table).

1 A student is investigating whether the distance that a toy truck will travel along a horizontal floor, before stopping, depends on its mass.

The following apparatus is available to the student:

a ramp
blocks to support the ramp as shown in Fig. 4.1
toy truck
a selection of masses
other standard apparatus from the physics laboratory.

Plan an experiment to investigate whether the distance that the toy truck will travel along a horizontal floor, before stopping, depends on its mass.

In your plan, you should:

- explain briefly how you would carry out the investigation
- state any apparatus that you would use that is not included in the list above
- state the key variables that you would control
- draw a table, or tables, with column headings to show how you would display your readings (you are **not** required to enter any readings in the table).

You may add to the diagram in Fig. 4.1 to help your description.

Fig. 4.1

4 A student is investigating the effect of double-walled insulation on the rate of cooling of hot water in a copper container. The student places the copper container inside a larger metal container. He is investigating the effect of the size of the air gap between the copper container and larger metal containers.

Plan an experiment to investigate the effect of the size of the air gap between the copper container and larger metal containers on the rate of cooling of hot water.

The following apparatus is available:

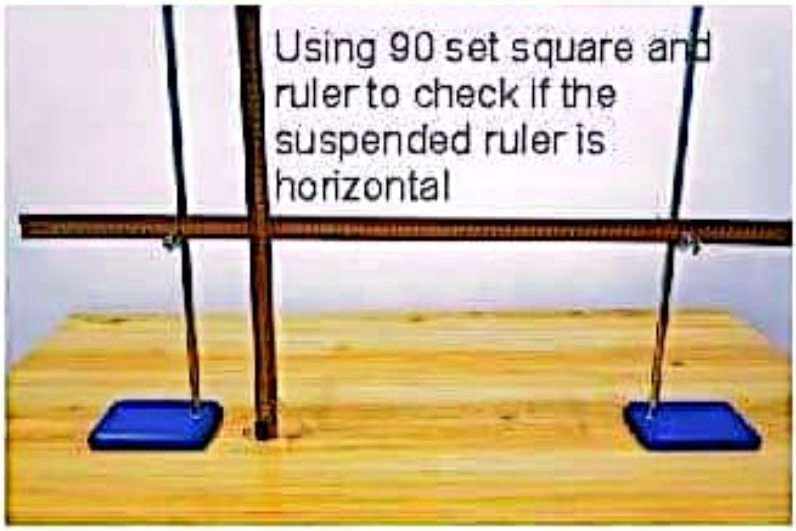
a copper container
a number of metal containers of different diameters (all larger than the copper container)
a thermometer
a stopwatch
a measuring cylinder
a supply of hot water.

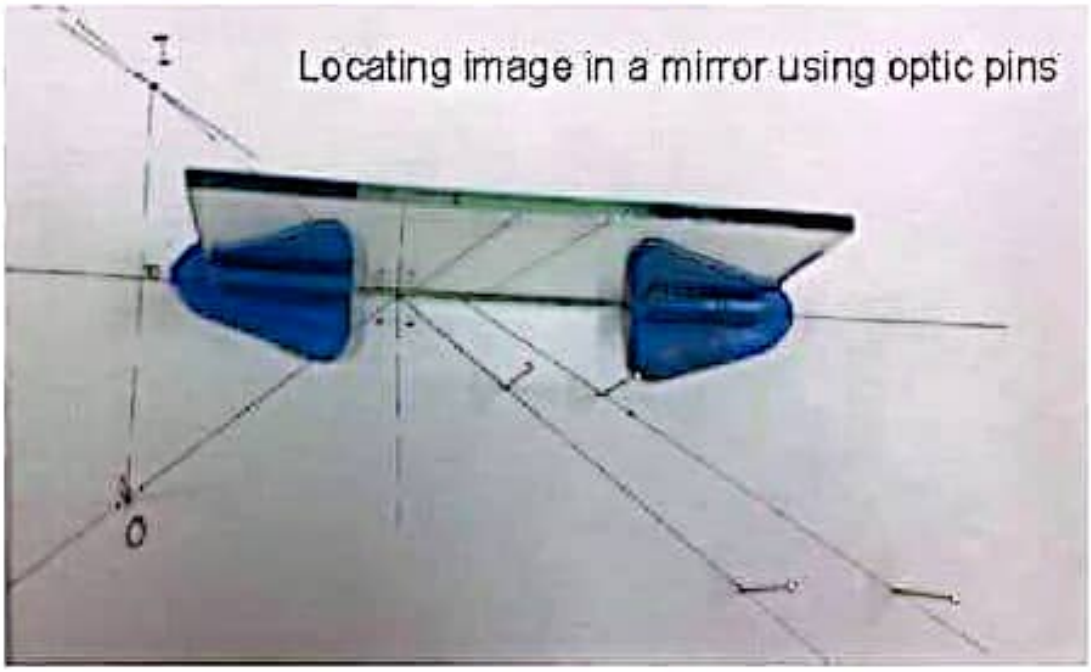
You can also use other apparatus and materials that are usually available in a school laboratory.

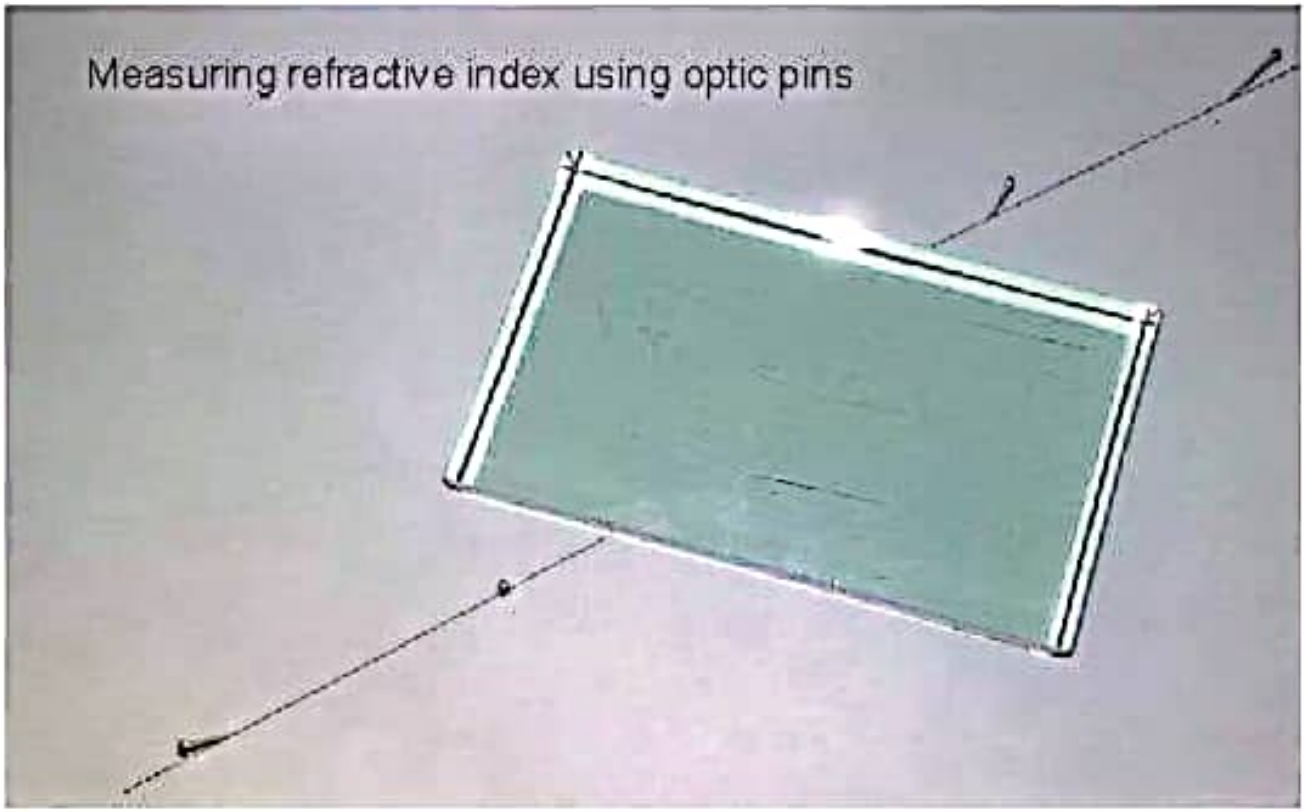
In your plan, you should:

- explain briefly how you would carry out the investigation
- state the key variables that you would control
- draw a table, or tables, with column headings, to show how you would display your readings (you are not required to enter any readings in the table)
- explain how you would use your readings to reach a conclusion.

You may draw a diagram if it helps your explanation.

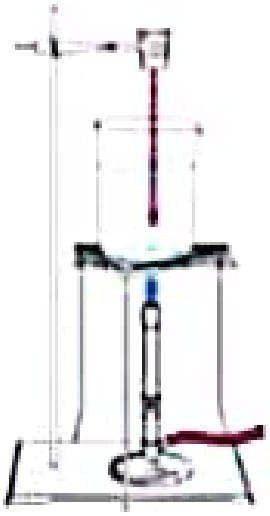






11) Heat related experiments:

- Choose volume/mass values of the quantities that give a change in temperature that is distant from melting or boiling points.
- Insulate the container using fibre glass, cotton wool, or polystyrene.
- Cover the container with a plastic lid (reduce evaporation and heat loss by convection).
- Stir (gently) and wait for highest temperature (responsiveness differs between thermometers; you need to wait for thermometer to gain heat).
- On heating, if the difference with room temperature increases, more heat loss, *rate of heating decreases*.
- On cooling, if the difference with room temperature decreases, less heat loss, *rate of cooling decreases*.
- If cold/hot water is added, you need to add equal volumes or masses at equal time intervals.
- Thermometer should be read with eye level at 90° to scale (position the eye so that the mercury thread appears to touch the scale), and should be placed in the middle of container and not touching walls of container.

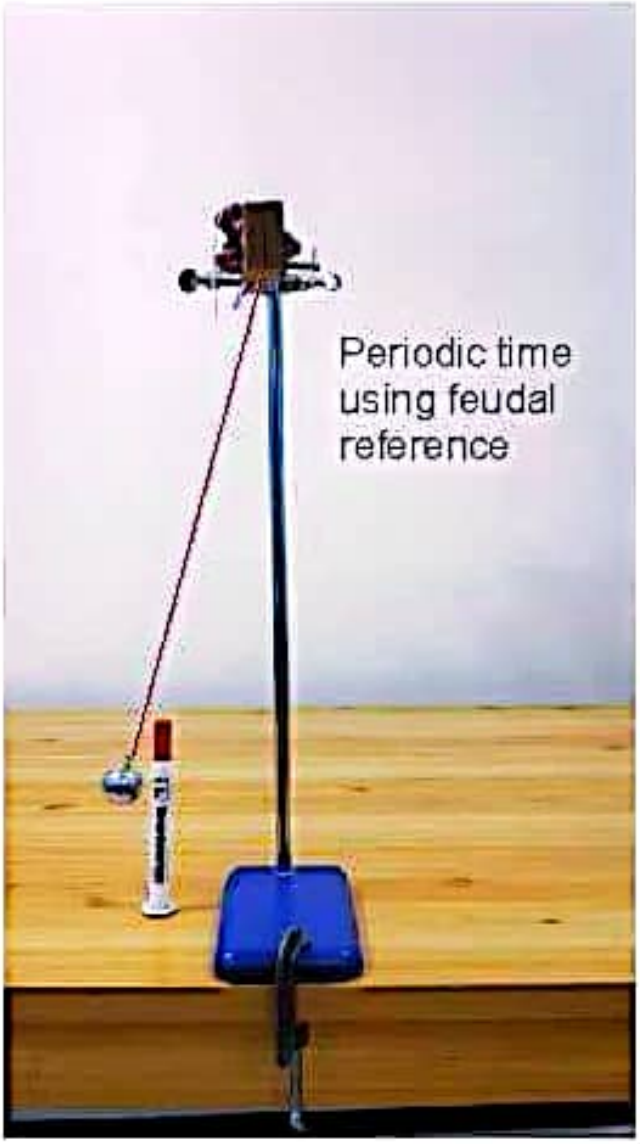


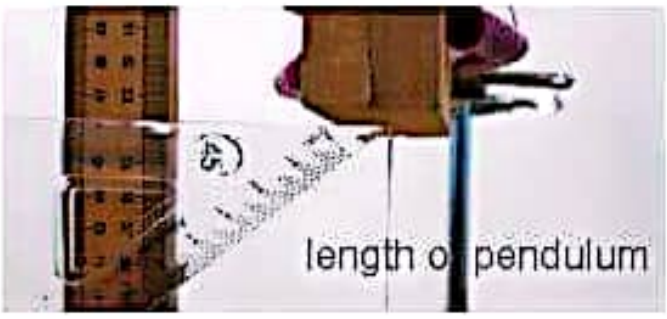
- Initially choose the highest range for the ammeter/voltmeter, then reduce the range (increase sensitivity) so that the deflection is almost full scale
- Ensure ammeter is connected in series while voltmeter is connected in parallel.
- Use variable resistor to change current.
- Always check that connections are clean and firm (dirt causes over resistance).
- Switch off the current when not making a measurement (to reduce heating effect that changes the resistance you are measuring).
- When measuring resistance use low currents/voltages to avoid heating effect.
- You may also add a lamp to avoid heating effect.
- Readings may change if repeated as resistance heats up and source gets used up.
- Avoid touching bare wire as it may be hot and causes burning.
- Hazard of electric shock may happen in high powered circuits.

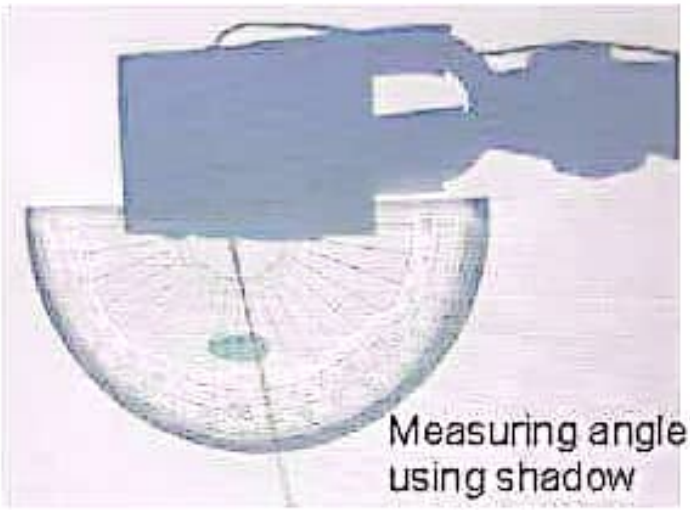
15) *A graph:*

is the best way to display the results of an experiment as:

- a graph can spot an anomaly (error) in readings.







g) When observing a moving object you may:

- spot light on the moving object and trace motion of shadow along a scale/graph paper
- use sand tray
- use carbon paper
- use ink on moving object
- fix rule along the path of motion
- use video recording or snapshot camera
- start/stop the motion remotely (e.g. photo gate)
- mark approximate position and repeat to confirm
- use feudal reference (e.g. fixed marker)

8) When measuring an interval of time:

a) Reset the stop watch to zero and check zero error.

b) For oscillations (of a pendulum or vibrating rule or spring):

- define a complete oscillation (when it passes the same point twice in the same direction)
- record time for N oscillations, usually N>10 and use the terminology periodic time $T = \frac{total\ time}{N}$
- Try to keep the amplitude of starting oscillation constant.

c) use feudal reference (e.g. fixed marker)

- a graph gives the average of a set of readings and which reduces the error.
- a graph gives the relation between plotted variables.

16) To draw a graph:

a) Each quantity must be plotted on the indicated axis.

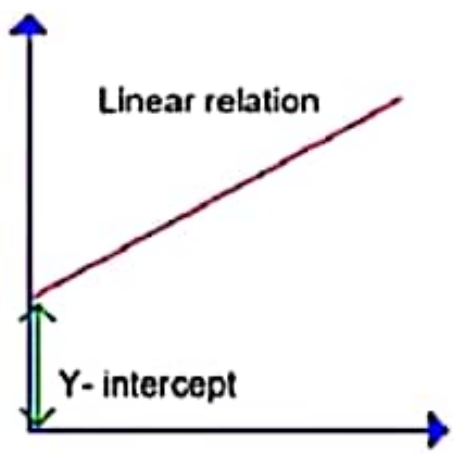
b) Axes should:

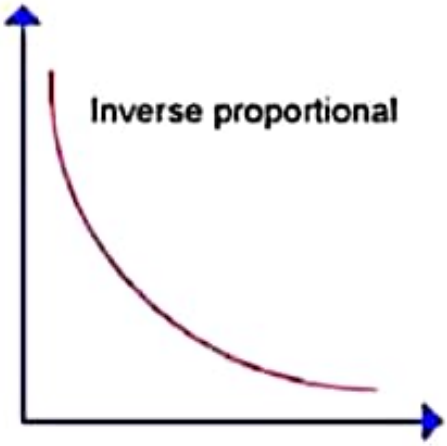
- Be labelled with quantity/unit (e.g. F/N against a / $\frac{m}{s^2}$)
- Have a uniform or linear scale.
- Scaled as small as possible *(to allow the distribution of points for more than 1/2 of the axis)*, but should not use an awkward scale (3,6, 7 ....) to achieve the size.

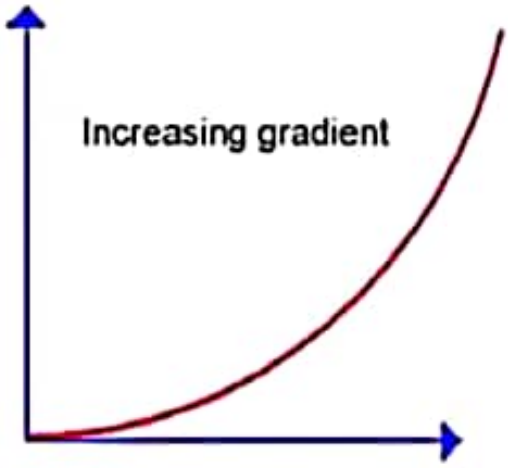
c) Students may *start from any value* (unless instructed to start from origin) *without using any marks*.

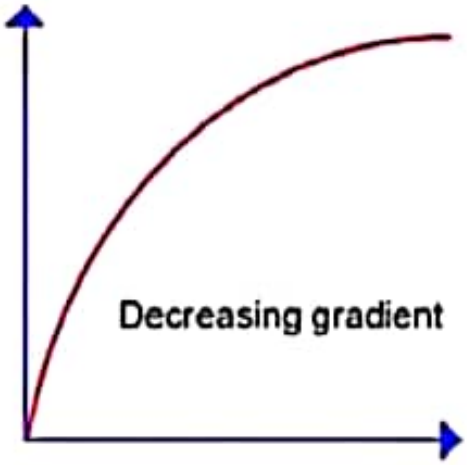
d) Plotting should be neat and as accurate as possible (for *half a square*) using X or .

e) *Graph line:* should be *neat, thin and of best fit and smooth if curved line* (if there is scatter of points they should lay either side of the line) and the line should **FILL** the graph section (even beyond the range of points).









5) You need to ensure a fair test by changing only on quantity/variable and keeping other variables constant, e.g. when investigating how rate of cooling depends on initial temperature of the liquid then the room temperature, room draughts, volume and type of liquid, and rate of stirring are all kept constant.

6) Errors in experiment may arise when not following procedure, e.g. you must record reading at lower point of water meniscus when recording volume using measuring cylinder or error will arise (also cylinder need to be vertical and eye level normal to scale).

9) When measuring length:

- You can measure to the nearest mm with a rule.
- You can measure to the nearest 0.01mm with a screw gauge
- When measuring heights ensure that the rule is held perpendicular to the base by placing it alongside a set square or along center-90° of a protractor (also a plump line or spirit level may be used)
- You must place the ruler alongside the item being measured (in case of spring a pointer or set square may be used)
- To check a level parallel to bench, measure height from the bench along the level using ruler and set square/protractor (spirit level may be used if the level is stable).
- You may arrange rectangular wooden blocks either side of cylinder/sphere/ lens to measure diameter/ thickness.
- You need to wait for a *spring* to stop moving before recording the length.
- Extension in a *spring* depends on sectional area, type of material, original length, thickness of wire and number of coils of the spring and the load used.

2) The choice of range for the measuring scale should match the size of the quantity being measured. e.g., a micrometer is used to measure a thickness about few millimetres while a measuring tape used for distances more than one meter.

3) All measurements must be recorded in a table.

- Recorded raw data must have the same degree of precision (check point 7-d for more details).
- Columns (or rows) in the table should be headed with *the symbol of the physical quantity and its unit*. The SI units are recommended.

If an equation is used to calculate a quantity, it must be mentioned.

Examples of labelling,

L/cm	T/s	T^2/s^2	R/Ω
θ / °	θ / °C	V/V	I/A
$\frac{1}{d}/\frac{1}{cm}$	V/cm^3	$\frac{1}{T^2}/\frac{1}{S^2}$	$\frac{m}{L}/\frac{g}{cm}$

Example of a table,

$$e = l - l_0$$

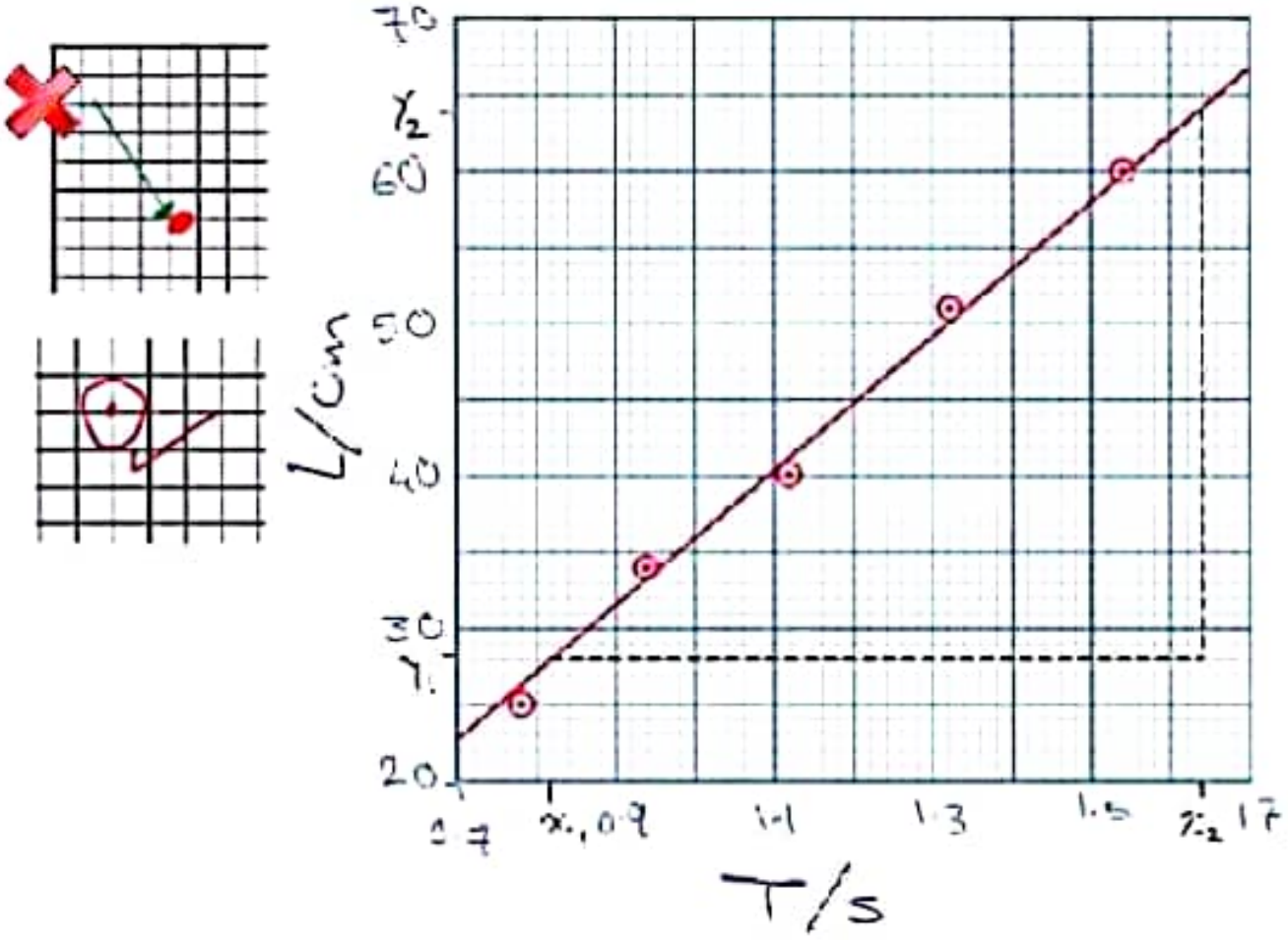
m/g	F/N	L/cm	e/cm
0	0	15.0	0
100	1.0	17.5	2.5
200	2.0	15.0	5.0

f) For a graph of V/cm^3 against m/g

$$\textit{The gradient} = \frac{\textit{raise}}{\textit{run}} = \frac{V_2 - V_1}{m_2 - m_1}$$

****You may use y and χ, but this helps to get to a unit cm^3/g (if required).

g) For gradient calculation, *use the largest range of $\Delta\chi$ and Δy* (choose two clear intersection points one close to the beginning and one close to the end, triangle *must be* shown on graph for more than half the line drawn).



Best wishes

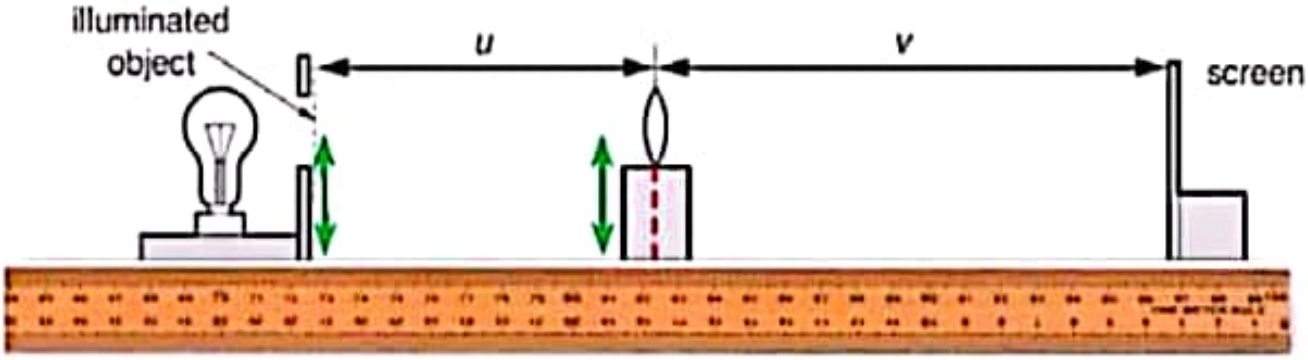
- Experiment results may be affected by:
  1- size/thickness/length/mass/volume/ type of material
  2- type of thermometer
  3- depth / immersion of thermometer (it is supposed to be $\frac{1}{3}$ immersion).
  4- surface area of surface material
  5- thickness/type of insulator/lid
  6- type/position of heater used
  7- initial/final temperatures
  8- room temperature/draughts
  9- rate of stirring

12) In ray tracing experiments:

- When using optic pins, place the pins so that they are at least 5 cm apart.
- Ensure that the pins are vertical
- View through the *pins bases* to avoid error due to tilting.
- Close one eye when aligning pins.
- Draw neat thin lines through centres of pins positions using sharp pencil.
- Use the largest angles available and draw the arms of the angle longer than the radius of any protractor being used, i.e. a large radius is desirable to allow accurate measurement of the angle.

- If ray box is used: use dark room, thin beam (small slit), and mark rays at the centre or edge of the beam.
- *sources of error that can't be eliminated:* the thickness of lines drawn, the thickness of pins used, thickness of ray, judgement of intersection points, (thickness of mirror glass if mirror is used) and difficulty in reading protractor to better than one degree.

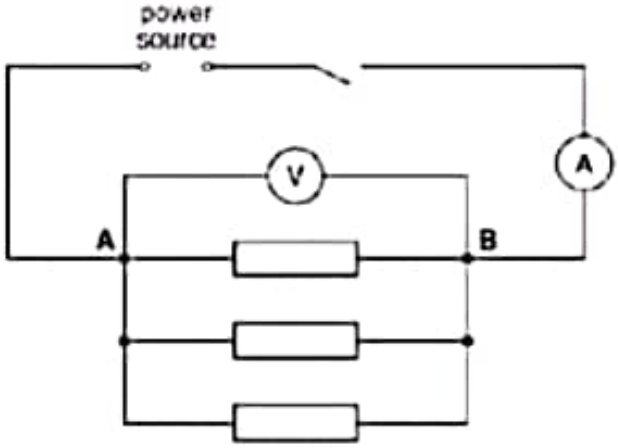
13) Lens experiment:



- Ensure that object and centre of lens are aligned at the same height (ideally their centres are along the optic axis).
- Items should be along a straight line (alongside/touching a wooden rule clamped to the table).
- Use an aid when measuring a length, e.g. mark the centre of the lens alongside the wooden base/holder using a fine marker and a set square.
- Perform the experiment in a dark room.

- Items should be normal to the table (if not, the image will be blurred/not focused).
- Repeat with different object distances.
- To obtain a focused image:
    1- Darkened room / brighter lamp
    2- Use object with fine detail e.g. cross-wires
    3- Measure at middle of range where image is sharp
    4- Move screen (slowly) back and forth to obtain best focused image
- To measure height of image (without interrupting light from source):
    1. use translucent screen and view from behind
    2. use transparent ruler
    3. fix ruler / grid to screen

14) In electrical experiments:

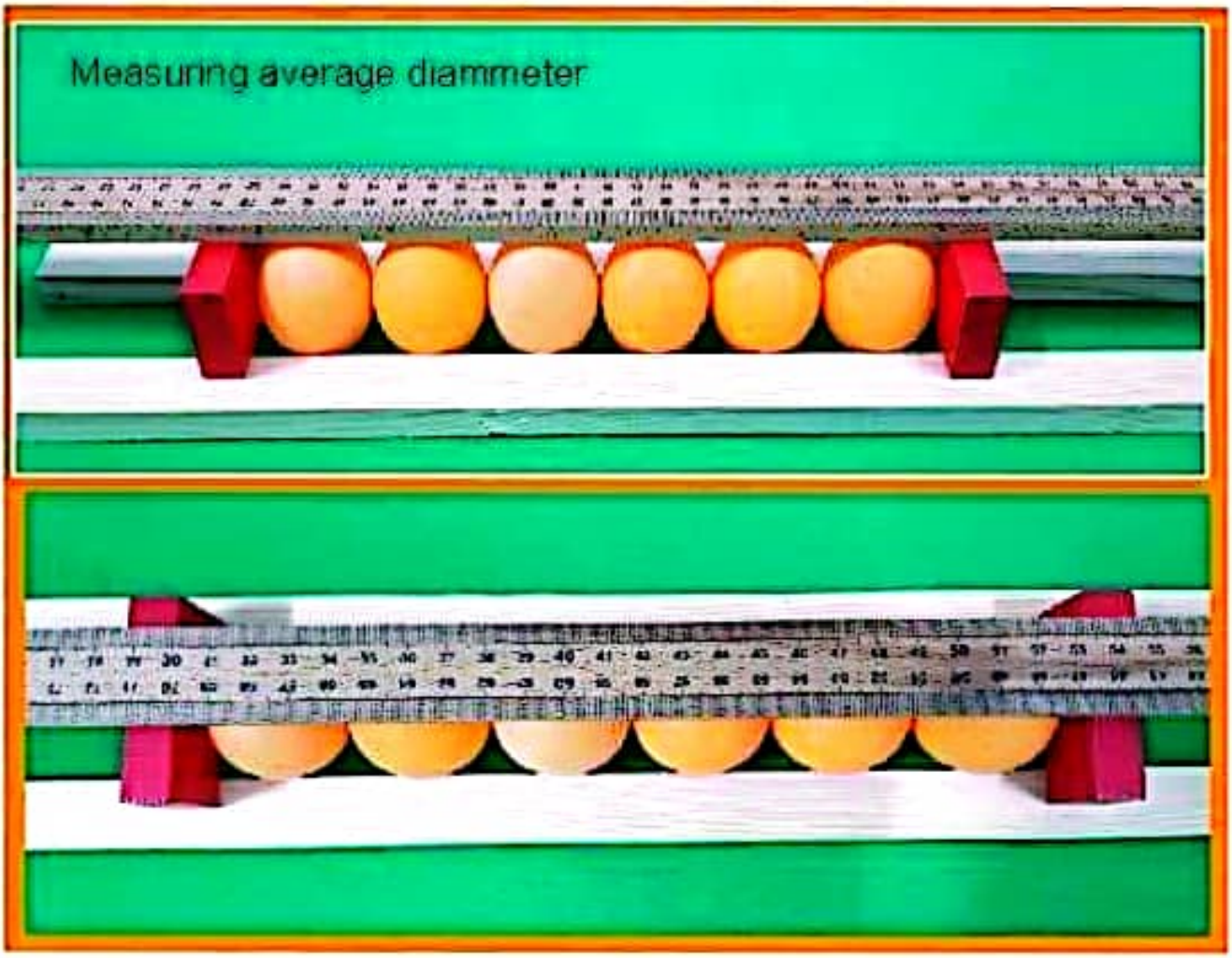


- Check for a zero error on ammeter and voltmeter.
- Tap the meters to ensure pointer is not stuck.

10) Balancing experiments:

- Rule needs to be level with it is centre of gravity on the pivot.
- If centre of gravity is not at 50 (because wooden ruler doesn't have uniform density) you may add a piece of clay to balance the ruler at 50 or just don't do anything since distances are measured from pivot.
- It is difficult to obtain balance (loads slip /covers marks), so record the readings for more than one trial then calculate the average.
- To locate the position of centre of mass of the object, record the readings at both sides then find the mean/average.
- If the object doesn't have uniform density, the location of its centre of mass will affect the result of the experiment (e.g. similar pieces of clay would give different readings at the same position).
- To place the centre of mass of the object at χ, measure its diameter/width then place it between the two marks $(\chi + \frac{d}{2})$ and $(\chi - \frac{d}{2})$.

1) This paper is an alternative to a practical exam, so each experiment is *exactly as described or drawn*.



7) Good procedures:

a) Repeat readings to spot anomalous errors or to calculate an average which reduces error.

b) Avoid making parallax error, (the line of sight should be perpendicular/ normal to the scale).

c) Look carefully at any scale that is used e.g. :

- notice the unit in which the scale is calibrated.
- check zero error on the scale.
- notice the maximum reading that can be obtained.
- notice the smallest change in value that can be obtained.
- aim to use quantities that have magnitudes that are towards the upper values of the scale.

d) The number of significant figures in processed data shouldn't exceed the minimum number of figures in raw data (i.e. calculation can't be more accurate than raw data)

e) Calculated (processed) data must have the same number of significant figures *(consistency is a must)*.

f) The judgement of the experimental value compared to the theoretical value depends on the *difference between the values* is it accepted or not accepted *within limits of experimental accuracy*.