Paper 6 Tips

General Rules:

- Remember that **Paper 6** is evaluating your logical thinking and interpretation of numbers and graphs, minimal knowledge of **Physics** will be assessed.
- Not all the precautions fit in all questions, please read your question carefully and understand what is going on then select the appropriate precautions that fit.
- Sometimes some precautions are already written in the question. **Avoid** rewriting them again!!
- There is a huge difference between **"Precautions"** and "**Variables that should be controlled** for fair experiment".
    - ○ **Examples of Precautions:** Look perpendicular to avoid parallax error, start reading from the zero mark, repeat and taker average, work in dark room.
    - ○ **Examples of variables to keep constant:** work in same room temperature, use same volume of water, same type of insulation, use same wire in electric circuits.
- Please stop writing **"Repeat and Take average"** before thinking. The same applies for **"Within experimental accuracy".** Just think a bit before writing them.
- Never forget the **UNITS** !!
- Write all your answers in 2 or maximum 3 **Significant Figures/ or to the least significant figures among the used values**.
- We can't prevent heat loss, but we can rather reduce it.
- To check if something is vertical, use a set square/ protractor/ plumbline (string and bob), Spirit Level (also to check if object is horizontal).
- Parallax error is avoided by looking perpendicular to the scale and it can be applied to any measuring instrument (with a pointer like Ammeter, Voltmeter, stop watch, or without like ruler, protractor or a measuring cylinder), but not digital devices.
- Whenever using a ruler or a protractor, keep the instrument **very close** (in contact) and **Parallel** to the object to be measured.
- When asked "why we make 10 repetitions rather than just one?". This is due to the fact that any error that happens during the experiment like delay in response or any human error will be reduced as it is being divided by the number of repetitions… This is the idea of taking the **AVERAGE**, OR to get more **Accurate** results.

Theories Statements and justifications:

Percentage error between the two values $= \dfrac{Difference\ between\ the\ 2\ values}{The\ smaller\ value} \ X\ 100$

$$= \frac{L-S}{S} \ X\ 100$$

<div style="border:1px solid red; color:red;">up to 10%</div>

1. Yes – As the **difference** between "X" (its value) and "Y" (its value) is minor / small, within experimental accuracy … **write their values !!**
2. No- As the **difference** between "X" (its value) and "Y" (its value) is large, **beyond** experimental accuracy… **write their values !!**

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Lenses Precautions:

1. Avoid parallax error by looking perpendicular to the scale of the ruler.
2. Carry out the experiment in the dark for clearer image (to be able to decide the best position of the focused image).
3. Use a set square to make sure the screen, the lens and the object are vertical (**Problem: the image will be distorted, so to get sharp, complete, and focused image, the three pieces of apparatus should be vertical**).
4. Drawing a vertical line on the holder to represent the centre of the lens. (**Problem: unable to determine the centre of the lens**)
5. Move the lens back and forth slowly till you have the best focused image.
6. The centres of the object, lens must have the same height from bench.
7. Object, lens and screen must be perpendicular to the bench.
8. Clamp rule or place on bench.
9. Choosing midpoint between acceptable positions (**Problem: sometimes the sharp image appears in a range of distance rather than a specific position**).
10. If the height of the image is to be measured, we have to look from behind the screen or fix a ruler to the screen or use transparent screen. (**Problem: hand or ruler in the way of the image.**)

Hints in Lenses experiments:

- The distance between the object and the lens (u) should be larger than the focal length (f).
- We only see real image, virtual image can't be represented on a screen.
- The image is always **inverted** (as it is real).
- The bench length to be used in this experiment is larger than four times the focal length (4f)
- If we need to repeat the experiment, we try it 5-10 times.

For more accuracy while taking readings from Voltmeter/Ammeter:

1. Repeat experiment several times and take average.
2. Check for zero error of Voltmeter and Ammeter.
3. Switch off circuit between readings (to reduce the heating effect).
4. Avoid loose connections, as it introduces air gaps that result in high resistance in the circuit/ or clean the connections.
5. Avoid parallax error by looking perpendicular to the scale (mention only if not digital).
6. **For reducing heating effect of wire,** reduce the current/voltage/power so temperature isn't increased (or by adding resistor/lamp)

Possible causes of inaccuracy while measuring angles of reflection:

1. Thickness of lines (draw lines as thin as possible)
2. Thickness of pins or Pin hole thicknesses
3. The protractor gives readings to the nearest degree
4. Pins might be **tilted** (not vertical)…that's why we view the bases of the pins.
5. Thickness of mirror (in case of a mirror being used)
6. Difficulty in lining up the pins exactly.

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Pins Precautions:

1- Place pins as far away from each other as possible (more than 5cm apart).
2- View the pins with one eye such that they appear as one.
3- View pins from their bases in case one of them isn't vertical.

Heating experiment Precautions for more accurate thermometer readings:

1. Insulate beaker to reduce amount of heat loss.
2. Carry out the experiment in short time to minimize heat loss to surrounding.
3. Repeat and take average
4. Gentle stirring to ensure water temperature is the same throughout the whole beaker.
5. Use a lid to reduce amount of heat loss
6. Look perpendicular to the Thermometer reading to avoid Parallax error.

Variables to be controlled concerning Heating/Cooling water in different beakers or other similar experiments:

1. Same Volume of water
2. Same Initial temperature of water
3. Same Size/shape/type of beakers
4. Same Room temperature
5. Same thickness/mass/volume of insulator. (only if an insulator was used)
6. Avoid Draughts/ air currents/ Wind
7. Same time intervals
8. Same type of thermometer
9. Same thermometer position
10. Same amount of stirring

Sources of error in determining circumference of an object by using string:

1. Thickness of string
2. Extension of string
3. Diagonal windings… **Avoid it !**
4. Spaces/gaps between windings/turns … Decrease it
5. Parallax error while reading scale.
6. If the object is conical, measure the circumference from the top then from the bottom then calculate the average.

Methods of improvement:

1. Use thinner string
2. Use an inextensible string
3. Parallel windings
4. Don't leave gaps between the windings
5. Repeat and take average

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Precautions while using springs:

- Always measure from the same point of spring
- Wait for spring/weight to stop bouncing before making measurements
- Make sure ruler is vertical
- Bench surface must be horizontal (not inclined)

Variables to be controlled concerning similar Spring experiments:

- Use same material of spring (Unless stated that the material is being tested, so we don't have to use same material)
- Same number of turns
- Same cross-sectional area (diameter of spring)
- Use same loads

Problems while measuring distance in pivot experiments with masses:
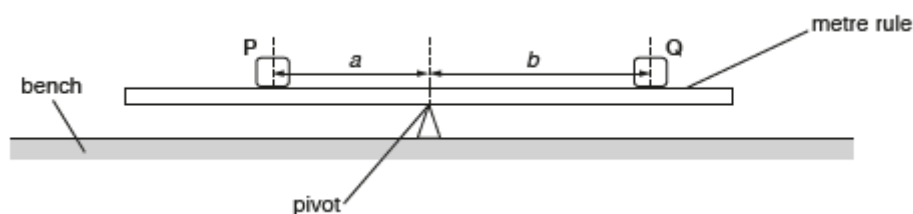
- Rule is unlikely to exactly balance (solve it by making the experiment twice and let the ruler to tip on each side at a time, then get the average of the results)
- Rule could slide on pivot (solve it by using rough ruler)
- Masses could slide on rule (solve it by using rough ruler)
- Rule isn't uniform so Centre of mass of rule is not on the 50cm mark (we check the centre of the ruler by balancing it horizontally on a pivot. Pivot at centre of mass)
- The load/object used might cover the rule marks …. **How to solve this problem**? by taking the readings from the rule at the edges of the object (before and after it), then get the average.

Variables to be controlled in Experiment investigating the effect of the Length of wire on its resistance:

- Diameter of Wire
- Same Material (Same resistivity)
- Same Power Source
- Same Measuring Devices (Voltmeter and Ammeter).

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Graphs:

1. While drawing the graph, if said a smooth line → use the ruler. If said a smooth curve→ draw it smoothly (you don't have to pass by all points, maybe there is a faulty point). If not said, the default is a smooth straight line unless it is a rate of cooling experiment or radioactivity (these have to be curves).

How to know if it a straight line or a curve: by connecting the first and the last points using a ruler, if all the rest of the points are on one side of this line and taking the shape of the curve, so this graph should be a curve rather than a straight line.

2. Represent each point as a small "x"
3. Do NOT force a line through the origin if not required !
4. Use appropriate scale for the axes that would allow you to use more than 50% of the graph.
5. A line of best fit doesn't necessarily include the first and last points
6. Do not draw broken lines!
7. If the origin is not already drawn on the graph and it is not stated to start by (0,0) and you don't need the origin (0,0) in your data, **you can start your axes by any number other than zero.**
8. NEVER forget the **LABELS** and the **UNITS** of the axes.
9. If a gradient is required, it should be calculated ONLY from the points on the line, not just from the table.
10. Choose two points away from each other in calculating the gradient.
11. Never forget the unit for the gradient of the graph when it's required. The unit of Gradient = $\frac{Unit\ of\ the\ Y-axis}{Unit\ of\ the\ X-axis}$
12. Always show how you got the gradient by drawing a triangle (rise and Run) from the points you have selected.
13. If asked to get the X-intercept or the Y-intercept, extend the drawn line until it touches the X-axis or the Y-axis respectively.
14. We have two types of relations in graphs:
    a. **Directly proportional:** Straight line (positive constant slope) passing through the origin. X and Y increase at the same rate.
    b. **Inversely proportional:** Curve. As X increases Y decreases at the same rate.

Variables to keep constant between different metal rods in a heating experiment to test thermal conduction:

- Length of rod
- Diameter/thickness/area(of cross-section)of rod
- Amount of wax /type of wax (only if wax is included)
- Power of Bunsen flame/(rate of)heating
- Position of Bunsen/flame
- Position of rod on tripod

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Measuring Cylinder Experiments:

- Read measuring cylinder levels at bottom of meniscus
- Repeat volume measurement and find average
- Look Perpendicular to water level or place eye level with surface in measuring cylinder (to avoid parallax error)
- Place the objects one at a time (if more than one object to be inserted in water) to avoid air bubbles between objects.
- Avoid splashing when adding coins to water
- Make sure the object is dry / clean
- Use narrow / small measuring cylinder to give higher length of water which is more accurate (Sensitive).
- Place the measuring cylinder on horizontal surface.
- Displacement can method: make sure dripping finishes before taking the reading.

Pendulum Experiments:

- The largest source of error in this experiment is the response time error during starting and stopping the stop watch. So we have to let the pendulum swing for 10-20 oscillations then divide the time by the number of oscillations… increasing the number of swings will increase the reliability of the results.
- Don't let it swing for more than 100 cycles as it may stop (due to air resistance) or you may lose count.
- Make sure that you start the stop watch at the same time of releasing the bob.
- **Mark the starting position (Fiducial mark) of the pendulum to stop the stop watch when it returns back to that position.**

Specific Heat and Latent Heat experiments (<u>Extended</u>):

- In case of working at a temperature above room temperature, you are losing heat to the environment, so the amount of heat energy calculated is higher than the real value used. Thus the **Specific Heat Capacity** or the **Latent Heat** calculated is higher than the actual value.
- In case of working at a temperature lower than room temperature (ex: dealing with ice), the opposite happens.

Mixture experiment:

Difference between the experimental result and the theoretical/ calculated value is due to:

- Heat lost to the surrounding/evaporation of liquid molecules lead to cooling effect
- Inaccuracies in measuring the liquid volumes used
- Inaccuracies in measuring the temperatures of cold and hot liquid

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Quantities and their measurements' values:

Temperature:

- Pure melting ice 0^0C
- Healthy person 37^0C
- Pure boiling water 100^0C
- Boiling oil 400^0C

Pressure:

- Student standing on one foot 4.0 – 5.0 N/cm^2

Mass:

- Protractor 5g
- Chocolate bar 50g
- Wooden metre rule 100g
- Apple 200g
- Average person 60/80 kg
- Empty 250 cm^3 beaker 0.07 kg

Area:

- Base of 250 cm^3 beaker 30 cm^2
- Keyboard of computer 0.07 m^2

Thickness:

- Metre Rule 4 mm

Time:

- One swing of simple pendulum of length 0.5m , 1.5 s

Volume:

- Test tube 10 cm^3
- Measuring cylinder 100 cm^3
- Beaker 250 cm^3
- Pepsi can 330 cm^3
- Small bottle of water 500 cm^3
- Large bottle of water 1500 cm^3
- Examination paper 6 cm^3
- Coffee cup 100 cm^3

Current:

- Filament bulb 1 A
- Air conditioner 20 A
- 1.5 V torch lamp at normal brightness Power 0.1-0.5 Watt
- 12 V ray box lamp at less than normal brightness Power 6 Watt
- Light emitting Diode Power 6-8 Watt
- Normal Fluorescent Lamp Power 12-15 watt
- Filament Lamp Power 50 -100 Watt

Circumference:

- 250 cm^3 beaker, 25 cm

Diameter:

- Test-tube 1.5 cm

Note: **These values are average, so might slightly differ in different exams.**

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Designing an experiment:

1   Draw a diagram to help your explanation (even if not asked to do).
2   State any apparatus/equipment used.
3   State in details the instructions to be followed (**Steps**).
4   State the range of values to be used and units of measurements (use **Wide Range**), at least do the experiment 5 times and the largest value should be at least twice the smallest.
5   The Table you will use with the headings and Units.
6   The Graph has to be plotted and the axes used with their Units.
7   Precautions to follow.
8   Variables to keep constant for Fair experiment.
9   Repeat the experiment and take average of readings.
10 State how to draw a Conclusion (if asked).

Specimen 2016 Experimentation Question:

A student's plastic bottle of water tips over in class.
Plan an experiment to investigate how the quantity of water in a plastic bottle affects its stability.
The plastic bottle holds up to 2000 cm3 of water and has a height of 42 cm.

Write a plan for the experiment, including:
• The apparatus needed
• Instructions for carrying out the experiment
• The values you will use for the quantity of water
• How you will make sure your results are as accurate as possible
• The graph you will plot from your results

A diagram is not required, but you may draw your own diagram, if it helps to explain your plan.

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Solution:

Diagram
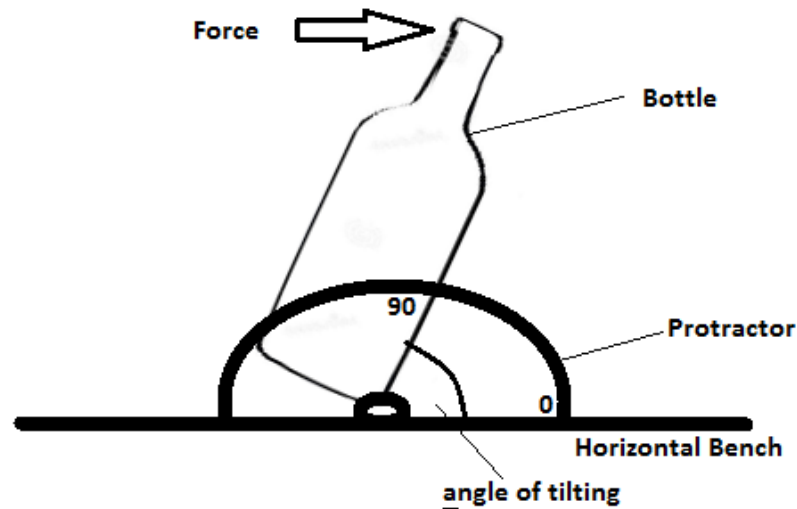
Equipment List:

1. Bottle
2. Protractor.
3. Measuring Cylinder

Instructions:

- In this experiment, we will measure the volume of water using a measuring cylinder
- Then pour it gently in the plastic bottle to avoid spillages.
- Start tilting the bottle slowly using your hand
- Record the angle at which the bottle will **just start** to topple using the protractor.
- Repeat the experiment for the same volume of water and take the average
- Repeat the whole experiment for different volumes of water.

Range of Values Used

- Start by 200 cm3 of water and add 200 cm3 per time for 10 times.
- **OR:** Values used for volume: 200,400,600,800,1000,1200,1400,1600,1800,2000 cm3

Graph and Table:
- Make a table with two columns, the first one for Volume of water/ cm3 and the second one for Angle of toppling/°.
- Plot a graph for the Volume of water/cm3 on the X-axis and the angle of toppling/° on the Y-axis and draw a smooth line between the points.

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Precautions and Variable to keep constant:

1- Repeat the experiment for each volume of water three times at least and take average to reduce error.
2- Look perpendicular to the readings on the protractor to avoid parallax error.
3- Use a large protractor (that measures to the nearest half degree) for more clear and accurate readings.
4- Push the bottle slowly to be able to be able to record the angle of toppling.
5- Work on a rough surface to avoid slipping of the bottle.
6- Use a cone to pour the water in the bottle to avoid spillages.
7- Draw a neat graph and take more than 50% of the graph grid.
8- Use the same bottle each time. (**Fair experiment**)

Experiment 2:

Design an experiment to define the effect of the length of pendulum on its periodic time of oscillation.

Write a plan for the experiment, including:
• The apparatus needed
• Instructions for carrying out the experiment
• The values you will use for the length of the pendulum
• How you will make sure your results are as accurate as possible
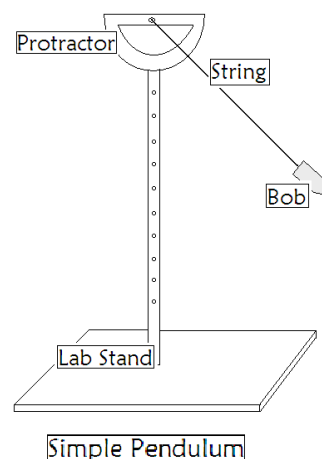• The graph you will plot from your results

A diagram is not required, but you may draw your own diagram, if it helps to explain your plan.

Solution:

Diagram

Simple Pendulum

Equipment:

- Stand
- String and Bob
- Protractor
- Ruler
- Stop watch

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Instructions (Steps):

- Measure the length of the string **from the beginning of the free end to the Centre** of the bob.
- Hang it from the stand as shown in diagram.
- Pull the bob at a certain small angle measured by the protractor, then release it to start oscillating.
- Start the stop watch as you just release the bob.
- Count 20 oscillations and stop the stop watch as it reaches its starting position in the last oscillation to get the time "t".
- Divide "t" by 20 to get the periodic time "T".
- Repeat the experiment three times and take the average value of T.
- Repeat the whole experiment for different lengths of pendulum.

Range of values used:
- Start by a length of 100 mm.
- Increase the length by 50 mm each time for 10 times.
- Values used for length :50,100,150,200,250,300,350,400,450,500 mm.

Graph and Table:

- Make a table of two columns, the first one for the (length/mm) and the second one for (Periodic time T/sec).
- Plot a graph for the (length/mm) on the X-axis and the (Periodic time T/sec) on the y-axis.

Precautions and variables to keep constant:

- Look perpendicular to avoid parallax error while using the ruler or the protractor.
- Use the same bob each time.
- Start the oscillation each time from the same angle.
- Work in a closed room to avoid air currents.
- Don't push the bob while staring, just release it to oscillate freely.
- Use **Fiducial** mark

Other Experiments to think about:

- The effect of the colour of the object on its rate of radiation emission.
- The effect of the colour of the object on its rate of radiation absorption.
- Get the centre of mass of a rule using an object with known weight.
- The centre of mass of a laminate/ piece of paper.
- The effect of the length of the wire on its resistance.
- The effect of the diameter/ cross-section area of the wire on its resistance.
- Thermometer scaling.
- Investigate how the angle of a solar panel affects its output power.
- How the rate of cooling of a beaker is affected by the thickness of insulation.
- How the rate of cooling of a beaker is affected by its exposed surface area.

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Extra Hint:

Reliability Vs Accuracy:

We always deal with reliability and accuracy as being nearly the same concept, except in some cases (like oscillations experiments).

If we consider a pendulum with T = 2 seconds. To measure the periodic time, we let the pendulum to swing for 10 oscillations then divide the time by 10.
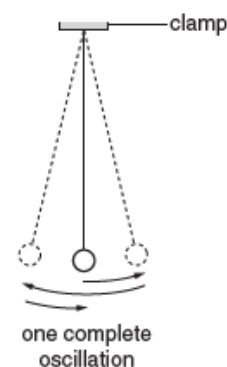
Reliability: means consistency of the measurements, that if the experiment is repeated with the same conditions it will give results similar to your results.

How to improve Reliability: Repeat the experiment several times and take the average, increase the number of swings, try different values of lengths of pendulum or try different masses of bob.

Accuracy: Shows how close is your result to the true value. It means that your value has minimal error.

How to improve Accuracy: increase the number of oscillations (swings) and take the average, or use fiducial mark, look perpendicular to avoid parallax error, use set square to measure the length correctly.

Extra Hint:

Percentage error between the two values $= \dfrac{Difference\ between\ the\ 2\ values}{The\ smaller\ value} \times 100$

$$= \frac{L-S}{S} \times 100 \qquad \boxed{\text{Most conservative}}$$

Percentage error between the two values $= \dfrac{Difference\ between\ the\ 2\ values}{The\ larger\ value} \times 100$

$$= \frac{L-S}{L} \times 100 \qquad \boxed{\text{Least conservative}}$$

Percentage error between the two values $= \dfrac{Difference\ between\ the\ 2\ values}{The\ average\ value} \times 100$

$$= \frac{L-S}{average} \times 100 \qquad \boxed{\textbf{Commonly used}}$$

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List of Tools and measuring devices:

Device	Used to measure
Meter rule	Length (up to 1m)
Tape meter (Measuring tape)	Length (more than 1m)
Protractor	Angle
Thermometer	Temperature
Measuring cylinder	Volume
Balance (digital, top pan)	Mass
Newton meter (Spring balance)	Force/ Weight
Stopwatch	Time
Barometer	Pressure
Manometer	Pressure
Voltmeter	Potential difference (Volt)
Ammeter	Current
Galvanometer	Current (small values)

Pendulum/ Plumbline (String + Bob)	Ruler and Pivot	Set square	Micrometer screw gauge	Tripod and Gauze
Heater (Bunsen burner or electric heater)	Beaker	Stirring rods	Insulation/Lagging (Polystyrene, wool, rubber)	Elastic bands
Power source (DC or AC)	Connecting leads (Crocodile clips)	Wires	Switch	Variable resistor
Laser beam or Ray box	Optical pins	Ray trace sheet		
Illuminated object + card with a hole	Lens with holder	Screen		
Stand	Boss	Clamp	Loads	Pulley + string

PUSH YOURSELF BECAUSE, NO ONE ELSE IS GOING TO DO IT FOR YOU.

Good Luck

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