AS LEVEL IMPORTANT NOTES & TIPS – PRACTICAL PAPER 3

AS Level Physics Practical Paper 3 Format

There are two questions in each paper. Each question should take one hour as both questions are of 20 marks.

Question 1: it requires candidate to collect data, plot a graph and draw simple conclusions.

Question 2: No graph will be required. It will require candidates to follow an inaccurate method, take several readings and then evaluate the results. It requires candidates to identify the problems faced in experiment and suggest improvements that can be made.

Now, before starting on the tips to ace the Physics Practical Paper 3, you should keep this thing in mind that most of the marks are for working, presentation and conclusions. So even if your practical work is not very accurate you should move to the tables, graph and working without wasting time in making it more accurate. There are only 2 marks of quality on whole paper.

Question 1

In this question, first set up the apparatus in exactly the same manner as shown on the question paper. The first part of this question usually involves measuring something like diameter of a wire, length of some part of experiment apparatus, potential difference, current etc. While measuring you should ensure that **you present the data to the appropriate number of significant figures so that if reflects the least count of the device being used** for example:

Micrometer Screw Gauge*: 0.01 mm
Meter rule: 0.5 mm
Vernier Caliper**: 0.1 mm
Protractor: 0.5 degrees
Graduated cylinder: 1/2 of the least count
Time: 1 decimal place
represent your all data in the SI units..meter (m) for length, radius e.t.c

In some cases, you have to measure something and judging by the space provided you have to show the evidence that you have taken repeated readings and averaged them out. Say you have to measure the diameter of a sample of wire, so using the micrometer screw gauze take 3 readings in three different parts along the length of the wire and show:

$$d = \frac{d_1 + d_2 + d_3}{3}$$

and show the value calculated. Also remember to add appropriate units along with the individual readings you measure. Then it says to repeat the procedure and get six different sets of data in a table. Students often have this thing out of their mind that the presentation is important and CIE in its examiner's report terms such students as 'weak candidates'. So first thing first, know how many variable you have to measure and/or calculate so you could draw appropriate columns.

Now before moving onto how to construct a 'nice' table, let's first consider what actually is demanded by the examiner in the table. A 'nice' table should have these features:

1. **Range and distribution:** Largest possible range is required. It means that for example if you have to measure length (L) from 0-100 cm, so we must take highest range while keeping the difference constant and getting 6 set of readings. The difference you can take here is 15, so the readings of L you'll take will be: 15 cm, 30 cm, 45 cm, 60 cm, 75 cm, 90 cm. These values of L you have cover almost the whole range of values possible from minimum to maximum. Same applies if you have set of resistors and you are asked to make different combinations of resistors to yield different values of resistances. These values of resistance must cover the whole range possible, like from minimum to maximum value possible [here keeping the difference between individual values of resistance for different combinations common is not necessary!]

2. **Quality of data:** In a nutshell this one mark is for how close your readings are to the readings of supervisor and does your readings have the points which make them look actual readings instead of made-up readings such as: (1) scatter of points about the graph, due to random error the points will never lie on a straight line (2) the trend is correct like dependent variable increasing with increasing independent variable and so on.

   You will get accuracy marks if you actually write the values which are there on the equipment instead of making
   your own and if you did the experiment as accurately as supervisor.

3. **Table:**
   i. **Layout:** You will draw one single table with headings. Each heading will have the name or symbol of quantity with it's standard units in brackets of after slash such as "L /m" or "Temperature (K)". using T can cause confusion so better write temperature or time instead of T or t unless the question explicitly says something like " t=time period". Writing "L m" or "temperature K" is not accepted.

   ii. **Raw data:** The data must be up to to the same precision. All the raw readings of a particular quantity should be recorded to the same number of decimal places which should in turn be consistent with the precision of the measuring instrument.

   iii. **Calculated quantities:** For example, you record the values for current (I) using the ammeter. Then the question asks you to include the values of 1/I in your table. That 1/I is calculated from I. Lets say, I was given to 3sf. Then the calculated form (1/I) must have same number of sf, i.e. 3sf or one more sf, i.e. 4sf. These number of significant figures for calculated quantity should be kept same throught out the colum for that quantity. However, if you are to calculate resistance from p.d and current, and the p.d was up to 2 significant figures while current was up to 3 significant figures. Then the number of sf in the calculated quantity must be equal to the least number of sf used in the calculation or one better. Therefore, the resistance calculated can only be given to either 2 sf (least sf used in calculation) or 3 sf (1 better sf).

Use the full space provided. First draw a rectangle covering whole of the space and then draw a upper row relatively wide. Then draw a narrow column headed, S.No. (serial number), then draw equal sized columns for the variables, then draw equal sized 6 rows below the heading row the column heading carries one mark 'quantity/unit'. Finally, record your raw data in to the table which is obtained from the experimental procedure. Afterwards, use this data to calculate other quantities. A 'nicely' made table looks like this (Here, I have taken the table from a question which involved measure of two quantities, x/m & I/A, and then involved a calculated quantity, 1/I) :

No.	X / (m)	I/ (mA)	1/I / (1/mA)
1	0.100	1.1	0.9
2	0.250	1.0	1.0
3	0.400	0.9	1.1
4	0.550	0.8	1.3
5	0.700	0.7	1.4
6	0.850	0.6	1.7

However, if you have to measure time period of an oscillating pendulum, make sure that the amplitude is not greater than 5 cm, then display 3 sets of data in 3 small columns for 10 oscillations 10t1 ,10t2, 10t3 and show in a separate column the calculated value of 't' stating the formula in the column heading. Again significant figure of the raw data should represent the precision of the instrument used, and s.f of any calculated value from those data should be in same or one more s.f – correct calculation carries one mark!

DO NOT panic if your data has some flaws; inform the supervisor and if he gives replacement of some instrument carry on or if he doesn't, hit him with the same instrument!! Just kidding. Any type of malfunctioning of instrument will be reported to CIE and you are not penalized for it as your practical skills are being assessed here.

4. Graphs:

i. **Layout:** The axes must be labeled with their appropriate units (same as the headings of table). The scale must not be odd such as each 1 cm block = 3 N. Appropriate scales are 1,2 and 5 units = 1 block. Scale must be chosen to give at least 50% of the graph in both of x- & y- directions. On the graph grid provided, there are about 8 big boxes horizontally & 12 big boxes vertically (when the paper is viewed in portrait form). Therefore, the graph you draw must cover ATLEAST 4 boxes horizontally and 6 boxes vertically – appropriate scales must be chosen to ensure this. The line drawn must be extended beyond the points to occupy full graph. False origin should be used if the values start far away from the origin. The numerical labels must be regularly spaced. Scale markings should be no more than three large squares apart so to be on the safe side label all the marks.

ii. **Plotting:** All points must be plotted accurately so they are not more than 1mm away from where they must be plotted(slight offsetting is pardoned). The point must be plotted sharply. If the points are not visible due to sharp lead then cross them or encircle them. Personally, I recommend using small crosses instead of dots (points), because blobs (points with diameter > 0.5 small square) are not accepted. Otherwise, if you find it easy to work with dots, use them, but make sure they are not blobs.

iii. **Trend:** The graph is a straight line. But it is not possible that all points lie on the line. A best-fit line has to be drawn. Most people don't get the idea of best-fit line. By best-fit we mean 'average of all points' line. There must be even distribution of points above and below the line. The scattering of points around the line is due to random errors.

Best fit line must have the balance of at least 5 points which means you can ignore any one point which does not fit into a trend . There must be an even distribution of points either side of the line along the full length, as we can call the best fit line 'Insaaf Wali Line' in Urdu, which means line doing fair treatment to all the points. So the vector displacement of the points from the line should cancel out to zero . Lines must not be kinked. Lines thicker than half a small square are not accepted so I recommend a sharp lead pencil and a transparent ruler for this job. All points in the table (minimum 5) must be plotted for this mark to be scored. All points must be within 2 cm (to scale) in x direction of a straight line.

iv. **Gradient & Finishing up:** When finding gradient from the line draw the triangle with the hypotenuse at least 70% of the graph. Label the points with their coordinates. Analysis conclusion and evaluation Finding gradient and y-intercept:

First you will need to revise the equation of linear lines if you don't remember them. A linear line can be written in equation as: y=mx+c. y is dependent variable, x independent variable, c is point where line touches y-axis(a constant), and m is gradient of graph.

Finding the gradient: From your points which you found by drawing triangle on the line, you can find gradient by this equation:

$$\boldsymbol{Gradient = \frac{Y_2 - Y_1}{X_2 - x_1}}$$

Both read-offs must be accurate to half a small square and sensibly quoted on the graph and in the calculations as well.

Finding the Intercept: Check correct read-off from a point on the line, and substitution into y = mx + c. Read-off must be accurate to half a small square **or** check read-off of intercept directly from graph. then a calculation follows which requires you to substitute the values obtained in previous calculation of gradient and intercept. A method mark and a accuracy mark for the new calculated value.

Question 2

This question is more accurately described as an 'error-question' – meaning that this question depends on how accurately you work, and in case your accuracy is compromised, how can you improve the experiment to avoid it. Throughout this question you should think: Why I am feeling that this is difficult? What is the problem with this experiment? How can I modify it to take better readings? This critical thinking is very important to do the last part of this question, but the observations are made while doing experiment and setting up the apparatus.

This question usually has something 'vulnerable' to error to be measured so in this case a repeated reading is required. Same as the method described in question 1 of this guide, take several readings (2-3 readings would be enough) and take their average. Proof of repeated readings is mostly required in marking schemes. Keep in mind! A consistent unit must be quoted with the appropriate number of significant figures.

The types of 'vulnerable-to-error' questions which may come include: finding maximum height after rebound, measuring the angle at which a water-filled bottle falls, timing the falling body in a fluid (like oil) etc.

After measurements follow the calculations for finding out the uncertainty in the readings or calculating another value using a given formula by putting in the measure values. Usually the absolute uncertainty is the least count of the device, but in most cases it is greater – for example, the least count of a digital stop watch is 0.01s, but it will not make sense if you quote the absolute uncertainty to be 0.01 s because human error is quite large here; therefore, you must write a sensible value (a range of values is given in the marking scheme, in most of the cases 0.2s to 0.5s – but once again it totally depends on the experiment. As a certain answer you can just put it to be 0.2 s).

1. **Percentage/Absolute uncertainty:**

   I. **in case of addition / subtraction: we add the individual uncertainties of the quantities added or subtracted. Take the following example:** a = 5 ± 0.2 & b = 2 ± 0.3, We are given, c = a + b. Find the absolute uncertainty & percentage uncertainty in c.

   c = 5 + 2 = 7
   absolute uncertainty in c = 0.2 + 0.3 = 0.5
   percentage uncertainty in c = 0.5/7 * 100 = 7.14% (up to 3 sf.)

   Note: whatever the case (subtraction or addition), the individual uncertainties are always ADDED never subtracted!

   II. **in case of multiplication / division: we add the fraction uncertainties of the involved quantities. Take the following example:** a = 2 ± 0.2 & b = 3 ± 0.3, We are given, c = b/a. Find the absolute uncertainty & percentage uncertainty in c.

   c = 3/2 = 1.5
   fractional uncertainty in a = Δa/a = 0.2/2 = 0.1
   fractional uncertainty in b = Δb/b = 0.3/3 = 0.1
   fractional uncertainty in c = (Δa/a + Δb/b) = 0.1 + 0.1 = 0.2
   absolute uncertainty in c = (Δa/a + Δb/b) * c = (0.1 + 0.1) * 1.5 = 0.3
   percentage uncertainty in c = (Δa/a + Δb/b) * 100 = 0.2 * 100 = 20%

   in case powers are involved: when powers are involved in the given expressions, we find the uncertainties in the same way as above, with just a small change: we multiply the power with the fractional uncertainty of the value which is raised to that power. For example:

   P = I2R

   when finding the percentage uncertainty of P, we'll do it like this:
   percentage uncertainty in P = (2 (ΔI/I) + ΔR/R) * 100

   Just see how everything is done exactly the same, except that inclusion of power 2. I hope this clears the concept of uncertainty calculations of quantities involving powers.

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After calculations involving a given formula to find a certain value, the candidate is usually asked to 'justify the number of significant figures' in the final answer to the value you were asked to calculate. Here you need to keep in mind that when you are calculating a certain value, its significant figures must be equal to or 1 more than the significant figures in the raw data. Let's take an example here (using May/June 2018 Paper 3 Variant 3, Question 2 as an example)

2. **In the example question, you are initially asked to measure angle A in part b(i). In part c(ii), you are asked to calculate a value 'd', using the formula:** d = sin A/sin 45°

   In c(iii), you are asked to justify your number of significant figures for value of 'd'. The calculation for 'd' involves the raw data, 'angle A', that you measured. Let's say the number of s.f. for 'A' were 2. Then the number of s.f. for 'd' that you give MUST be equal to 2 s.f or 1 more (i.e. 3 s.f.). This is the justification you are supposed to provide for this type of questions.

   The example question involved only ONE measured quantity; what if there are more than one? In that case, your significant figures for the calculated quantity (in the example, value 'd'), must be equal to the smallest number of significant figures in the raw data or 1 more than that.

   Following this type of question, you are usually asked to alter the apparatus in some way, and record set of values, and do calculations for the new arrangement.

   Finally, a relationship is usually suggested between the values you calculated in previous parts, and you are required to find 2 different values of a constant 'k' for the respective data sets using the given relationship. In the part following it, you are asked 'Explain whether your results support the suggested relationship'. Here you need to set a certain criterion for yourself. Let's say you set the criterion to be : "The suggested relationship will be valid, if the percentage difference between the two values of 'k' is within 20%".

   Suppose the values of 'k' you calculate come out to be : k1 = 0.456 and k2=0.461
   Percentage difference between these values of 'k' is:

   $$k = \frac{K_2 - K_1}{K_1} \text{ X } 100\ \%$$

   % difference of k = (k2-k1)/k1 * 100 = (0.461-0.456)/0.456 * 100 = 1.09% (which is <20%), Therefore, as 1.09% is less than 10%, according to given criterion, the suggested relationship is valid.

   A thing to keep in mind is that there is no specified criterion to judge the validity of a relationship; it is entirely up to the the candidate to set it. A candidate can set the criterion to be <20% or <5%; it is entirely up to the candidate! However, setting a criterion like <50% difference for the relationship to be valid is totally stupid. So set a sensible criterion. You may sometimes be asked to justify the number of s.f. used in values of 'k' calculated; again give the same justification as described previously relating the s.f. in 'k' to the s.f. in raw data.

3. Errors & Improvements
   This last part is worth 6 marks which asks you to describe four sources of error and suggest the appropriate remedies. At the start of this guide for question 2, we mentioned this :

   "Throughout this question you should think: Why I am feeling that this is difficult? What is the problem with this experiment? How can I modify it to take better readings? This critical thinking is very important to do the last part of this question, but the observations are made while doing experiment and setting up the apparatus."

   Pro-Tip: The first error and improvement works for ALL experiments. So better memorize it as it is :)

   If you thought about these points while performing, you would have definitely no problem dealing with this part of the question. There are no set "errors and improvements", as the errors are specific to a particular experiment you perform. However, some general errors and improvements are given below:

   Format Answer (Works for all Experiment):
   Error: Two readings are not enough to draw a valid conclusion
   Improvement: Take many readings and plot a graph.

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Different Experiment Scenarios (and their potential errors and improvements):

A. Water related experiment:

Errors	Improvements	Rejected Answers
Hard to see water surface due to refraction effects	Use coloured liquid	Bottle not vertical
Meniscus effect	Use waterproof labels/ink	
Labels get wet/ink runs		

B. Ball related experiment:

Errors	Improvements	Rejected Answers
Locating the centre of the ball when reading rule	Mark the centre of the ball with marker	
Inconsistent bounce	Use a flat surface/ Turn off fan	

C. Fast- moving object experiment:

Errors	Improvements	Rejected Answers
Difficult to judge when the ball is at its (maximum displacement, highest point & etc)	Position sensor above or below with data logger/ Video camera to play back frame by frame	reaction time ideas/ difficult to release from the same point each time
Hard to see when object strikes floor	Use pressure sensor to stop timer	
Difficult to judge end point	Mark distance with lines on ramp (to eliminate parallax error)	
Difficulty in deciding the toppling point	Move by increments	

D. Releasing object from rest experiment:

Errors	Improvements	Rejected Answers
Difficulty in releasing the object due to (applied force etc)	Use a remote-controlled clamp to release the object/ slot in tube + card/electromagnet	
For Light object, (Object) falls at an angle due to wind.	Turn off fans	
For Heavy Object, Rod falls sideways/not entering sand vertically.	Practical method to keep rod vertical e.g. guide for rod.	

E. Force experiment:

Errors	Improvements	Rejected Answers
Maximum force reached without warning	Practical method of recording maximum value e.g force sensor with data logger	Increase force slowly/reaction time error
Weights move	Method of fixing cotton loop to rule e.g. tape, glue.	

F. Oscillation experiment:

Errors	Improvements	Rejected Answers
T or time short/large uncertainty in T	A marker to time as reaches maximum displacement with (motion sensor) at end with video with timer (playback) in slow motion/ Increase the magnitude of the independent variable	
Object does not swing freely/ friction between pivot and object		
Not swinging in one plane only/idea of non-uniform oscillation (Light object only)		
Oscillations die out quickly/ heavy damping (Light object only)	Make hole bigger/bush or bearing idea or Turn off fan(Light object only)	
Difficult to judge end/ start/ centre of swing/ difficult to judge complete swing	For heavy object, no improvement available or Use increased thickness of object or Use of fiducial marker/pointer	

G. Electricity experiment:

Errors	Improvements	Rejected Answers
Resistance / current fluctuating	Clean contacts	Voltmeter not accurate enough. More accurate voltmeter/ Parallax error/zero error on meters/heating effects of wire
Voltmeter scale not sensitive enough	Use a digital voltmeter	
Wires not straight	Method of keeping wire (during experiment) straight e.g. tape to ruler, hang weights off end, clamp wire.	

H. Pulley experiment:

Errors	Improvements	Rejected Answers
Masses hit each other	Use a larger pulley or Lubricate pulley	Friction between pulley and string
Friction at pulley	Method of fixing rule e.g. clamp rule/ electromagnetic with steel /magnetic material ball) release mechanism	
Uncertain starting position		

I. Moment experiment:

Errors	Improvements	Rejected Answers
Rule hits bench	Method of preventing rule hitting bench, e.g. project end of cylinder over the bench or elevate apparatus	Difficult to start at the same amplitude each time
Ruler slips on support	Glue support to block.	

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J. Magnetism experiment:

Errors	Improvements	Rejected Answers
Glass may affect magnetic force / effect of surrounding magnetic materials	Use a variety of materials to separate magnets and test if the material affects results	Reference to Earth's field/Move object further away

K. Bench/Ramp (Surface) related experiment:

<table>
<tr><th>Errors</th><th>Improvements</th><th>Rejected Answers</th></tr>
<tr><td>Some parts of the board rougher than others/ surface of the board is uneven/board not flat</td><td>Method to ensure the same section of the board used in each experiment (e.g. mark one section)</td><td rowspan="2">Board is rough/ there is friction between the block and the board/use a smoother surface/ references to oil/lubricants</td></tr>
<tr><td>Board tends to slip/board not stable/supporting block can topple</td><td>Method described to Secure board/block/ support e.g. clamp the board, fix the supporting blo the bench with tape/blu- -tack</td></tr>
</table>

L. Heat loss experiment:

<table>
<tr><th>Errors</th><th>Improvements</th><th>Rejected Answers</th></tr>
<tr><td>Heat lost through sides and /or Bottom or Low precision of thermometer</td><td>Method to reduce heat loss/lag/insulate/ polystyrene container</td><td rowspan="4">Switch off fans to reduce convection/ Just "weigh water"/ different starting temperatures of water; uneven temperature distribution in the beaker/parallax errors in reading volume or temperature/use of lid/heat loss in warming bowl/cup/draughts/ heat loss to surroundings/ use more accurate thermometer/ thermometer not precise enough/ not just 'digital thermometer'</td></tr>
<tr><td>thermometer is not completely immersed</td><td>Thermometer with specified better precision, e.g. 0.1oC, 0.5oC</td></tr>
<tr><td rowspan="2">Resistor continues to give out heat when switched off/ temperature continues to rise after switching off</td><td>Use a larger volume of water/use of thermocouple /other small temperature sensor(e.g. probe)</td></tr>
<tr><td>Wait until temperature reaches a maximum before reading</td></tr>
</table>

M. Terminal velocity experiment:

Errors	Improvements	Rejected Answers
(Object) may not have reached terminal velocity.	Time constant over three markers	

N. Light-dependent experiment:

Errors	Improvements	Rejected Answers
External light affects (LDR)	Conduct the experiment in a dark room.	

Errors and improvement of common apparatus:

A. Metre rule:

<table>
<tr><th>Errors</th><th>Improvements</th><th>Rejected Answers</th></tr>
<tr><td>Ruler not vertical</td><td rowspan="7">Sensible method to ensure ruler vertical or Put coloured paper behind (object) /Description of method of reducing parallax error requiring additional equipment, e.g. !shadow projection/ extend mark to wood or track / pointer on rule / travelling microscope) or Mount ruler in stand or Clamp rule / ensure rule is vertical using a set square on the bench or Method to improve measurement of d e.g. travelling microscope orUse thinner string or Use rulers of similar thicknesses/ readings/ method to take thickness into account /use rulers of the same length</td><td rowspan="7">View at eye level.</td></tr>
<tr><td>Parallax error</td></tr>
<tr><td>Difficult to hold rule still</td></tr>
<tr><td>Difficult to take measurements because the ruler moves / is not vertical</td></tr>
<tr><td>Reason for difficulty in measuring d e.g. viewed through ruler/parallax error in d</td></tr>
<tr><td>String too wide for markings on rule</td></tr>
<tr><td>Rules have different thicknesses /different lengths so not a fair test</td></tr>
</table>

B. Newton metre:

<table>
<tr><th>Errors</th><th>Improvements</th><th>Rejected Answers</th></tr>
<tr><td>Difficult to pull newton-meter parallel to ruler/ bench</td><td rowspan="3">Method to ensure force is parallel to ruler e.g. use a long string/pulley and weights or Method to read force at detachment e.g. newton meter with a 'max hold' facility/video and playback or freeze frame/ use system of pulley and weights or sand to measure F/ use force sensor and data logger or computer or Improved method to measure F: e.g. use system of pulley and weights or sand/use force sensor with datalogger or computer</td><td rowspan="3">Video to take reading/digital (electronic) newton meter/parallax related to newton meter/difficult to measure force/issue of viewing ruler and meter simultaneously /zero error in newton-meter/ just a pulley</td></tr>
<tr><td>Difficult to judge reading on newton-meter when detaches with reason e.g. ruler moves suddenly/ without warning (so difficult to read newton-meter at the instant the ruler starts to move)/ force drops to zero immediately after detachment</td></tr>
<tr><td>Difficult to zero newton-meter when used horizontally</td></tr>
</table>

C. Slotted mass:

Errors	Improvements	Rejected Answers
Labelled values of mass may not be accurate.	Use balance/method of weighing mass.	Weigh mass.

D. Objects with unfixed diameter (Circular objects):

Errors	Improvements	Rejected Answers
Difficult to measure diameter because (object) is flexible/not circular.	Measure diameter of (object) in two directions and average/ Use vernier calipers or micrometer screw gauge to measure average diameter or Method to make uniform spheres/discs e.g. moulds	
Difficult to form a perfect sphere		
disc/diameter of sphere or disc varied		

E. Protractor:

Errors	Improvements	Rejected Answers
Protractor "wobbles" when being held by hands/ Difficulty in measuring θ owing to container not perfectly right-angled (curved) at the bottom/ difficult to line up protractor/horizontal line of protractor not on table	use protractor with horizontal line flush to table top/freestanding or clamped protractor or use mirror scale	View at right angles
parallax error in θ measurement		
θ (or reading) is difficult (or inaccurate, or imprecise) because pointer is thick		

GENERAL TIPS FOR ERRORS & IMPROVEMENTS

If the value of the quantity measured is very small, can write increase the magnitude of the quantity of the independent variable.

Credit is not given for suggestions that should be carried out anyway, such as repeating measurements and calculating average or avoiding parallax errors by looking at an instrument "square on". Ask yourself whether the improvement is practical or not.

Common answers that are rejected by mark scheme : Repeat experiment, Human error, Use a computer to improve the experiment, Use assistant, If clay/plasticine/heavy object is used in the experiment, wind movement doesn't affect it anymore.(Think whether turning off fan will make a difference or not).