Raffles Institution
Physics Department

Physics Practical
Final Revision Notes

Raffles Institution
Physics Department

H2 Physics 9749/ Paper 4 (Practical)

The following revision notes apply to Prelim and A-Level Practical.

Format of paper:

Paper number	Total duration	Weighting (%)	Marks
Paper 4	2 hr 30 min	20	55

A-Level format **for reference** :

- 1st hour : either 1 long or 2 short experiments
- 2nd hour: change over to the other experiment/s
- Last ½ hour : Planning question (**cannot touch apparatus during this last 30 min or you will be penalised !**)

In 2021 : The short questions were Q1 [10 marks] and Q2 [11 marks].
The long question was Q3 [22 marks].
The planning question was Q4 [12 marks].

In 2022 : The short questions were Q1 [12 marks] and Q2 [9 marks].
The long question was Q3 [22 marks].
The planning question was Q4 [12 marks].

Note that the number of experiments (long and short) for this year's A-Level may or may not be the same as previous years.
What is definite is that the last ½ hour is set aside for 1 standard Planning question and you are not allowed to touch the apparatus during that time. (There may also be a short planning question as part of the hands-on experiment, besides the 30 min standard planning question.)

Things to bring :

1. NRIC (or Foreign Identification document).
2. Entry proof (for A-level).
3. Blue/black pen and sharp pencil, eraser.
4. 30 cm long plastic rule and Flex curve.
5. Mathematical set (including protractor, pair of compasses, set-square). Remove the instruction sheet inside the mathematical set.
6. Calculator (with extra batteries), extra calculator if possible (if using graphic calculator – learn how to clear memory!). Check SEAB Website for approved calculators list.
7. Light snacks and drinks (may consume during *holding periods* for shifts 1 and 3). Water bottles must **not** be brought into the laboratories.
8. Revision notes (optional, to revise while in holding venue).
9. Sweater (optional, to be used in holding venue).

Things to note :

1. Handphones (or other communication devices, e.g. smart watches) must **not** be brought into holding venues and exam venues. Leave all valuables in the lockers before reporting for your attendance at the reporting venue.
2. Listen to instructions from invigilators – do not write or touch apparatus if no instructions are given (including writing of name).

   Do not continue to write when told that time is up (including writing of names, e.t.c. Request for permission first).

   This includes the change-over time, when a couple of minutes are given to check apparatus. You are **not** to do any writing during this period of time.
3. There should be no communication with friends, hand-shakes, "high-five" e.t.c., and do not borrow stationery, or ask friends to help clear memory of your graphic calculators.
4. Monitor the time, do not take too much time taking readings.
5. Scan through the whole question first and ensure you have taken readings for every part within the hour. After that you will not have access to the apparatus anymore and so it could mean you cannot complete your report.
6. If you suspect instruments are faulty, raise your hand and request for help. There will be no deduction of marks if the instruments are faulty.
7. If you are unable to proceed with the experiment, you may raise your hand and request for help. Assistance rendered will have to be reported and marks may, or may not, be deducted. However, this is better than not being able to get any readings to complete the report or submitting a blank report.
8. When you do ask for help with the set-up, be specific in your request so that you are not overly helped or under helped as all help must be reported which may have implications on your marks.

   For e.g. instead of saying 'I don't know what's wrong with my set-up',

   say 'I am not able to get any readings on my DMM' or 'I am unable to take readings because the plasticine keeps slipping off the wire'.

9. There may be an announcement of "*The Examiners do not want you to waste time through inability to proceed with the experiment. Any candidate, who is unable to get on with the experiment after spending 15 minutes on it, may ask for help. The extent of this help will be reported to the Examiners, who may make a deduction of marks.*"

   Note that if you have difficulty, you do not need to wait for 15 minutes. You may request for help anytime. However do note that help rendered will be recorded and reported to the Examiners.
10. Your answer script is with you for the whole 2.5 hours. You may work on **any** of the questions at any time or start on the planning question if you have time during the first 2 hours (during the time you are allowed to write, refer to point 2 in this section).
11. Refrain from discussing the practical after it is over. Just be glad that you have done your best :)

Practical and Recording skills : Important Reminders

1. Practice tying of knots!
2. You are advised not to use correction fluid. Just cancel neatly and write again.
3. Record in blue/black ink for all readings and workings.
4. Use pencil for graph work and drawing of table outline (to record readings).
5. Uncertainty in a measurement : normally more than the least count of instrument, depending on the nature of the experiment.

   The uncertainty may also be estimated using $\Delta x = \frac{x_{max} - x_{min}}{2}$.

   Quote the larger value of the two approaches.

   Be mindful of the possible sources of uncertainty when doing the experiment.
6. % uncertainty: 1 or 2 s.f.
7. absolute uncertainty: 1 s.f.
8. s.f. : quote to least s.f. of raw data in calculations. Sometimes in the tabulation, you may add one more s.f. consistently in that column when the readings are too similar to one another.
9. Repeat readings – take multiple readings and find average for measurements that may not be uniform or cannot be measured precisely due to random errors (e.g. diameter of a wire, timing of oscillations e.t.c). If unsure, just repeat them without compromising the time to complete the experiment.
10. Number of oscillations for oscillatory experiments – the time for *N* oscillations should be at least 20 s. For cases when the oscillations die off before 20 s, repeat to obtain 3 sets of readings instead of 2 sets (without compromising the time to complete experiment).
11. Mass of mass hanger is usually 50 g – the value is normally printed on the hanger itself.
12. If vernier calipers or micrometer screw-gauge is used, state the value of the zero error (even if it is zero), the reading from the instrument and the corrected value.
13. Column headings in the tabulation and recording of all quantities must include units.
14. For straight line, at least 6 readings. If non-linear: at least 8 readings (take more around turning point).
15. For tabulation of values, remember to include the first set of reading (which is taken prior to tabulation).
16. After calculation of constants, the values of the constants must include units (if any).
17. Analysis of graph (e.g. gradient and intercept) must be based on Best-fit line (BFL), and not on the plotted points (as plotted points may not lie on BFL). If point lies on BFL, the reading of that point should still be based on ½ smallest square precision and not on precision of tabulated value.

Precision of common instruments (decimal places):

Meter rule	1 d.p. in cm; 3 d.p. in m
Vernier calipers	for some models 2 d.p. in cm (or refer to precision printed on instrument)
Micrometer screwgauge	for some models 3 d.p. in cm (equivalent to 2 d.p. in mm) (or refer to precision printed on instrument)
Stop-watch	2 d.p. in seconds
Digital multimeter	record the number of d.p. reflected on the screen (may need to adjust setting to achieve greater precision)
Thermometer	½ smallest division
Protractor	1 degree
Measuring cylinder	½ smallest division

Graphing skills

1. Scales must be 1:1, 1:2 or 1:5. (in some cases, 1:4 may be accepted).
2. Graph can be in portrait or landscape orientation (choose an orientation such as to maximise your scale). 1st and last points must cover at least ½ of graph paper horizontally and vertically. You may use a ruler to check, e.g. horizontally, if the graph is 16 cm, your 1st and last point should therefore be at least 8 cm.
3. Gradient triangle must be at least ½ the size of the BFL. Write the coordinates (read to ½ smallest square precision) of the gradient triangle drawn.
4. Axes must be labelled with units.
5. Points must be plotted to ½ smallest square precision.
6. All readings recorded must be plotted.
7. BFL should balance number of points on both sides, as far as possible (evenly scattered).
8. Do not always assume it is a straight line. Trend may be a curve.
9. **Hint** that it is a straight line includes question with equation given and the need to manipulate it in order to draw a straight line so that gradient of the graph can be found (or could be implied if a constant needs to be calculated from the gradient).
10. **Hint** that it is a curve includes question asking you to find gradient of a tangent at a particular point.

Anomaly and Improvement discussions

1. **Anomaly :** must identify anomalous point on graph – **circle the point and label "anomaly"**

2. **Discussion on anomaly :**
   Since all the points lie on or close to the best-fit line, there is no anomalous data.
   OR
   There is an anomalous data as it lies far from the best-fit line compared to the other points.
   OR
   While there is some scatter of points, they generally follow a linear trend, hence there is no anomaly.

3. **Question on whether your results support hypothesis (relationship):**
   You may need to calculate percentage difference and compare the value to the percentage uncertainty of an earlier calculated quantity to draw your conclusion. Use

$$\%\ \text{error in } k = \frac{k_2 - k_{avg}}{k_{avg}} \times 100\ \%\ \text{ or } \frac{k_{avg} - k_1}{k_{avg}} \times 100\ \%\ \text{ or } \frac{1}{2}\left(\frac{k_2 - k_1}{k_{avg}}\right) \times 100\ \%$$

4. **Sources of significant errors and improvements:**

   Sources of errors can arise from measuring instruments or experimental techniques.
   For errors arising from measuring instruments, propose more precise instruments.
   For errors arising from experimental techniques, propose alternative approach.
   Need to mention which measured quantity the error affects.

   Improvements may involve use of other commonly found laboratory apparatus.
   Improvements should not be procedures of good practices already given in the question or expected in the experiment.

   Please refer to sample solution of practical sessions that we have done in Y5 and Y6.

Planning question

Note : Looking at the trend of the past few years, there seems to have a "mini" planning question as part of the "hands-on" experiment. For such "mini-planning", which could be say 4 or 5 marks, focus on the points stated in the question and NOT the full format of the long planning question.

The following format is for the Full Planning Question (normally 11 or 12 marks)

(a) Diagram:

- Draw **clearly labelled** 2D diagram(s) – top and/or side view - that show the relative positions of the apparatus in workable arrangements. As much as possible, the labelling should include the quantities to be measured (e.g. distances).
- All apparatus should be supported by clamps and stands, and be laid on the table top (draw line for table top). They should not be hanging in the air.
- Apparatus which are in danger of toppling (such as motor, pulley, retort stands) must be firmly clamped to the workbench.
- Conventional circuit symbols must be used for circuit diagrams.
- You may use some or all of the apparatus suggested in the question, as well as any other equipment usually found in a Physics laboratory.
- If data-loggers are used, details like the type of sensors used, data collected and interpretation of graphs/data must be included in the procedure.

(b) Defining the problem

- Identify the independent and the dependent variables. (There may be more than one independent variable).
- Identify those variables that must be controlled (these variables must be relevant to the experiment, and not trivial discussions like perform in same lab, etc).
- All variables should be quantifiable.

(c) Methods of data collection (to be included in the procedure)

Describe

- how the independent variable is to be varied
- how the independent and the dependent variables are measured (with reference to instruments used for measurements)
- how the other variables are controlled
- Be clear which steps to repeat and state how may sets of readings to be taken.

(d) Method of analysis

Case 1: If relationship is given or known:

Linearise the equation and explain how unknown constants or relationship can be determined from the equation or graph.

E.g. $s = v\,t$
Plot a graph of s against t.
The speed v can be obtained from the gradient of the graph.

Case 2: If relationship is NOT given and NOT known.

Assume $y = k\,x^n$ where k and n are constants.
Linearise the equation and explain how unknown constants or relationship can be determined from the equation or graph.

E.g. $y = k\,x^n$ where k and n are constants.
$\lg y = \lg k + n \lg x$
Plot a graph of $\lg y$ against $\lg x$. Gradient $= n$ and vertical-intercept $c = \lg k$, hence $k = 10^c$.

(e) Safety Precautions

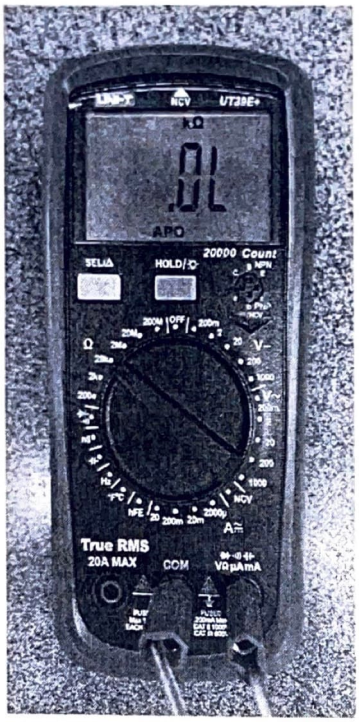
- State reasonable hazards that are specific to the experiment **AND** how to avoid them, even if question did not ask.
- State actions to be taken, **NOT** actions to avoid.
  (e.g. "wear glove to handle hot beaker", **NOT** "do not handle beaker with bare hands").
- Rationale must be given for the steps taken.
- Hazards can be due to apparatus (e.g. high-voltage supply), material (e.g. mercury) or procedures (e.g. oscillation of a heavy mass).

(f) Additional Details (for reliability or accuracy)

Include details which improve the reliability (i.e. accuracy and precision) of the results, even if the question did not explicitly ask for them. These may include:

- crucial arrangement of apparatus,
- steps to reduce/eliminate sources or error,
- proper use and calibration of equipment.
- preliminary readings to obtain suitable range for measurements.

DMM settings



This message on the display may indicate the setting is inappropriate.

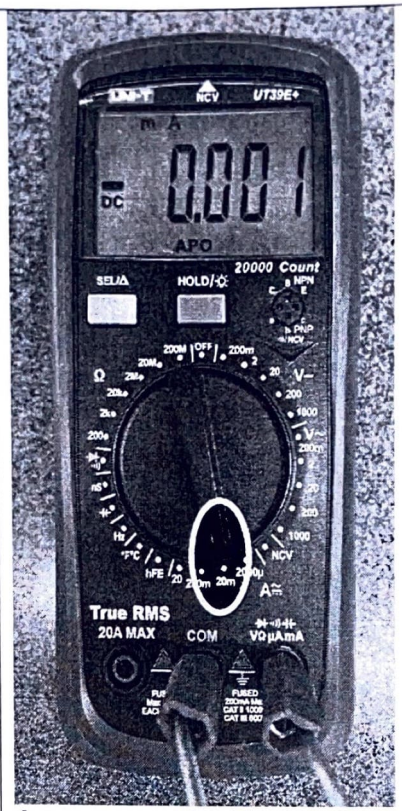
- Use a setting that maximise precision (i.e. most number of d.p. displayed).
- Try to maintain the same setting for the whole range of readings taken.
- Common questions from students :
    - "APO" displayed on screen: means Auto Power Off. **Press the yellow button** to turn on display again if it goes to off.
    - Battery symbol on top of screen : DMM's battery is weak – request for a new one
    - "exceeded" error message (".0L") : change DMM setting
      Note that this message (".0L") is shown when the Ohmmeter is not connected to any component, it is not an error.
    - Negative values displayed : swop the two connecting leads position, or ignore the negative sign.
    - "H" button displayed on screen. Release the "holding" value by pressing the HOLD button.

Note:

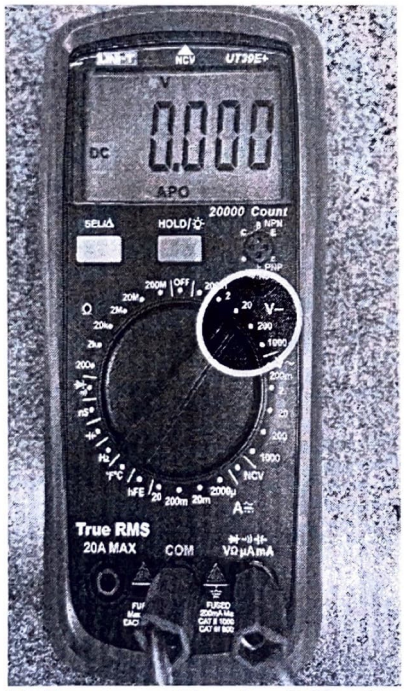
- If the dial is taped up or covered with a paper sleeve, do not remove the tape or sleeve.
- If any of the sockets at the bottom of the DMM is covered with tape, do not remove the tape.

Examples of DMM Settings :

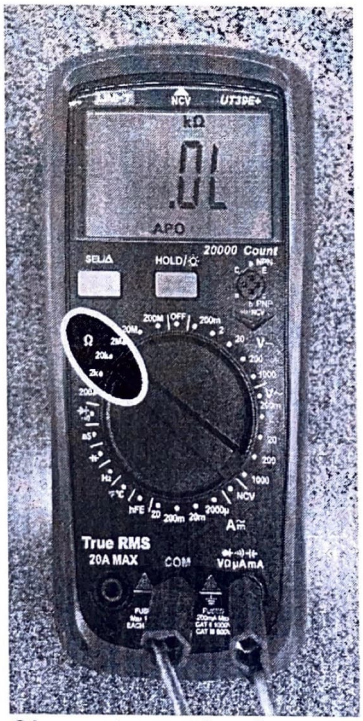
Ammeter setting for large current
Rotary switch at 20
Plug at COM and 20A



Ammeter setting for small current
Rotary switch at 200μ / 20m / 200m
Plug at COM and VΩμAmA



Voltmeter setting for DC voltage
Rotary switch at DC V
Plug at COM and VΩμAmA



Ohmmeter setting for resistance
Rotary switch at Ω
Plug at COM and VΩμAmA