H2 Physics (Practical)

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Contents

§1 Format

Total duration: 2 h 30 mins

Total marks: 55 marks

Component	Time	Marks
2 short experiments	1 h	20-23
1 long experiment (including mini planning)	1 h	20-23
Planning	0.5 h	12

§1.1 Experiments

Strategy

1. Linearise expression
2. Collect data (quantitative questions: refer to section 2)
3. Answer all other questions (qualitative questions: refer to section 3)

> **Remark.** Do not be bothered by accuracy (whether data collected is correct or not) when doing experiment; accuracy is only one mark.

Always take note of

- d.p. / s.f.
- units
- presentation of work
  Define any undefined variables e.g. "let t be ..."

Mini planning: refer to section 4.

§1.2 Planning

Long planning: refer to section 4.

§2 Quantitative Questions

§2.1 Decimal places and significant figures

Decimal places are henceforth known as "d.p.", significant figures as "s.f.".

- Addition and subtraction: follow least d.p.
- Multiplication and division: follow least s.f.
- Percentage uncertainty: 2 s.f.
- Logarithm: # d.p. = # s.f. of raw data

For recording d.p. of instruments, refer to appendix A.

§2.2 Measure and record

1. Explicitly state what you are measuring and/or number of measurements.
2. Show evidence of repeated measurements

> **Example.** Let t be time taken for 20 oscillations.
>
> $$\begin{aligned} t_1 &= 50.4 \text{ s} \\ t_2 &= 49.4 \text{ s} \\ t_{\text{avg}} &= \frac{50.4 + 49.4}{2} = 49.9 \text{ s} \\ T &= \frac{49.9}{20} = 2.50 \text{ s} \end{aligned}$$
>
> **Remark.** s.f. of T follows s.f. of t_{avg}.

§2.3 Estimate percentage uncertainty

Use minimum $2 \times \Delta R$ for actual uncertainty:

$$\% \text{ uncertainty} = \frac{2\Delta R}{R} \times 100\%$$

§2.4 Table for recording readings

Presentation:

- Solidus notation (symbol + notation) to denote physical quantities.
- Header in the order of experiment, record raw data followed by calculated values.
- Follow d.p. for raw data, s.f. for calculated values.
- Correct number of data sets: minimum 6 for straight line, 8 for curve.

Format of table:

n	t_1/s	t_2/s	t_{avg}/s	T/s	$\sqrt{n}$
6	20.0	20.2	20.1	1.05	2.45
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$

§2.5 Graph

§2.5.1 Linearising

1. Manipulate the given equation such that the independent variable is on one side, the dependent variable on the other side.
2. The "golden" statement:

   Plot Y against X. If the relationship is valid, a straight line graph with gradient P, y-intercept Q will be obtained.

§2.5.2 Graph plotting

1. **Scale**

   No odd scale; the acceptable ratios of big squares to small squares are only **1:1, 1:2, 1:5**.

   Label all bold lines (do not skip any).

   Plotted points must take up at least half of the space.

   Do not mark non-data points with 'x', use circular dot instead.
2. **Line**

   Line of best fit, (roughly) equal number of points on both sides.
3. **Points**

   Points plotted to half the smallest square.

   Circle and label any anomalies (max 1 allowed).

§2.5.3 Gradient and y-intercept

Gradient: when substituting values, read off d.p. to half the smallest square. E.g. if one big square is 0.50, then 0.50/20=0.025 so record to 3 d.p.

y-intercept: use gradient coordinates for substitution (NOT values from data collected!)

Remember units for both

When calculating, do +/- first (follow least d.p.), then times/divide (follow least s.f.)

§2.6 Calculations

Show all steps of working, d.p. and s.f.

Do not use intermediate values, just use final answers

§3 Qualitative Questions

- **Support suggested relationship**

  1. My measurements do (do not) support the relationship because
  2. % difference is smaller (larger) than % uncertainty.

  $$\% \text{ difference} = \left| \frac{x_1 - x_2}{(x_1 + x_2)/2} \right| \times 100\%$$

  (Percentage uncertainty would have already been calculated in an earlier question.)

- **Point agrees with pattern**

  (If plot this point, is it considered anomalous?)

  1. Since point X is close to (far from) the best fit line, it agrees (does not agree) with the pattern of the other points.
  2. Show that $\Delta l_1 \leq \Delta l_2$ ($\Delta l_1 > \Delta l_2$)
     For a value l on the best fit line, there is an error bar of $\pm\Delta l$.

  $$\Delta l = \frac{l_{\text{max}} - l_{\text{min}}}{2}$$

  l_{max} and l_{min} can be found from data points collected during experiment.

- **Source of error + improvement**

  > **Example** (Falling paper helicopter)**.**
  > Significant source of error:
  >
  > 1. Time of fall too short, making % uncertainty of t very large.
  > 2. Difficult to start and stop timing at the precise position (moving too fast), making the values of t and h unreliable.
  >
  > Improvement:
  >
  > 1. Allow helicopter to fall through greater height to increase duration of fall.
  > 2. Use helicopters of <u>wider</u> blades so that force due to air resistance is greater, increase duration of fall.
  > 3. Use <u>light gates and electronic timer</u> to detect the fall of the helicopter to have more precision in timing of the fall.
  > 4. <u>High speed video recording</u> to track the motion to get more precise timing of fall.

- **Comment on value obtained**

  1. The value is correct / wrong.
  2. (How it affects graph)

- **Comment on trend**

  Specify 1) direction 2) linear/non-linear.

  > **Example.** Value of t <u>increases</u> <u>non-linearly</u> with value of x.

- **Choose same value of x to be used throughout**

  Largest value of x has lowest % uncertainty.

  > **Example.** At $x = 20.0$ cm, values of t are the largest, thus % uncertainty of t will be the smallest (least error).

- **Justify number of s.f.**

Example. $k = ty$

1. (list out all precisions of variables used in calculation) y recorded to 2 s.f., t recorded to 3 s.f.
2. (type of operation) k is product of y and t.
3. Record to least s.f. based on those of y and t.

§4 Planning

Format

1. **Diagram**
   - Big, clear, well-labelled, 2D
   - Show relative positions of apparatus, include lab bench, retort stand (to ensure apparatus are not floating in the air)

2. **Objective**

   To investigate how (dependent variable) varies with (independent variable)

   - **Independent** variable
   - **Dependent** variable
   - **Controlled** variables - ensure same throughout experiment

   For each type of variable,

   - *direct* measurement: state what (physical quantity) you measure and the apparatus you use.
   - *indirect* measurement: state what (physical quantity) you want to determine and describe how (the physical quantities to be measured; apparatus, techniques and equations used; illustrate if necessary).

3. **Procedure**

   (a) Set up the apparatus as shown in Fig. 1.

   (b) [clearly describe procedure to determine dependent variable]

   (c) Repeat steps xxx to xxx by [describe method] of varying [independent variable; give range of values] to obtain xxx sets of readings.

   Measure physical quantities

   - Measuring instruments, operating procedures
   - Pros and cons in each measuring instrument e.g. which measuring instrument is most suitable in terms of resolution and range

4. **Analysis**

   Mini planning (1 independent variable)

   (a) Given (or assume) that $y = kx^n$,

   (b) Taking log on both sides, $\log y = n \log x + \log k$.

   (c) Plot graph of $\log y$ against $\log x$.

   (d) If the relationship $y = kx^n$ is true, straight-line graph will be obtained where gradient equals to n, y-intercept equals to $\log k$.

   Long planning (2 independent variables)

   (a) Experiment 1 (vary p): Given (or assume) that $y = kp^m q^n$, taking log on both sides, $\log y = m \log p + n \log q + \log k$. Plot graph of $\log y$ against $\log p$. If the relationship $y = kp^m q^n$ is true, straight-line graph will be obtained where gradient equals to m, y-intercept equals to $\log kq^n$.

   (b) Experiment 2 (vary q): Plot graph of $\log y$ against $\log q$. If the relationship $y = kp^m q^n$ is true, straight-line graph will be obtained where gradient equals to n, y-intercept equals to $\log kp^m$.

   > **Remark.** Show full linearisation steps.

5. **Safety precautions**

   How to prevent injuries/accidents

   Pressure:

   - Use safety screens in case of implosion/explosion.

- Container must be strong enough to withstand high pressure.
- Water flow rate should not be too high to avoid water from splashing on the floor, as a wet floor might cause slipping.
- e.g. safety googles can be worn to protect eyes in case a piece of something breaks off during experiment.

Sound:

- Wear ear plugs to protect against loud sound.
- Switch on sound source only for short period of time to protect against loud sound.

Electricity:

- Switch off power supply between readings to avoid overheating of apparatus.
- When handling high voltage, wear rubber gloves to avoid electric shock.
- To minimise risk from high current, connect rheostat/protective resistor in series.
- Prevent electrical circuit from coming into contact with water to prevent short circuit.

Light:

- To minimise ambient light, perform experiment in dark room OR black coloured container large enough to house apparatus.
- Do not look into bright light source / wear dark glasses to protect eyes.
- Do not touch hot light source.

Mechanics:

- Heavy mass clamped to retort stand: use G-clamp to secure retort stand / place weights/bricks on base of retort stand.
- Falling mass: keep well away, use sand trays to catch falling object.

Magnetic field:

- Switch off hall probe when not in use to avoid overheating coil.
- Do not touch coil because it is hot.

Heat:

- Use gloves/tongs when handling hot container.
- Wait to cool down.

Radioactivity:

- Use forceps or tongs when handling source, to avoid contact with radioactive material.
- Do not point the source at people / do not look directly at source.
- Store source in lead-lined box when not in use.

6. **Improve accuracy/reliability**

   Potential significant systematic & random error + apparatus/method to eliminate/reduce

   - e.g. heat loss + use jacket
   - e.g. % uncertainty + reduce by using larger volume of water / larger time / larger distance, average more

§A Common Apparatus

Instrument	**Resolution**	**Used for measurement of**
Metre rule	0.1 cm	height/length of object
Half metre rule	0.1 cm	height/length of object
30-cm rule	0.1 cm	height/length of object
Measuring tape	0.1 cm	long distances
Vernier caliper	0.01 cm	Outer jaws: coins or rod Inner jaws: interior of hollow pipe Depth rod (tail): holes or steps
Micrometer	0.01 mm	diameter of ball bearings, thickness of wires
Travelling microscope	0.01 mm	short lengths that cannot be measured by micrometer e.g. holes, indents, writings, biological specimens
Stopwatch	0.01 s (record to 0.1 s)	experiments in which human reaction time (0.3 s) has low percentage uncertainty e.g. 20 oscillations
High speed camera on a tripod	1 μs	experiments in which human reaction time has high percentage uncertainty
Electronic balance / weighing machine	0.001 g	mass
Spring balance	depends	small (tensional) forces between 1 N and 30 N
Strain gauge	depends	relatively large forces
Measuring cylinder	depends	volume of liquid
Barometer	depends	atmospheric pressure
Nanometer	depends	pressure near atmospheric pressure
Pressure gauge	depends	gauge pressure (difference between absolute gas pressure and atm pressure)
Mercury-in-glass thermometer	depends	temperature of liquid between −10°C and 110°C, room temperature, body temperature
Thermocouple	depends	temperature range between −200°C and 1300°C
Digital multi-meter	based on setting	all purpose
Voltmeter	depends	e.m.f./p.d.
Ammeter	depends	current
Cathode ray oscilloscope (c.r.o.)	depends	<u>period</u> of sound wave by connecting c.r.o. to microphone
Photometer / light sensor connected to data logger	depends	<u>intensity</u> of incident UV, visible, infrared
Stroboscope	depends	<u>frequency</u> of oscillating object, typically a stationary mechanical wave formed by transverse waves
Diffraction grating	depends on $1/d$, usually number of lines per mm	(indirect) measurement of frequency of visible light (use $d\sin\theta = n\lambda$, $c = f\lambda$, and small angle approx $x/D \approx \tan\theta \approx \sin\theta$)
Gaussmeter connected to hall probe	depends	magnetic flux density [use of current balance is too complicated to describe]
Geiger counter	depends	ionising radiation (in counts per minute)

§B Common Experiments

Mechanics

Thermal physics

Electricity

Waves

Oscillations

Magnetism

Nuclear physics