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Mark Scheme (Results)

January 2014

IAL Physics (WPH06/01)

Unit 6: Experimental Physics

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:

- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Mark Scheme Notes

Underlying Principle

The mark scheme will clearly indicate the concept that is being rewarded, backed up by examples. It is not a set of model answers.

For example:

(iii)	Horizontal force of hinge on table top 66.3 (N) or 66 (N) and correct indication of direction [no ue] [Some examples of direction: acting from right (to left) / to the left / West / opposite direction to horizontal. May show direction by arrow. Do not accept a minus sign in front of number as direction.]	✓	1

This has a clear statement of the principle for awarding the mark, supported by some examples illustrating acceptable boundaries.

1. Mark scheme format
   - 1.1 You will not see 'wtte' (words to that effect). Alternative correct wording should be credited in every answer unless the ms has specified specific words that must be present. Such words will be indicated by underlining e.g. 'resonance'
   - 1.2 Bold lower case will be used for emphasis.
   - 1.3 Round brackets ( ) indicate words that are not essential e.g. "(hence) distance is increased".
   - 1.4 Square brackets [ ] indicate advice to examiners or examples e.g. [Do not accept gravity] [ecf].

2. Unit error penalties
   - 2.1 A separate mark is not usually given for a unit but a missing or incorrect unit will normally mean that the final calculation mark will not be awarded.
   - 2.2 Incorrect use of case e.g. 'Watt' or 'w' will not be penalised.
   - 2.3 There will be no unit penalty applied in 'show that' questions or in any other question where the units to be used have been given, for example in a spreadsheet.
   - 2.4 The same missing or incorrect unit will not be penalised more than once within one question (one clip in epen).
   - 2.5 Occasionally, it may be decided not to penalise a missing or incorrect unit e.g. the candidate may be calculating the gradient of a graph, resulting in a unit that is not one that should be known and is complex.
   - 2.6 The mark scheme will indicate if no unit error penalty is to be applied by means of [no ue].

3. Significant figures
   - 3.1 Use of an inappropriate number of significant figures in the theory papers will normally only be penalised in 'show that' questions where use of too few significant figures has resulted in the candidate not demonstrating the validity of the given answer.
   - 3.2 The use of g = 10 m s^{-2} or 10 N kg^{-1} instead of 9.81 m s^{-2} or 9.81 N kg^{-1} will be penalised by one mark (but not more than once per clip). Accept 9.8 m s^{-2} or 9.8 N kg^{-1}

4. Calculations
   - 4.1 Bald (i.e. no working shown) correct answers score full marks unless in a 'show that' question.
   - 4.2 If a 'show that' question is worth 2 marks then both marks will be available for a reverse working; if it is worth 3 marks then only 2 will be available.
   - 4.3 use of the formula means that the candidate demonstrates substitution of physically correct values, although there may be conversion errors e.g. power of 10 error.
   - 4.4 recall of the correct formula will be awarded when the formula is seen or implied by substitution.
   - 4.5 The mark scheme will show a correctly worked answer for illustration only.
   - 4.6 Example of mark scheme for a calculation:

     'Show that' calculation of weight

     Use of L × W × H ✓

     Substitution into density equation with a volume and density ✓

     Correct answer [49.4 (N)] to at least 3 sig fig. [No ue] ✓
     [If 5040 g rounded to 5000 g or 5 kg, do not give 3rd mark; if conversion to kg is omitted and then answer fudged, do not give 3rd mark] 3
     [Bald answer scores 0, reverse calculation 2/3]

     Example of answer:

     80 cm × 50 cm × 1.8 cm = 7200 cm^3

     7200 cm^3 × 0.70 g cm^{-3} = 5040 g

     5040 × 10^{-3} kg × 9.81 N/kg

     = 49.4 N

5. Quality of Written Communication
   - 5.1 Indicated by QoWC in mark scheme. QWC – Work must be clear and organised in a logical manner using technical wording where appropriate.
   - 5.2 Usually it is part of a max mark, the final mark not being awarded unless the QoWC condition has been satisfied.

6. Graphs
   - 6.1 A mark given for axes requires both axes to be labelled with quantities and units, and drawn the correct way round.
   - 6.2 Sometimes a separate mark will be given for units or for each axis if the units are complex. This will be indicated on the mark scheme.
   - 6.3 A mark given for choosing a scale requires that the chosen scale allows all points to be plotted, spreads plotted points over more than half of each axis and is not an awkward scale e.g. multiples of 3, 7 etc.
   - 6.4 Points should be plotted to within 1 mm.
     - Check the two points furthest from the best line. If both OK award mark.
     - If either is 2 mm out do not award mark.
     - If both are 1 mm out do not award mark.
     - If either is 1 mm out then check another two and award mark if both of these OK, otherwise no mark.

For a line mark there must be a thin continuous line which is the best-fit line for the candidate's results.

Question Number	Answer		Mark
1(a) (i)	Check for <u>zero</u> error **Or** avoid squashing the string [Accept any relevant practical good physics answer]	(1)	**1**
1(a) (ii)	Correct substitution and calculation With 3 or 4 SF and unit (74.96 mm or 75.0 mm) <u>Example of calculation</u> $C = (803/10) - \pi \times 1.70 = 74.96$ mm	(1) (1)	**2**
1(a) (iii)	Percentage uncertainty is the same **Or** original uncertainty divided by number of repeats **Or** U in $x/10$ is $4/10 = 0.4$ mm (need more than $4/10 = 0.4$ mm) <u>Example of calculation</u> U in x is 4 mm, U in $x/10$ is $4/10 = 0.4$ mm	(1)	**1**
1(a) (iv)	0.126 (mm) (minimum of 3 sig figs) <u>Example of calculation</u> $\Delta d \times \pi = .04 \times \pi = 0.126$ mm	(1)	**1**
1(a) (v)	Quantities in original equation are subtracted (not multiplied), **Or** calculation to find max and min [Do not allow 0.4 + 0.13 without explanation] <u>Example of calculation</u> $x/10 = 80.3 \pm 0.4$ mm $\quad \pi d = 5.34 \pm 0.13$ mm $75.49 > C > 74.43$ so $C = 74.96 \pm 0.53$ mm Same as 0.4 + 0.13	(1)	**1**
1(a) (vi)	Candidate's uncertainty in C (v) divided by their value of C (ii) [Need not see '%'] <u>Example of calculation</u> $\%U = (0.53/74.96) \times 100\% = 0.7\%$ [Do not allow 1%]	(1)	**1**

1(b) (i)	447.1 mm^2 with 3 or 4 SF and unit – ecf on their value for *C* (*C* =75.0 mm → 447.6 mm^2) Example of calculation $A = (74.96)^2/4\pi = 447.1\ mm^2$	(1)	**1**
1(b) (ii)	Double their value in (a) (vi) Example of calculation $2 \times 0.7\% = 1.4\%$	(1)	**1**
1(c) (i)	Precision (much) less than measurement **Or** small percentage uncertainty (can be by calculation) **Or** reference to measurement of circular object	(1)	**1**
1(c) (ii)	divides half range or full range by the mean Multiplies answer by 2 and expresses as percentage (half range → 0.4% full range → 0.8% (if whole range used but not doubled gives 0.4% MP1 only) Example of calculation $\%U = (0.05/23.91) \times 2 \times 100\% = 0.4\%$	(1) (1)	**2**
	Total for Question 1		**12**

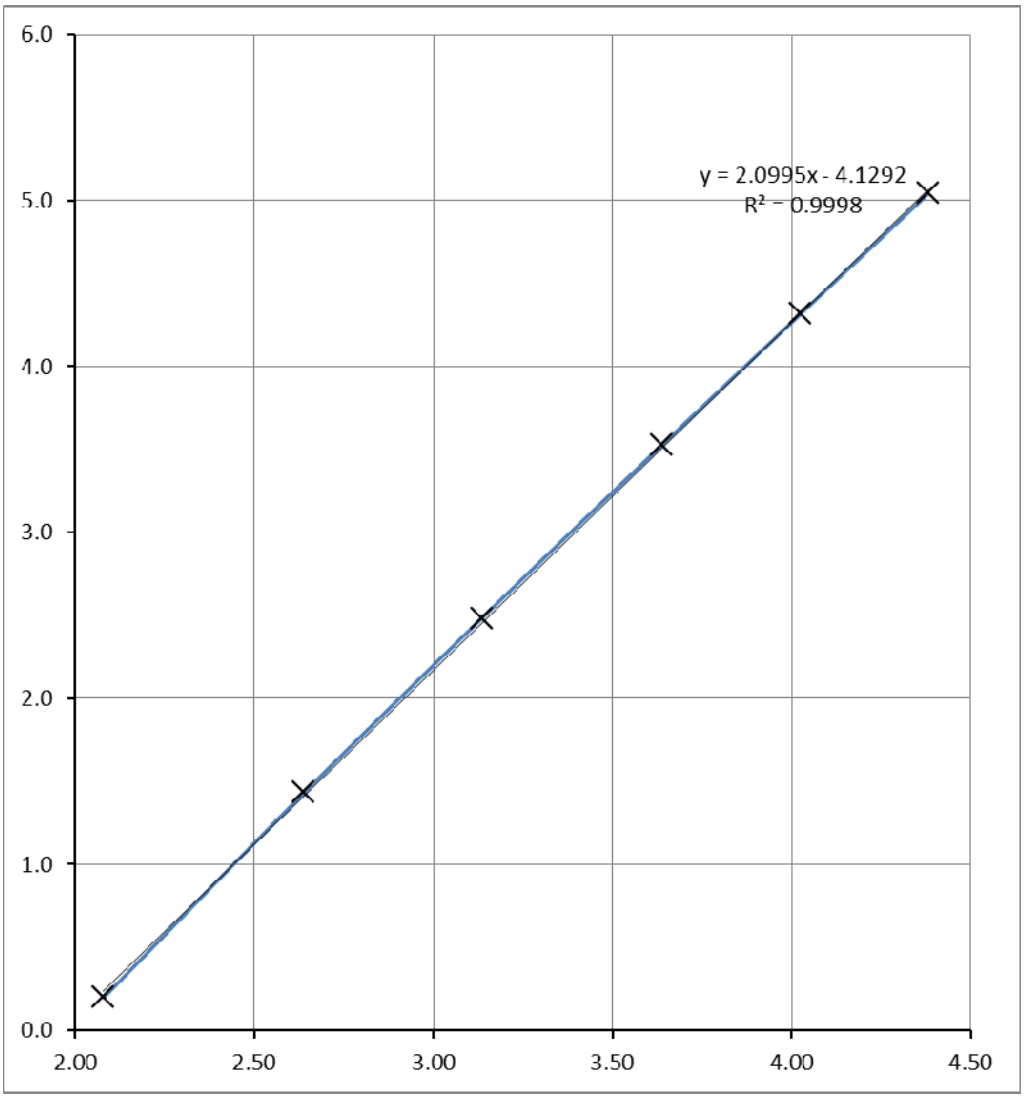
Question Number	Answer		Mark
2	**This question must be marked holistically and in the context of the experiment described** a) Measurements: mass of screw **and** mass of water original temp (of water) **and** final temp (of water) [do not allow temperature change] b) Technique: Any **one** Avoid spilling water from test tube Transfer screw quickly Stir water **and** take highest temperature Read thermometer with eye close to and level with scale Repeat **and** average c) Error: Any **two** Thermal energy transferred from screw to surroundings Energy gained by tube Screw not at hottest temp of flame Steam produced when screw dropped in [Do not allow thermal energy lost by water nor energy lost to surroundings] d) %U: Rise in temp of water [allow $\Delta\theta$] since U is approximately 1° **and** rise will be small (single figures) e) Safety: Hazard and precaution e.g. goggles to avoid splashes don't touch screw, danger of burns take care with naked flames, danger of burns	(1) (1) (1) (2) (1) (1) (1)	**8**
	Total for Question 2		**8**

Question Number	Answer		Mark
3(a) (i)	Line of Best Fit has a definite minimum Line smooth, thin with minimum value in range 0.26 – 0.30 [line should pass through 4 plots – 2 on either side of minimum] [straight lines score zero]	(1) (1)	**2**
3(a) (ii)	Values of h and T from **their** curve within 1 small square to at least 3 sf, no units required. [allow readings from where their straight line crosses edge of grid]	(1)	**1**
3(b)	Plot $T^2 h$ against h^2 (do not allow log graph) C is intercept on $T^2 h$ axis (allow y-axis or vertical axis if first mark awarded) **or** value of $T^2 h$ when h^2 is zero (dependent mark) m s^2	(1) (1) (1)	**3**
	Total for Question 3		**6**

Question Number	Answer		Mark
4(a)	**Max 2** Energy has specific values **or** specific difference between levels Electrons move down between levels $E_1 - E_2 = hf$	 (1) (1) (1)	 **Max 2**
4(b)	$\ln f = n \ln Z + \ln P$ is similar to y = mx + c (comparison need not be direct) Graph will be straight because n is a constant.	 (1) (1)	 **2**
4(c) (i)	Logarithm values correct to 3 or 4 SF (ignore SF for first value) Axes & labels [check for transcription errors] Scales and plots Line of best fit (joining top and bottom plots loses mark)	 (1) (1) (1) (1)	 **4**
4(c) (ii)	Large triangle – both sides half the plotted lengths $2.05 < n < 2.15$ **and** no unit **and** triangle used to calculate value for n <u>Example of calculation</u> $(40.0 - 34.6)/(4.57 - 2.00) = 2.10$	(1) (1)	 **2**
4(d)	Uses their value for n to calculate % Difference using 2.00 or mean Comment based on reference to reasonable (experimental) uncertainty [Allow comparison with 10% and 'small' if %D<5%] <u>Example of calculation</u> $(2.10 - 2.00)/2.00 \times 100\% = 5\%$	(1) (1)	 **2**
4(e)	Take values for $\ln f$ and $\ln z$ from a point on the BFL & substitute into c = y – mx **Or** use of similar triangles to find c P is anti log of c **Or** $\ln P = y$ $e^y = P$ (Allow numerical method that correctly finds P) <u>Example of calculation</u> Take (2.65, 36.0) with n = 2.10 $2.65 \times 2.10 = 5.57$, so c = 36.0 – 5.57 = 30.4 $P = e^{30.4} = 1.59 \times 10^{13}$ (Hz)	 (1) (1)	 **2**
	Total for Question 4		**14**

f/Hz× 10^{15}	Z	ln Z	ln (f/10^{15} Hz)	ln (f/Hz)	log (f/10^{15}Hz)	Log Z
1.22	8	**2.08**	**0.199**	**34.74**	0.0864	0.903
4.19	14	**2.64**	**1.433**	**35.97**	0.622	1.146
12.0	23	**3.14**	**2.485**	**37.02**	1.079	1.362
34.0	38	**3.64**	**3.526**	**38.07**	1.531	1.580
75.0	56	**4.03**	**4.318**	**38.86**	1.875	1.748
155	80	**4.38**	**5.043**	**39.58**	2.190	1.903

Graph of ln (f/10^{15} Hz) against ln Z



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