

Mark Scheme (Results)

June 2022

Pearson Edexcel
International Advanced Level
in Physics (WPH16)
Paper 01 Practical Skills in Physics II

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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.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate.

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.

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 e.g. '**and'** when two pieces of information are needed for 1 mark.

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 This does not apply in 'show that' questions or in any other question where the units to be used have been given, for example in a spreadsheet.

2.3 The mark will not be awarded for the same missing or incorrect unit only once within one clip in epen.

2.4 Occasionally, it may be decided not to insist on a 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.

2.5 The mark scheme will indicate if no unit error is to be applied by means of [no ue].

3. Significant figures

3.1 Use of too many significant figures in the theory questions will not be prevent a mark being awarded if the answer given rounds to the answer in the MS.

3.2 Too few significant figures will mean that the final mark cannot be awarded in 'show that' questions where one more significant figure than the value in the question is needed for the candidate to demonstrate the validity of the given answer.

3.3 The use of one significant figure might be inappropriate in the context of the question e.g. reading a value off a graph. If this is the case, there will be a clear indication in the MS.

3.4 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 mean that one mark will not be awarded. (but not more than once per clip). Accept 9.8 m s^{-2} or 9.8 N kg^{-1}

3.5 In questions assessing practical skills, a specific number of significant figures will be required e.g. determining a constant from the gradient of a graph or in uncertainty calculations. The MS will clearly identify the number of significant figures required.

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.

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.

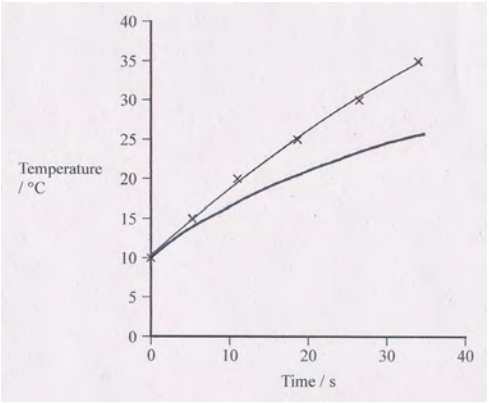
6.3 A mark given for choosing a scale requires that the chosen scale allows all points to be plotted, spreads plotted points over more than half of each axis and is not an awkward scale e.g. multiples of 3, 4, 7 etc.

6.4 Points should be plotted to within 1 mm.

6.5 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.

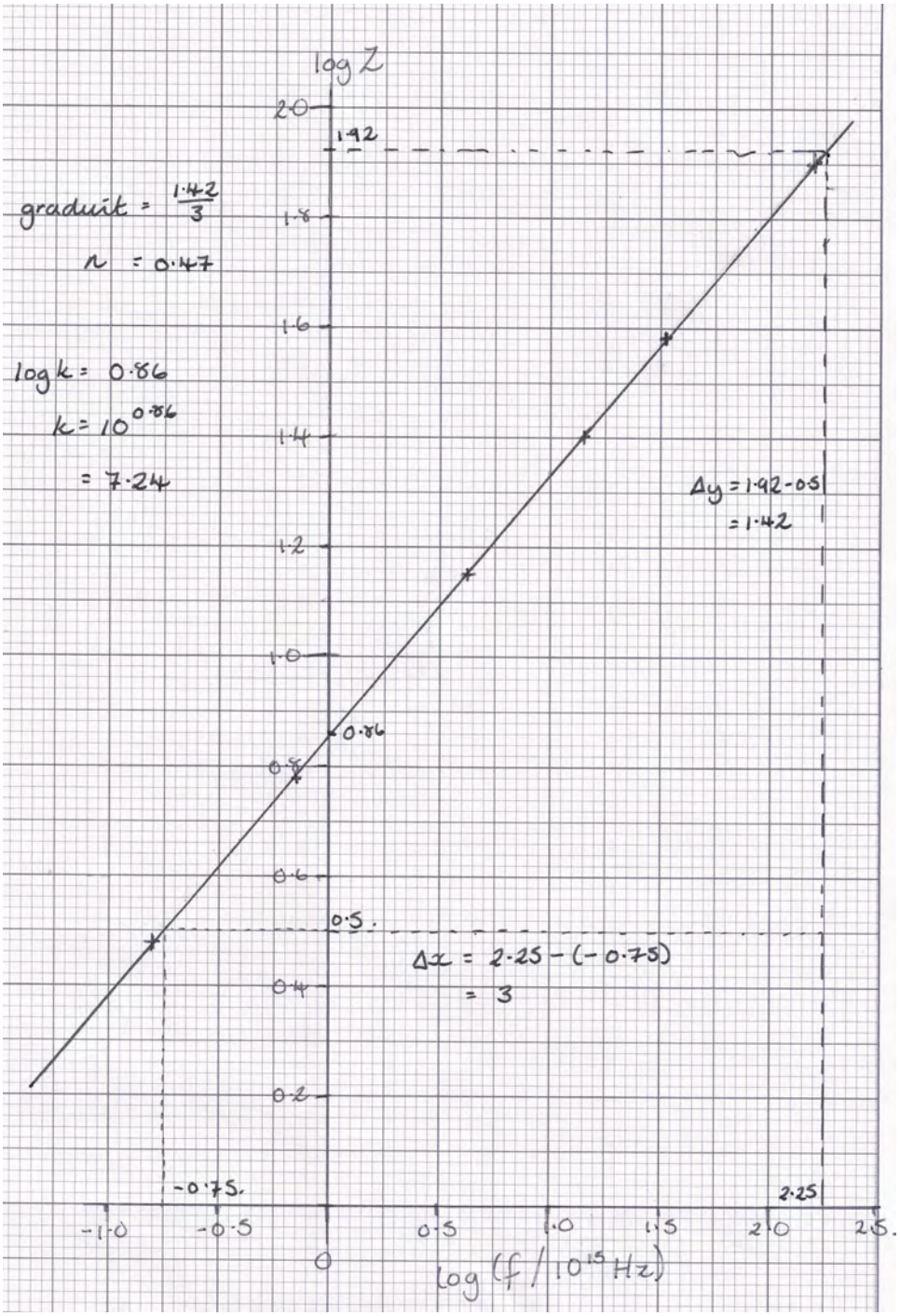
6.6 For a line mark there must be a thin continuous line which is the best-fit line for the candidate's results.

Question Number	Answer	Mark
1 (a)(i)	5 (°C) (1)	**1**
1 (a)(ii)	The resolution of the stopwatch is better (than the resolution of the thermometer) (1) Therefore there will be a smaller (percentage) uncertainty (in temperature) (1) **Or** Using fixed interval of time the temperature may be between values of temperature on the scale (1) which will lead to a larger (percentage) uncertainty (in temperature) (1) MP2 dependent on MP1 Do not accept precision for resolution	**2**
1 (b)(i)	Mass (of liquid) **Or** Flow rate (of the steam) **Or** Position of control tap (1) Ignore reference to amount and temperature [Do not accept volume]	**1**
1 (b)(ii)	Line starts at 10 °C (1) Line drawn below and curved with decreasing gradient (1)  	**2**
1 (c)	**Any TWO from** More readings can be taken in a given time (1) Measurements (of θ and t) can be taken simultaneously (1) The temperature probe will have a smaller resolution (1)	**2**
	Total for question 1	**8**

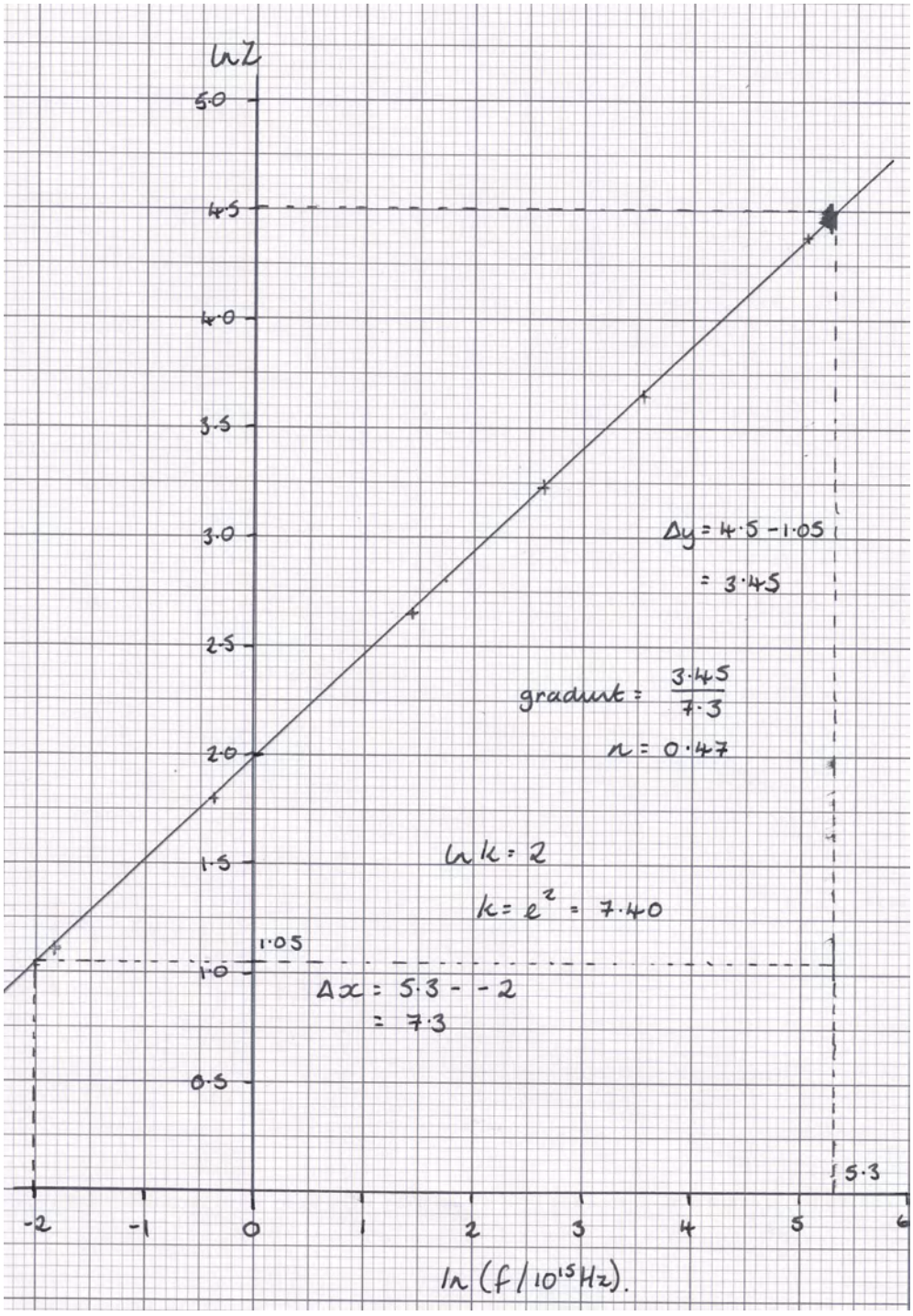
Question Number	Answer	Mark
2 (a)	Method to ensure rubber band is level (1) Measure distance L with a metre rule [Accept Vernier calipers] Repeat for at least 5 different values of L Plot a graph of log P against log L to check it is a straight line (1) Any TWO from: (1) Ensure the ruler is vertical using the set square Measure a number of cycles and divide by the number of cycles to get P (1) (1) Repeat the measurement (of P) and calculate a mean (1) (1)	**6**
2 (b)	It may be difficult to judge the exact moment the pendulum stops moving (1) Motion can be viewed more slowly so minimum can be found more reliably **Or** Motion can be viewed more slowly which reduces effect of reaction time (1)	**2**
	Total for question 2	**8**

Question Number	Answer	Mark
3 (a)	$\log Z = \log k + n \log f$ (1) Is in the form $y = c + mx$ with a constant gradient (= n) (1) **Or** $\log Z = n \log f + \log k$ (1) Is in the form $y = mx + c$ with a constant gradient (= n) (1) MP2 dependent on MP1	**2**
3 (b)(i)	Values of $\log Z$ correct to 2 d.p. [Accept ln values, 3 d.p.] (1) Values of $\log f$ correct to 2 d.p. [Accept ln values, 3 d.p.] (1) Axes labelled: y as $\log Z$ and x as $\log (f / 10^{15}\text{Hz})$ [Accept ln for ln values] (1) Appropriate scales chosen (1) log values plotted accurately (1) Best fit line drawn (1)	**6**
3 (b)(ii)	Gradient calculation using correct data and large triangle shown (1) Value of n in range 0.45 to 0.49, (1) to 2 or 3 s.f, no unit (1) <u>Example of calculation</u> $n = (1.92 - 0.5) / (2.25 - -0.75) = 1.42 / 3 = 0.47$	**3**
3 (b)(iii)	Correct value of y intercept shown (1) Value of k in range 6.9 to 7.3 [e.c.f. for value of n in (b)(ii)] (1) Value given to 2 or 3 s.f., (1) <u>Example of calculation</u> Log $k = 0.86$ $k = 10^{0.86} = 7.24$	**3**
3 (c)	**Either** States mathematical relationship using calculated values of n (and k) (1) Conclusion based on comparison with $Z \propto f^{0.5}$ (1) **Or** A graph of $\log Z$ against $\log f$ would be a straight line with a gradient of 0.5 (1) Conclusion based on comparison with calculated n (1)	**2**
	Total for question 3	**16**

Element	Z	$f / 10^{15}$ Hz	log Z	log ($f / 10^{15}$ Hz)
Li	3	0.16	0.48	–0.80
C	6	0.69	0.78	–0.16
Si	14	4.19	1.15	0.62
Mn	25	13.82	1.40	1.14
Sr	38	33.98	1.58	1.53
Hg	80	154.64	1.90	2.19



Element	Z	$f / 10^{15}$ Hz	ln Z	ln ($f / 10^{15}$ Hz)
Li	3	0.16	1.10	–1.83
C	6	0.69	1.79	–0.37
Si	14	4.19	2.64	1.43
Mn	25	13.82	3.22	2.63
Sr	38	33.98	3.64	3.53
Hg	80	154.64	4.38	5.04



Question Number	Answer	Mark
4 (a)(i)	Digital calipers have a smaller resolution [Accept converse] (1) Calculation of percentage uncertainty using (half) resolution shown (1) %U for Vernier = 0.8% **and** %U digital = 0.08% (1) Hence the percentage uncertainty for digital calipers will be smaller (1) <u>Example of calculation</u> %U in Vernier reading = 0.05 / 6.6 × 100 = 0.8 % %U in digital reading = 0.005 / 6.58 × 100 = 0.08 %	**4**
4 (a)(ii)	Any **PAIR** from: Repeat at different orientations and calculate a mean (1) Hence reduces (the effect of) <u>random errors</u> (1) **Or** Check and correct for zero error [Accept suitable method] (1) Hence eliminates <u>systematic error</u> (1)	**2**
4 (a)(iii)	Mean d = <u>6.55</u> (mm) (1) Calculation using half range shown [Accept furthest from mean] (1) Uncertainty in d = <u>0.03</u> (mm) (1) <u>Example of calculation</u> Mean d = (6.57 + 6.58 + 6.54 + 6.52) / 4 = 26.21 / 4 = 6.55 (mm) Uncertainty = (6.58 – 6.52) / 2 = 0.06 / 2 = 0.03 (mm)	**3**

4 (b)	Use of 2 × %U in s or d shown Calculation of U in s^2 or d^2 using 2 × %U shown Addition of U in s^2 and U in d^2 shown U = 0.011 (cm^2) <u>Example of calculation</u> %U in s^2= 2 × (0.02 / 16.83) × 100 = 2 × 0.12% = 0.24 % U in s^2 = 1.683^2 × 0.24 % = 6.80×10^{-3} cm^2 %U in d^2= 2 × (0.04 / 8.55) × 100 = 2 × 0.47% = 0.94 % U in d^2 = 0.855^2 × 0.94 % = 6.87×10^{-3} cm^2 U in A = $(6.80 \times 10^{-3} \times \sqrt{3}) / 2 + (6.87 \times 10^{-3} \times \pi) / 4$ = $5.89 \times 10^{-3} + 5.40 \times 10^{-3}$ = 0.011 cm^2 **Or** Use of correct absolute uncertainties for s and d Use of maximum and minimum values to calculate limit of A shown Correct value of maximum or minimum A Subtraction to obtain uncertainty in A approximately 0.01 cm^2 MP4 dependent on MP3 <u>Example of calculation</u> minimum s^2 = $(1.683 - 0.002)^2$ = 1.681 cm^2 maximum d^2= $(0.855 + 0.004)^2$ = 0.738 cm^2 minimum A = $\sqrt{3} \times 1.681/2 - \pi \times 0.738/4$ = 1.867 cm^2 uncertainty in A = 1.88 – 1.867 = 0.013 cm^2	(1) (1) (1) (1)	**4**
4 (c)(i)	Use of $\rho = m / Ax$ ρ = 6.91 g cm^{-3} [3 s.f. only] [Accept 6.92 g cm^{-3}] <u>Example of calculation</u> ρ = 10.3 / (1.88 × 0.792) = 10.3 / 1.49 = 6.91 g cm^{-3}	(1) (1)	**2**

4 (c)(ii)	Calculation of %U in ρ shown	(1)	
	Correct calculation of relevant limit using %U shown [e.c.f. (c)(i)]	(1)	
	Conclusion based on comparison of limit and calculated ρ	(1)	
	[MP3 dependent MP2]		
	<u>Example of calculation</u>		
	%U in ρ = (0.1 / 10.3) × 100 + (0.01 / 1.88) × 100 + (0.03 / 7.92) × 100		
	= 0.97 % + 0.53 % + 0.38 % = 1.88 %		
	Upper limit of ρ = 6.91 × (1 + 0.0188) = 7.04 g cm^{-3}		
	As the upper limit is lower than 7.85 g cm^{-3} the hexagonal metal nut is not made from steel.		
	Or		
	Use of maximum or minimum values shown	(1)	
	Maximum ρ = 7.05 g cm^{-3} **Or** Minimum ρ = 6.79 g cm^3	(1)	
	Conclusion based on comparison of maximum or minimum ρ with calculated ρ	(1)	
	[MP3 dependent MP2]		
	<u>Example of calculation</u>		
	Maximum ρ = (10.3 + 0.1) / ((0.792 – 0.003) × (1.88 – 0.01) = 7.05 g cm^{-3}		
	As the maximum value is lower than 7.85 g cm^{-3} the hexagonal metal nut is not made from steel.		
	Or		
	Calculation of %U in ρ shown	(1)	
	Correct calculation of relevant %D shown [e.c.f. (c)(i)]	(1)	
	Conclusion based on comparison of %D and %U	(1)	**3**
	[MP3 dependent MP2]		
	<u>Example of calculation</u>		
	%U in ρ = (0.1 / 10.3) × 100 + (0.01 / 1.88) × 100 + (0.03 / 7.92) × 100		
	= 0.97 % + 0.53 % + 0.38 % = 1.88 %		
	%D = (7.85 – 6.91) / 7.85 × 100 = 12 %		
	As % D for lower value is greater than the %U then the hexagonal metal nut is not made from steel.		
	Total for question 4		**18**

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