Mark Scheme (Results)

January 2021

Pearson Edexcel International Advanced Level
In Physics (WPH16)
Paper 1 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 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)	**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 o**f 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.

Example of mark scheme for a calculation:

<u>'Show that' calculation of weight</u>

Use of L × W × H	(1)	
Substitution into density equation with a volume and density	(1)	
Correct answer [49.4 (N)] to at least 3 sig fig. [No ue]	(1)	**3**

[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]
[Bald answer scores 0, reverse calculation 2/3]

<u>Example of calculation</u>
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. Graphs

5.1 A mark given for axes requires both axes to be labelled with quantities and units, and drawn the correct way round.

5.2 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.

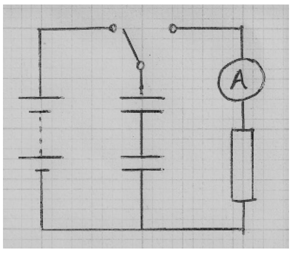
5.3 A mark given for choosing a scale requires that the chosen scale allows all points to be plotted, spreads plotted points over more than half of each axis and is not an awkward scale e.g. multiples of 3, 4, 7 etc.

5.4 Points should be plotted to within 1 mm.

- Check the two points furthest from the best line. If both are OK award the 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 are OK, otherwise no mark.

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

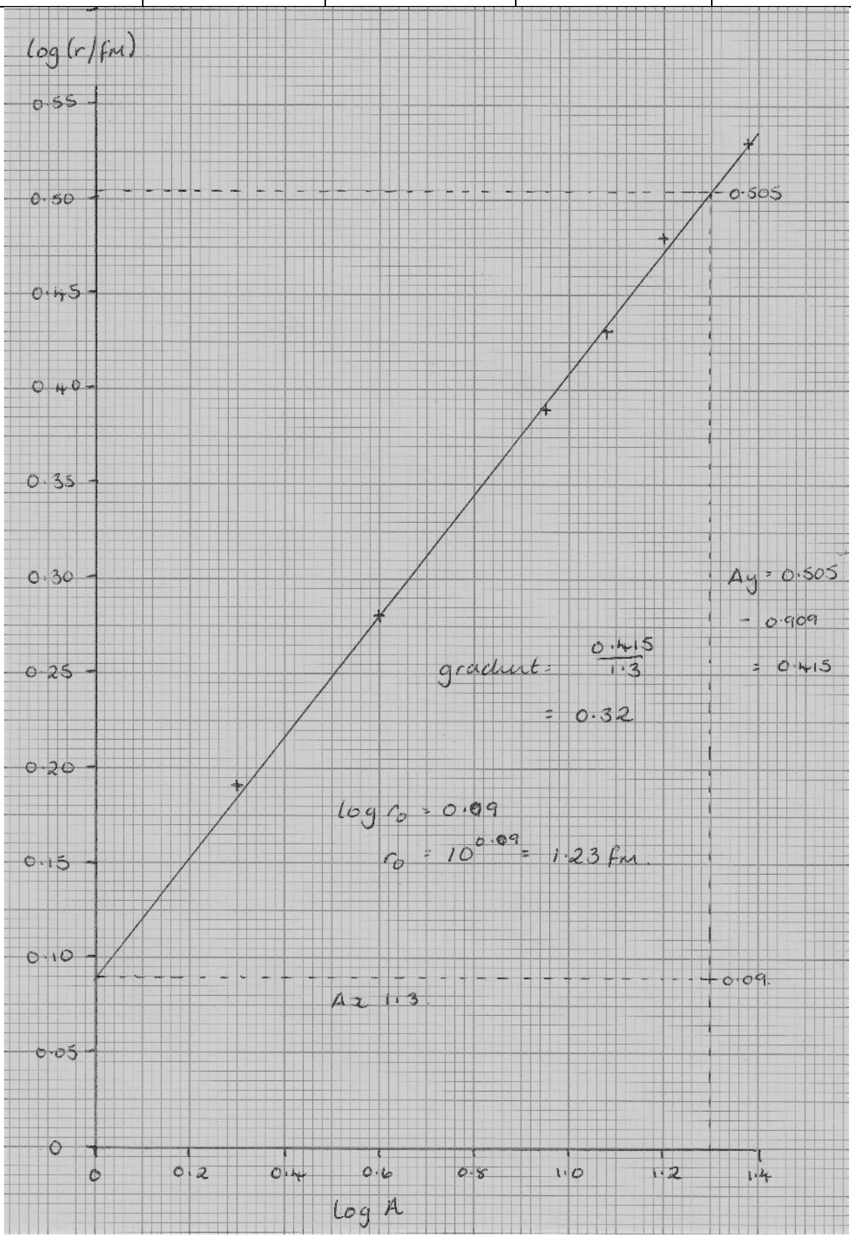
Question number	Answer		Mark
1(a)	Any **THREE** from: Use a timing marker (at the centre of the oscillation) Measure multiple oscillations **and** divide by the number of oscillations Repeat **and** calculate a mean Start timing after several oscillations have completed	 (1) (1) (1) (1)	 **(3)**
1(b)	Use a metre rule and set square (to ensure metre rule is horizontal) **Or** use a metre rule and spirit level (to ensure metre rule is horizontal) View metre rule perpendicularly (to avoid parallax error) [Accept valid alternative to ensure metre rule is horizontal]	 (1) (1)	 **(2)**
1(c)	Use of $T = k\sqrt{D}$ **Or** $T^2 = kD$ Three relevant calculations shown [minimum 2 s.f.] Comment consistent with comparing calculations [dependent MP2] [Accept other valid routes] <u>Example of calculation</u> $k = 0.78/\sqrt{0.235} = 1.61$ $k = 0.94/\sqrt{0.335} = 1.62$ $k = 1.09/\sqrt{0.445} = 1.63$ As these values are consistent the prediction is correct.	 (1) (1) (1)	 **(3)**
			Total mark for Question 1 = 8

Question number	Answer		Mark
2(a)	Capacitors connected in series with a d.c. power supply Circuit to discharge capacitors through resistor **and** ammeter Method of switching between charging and discharging <u>Example of circuit diagram</u>  	(1) (1) (1)	**(3)**
2(b)	Ensure the working p.d. is not exceeded **Or** Ensure the capacitors are fully discharged after the experiment [Accept any other appropriate precaution] [Accept reference to electrolytic capacitors]	(1)	**(1)**
2(c)	<u>Graphical Method</u> Any **SIX** from: 1. Choose the value of resistor to give a reasonable discharge time 2. Measure the resistance of the resistor (using a multimeter) 3. Charge the capacitors to the initial p.d. 4. Ensure that the ammeter and stopwatch are close together **Or** use the laptimer on the stopwatch 5. Start the stopwatch at the same time as changing the switch **Or** (Change the switch) and start the stopwatch at the initial current 6. Record the current (from the ammeter) at times determined using the stopwatch 7. Record measurements over at least one half-life **Or** time constant **Or** Take many measurements <u>Alternative graphs</u> 8. Plot a graph of ln *I* against *t* 9. Gradient = $-1/RC$ [dependent on MP8] **Or**	(1) (1) (1) (1) (1) (1) (1) (1) (1) (1)	

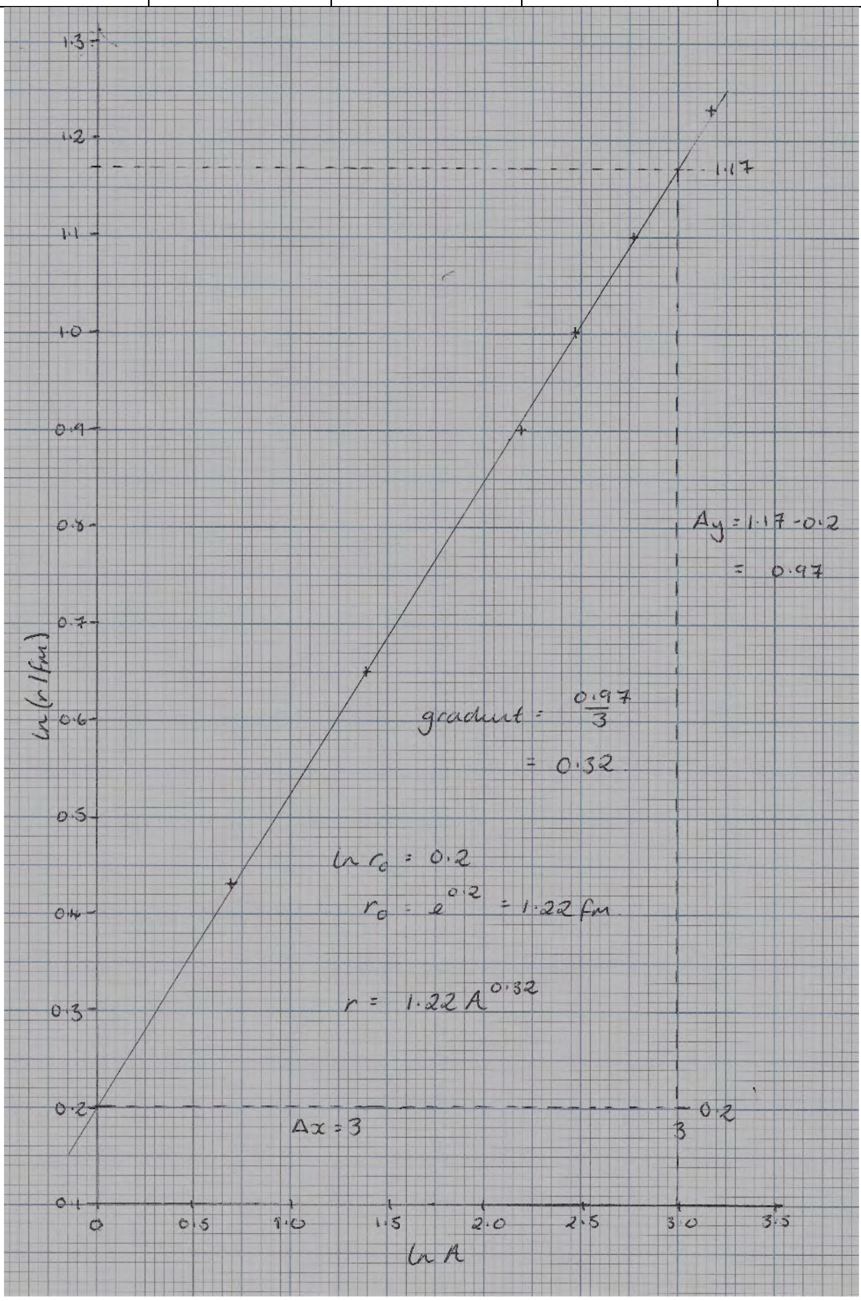
	8. Determine the time for *I* to halve from a graph of *I* against *t*	(1)	
	9. $t_{½} = RC \ln 2$ [dependent on MP8]	(1)	
	Or		
	8. Determine the time for *I* to fall to 37% from a graph of *I* against *t*	(1)	
	9. $\tau = RC$ [dependent on MP8]	(1)	
	<u>Non-graphical Method</u>		
	Any **SIX** from:		
	1. Choose the value of resistor to give a reasonable discharge time	(1)	
	2. Measure the resistance of the resistor using a multimeter	(1)	
	3. Charge the capacitors to the initial p.d.	(1)	
	4. Ensure that the ammeter and stopwatch are close together **Or** use the laptimer on the stopwatch	(1)	
	5. Start the stopwatch at the same time as changing the switch **Or** (Change the switch) and start the stopwatch at the initial current	(1)	
	6. Charge to the same initial p.d. each time	(1)	
	7. Obtain minimum of 3 measurements and calculate a mean	(1)	
	8. Record the time taken for the initial current to halve	(1)	
	9. $t_{½} = RC \ln 2$ [dependent on MP8]	(1)	
	Or		
	8. Record the time taken for the initial current to reach 37%	(1)	
	9. $\tau = RC$ [dependent on MP8]	(1)	**(6)**
2(d)	Readings (of current and time) can be taken simultaneously	(1)	
	Many readings can be taken in a short time	(1)	**(2)**
			Total mark for Question 2 = 12

Question number	Answer		Mark
3(a)	$\log r = \log r_0 + n \log A$ This in the form of $y = c + mx$ where the gradient is n [MP2 dependent on MP1]	(1) (1)	**(2)**
3(b)(i)	All log r values correct to 2 d.p. [accept 3 d.p.] All log A values correct to 2 d.p. [accept 3 d.p.] Axes labelled: y as log(r / fm) and x as log A Most appropriate scales for both axes Plots accurate Best fit line with even spread of plots	(1) (1) (1) (1) (1) (1)	**(6)**
3(b)(ii)	Correct calculation using large triangle shown Value of n in range 0.30 to 0.34 to 2 or 3 s.f., no unit <u>Example of calculation</u> $n = (0.505 - 0.09)/(1.3 - 0) = 0.415/1.3 = 0.32$	(1) (1)	**(2)**
3(b)(iii)	Value of y-intercept read from graph shown **Or** Use of coordinates from point on best fit line with gradient to determine log r_0 shown. Value of r_0 consistent with their value of log r_0 States relationship using their values given to 2 or 3 s.f. <u>Example of calculation</u> $\log(r_0/\text{fm}) = 0.09$ $r_0 = 10^{0.09} = 1.23$ (fm) Hence $r = 1.23\, A^{0.32}$ [Accept 1/3 for n]	(1) (1) (1)	**(3)**
			Total mark for Question 3 = 13

Isotope	*A*	*r* / fm	log *A*	log (*r* / fm)
H-2	2	1.54	0.30	0.19
He-4	4	1.92	0.60	0.28
Be-9	9	2.47	0.95	0.39
C-12	12	2.72	1.08	0.43
O-16	16	3.00	1.20	0.48
Mg-24	24	3.42	1.38	0.53



Isotope	A	r / fm	ln A	ln (r / fm)
H-2	2	1.54	0.69	0.43
He-4	4	1.92	1.39	0.65
Be-9	9	2.47	2.20	0.90
C-12	12	2.72	2.48	1.00
O-16	16	3.00	2.77	1.10
Mg-24	24	3.42	3.18	1.23



Question number	Answer		Mark
4(a)	The uncertainty is the same for both methods **Or** The resolution of the metre rule is 1mm	(1)	
	Student B's measurement will be larger therefore the percentage uncertainty will be smaller	(1)	
	Or		
	Calculation of percentage uncertainty for both methods using same uncertainty shown	(1)	
	Conclusion based on comparison of correct values of percentage uncertainty	(1)	**(2)**
	<u>Example of calculation</u> Student A %U = $\frac{0.1}{10} \times 100\% = 1\%$ Student B %U = $\frac{0.1}{10\pi} \times 100\% = 0.32\%$ Therefore Student B has a smaller percentage uncertainty. [Accept 0.5% and 0.16% if uncertainty of 0.05cm used]		
4(b)(i)	Any **TWO** from:		
	Check for zero error to eliminate <u>systematic</u> error	(1)	
	Repeat at different places **and** calculate a mean to reduce the effect of <u>random</u> errors	(1)	
	Avoid squashing the string to reduce the effect of <u>random</u> errors	(1)	**(2)**
4(b)(ii)	mean t = <u>2.10</u> mm	(1)	
	Correct uncertainty from calculation of half range shown	(1)	**(2)**
	<u>Example of calculation</u> mean t = (2.15+2.06+2.13+2.08+2.10) mm/5 = 2.104 = 2.10 mm Uncertainty = (2.15–2.06) mm/2 = 0.045 = 0.05 mm		
4(c)(i)	Use of $C = x - \pi t$	(1)	
	Value of C correct to 3 s.f. [e.c.f (b)(ii)]	(1)	**(2)**
	<u>Example of calculation</u> C = 25.8cm – (π × 0.21 cm) = 25.8 – 0.66 = 25.1 cm		

4(c)(ii)	Addition of uncertainties shown to minimum 2 s.f. [e.c.f. (b)(ii)] <u>Example of calculation</u> 0.2 cm + 0.005 cm = 0.205 cm	(1)	**(1)**
4(d)	Value of V correct to 3 s.f. [e.c.f. (c)(i)] Use of 2× %U in C and %U in L shown [e.c.f. (c)(i), (c)(ii)] Use of %U to calculate uncertainty in $\frac{C^2L}{4\pi}$ shown Correct uncertainty from addition of final uncertainties <u>Example of calculation</u> $V = (25.1^2 \times 19.9)\ \text{cm}^3/4\pi - 810\ \text{cm}^3 = 998\ \text{cm}^3 - 810\ \text{cm}^3$ $= 188\ \text{cm}^3$ %U in $\frac{C^2L}{4\pi}$ = (2 × 0.205 cm³/25.1 cm³)×100% + (0.05 cm/19.9 cm)×100% = 1.63% + 0.25% = 1.88% U in $\frac{C^2L}{4\pi}$ = (998 cm³ × 1.88%) = 18.6 = 19 cm³ U in V = (19 + 5) cm³ = 24 cm³ **Or** Value of V correct to 3 s.f. [e.c.f. (c)(i)] Use of uncertainties to calculate upper or lower limit of V shown [e.c.f. (c)(ii)] Correct upper or lower limit calculated Uncertainty correct from half range of V <u>Example of calculation</u> $V = (25.1^2 \times 19.9)\ \text{cm}^3/4\pi - 810\ \text{cm}^3 = 998\ \text{cm}^3 - 810\ \text{cm}^3$ $= 188\ \text{cm}^3$ Upper limit of $V = \frac{(25.1+0.2)^2\times(19.90+0.05)}{4\pi} - (810 - 5)$ = 1016 - 805 = 211 cm³ U = 211 - 188 = 23 cm³	(1) (1) (1) (1) (1) (1) (1) (1)	**(4)**

4(e)	Calculation of $\rho = \frac{m}{V}$ shown [e.c.f. (d)] Correct calculation of %U in ρ shown [e.c.f. (d)] Calculation of relevant upper and/or lower limit shown Valid conclusion based on comparison [dependent MP3] <u>Example of calculation</u> ρ = 463 g/188 cm^3 = 2.46 (g cm^{-3}) %U = (1/463 × 100) + (24/188 × 100) = 0.2 + 12.8 = 13% Upper limit = 2.46 × 1.13 = 2.78 (g cm^{-3}) Lower limit = 2.46 × (1–0.13) = 2.14 (g cm^{-3}) As both soda glass and borosilicate lie in the range the container may not be safe to heat. **Or** Calculation of $\rho = \frac{m}{V}$ shown [e.c.f. (d)] Correct calculation of %U in ρ shown [e.c.f. (d)] Correct calculation of %D shown for relevant materials Valid conclusion based on comparison [dependent MP3] <u>Example of calculation</u> ρ = 436 g/188 cm^3 = 2.46 (g cm^{-3}) %U = (1/463 × 100) + (24/188 × 100) = 0.2 + 12.8 = 13% Soda glass %D = (2.52–2.46)/2.52 × 100 = 2.38% Borosilicate %D = (2.46–2.23)/2.23 × 100 = 10.3% As both %D are less than the %U we cannot be sure the container is safe to heat. **Or** Use of uncertainties to calculate maximum or minimum ρ shown Correct calculation of upper limit of ρ shown Correct calculation of lower limit of ρ shown Valid conclusion based on comparison of their values	(1) (1) (1) (1) (1) (1) (1) (1) (1) (1) (1) (1)	**(4)**

	Example of calculation Upper limit of $\rho = \frac{463+1}{188-24} = \frac{464}{164}$ = 2.83 (g cm^{-3}) Lower limit of $\rho = \frac{463-1}{188+24} = \frac{462}{212}$ = 2.18 (g cm^{-3}) As both soda glass and borosilicate lie in the range the container may not be safe to heat.		
Total mark for Question 4 = 17			

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