Pearson Edexcel

Mark Scheme (Results)

January 2025

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 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. '<u>resonance</u>'

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 placing brackets around the unit.

3. Significant figures

3.1 Use of too many significant figures in the theory questions will not 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 be penalised by one mark (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 **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.

4.2 If a 'show that' question is worth 2 marks, then both marks will be available for a reverse working. If the question is worth 3 marks then only 2 marks will be available.

4.3 The mark scheme will show a correctly worked answer for illustration only.

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, 7 etc.

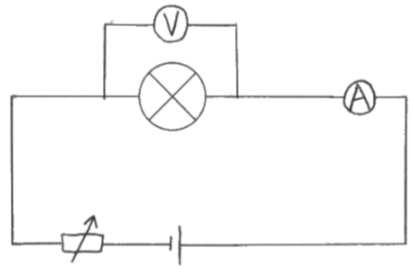
5.4 Points should be plotted to within 1 mm.

- Check the two points furthest from the best line. If both 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.

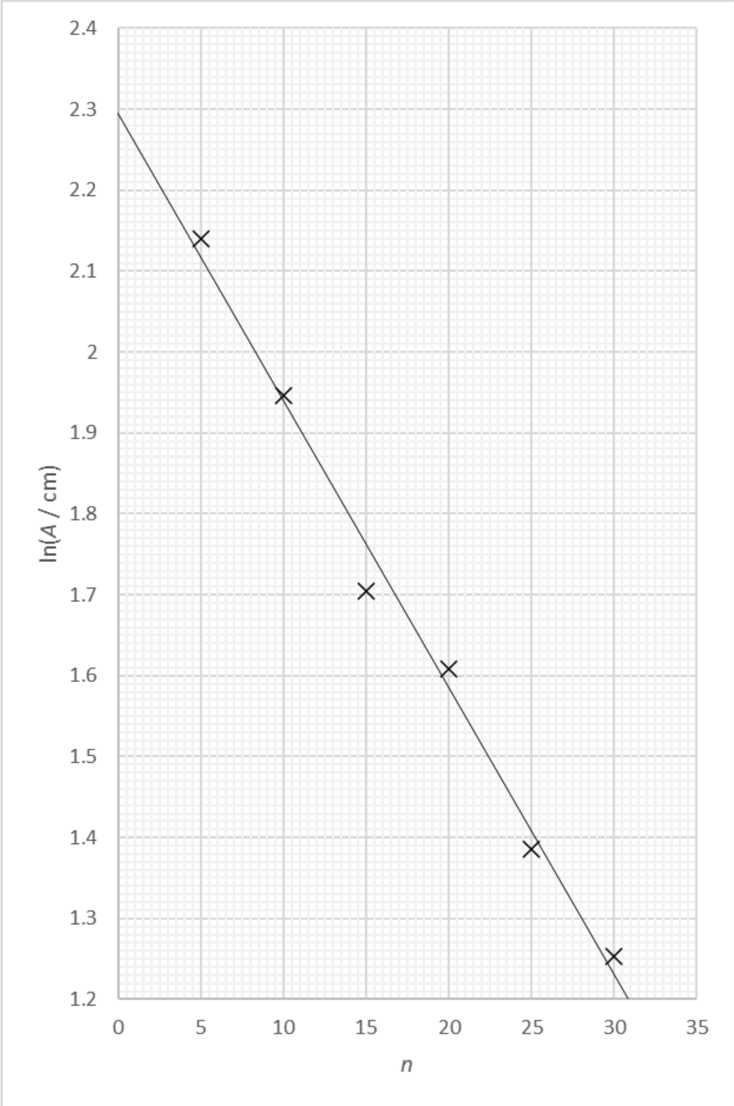
Question Number	Answer	Mark
1(a)	**EITHER** The immersion heater will be hot **Or** the immersion heater will cause burns (if touched) **(1)** Switch off the immersion heater (before removing) **Or** use tongs **or** insulated gloves (to move the immersion heater) **(1)** **OR** The glass beaker **or** metal flask will be hot **Or** the (hot) glass beaker **or** (hot) metal flask **or** hot water will cause burns (if touched) **Or** hot water may spill (onto student) **(1)** Use tongs **or** insulated gloves (to move the beaker **or** flask) **(1)** **OR** The leads may cause the beaker to topple over **(1)** Clamp the immersion heater in position **(1)**	**2**
1(b)	Use a thermometer (to measure the temperature of the water) **(1)** Place (the thermometer) close to the flask **Or** Place (the thermometer) on the opposite side to the heater **(1)** Stir the water (to ensure thermal equilibrium) **Or** Read the scale perpendicularly **(1)**	**3**

1(c)(i)	Mean $\theta = 42.3°C$ Accept 1 d.p. only **(1)** <u>Example of calculation</u> Mean $\theta = \frac{(42.5 + 41.0 + 42.0 + 43.5)°C}{4} = 42.25 = 42.3°C$	**1**
1(c)(ii)	Calculation of half range shown **Or** Calculation of furthest from mean shown **(1)** Percentage uncertainty = 3% Accept 1 or 2 s.f. only e.c.f. (c)(i) **(1)** <u>Example of calculation</u> Half range = $\frac{(43.5 - 41.0)°C}{2} = 1.25°C$ Percentage uncertainty = $\frac{1.25°C}{42.3°C} \times 100 = 2.96\%$ Rounding half range to 1.3 gives 3.1%	**2**
1(c)(iii)	Conversion of °C to K **(1)** Uses $V = \frac{4}{3}\pi r^3$ **(1)** Use of $pV = NkT$ **(1)** Number of air molecules = 4.5×10^{22} Accept 2 or 3 s.f. only e.c.f. (c)(i) **(1)** <u>Example of calculation</u> $T = 42.3°C + 273\ K = 315.3\ K$ $V = \frac{4}{3}\pi(0.075\ m)^3 = 1.77 \times 10^{-3}\ m^3$ $N = \frac{(110 \times 10^3\ Pa) \times (1.77 \times 10^{-3}\ m^3)}{(1.38 \times 10^{-23}\ J\ K^{-1}) \times 315.3\ K} = 4.47 \times 10^{22}$	**4**
	Total for question 1	**12**

Question Number	Answer		Mark
2(a)	Circuit diagram containing power supply **and** means of varying current	(1)	
	Voltmeter connected in parallel across filament bulb **and** ammeter connected in series	(1)	2
	<u>Example of circuit</u> 		
2(b)	1. Ensure the distance/alignment between the light sensor and filament bulb remains constant	(1)	
	2. Remove background light Accept valid method	(1)	
	3. Record current I and potential difference V	(1)	
	4. Calculate power $P = IV$	(1)	
	5. (Vary resistance and) record at least 5 sets of X for different values of P.	(1)	
	6. Plot a graph of P against X^4 **and** check it is a straight line **Or** Plot a graph of log P against log X **and** check it is a straight line **Or** Plot a graph of log P against log X **and** check gradient = 4	(1)	6
	Total for question 2		**8**

Question Number	Answer	Mark
3(a)	It is difficult to judge the exact moment the maximum displacement is reached **Or** The pendulum changes direction quickly **Or** The pendulum is moving quickly **Or** The displacement is (constantly) changing **(1)** Difficult to ensure line of sight is perpendicular to the scale **Or** The cone is not close to the rule **Or** The pendulum may not oscillate in line with the rule **(1)**	**2**
3(b)(i)	**EITHER** $\ln A = \ln A_0 - \lambda n$ **(1)** Compares to $y = c + mx$ where the gradient is $-\lambda$ (which is constant) **(1)** MP2 dependent on MP1 **OR** $\ln A = -\lambda n + \ln A_0$ **(1)** Compares to $y = mx + c$ where the gradient is $-\lambda$ (which is constant) **(1)** MP2 dependent on MP1	**2**
3(b)(ii)	Values of ln A correct **and** consistent to 3 d.p. Accept correct **and** consistent to 2 d.p. **(1)** Axes labelled: y as ln (A / cm) and x as n **(1)** Appropriate scales chosen **(1)** ln values plotted accurately **(1)** Best fit line drawn **(1)**	**5**

n	*A* / cm	ln (*A* / cm)	ln (*A* / cm)
5	8.5	2.140	2.14
10	7.0	1.946	1.95
15	5.5	1.705	1.70
20	5.0	1.609	1.61
25	4.0	1.386	1.39
30	3.5	1.253	1.25

Question	Answer		Mark
			
3(b)(iii)	Uses large triangle to calculate gradient	(1)	
	Value of λ in range (−)0.0335 to (−)0.0384	(1)	
	Calculated value of λ given to 2 or 3 s.f., no unit, positive	(1)	3
	<u>Example of calculation</u>		
	$\lambda = -\text{gradient} = -\dfrac{2.10 - 1.23}{5.5 - 30} = -\dfrac{0.87}{-24.5} = 0.0355$		
3(b)(iv)	Correct y-intercept read from graph **Or** Correct y-intercept using gradient and data point from best fit line	(1)	
	Conversion of log value shown	(1)	
	Correct value of A_0 given to nearest mm, units consistent with y-axis e.c.f. (b)(iii)	(1)	3
	<u>Example of calculation</u>		
	$\ln A_0 = y\text{-intercept} = 2.295$		
	$A_0 = e^{2.295} = 9.9$ cm		

3(b)(v)	**EITHER** There is significant scatter in the data **(1)** Therefore, the best fit line is uncertain **(1)** MP2 dependent on MP1 [Do not accept reference to number of data points or range] **OR** There may be a systematic error (in the measurement of A) **(1)** Therefore, the best fit line may be shifted **(1)** MP2 dependent on MP1 [Ignore reference to random error] **OR** The initial angle of the pendulum may be too large to apply small angle approximation **(1)** Therefore, extrapolating back from a straight line is not valid **(1)** MP2 dependent on MP1 Allow 1 mark for "There is no data at $n < 5$ so the line may not be straight" or "There is no data at $n < 5$ so cannot draw an accurate best fit line"	**2**
	Total for question 3	**17**

Question Number	Answer	Mark
4(a)	The resolution (of the metre rule) is 1 mm **(1)** The uncertainty in a single measurement is half the resolution (of the rule) **Or** The uncertainty in each measurement is 0.5 mm **(1)** (As the measurements are subtracted,) the uncertainties are added **Or (**As the measurements are subtracted,) 0.5 (mm) + 0.5 (mm) = 1 (mm) **(1)** MP3 dependent on MP2 Do not accept precision/accuracy for resolution.	**3**
4(b)	(Moving marker 2 will increase *s* so) value of *t* will increase **(1)** (Absolute) uncertainty in *t* remains constant **(1)** So percentage uncertainty (in *t*) decreases **(1)** MP3 dependent on MP1 or MP2	**3**
4(c)(i)	Uses $t^2 = \frac{14s^2}{5g\Delta h}$ **(1)** $g = 9.6\ \mathrm{m\ s^{-2}}$ Accept $9.57\ \mathrm{m\ s^{-2}}$ 2 or 3 sig fig only **(1)** <u>Example of calculation</u> $g = \frac{14s^2}{5t^2\Delta h} = \frac{14 \times (0.9\ \mathrm{m})^2}{5 \times (3.36\ \mathrm{s})^2 \times 21 \times 10^{-3}\ \mathrm{m}} = 9.57\ \mathrm{m\ s^{-2}}$	**2**
4(c)(ii)	**EITHER** Uses %U in **one** of *s*, Δh **or**, *t* Accept fractional uncertainty **(1)** Uses 2 × %U in *s* **or** 2 × %U in *t* Accept $2 \times \frac{\Delta s}{s}$ or $2 \times \frac{\Delta t}{t}$ **(1)** Correct %U given to minimum 2 s.f. **(1)** <u>Example of calculation</u> %U in $s = \frac{0.001\ \mathrm{m}}{0.900\ \mathrm{m}} \times 100 = 0.11\%$ %U in $\Delta h = \frac{1\ \mathrm{mm}}{21\ \mathrm{mm}} \times 100 = 4.76\%$ %U in $t = \frac{0.03\ \mathrm{s}}{3.36\ \mathrm{s}} \times 100 = 0.89\%$ %U in *g* = 2 × %U in *s* + %U in Δh + 2 × %U in *t* = 2 × 0.11% + 4.76% + 2 × 0.89% = 0.22% + 4.76% + 1.78% = 6.76% **OR** Uses uncertainties to calculate maximum **or** minimum *g* **(1)**	

	Calculation of half range shown **(1)** Correct %U given to minimum 2 s.f. e.c.f. (c)(i) **(1)** <u>Example of calculation</u> Maximum $g = \frac{14s^2}{5t^2\Delta h} = \frac{14 \times (0.901\ \text{m})^2}{5 \times (3.33\ \text{s})^2 \times 20 \times 10^{-3}\ \text{m}} = 10.25\ \text{m s}^{-2}$ Minimum $g = \frac{14s^2}{5t^2\Delta h} = \frac{14 \times (0.899\ \text{m})^2}{5 \times (3.39\ \text{s})^2 \times 22 \times 10^{-3}\ \text{m}} = 8.95\ \text{m s}^{-2}$ U in $g = \frac{(10.25 - 8.95)\ \text{m s}^{-2}}{2} = 0.65\ \text{m s}^{-2}$ %U in $g = \frac{0.65\ \text{m s}^{-2}}{9.6\ \text{m s}^{-2}} \times 100 = 6.8\%$	**3**
4(c)(iii)	**EITHER** Correct value of relevant limit shown e.c.f. (c)(i), (c)(ii) **(1)** Conclusion based on comparison of relevant limit with 9.81 m s^{-2}. **(1)** MP2 dependent MP1 <u>Example of calculation</u> Upper limit of $g = 9.6\ \text{m s}^{-2} \times (1 + 0.068) = 10.3\ \text{m s}^{-2}$ The upper limit is greater than the value of $g = 9.81\ \text{m s}^{-2}$ so the value is accurate **OR** Calculation of %D shown e.c.f. (c)(i), (c)(ii) **(1)** Conclusion based on comparison of %D and %U **(1)** MP2 dependent MP1 <u>Example of calculation</u> $\%D = \frac{(9.81 - 9.6)\ \text{m s}^{-2}}{9.81\ \text{m s}^{-2}} \times 100 = 2.1\%$ As % D is less than %U the value is accurate	**2**
	Total for question 4	**13**

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