Pearson Edexcel

Mark Scheme (Results)

January 2024

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.

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 $g = 10\ \text{m s}^{-2}$ or $10\ \text{N kg}^{-1}$ instead of $9.81\ \text{m s}^{-2}$ or $9.81\ \text{N kg}^{-1}$ will be penalised by one mark (but not more than once per clip). Accept $9.8\ \text{m s}^{-2}$ or $9.8\ \text{N kg}^{-1}$

3.3 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 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>
$80 \text{ cm} \times 50 \text{ cm} \times 1.8 \text{ cm} = 7200 \text{ cm}^3$
$7200 \text{ cm}^3 \times 0.70 \text{ g cm}^{-3} = 5040 \text{ g}$
$5040 \times 10^{-3} \text{ kg} \times 9.81 \text{ N/kg} = 49.4 \text{ N}$

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.

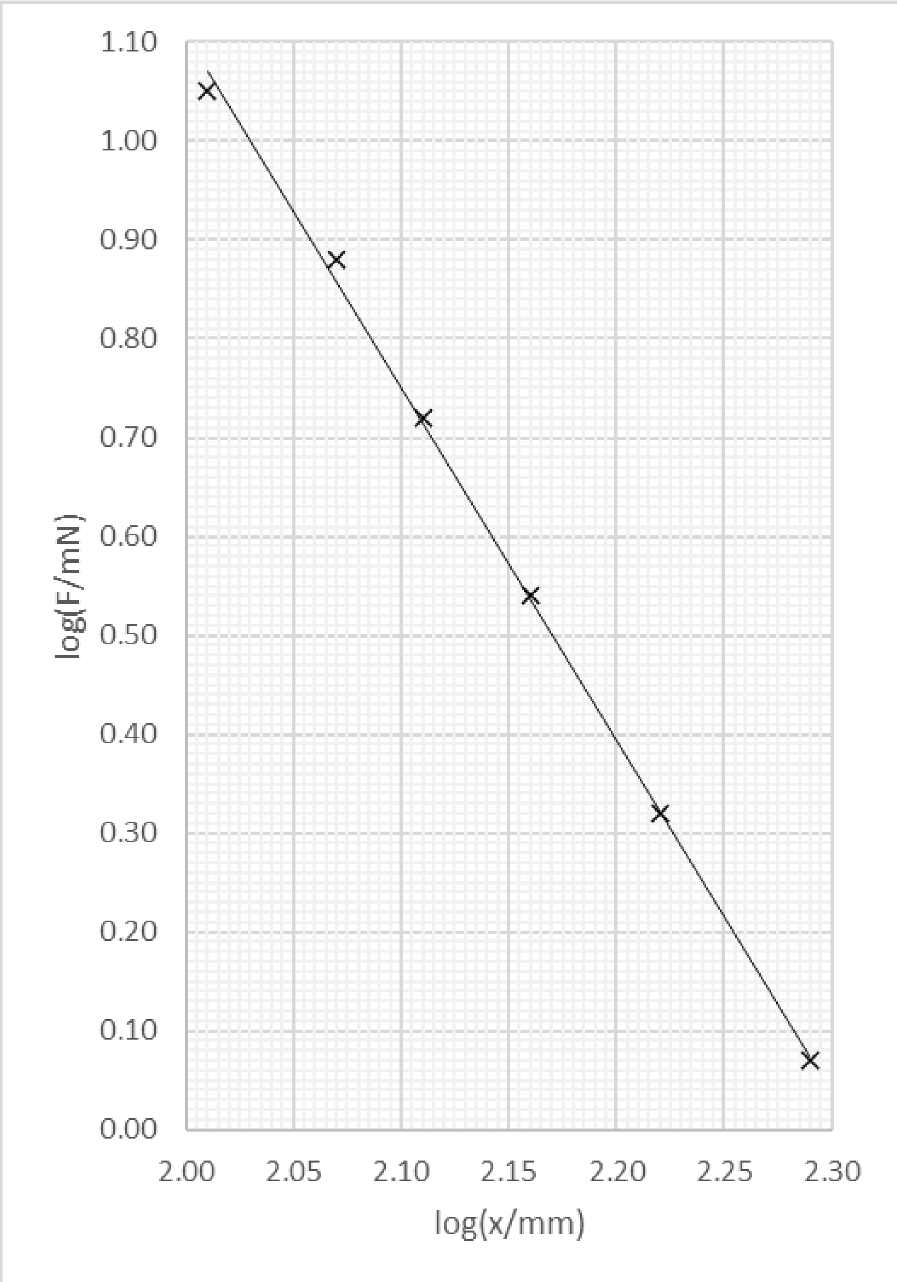
5.5 For a line mark there must be a thin continuous line which is the best-fit line for the candidate's results.

Question Number	Answer		Mark
1(a)	Use a (timing) marker (at the centre of the oscillation) Allow the oscillations to settle before timing Measure multiple oscillations **and** divide by the number of oscillations **Or** Repeat the measurement (of T) **and** calculate a mean	(1) (1) (1)	3
1(b)(i)	f_0 in range 1.50 Hz to 1.54 Hz 3 s.f. only	(1)	1
1(b)(ii)	Use of $T = \frac{1}{f_0}$ Use of $T = 2\pi\sqrt{\frac{m}{k}}$ Correct mass given to 2 or 3 s.f. with unit e.c.f. 1(b)(i) <u>Example of calculation</u> $T = \frac{1}{1.52\text{ Hz}} = 0.658\text{ s}$ $m = \frac{kT^2}{4\pi^2} = \frac{30\text{Nm}^{-1} \times (0.658\text{s})^2}{4\pi^2} = 0.329\text{ kg}$	(1) (1) (1)	3
1(b)(iii)	There are not enough readings around the maximum value **Or** There are not enough readings between 1.4 Hz and 1.6 Hz Therefore the best fit line is uncertain **Or** The position of the peak (of the graph) is uncertain	(1) (1)	2
1(c)	Data loggers have a high sampling rate So there is less uncertainty in the measurement of amplitude (at each frequency)	(1) (1)	2
	Total for question 1		**11**

Question Number	Answer		Mark
2(a)	**EITHER**		
	The hot plate **or** glass beaker will be hot **Or** the hot plate **or** glass beaker will cause burns (if touched) **Or** hot water may spill onto student	**(1)**	
	Use tongs or insulated gloves (to move the beaker)	**(1)**	
	OR		
	The hot plate will be hot **Or** the hot plate will cause burns (if touched)	**(1)**	
	So turn off the hot plate (when water has boiled)	**(1)**	
	OR		
	Thermometer may break (when moving beaker)	**(1)**	
	So remove the thermometer (before moving the beaker)	**(1)**	**2**
2(b)	1. Use a stopwatch (to measure time)	**(1)**	
	2. Record the initial temperature and start the stopwatch (simultaneously)	**(1)**	
	3. Stir the water (before measuring the temperature)	**(1)**	
	4. Record the temperature at (regular) time intervals **Or** Record the time at (regular) temperature intervals	**(1)**	
	5. Record many temperature readings (as the water cools) **Or** Keep recording until temperature similar to temperature of the surroundings	**(1)**	
	6. Plot a graph of $\ln\theta$ against t to check it is a straight line **Or p**lot a graph of $\ln\theta$ against t to check the gradient is constant	**(1)**	**6**
	Total for question 2		**8**

Question Number	Answer	Mark
3(a)	Record position of top of lower magnet and bottom of upper magnet **and** subtract to give x **(1)** Any **TWO** from: Ensure the ruler is close to the bar magnets **(1)** Read perpendicular to the scale **Or** measure the position of the bar magnets using a set square **(1)** Clamp the (30 cm) ruler in position **and** use a set square to ensure the (30 cm) ruler is vertical **(1)**	3
3(b)	**EITHER** $\log F = \log k + p \log x$ **(1)** Compares with y = c + mx where p is the gradient (which is constant) **(1)** MP2 dependent on MP1 **OR** $\log F = p \log x + \log k$ **(1)** Compares with y = mx + c where p is the gradient (which is constant) **(1)** MP2 dependent on MP1	2
3(c)(i)	Values of log x correct and consistent to 2 d.p. Accept consistent to 3 d.p. **(1)** Values of log F correct and consistent to 2 d.p. Accept consistent to 3 d.p. **(1)** Axes labelled: y as log (F / mN) and x as log (x / mm) **(1)** Sensible scales chosen **(1)** log values plotted accurately **(1)** Best fit line drawn **(1)** Accept ln values	6

x / mm	F / mN	log (x / mm)	log (F / mN)
102	11.22	2.01	1.05
117	7.56	2.07	0.88
128	5.25	2.11	0.72
145	3.43	2.16	0.54
166	2.09	2.22	0.32
197	1.18	2.29	0.07



3(c)(ii)	Calculation of gradient using large triangle shown **(1)** Value of gradient in range (–)3.40 to (–)3.80 **(1)** Value of calculated gradient given to 2 or 3 s.f., negative, no unit **(1)** <u>Example of calculation</u> gradient $= \dfrac{1-0.2}{2.03-2.255} = \dfrac{0.8}{-0.225} = -3.6$	**3**
3(c)(iii)	States form of inverse square relationship as $F \propto x^{-2}$ **(1)** States gradient (p of log F against log x for inverse square law) should be −2 **and** states calculated gradient p **Or** States relationship from graph $F \propto x^{p}$ with p as calculated gradient **(1)** States valid conclusion **(1)** MP3 dependent on MP1 and MP2	**3**
	Total for question 3	**17**

Question Number	Answer	Mark
4(a)(i)	**EITHER** Repeat at different orientations and calculate a mean **(1)** To reduce (the effect of) <u>random errors</u> **(1)** MP2 dependent on MP1 **OR** Check and correct for zero error on the calipers **(1)** To eliminate <u>systematic error</u> **(1)** MP2 dependent on MP1	2
4(a)(ii)	Calculation of %U shown using half resolution **(1)** States instrument based on justification using calculation of %U from corresponding resolution **(1)** <u>Example of calculation</u> $\%U = \frac{0.005\text{mm}}{5\text{mm}} \times 100 = 0.1\%$ So use a micrometer screw gauge as the %U is small	2

4(b)	**EITHER** Uses %U in u **and** v Accept fractional uncertainty $=\frac{\Delta u}{u}$ and $\frac{\Delta v}{v}$ Calculation of %U in (u + v) Accept fractional uncertainty Addition of all %U Accept fractional uncertainty U = 0.15 (cm) 2 s.f. only <u>Example of calculation</u> %U in $u = \frac{0.1\text{cm}}{29.6\text{cm}} \times 100 = 0.34\%$ %U in $v = \frac{0.1\text{cm}}{19.2\text{cm}} \times 100 = 0.52\%$ %U in $u + v = \frac{(0.1 + 0.1)\text{cm}}{(29.6 + 19.2)\text{cm}} \times 100 = \frac{0.2\text{cm}}{48.8\text{cm}} \times 100 = 0.41\%$ %U in $f = 0.34\% + 0.52\% + 0.41\% = 1.3\%$ U in $f = 11.6 \times 1.3\% = 0.15$ (cm) **OR** Uses uncertainties to calculate maximum or minimum f Correct calculation of maximum or minimum f Calculation of half range shown U = 0.15 (cm) 2 s.f. only <u>Example of calculation</u> maximum $f = \frac{(29.6 + 0.1)\text{cm} \times (19.2 + 0.1)\text{cm}}{(29.6 - 0.1)\text{cm} + (19.2 - 1)\text{cm}} = \frac{(29.7 \times 19.3)\text{cm}^2}{(29.5 + 19.1)\text{cm}} = \frac{573.2\text{cm}^2}{48.6\text{cm}} = 11.8$ (cm) minimum $f = \frac{(29.6 - 0.1)\text{cm} \times (19.2 - 0.1)\text{cm}}{(29.6 + 0.1)\text{cm} + (19.2 + 0.1)\text{cm}} = \frac{(29.5 \times 19.1)\text{cm}^2}{(29.7 + 19.3)\text{cm}} = \frac{563.5\text{cm}^2}{49\text{cm}} = 11.5$ (cm) U in $f = \frac{(11.8 - 11.5)\text{cm}}{2} = 0.15$ (cm)	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**4**
4(c)(i)	Uses $n = 1 + \frac{d^2}{8tf}$ $n = 1.63$ 3 s.f. only <u>Example of calculation</u> $n = 1 + \frac{(5.02\text{cm})^2}{8 \times 0.428\text{cm} \times 11.6\text{cm}} = 1 + \frac{25.2\text{cm}^2}{39.7\text{cm}^2} = 1.63$	**(1)** **(1)**	**2**

4(c)(ii)	**EITHER** Uses 2 × %U in d Accept $2 \times \frac{\Delta d}{d}$ %U in n = 1% Accept 1.1% Allow use of value from (b) <u>Example of calculation</u> %U in $\frac{d^2}{8tf} = (2 \times \frac{0.02\text{cm}}{5.02\text{cm}} + \frac{0.01\text{mm}}{4.28\text{mm}} + \frac{0.2\text{cm}}{11.6\text{cm}}) \times 100$ $= 0.797\% + 0.234\% + 1.72\% = 2.8\%$ %U in $n = \frac{(0.63 \times 0.028)}{1.63} \times 100 = 1.1\%$ **OR** Correct calculation of maximum or minimum n %U in n = 0.9% Accept 0.92% <u>Example of calculation</u> Maximum $n = 1 + \frac{(5.04\text{cm})^2}{8 \times 0.427\text{cm} \times 11.4\text{cm}} = 1.65$ Minimum $n = 1 + \frac{(5.00\text{cm})^2}{8 \times 0.429\text{cm} \times 11.8\text{cm}} = 1.62$ $\%U = \frac{(1.65 - 1.62)}{2 \times 1.63} \times 100 = 0.92\%$	**(1)** **(1)** **(1)** **(1)**	2
4(c)(iii)	**EITHER** Correct value of relevant limit (e.c.f. (c)(i), (c)(ii)) Conclusion based on comparison of relevant limit to n = 1.52 MP2 dependent MP1 <u>Example of calculation</u> lower limit of $n = 1.63 \times (1 - 0.01) = 1.61$ As the lower limit is greater than 1.52 the lens could not be made of crown glass **OR** Correct calculation of %D shown (e.c.f. (c)(i), (c)(ii)) Conclusion based on comparison of %D and %U MP2 dependent MP1	**(1)** **(1)** **(1)** **(1)**	2

	Example of calculation $\%D = \frac{1.63 - 1.52}{1.52} \times 100 = 7.2\%$ As % D is greater than the %U then lens could not be made of crown glass	
	Total for question 4	**14**

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