



Rewarding Learning

ADVANCED
General Certificate of Education
2023

Physics

Assessment Unit A2 3B

assessing

**Practical Techniques
and Data Analysis**

[APH32]

MONDAY 26 JUNE, MORNING

**MARK
SCHEME**

Physics Subject Specific Instructions

It is essential that, before using the mark scheme, markers familiarise themselves with the following guidance.

General

To ensure that all candidates receive the same treatment, the mark scheme must be applied consistently.

The mark scheme for each question shows typical intermediate steps, the answer expected and the marks available for each part of the question.

In cases where a candidate has responded with a seemingly correct response which has not been anticipated in the mark scheme, the marker must make a professional judgement of the correct physics/validity of the response when awarding marks.

Brackets (...) are used to indicate information which is not essential for the mark to be awarded. Alternative answers are indicated by 'or', or the symbol for or, '/'.

Multiple/Cancelled Responses

If a candidate provides multiple responses, the general principle to be followed is that 'right + wrong = wrong'.

Responses considered to be neutral are not penalised. For example, if additional irrelevant information is given in an explanation that does not contradict the correct information given, the mark(s) can be awarded.

In a numerical problem if two different solutions are presented without a definitive answer on the answer line, credit should not be given. If an answer is given on the answer line, then the solution that has led to the answer given should be marked according to the mark scheme.

If a candidate clearly cancels their working by scoring it out, then this should not be marked. It is not the role of the marker to select from the candidate's response what should or should not be marked.

Marking Numerical Problems

In numerical problems, the marks for the intermediate steps shown in the mark scheme are for the benefit of candidates who do not obtain the final correct answer.

A correct answer, if obtained from a valid starting point, gets full credit, even if all the intermediate steps are not shown.

This “correct answer” rule does not apply in situations where candidates have been asked to ‘show your working’ or ‘show that’. These answers must be valid in all stages to obtain full credit.

The answer to a ‘show that’ question should be quoted to one more significant figure than that given in the question.

Do not reward wrong physics. No credit is given for consistent substitution of numerical data, or subsequent arithmetic, in a physically incorrect equation.

The normal penalty for an arithmetical error is to lose the mark(s) for the answer/unit line. An arithmetic error should be penalised for one mark only. Arithmetic errors may arise from a slip in a calculation or from an incorrect transfer of a numerical value of a quantity given in a question.

10^n errors count as arithmetical slips and incur a penalty of one mark.

If a candidate rounds a value incorrectly this should be penalised one mark. However, care must be taken not to penalise a candidate for rounding correctly in parts leading up to their final answer in an unstructured numerical problem.

Answers should be given in decimal form. Fractional answers will not be credited with the answer mark.

Error Carried Forward

An ECF can occur between parts of a question or, in more unstructured numerical problems, within a part.

When an incorrect answer is carried forward from one question to the next, full credit should be awarded in the part where the incorrect answer is used, provided all the working is correct.

Within a part, ECF is applied where a candidate does an incorrect calculation, for example calculates a value for R incorrectly using V/I and then goes on to use their calculated value for R to calculate a resistivity value. The penalty is applied in the V/I calculation but then the value of R can be carried forward so that the remainder of the marks are available to the candidate provided all the remainder of their working is correct.

The ECF within a part will only apply in numerical problems where more than one calculation is required in a part.

Significant Figures

Candidates should show an awareness of using a sensible number of significant figures in their answers, based on the values given in the question. In SPH11, SPH21, APH11 and APH21, unless specifically asked for in the question, candidates will not be penalised for incorrect significant figures.

In SPH31, SPH32, APH31 and APH32, all answers should be given to a suitable number of significant figures and penalties will be applied in these papers unless otherwise stated in the mark schemes.

Units

In the majority of questions, the unit will be stated on the answer line.

When the unit is omitted, candidates will be clearly asked to state an appropriate unit and this will be credited in the mark scheme.

Where there is a final calculation required to get from the unit of the answer calculated to the unit on the answer line the required unit will be stated in the question. For example, if wavelength was calculated and the answer line was in nm a statement 'Give your answer in nanometres' would be included.

The unit on the answer line will generally be the SI unit but may in some cases be a more appropriate unit. For example, if values of mass in g and momentum in g cm s^{-1} were given, the unit on the answer line for speed could reasonably be cm s^{-1} without prompt.

Graphs

In marking **graphs** you will have to exercise some professional judgement, but other features must be marked strictly according to the scheme.

The mark(s) for "Scales" is normally awarded only if the plotted points occupy at least half of the printed graph along each axis. In addition, the scale must be to an easily manageable factor, such as 1:2, 1:4, 1:5, 1:10, 1:20. A factor of, for example 10 mm to represent 30 cm does not score because of the difficulty of accurately plotting or reading off values.

Points plotted correctly means to within \pm one small square (\pm 2 mm) on the printed grid in either x-or y-direction. The marker's professional judgement comes in here.

One mark is to be awarded for drawing the best fit line through the points. Do not agonise over scoring (or not) this mark, your professional judgement will allow you to come to a decision very quickly.

In measuring the gradient, the mark for a "large triangle" means that either rise or run (or both) must be at least 5 cm on the printed graph/grid. Some candidates do not draw their triangle, but use points read off from the line. Provided the rise and/or run in this virtual triangle meet the 5 cm criterion, the mark is scored. Beware of candidates who read off their gradient points directly from a table. The marker must check that the points used actually on the line and meet the 5 cm test.

			AVAILABLE MARKS	
1	(a)	$C_L = \frac{\text{kg m s}^{-2}}{\text{kg m}^{-3} (\text{m s}^{-1})^2 \text{ m}^2}$	[1]	
			[1]	
		cancellation to zero units or to at least obvious equality and comment	[1]	[3]
	(b)	(i) The second reading at 30 m s^{-1} of 8.36 is an anomaly and is not included when calculating the average.		[1]
		(ii) Best fit straight line, not through the origin		[1]
		(iii) The line of best fit does not go through the origin		[1]
		(iv) Pupil quotes y-intercept \rightarrow guide 1.2 not zero		[1]
	(c)	(i) Large triangle	[1]	
		Gradient between 2.9 and 3.0×10^{-3}	[1]	
		Unit $\text{N s}^2 \text{ m}^{-2}$ or equivalent	[1]	[3]
(ii) $2 \times \text{gradient}/\rho A = C_L$ correct substitutions		[1]		
		Correctly calculated C_L value from pupils values	[1]	[3]
	(iii) The zero error does not effect the gradient		[1]	
2	(a)	multiple cycles correctly measured	[1]	
		1 wave = 3.4 cm	[1]	
		$T = 17 \text{ ms}$	[1]	
		$f = 1/T$	[1]	
		$f = 59 \text{ Hz}$	[1]	
		uncertainty calculated consistent with candidate's values	[1]	[6]
	(b)	$m = 8.2 \times 10^{-4} \text{ kg}$	[1]	
		T correctly calculated to 2sf	[1]	
		Adds three uncertainties correctly	[1]	
		$2 \times \% \text{ unc in } f$	[1]	[4]
				14
				10

3 (a) (i) P_0 is the pressure when the height = 0 or sea level, not initial height [1]

(ii) $P = P_0 e^{-h/k}$
 Take natural logs of both sides:
 $\ln(P) = \ln(P_0 e^{-h/k})$ [1]

Split the r.h.s.:
 $\ln(P) = \ln(P_0) + \ln(e^{-h/k})$
 Bring down the index and $\ln(e) = 1$

$$\ln(P) = -\frac{1}{k} h + \ln(P_0) \quad [1]$$

and mapping to $y = mx + c$ [1] [3]

(iii)

h/m	P / kPa	$\ln(P / \text{kPa})$	$\ln(P / \text{Pa})$
1000	92.4	4.53	11.43
2000	78.9	4.37	11.28
3000	71.2	4.27	11.17
4000	65.2	4.18	11.09
5000	56.4	4.03	10.94
6000	49.3	3.90	10.81

$\ln(P / \text{kPa})$ or $\ln(P / \text{Pa})$ [1]
 Correctly calculated [1]
 All to 2 decimal places [1] [3]

(b) (i) Axis scaled correctly [1]
 Labels correct [1]
 Points plotted accurately [2]
 Best fit line [1] [5]

(ii) Read intercept correctly [1]
 Intercept = $\ln(P_0)$ [1]
 Correctly calculates P_0 (Guide 101 kPa) [1] [3]

(iii) Draws an extreme fit line [1]
 Correctly finds P_0 from new intercept [1]
 Finds difference between new and old P_0 [1] [3]

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4 (a) Record the time for N oscillations, repeat and find average, if number mentioned, must be 5 or greater [1]
 Divide by N [1] [2]

(b) (i) The line is not straight [1]

(ii) The gradient is positive/upward sloping or goes through origin [1]

(iii) The gradient gets less as L increases/graph gets less steep [1]

(c) $k = T/L^{1/2}$ [1]
 Finds k for one set of correct values read from graph (guide 2.0) [1]
 Finds second value of k from second pair of values and averages [1] [3]

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Total

50