



Rewarding Learning

ADVANCED
General Certificate of Education
2025

Physics

Assessment Unit A2 2

assessing

Fields, Capacitors and Particle Physics

[APH21]

MONDAY 9 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.

10ⁿ 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.

			AVAILABLE MARKS
1	(i) $V = IR$ $4.5 = I \times 200$ $I = 0.0225 \text{ A}$	[1]	
		[1]	
		[1] [3]	
	(ii) $I = 1.42 \times 10^{-3} \text{ A}$ $I = I_0 e^{-\frac{t}{\tau}}$ Use of $1.42 \times 10^{-3} = 0.0225 e^{-\frac{120}{\tau}}$ Correct use of natural logs $\tau = 43.4 \text{ s}$	[1]	
		[1]	
		subs [1]	
		[1]	
		[1] [5]	
	(iii) $43.4 = 200 C_T$ ecf for 1(ii) $C_T = 0.217\text{F}$ $C = 0.434\text{F}$	sub [1]	
		[1]	
[1] [3]			
2	(i) A region of space where an object will experience a force	[1]	
		[1] [2]	
	(ii) Similarity: Both obey inverse square law (with respect to separation) Or Both have infinite range Differences: Electric fields act on charged particles/Gravitational fields act on mass Gravitational fields can only be attractive/Electric fields can produce attraction and repulsion. Electric fields can be shielded Gravitational fields are weaker than electric fields Any 2 differences [1] each	[1]	
		[2] [3]	
		[1] [3]	
	(iii) Arrows away from particle Symmetry More radial field lines	[1]	
		[1]	
		[1] [3]	
	(iv) Field lines show the direction of a field A field cannot have two directions at a single point	[1]	
		[1] [2]	
			11
			10

- 3 (a) (i) The square of the time period of the orbit of a planet
Is directly proportional to the cube of its mean distance from
the Sun [1] [2]
- (ii) Use of $mr\omega^2$ or $\frac{mv^2}{r}$ [1]
 $\omega = \frac{2\pi}{T}$ or $\frac{2\pi r}{T}$
conversion to $mr\left(\frac{2\pi}{T}\right)^2$ [1]
Equating with $G \frac{m_1 m_2}{r^2}$ [1]
Cancelling masses and rearranging to either:
 $T^2 = \frac{4\pi^2 r^3}{Gm_s}$ or $\frac{T^2}{r^3} = \frac{4\pi^2}{Gm_s}$ [1]
Statement that $\frac{4\pi^2}{Gm_s}$ is a constant [1] [5]
- (b) (i) $r_s = 6.40 \times 10^3 + 12.5 \times 10^3 = 18.9 \times 10^3 \text{ km}$ [1] = $18.9 \times 10^6 \text{ m}$ [1][2]
 $\frac{27.3^2}{(3.84 \times 10^8)^3} = \frac{T^2}{(18.9 \times 10^6)^3}$ subs [1]
 $T = 0.298 \text{ d}$ [1] = $2.57 \times 10^4 \text{ s}$ [1] [2] [5]
- (ii) $a = \omega^2 r$ or $a = \frac{v^2}{r}$ [1]
subs [1]
 $a = 1.12 \text{ m s}^{-2}$ ecf for (i) [1] [3]
- (iii) $g = \frac{GM_E}{r^2}$ [1]
 $1.12 = \frac{6.67 \times 10^{-11} M_E}{(18.9 \times 10^6)^2}$ correct subs ecf for (b)(ii) [1] [2]
- 4 (i) $E_{\text{plates}} = \frac{V}{d}$ or $\frac{450}{0.15}$ [1]
= 3000 V m^{-1} [1]
 $E_{\text{electrons}} = \frac{q}{4\pi\epsilon_0 r^2}$ [1]
 $E_{\text{electrons}} = \frac{1.6 \times 10^{-19}}{4\pi \times 8.85 \times 10^{-12} (5.2 \times 10^{-3})^2}$ correct subs [1]
 $E_{\text{electrons}} = 5.32 \times 10^{-5} \text{ V m}^{-1}$ [1]
Statement that $E_{\text{electrons}} \ll E_{\text{plates}}$ [1] [6]
- (ii) $F = eE$ [1]
 $F = 1.6 \times 10^{-19} \times 3000$ subs ecf for E from (i) [1]
 $F = 4.8 \times 10^{-16} \text{ N}$ [1] [3]
- (iii) $F = ma$ [1]
 $a = 5.27 \times 10^{14} \text{ m s}^{-2}$ ecf for F from (ii) [1]
 $v^2 = u^2 + 2as$ [1]
subs [1]
 $v = 1.26 \times 10^7 \text{ m s}^{-1}$ [1] [5]

AVAILABLE
MARKS

17

14

- 5 (a)** (The magnetic flux linkage will change with time) and as Faraday's law states that a voltage will be induced proportional to the rate of change of magnetic flux linkage [1]
- The output will alternate as the magnetic flux linkage changes from increasing to decreasing with time [1] [2]
- (b) (i)** Draws tangent to graph at 0.18s [1]
 Gradient = $\frac{\text{Rise}}{\text{Run}}$ and large triangle [1]
 Correct values read from graph and gradient correctly calculated [1]
- $E = \frac{\Delta N\Phi}{\Delta t}$ or correct subs [1]
 correct value by candidate's tangent ($40 \times$ gradient) [1] [5]
- (ii)** $T = 0.16\text{s}$ [1]
 $\therefore f = \frac{1}{T}$ [1]
 $\therefore 6.25\text{Hz}$ [1] [3]
- 6 (i)** Arrow drawn upwards [1]
- (ii)** $F = Bqv$ [1]
 $F = 490 \times 10^{-9} \times 1.6 \times 10^{-19} \times 5.20 \times 10^5$ subs [1]
 $F = 4.08 \times 10^{-20} \text{ N}$ [1] [3]
- (iii)** $F = \frac{mv^2}{r}$ subs [1]
 $r = 1.1 \times 10^4 \text{ m}$ [1] [2]
- (iv)** Path will be in opposite direction as charge is opposite [1]
 Size of force is the same as size of charge is the same [1]
 radius will be smaller as mass is smaller [1] [3]

AVAILABLE
MARKS

10

9

- 7
- Cavities/electrodes
 - use electric fields to increase the speed/energy of the particles
 - Electromagnets
 - are used to change the direction/maintain a fixed radius
 - The current must be increased to the electromagnets
 - To produce a stronger magnetic field
 - A stronger force is needed to maintain the circular path (as the speed has increased)
 - The relativistic mass has increased

AVAILABLE
MARKS

Response	Marks
Candidate identifies and describes 7 or 8 of the points shown in the indicative content. There is widespread and accurate use of appropriate scientific terminology. Presentation, spelling, punctuation and grammar are excellent. Candidates use the most appropriate form and style of writing. Relevant material is highly organised with clarity and coherency.	[7]–[8]
Candidate clearly identifies 5 or 6 of the points shown in the indicative content. There is good use of appropriate scientific terminology. Presentation, spelling, punctuation and grammar are good. Candidates use appropriate form and style of writing. There is good attempt to organise material.	[5]–[6]
Candidate clearly identifies 3 or 4 of the points shown in the indicative content. There is some use of appropriate scientific terminology. Presentation, spelling, punctuation and grammar are sufficient to make the meaning clear. Candidates use an appropriate form and style of writing. There is some attempt to organise material.	[3]–[4]
Candidates clearly identify at least 1 or 2 of the points shown in the indicative content. There is limited reference to scientific terminology. Presentation, spelling, punctuation and grammar may contain some errors. The form and style are of a satisfactory standard. There is only a limited attempt to organise material.	[1]–[2]
Response is not worthy of credit.	[0]

8

- 8 (i) The neutron consists of (an up and two down) quarks [1]
A fundamental particle cannot be made up of smaller particles. [1] [2]
- (ii) Charge is not conserved 2 marks for each line if both LHS and
 $0 \rightarrow -2$ or $0 \rightarrow -1 + -1 + 0$ RHS are correct with correct statement
 Lepton number is not conserved
 $0 \rightarrow 2$ or $0 \rightarrow 1 + 0 + 1$ 1 mark for each conservation rule if either
 Baryon number is not conserved LHS or RHS is correct (ignore statement)
 $1 \rightarrow -1$ or $1 \rightarrow 0 - 1 + 0$ [6]
- (iii) $n \rightarrow \beta^- + p^+ + \bar{\nu}_e$ [1]
- (iv) a down quark changes into an up quark [1]

10

- 9 (i) Any **two** from:
 Eddy currents
 Resistive (heat) losses in coils
 Not all magnetic flux from the primary passes through the secondary/flux leakage
 Heating of the iron core due to alternating magnetic field/hysteresis [2]
- (ii) 304 MW [1]
 Mega conversion [1]
 $P = IV$ [1]
 $I = 2764 \text{ A}$ [1] [4]
- (iii) $R = 1.6 \Omega$ [1]
 $P = I^2R$ [1]
 $P = 12 \text{ MW}$ [1]
 $320 - 304 = 16 \text{ MW}$ [1]
 28 MW [1] [5]

Total

**AVAILABLE
MARKS**

11

100