Pearson Edexcel

Mark Scheme (Results)

November 2021

Pearson Edexcel GCE
In Physics (9PH0)
Paper 1: Advanced Physics I

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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 means of [no ue].

3. Significant figures

3.1 Use of too many significant figures in the theory questions will not be 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 mean that one mark will not be awarded. (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 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** 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.

4.4 **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.

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.

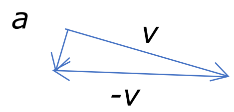
- Check the two points furthest from the best line. If both OK award mark.
- If either is 2 mm out do not award mark.
- If both are 1 mm out do not award mark.
- If either is 1 mm out then check another two and award mark if both of these OK, otherwise no mark.

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

Question Number	Acceptable answers	Additional guidance	Mark
1	**The only correct answer is A** B is not correct as the peak value is 2 V C is not correct as the period is 0.22 s D is not correct as r.m.s. value of p.d. is 1.4 V		1
2	**The only correct answer is C** A is not correct as the particle is a meson B is not correct as the particle is a meson D is not correct as the mass cannot be negative		1
3	**The only correct answer is A** B is not correct as the rebound velocity wil be about 0.7 × v_{initial} C is not correct as the velocity must switch sign on rebound D is not correct as the velocity must switch sign on rebound		1
4	**The only correct answer is D** A is not correct as current through 60 Ω is 4 A so I = 6 A B is not correct as current through 60 Ω is 4 A so I = 6 A C is not correct as current through 60 Ω is 4 A so I = 6 A		1
5	**The only correct answer is B** A is not correct as 120 Ω / 3 = 40 Ω C is not correct as 120 Ω / 3 = 40 Ω D is not correct as 120 Ω / 3 = 40 Ω		1
6	**The only correct answer is A** B is not correct as these forces are not in equilibrium C is not correct as these forces are not in equilibrium D is not correct as these forces are not in equilibrium		1
7	**The only correct answer is B** A is not correct as the p.d. across the resistor will increase C is not correct as the resistance of the LDR will decrease D is not correct as the resistance of the LDR will decrease		1
8	**The only correct answer is C** A is not correct as $E_{\text{initial}} = F/Q = 10F$, if d halved then E_{after}= 20F B is not correct as $E_{\text{initial}} = F/Q = 10F$, if d halved then E_{after}= 20F D is not correct as $E_{\text{initial}} = F/Q = 10F$, if d halved then E_{after}= 20F		1
9	**The only correct answer is C** A is not correct as the increase in energy is the change in the area under the graph line : rectangle area $V_0 \times \Delta Q$		1

	B is not correct as the increase in energy is the change in the area under the graph line : rectangle area $V_0 \times \Delta Q$ D is not correct as the increase in energy is the change in the area under the graph line : rectangle area $V_0 \times \Delta Q$		
10	**The only correct answer is C** A is not correct as this is a unit of electric field strength B is not correct as units T m^2 could be used as a unit of flux D is not correct as Wb is a unit of flux		**1**

(Total for Multiple Choice Questions = 10 marks)

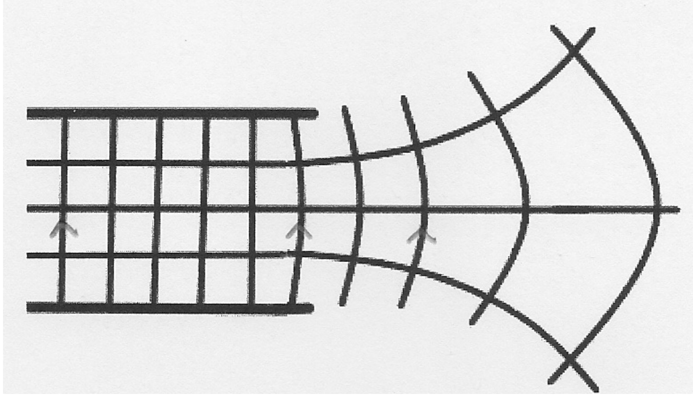
Question Number	Acceptable answers		Additional guidance	Mark
11(a)	• vector velocities of same length with arrows as shown to indicate a difference. The "minus" v line should be approximately horizontal. • third side identified as Δv/acceleration in direction approximately towards centre of circle	**(1)** **(1)**	Example of diagram  Accept "-v" line as arrow to right and labelled "v"	**2**
11(b)(i)	• Use of $v = \frac{2\pi r}{T}$ or $\omega = \frac{2\pi}{T}$ • Use of $a = \frac{v^2}{r}$ or $r\omega^2$ • $a = 8.8 \text{ m s}^{-2}$	**(1)** **(1)** **(1)**	<u>Example of calculation</u> $v = \frac{2\pi 6800000\text{m}}{92\times 60\text{s}} = 7740 \text{ m s}^{-1}$ $a = \frac{7740^2 (\text{m s}^{-1})^2}{6800000 \text{ m}} = 8.81 \text{ m s}^{-2}$ or $\omega = \frac{2\pi}{92\times 60 \text{ s}} = 1.14 \times 10^{-3} \text{ rad s}^{-1}$ $a = 6800000 \text{ m} \times (1.14 \times 10^{-3} \text{ rad s}^{-1})^2$ $a = 8.81 \text{ m s}^{-2}$	**3**
11(b)(ii)	• The astronauts have weight or not weightless **Or** Earth's gravitational field = 8.8 N kg^{-1} on ISS (ECF from (b)(i)) • Earth's gravitational field keeps astronauts/ISS in circular motion **Or** Weight provides the centripetal force • Our notion of "weight" is reaction force acting on us from the ground/floor • There are no reaction forces from the ISS on the astronauts so they "feel" weightless	**(1)** **(1)** **(1)** **(1)**		**4**

(Total for Question 11 = 9 marks)

Question Number	Acceptable answers		Additional guidance	Mark
12(a)	• Impulse is the product *Ft* which is area under this graph	**(1)**		**1**
12(b)(i)	• Attempt to determine an area • Uses area = change of momentum • velocity in range 28 – 33 (m s^{-1})	**(1)** **(1)** **(1)**	eg markings on the graph Example of calculation: Approximates area = triangle = (0.0005 s × 5500 N) / 2 Area = 1.375 Ns Velocity = 1.375 Ns / 0.046 kg = 29.1 ms^{-1}	**3**
12(b)(ii)	• Use of $s = ut + \frac{1}{2}at^2$ in vertical direction • if *s* + then *ut* + and at^2 negative **Or** if *s* – then *ut* – and at^2 positive • Use of velocity = distance / time in horizontal direction • Correct component of velocity in each direction • Distance = 76 m and comment such as yes it reaches the green. (ECF from bi) Range of distance 70.5 m for b(i) $v = 28$ m s^{-1} to 93.6 m for $v = 33$ m s^{-1}	**(1)** **(1)** **(1)** **(1)** **(1)**	Alt: Use of pythagorus to find resultant velocity Also accept conclusion based on a comparison of velocity values from (i) and (ii) Example of calculation: $7.5\text{m} = 29\text{m s}^{-1}\sin\theta 3.5\text{s} - \frac{1}{2}9.81\text{m s}^{-2}3.5^2\text{s}^2$ 7.5m = 101.5 sinθ − 60.1 sinθ = 67.6 / 101.5 $\theta = 41.8^\circ$ 29 ms^{-1} cos 41.8 = x / 3.5 s x = 75.7 m Using the "show that" value:	**5**

		$7.5\text{m} = 30\text{m}\,\text{s}^{-1}\sin\theta 3.5\text{s} - \frac{1}{2}9.81\text{m}\,\text{s}^{-2}3.5^2\text{s}^2$ $7.5\text{m} = 105\sin\theta - 60.1$ $\sin\theta = 67.6 / 105$ $\theta = 40.1^\circ$ $30\ \text{ms}^{-1}\cos 40.1 = x / 3.5\ \text{s}$ $x = 80.3\ \text{m}$	

(Total for Question 12 = 9 marks)

Question Number	Acceptable answers	Additional guidance	Mark
13(a)	• Arrow upwards on at least one line. **(1)** Uniform section: • at least 3 parallel, perpendicular straight lines, equispaced **(1)** Non-uniform: • at least 2 lines perpendicular to equipotentials **(1)** • spacing getting larger **(1)**		**4**
13(b)	• Use of $\ln V = \ln V_o - \frac{t}{RC}$ **(1)** **Or** Draws initial tangent to curve and uses $T = RC$ **Or** Determines t when V has decreased to approx. 37% • Conversion hours to seconds **(1)** • Calculates resistance in range 2.4×10^{11} to 2.8×10^{11} (Ω) **(1)** • Use of $R = \rho l / A$ **(1)** • Resistivity in range $2.2 \times 10^{15}\ \Omega$ m to $2.6 \times 10^{15}\ \Omega$ m so yes above $10^{14}\ \Omega$ m **(1)**	<u>Example of calculation</u>: $ln6 = ln100 - \frac{20 \times 3600\ \text{s}}{R\ \times 0.1 \times 10^{-6} (\text{s})}$ $R = 2.6 \times 10^{11}\ \Omega$ $2.6 \times 10^{11} \Omega = \frac{\rho \times 0.6 \times 10^{-6}\ \text{m}}{5.6 \times 10^{-3}\ \text{m}^2}$ Resistivity = $2.4 \times 10^{15}\ \Omega$ m Using $T = RC$ $7 \times 3600\ \text{s} = 0.1 \times 10^{-6}\ \text{F} \times R$ $R = 2.5 \times 10^{11}\ \Omega$ (allow T in range 7 – 8 hour)	**5**

(Total for Question 13 = 9 marks)

Question Number	Acceptable Answers	Additional Guidance	Mark
14(a)	• Calculates p.d. across internal resistance **(1)** • Use of $R = V / I$ **(1)** • Internal resistance = 6 Ω **(1)**	Example of calculation: $V_r = 8.2\text{V} - 5.5\text{V} = 2.7\text{V}$ $r = \frac{2.7\text{ V}}{0.45\text{ A}}$ $r = 6.0\ \Omega$	**3**
14(b)	• Use of $P = VI$ for panel **(1)** • Use of $P = \frac{E}{t}$ **(1)** • Time = 13 hours **(1)**	Example of calculation: Total Power of panels=380 ×5.5 V ×0.45 A = 940.5 W Time to charge = 12000 / 940.5 = 12.8 hours	**3**
14(c)(i)	• Use of $\Delta W = F\Delta s$ and $P = W / t$ **(1)** • Use of $F = ma$ **(1)** • $a = 0.31\text{ m s}^{-2}$ **(1)**	Example of calculation: In 1 second $W = F\Delta s$ $4500\text{ W} = F \times 34\text{ m s}^{-1}$ Force applied by motor = 132 N $F = ma$ $132\text{ N} = 420\text{ kg} \times a$ $a = 0.31\text{ m s}^{-2}$	**3**
14(c)(ii)	• Neglect friction forces when it starts from rest **(1)** **Or** Motor/Driving force independent of speed	Do not accept "force" without a description	**1**
14(d)	Max 2 • normal car would have much more mass **(1)** • too much area of solar cell needed so impractical **(1)** • going uphill would need far more power **(1)**		**2**

(Total for Question 14 = 12 marks)

Question Number	Acceptable answers		Additional guidance	Mark
15(a)	Before scattering experiment: • atom containing equally distributed mass/charge After experiment: • very small nucleus containing (almost all) the mass of the atom • atom mainly empty space • nucleus is charged	**(1)** **(1)** **(1)** **(1)**	alt: reference to 'plum pudding model'	**4**
15(b)	• Use of $V = Q/4\pi\varepsilon_0 r$ • Conversion MeV to J • Use of $V = W/Q$ • $r = 3.0 \times 10^{-14}$ m	**(1)** **(1)** **(1)** **(1)**	allow for $Q = 2$ or 79, accept $V = kQ/r$ Must use $e = 1.6 \times 10^{-19}$ C to convert atomic number to C <u>Example of calculation</u>: $7.7 \times 10^6 \mathrm{eV} \times 1.6 \times 10^{-19} \mathrm{J\,eV^{-1}}$ $= 8.99 \times 10^9 \mathrm{N\,m^2C^{-2}} \times 2 \times 79 \times (1.6 \times 10^{-19}\ \mathrm{C})^2 \div r$ $r = 2.27 \times 10^{-7} \div 7.7 \times 10^6$ $r = 2.95 \times 10^{-14}$ m	**4**
15(c)	An explanation that makes reference to the following points: Observation 1 • (the fraction of alpha scattering is less for aluminium) so the force of repulsion is less (at a given distance) • therefore the charge on an aluminium nucleus is less than on gold nucleus Observation 2	 **(1)** **(1)**		**4**

	• (the E_k is less for scattered alpha for aluminium) so recoiling nucleus must have some/more kinetic energy **(1)** • The mass of an aluminium nucleus is less than mass of a gold nucleus **(1)**		

(Total for Question 15 = 12 marks)

Question Number	Acceptable Answers	Additional Guidance	Mark
*16 (a)	This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning. Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning. The following table shows how the marks should be awarded for indicative content. Indicative content: • the lambda particle is neutral • because it does not leave a track **Or** two tracks are opposite charged • momentum of proton/ pion can be determined by measuring radius of curve • using $p = Bqr$ • law of conservation of momentum can then be applied • so momentum/energy of the lambda particle can be determined	<table><tr><th>IC points</th><th>IC mark</th><th>Max linkage mark availabl e</th><th>Max final mark</th></tr><tr><td>**6**</td><td>4</td><td>2</td><td>**6**</td></tr><tr><td>**5**</td><td>3</td><td>2</td><td>**5**</td></tr><tr><td>**4**</td><td>3</td><td>1</td><td>**4**</td></tr><tr><td>**3**</td><td>2</td><td>1</td><td>**3**</td></tr><tr><td>**2**</td><td>2</td><td>0</td><td>**2**</td></tr><tr><td>**1**</td><td>1</td><td>0</td><td>**1**</td></tr><tr><td>**0**</td><td>0</td><td>0</td><td>**0**</td></tr></table> IC4 – p and r recognisable from the context of the answer IC5 and 6 can be awarded for a labelled momentum vector triangle	6

16 (b)	An explanation that makes reference to the following points: • charge: 0 = +1 identified as proton **(1)** −1 identified as pion • Baryon number: 1 = 1 identified as proton **(1)** + 0 identified as pion • Lepton number: 0 = 0 + 0 **(1)** **Or** there are no leptons involved		3
16(c)	• $(\Lambda^0) \rightarrow p^{(1)} + \pi^{-1}$ **(1)**		1
16(d)(i)	• Converts eV to J **(1)** • use of $\Delta m = \Delta E / c^2$ **(1)** • mass = 1.98×10^{-27} (kg) **(1)**	<u>Example of calculation</u> $m = \frac{1115\text{ V} \times 1.6 \times 10^{-19}\text{C} \times 10^6}{(3 \times 10^8)^2(\text{ms}^{-1})^2}$ $m = 1.98 \times 10^{-27}$ kg	3
16(d)(ii)	• Converts prefix G to M **Or** M to G **(1)** • Determines total energy / mass of lambda before decay **(1)** • kinetic energy = 4985 MeV **(1)**	<u>Example of calculation</u> 4.95 GeV = 4950 MeV Total Energy and mass before decay = 4950 + 1115 = 6065 MeV Total after = 140 + 940 + E_k E_k = 6065 – 1080 = 4985 MeV	3

(Total for Question 16 = 16 marks)

Question Number	Acceptable Answers		Additional Guidance	Mark
17 (a)(i)	An explanation that makes reference to the following points: • Fleming left hand rule force will cause force on left hand side of coil into page **Or** right hand side of coil out of page • The coil will turn clockwise as shown in the plan view (MP2 dependent on MP1)	**(1)** **(1)**	allow 1 mark for statement "rotates clockwise because of FLHR"	**2**
17 (a)(ii)	• Moment of F around pivot = $F \times w/2$ • Use of $F = BIl$ • Moment due to F on both sides = $2 \times BIl \times w/2$ • As N turns and $l \times w = A$; Total moment = $BAIN$	**(1)** **(1)** **(1)** **(1)**	alt: Use of Torque of a couple $= F \times w$ then MP1 and 3 This equation should be substituted into a product with a "distance" to be awarded 'use of'	**4**
17(b)	• Use of $V = IR$ • Use of $V_{total} = V_{meter} + V_{multiplier}$ • Choice of $R = 2500\ \Omega$	**(1)** **(1)** **(1)**	<u>Example of calculation</u> V across meter = 0.0016 A × 625Ω = 1.0 V V across multiplier = 5.0 V – 1.0 V = 4.0 V $R_{multiplier} = \frac{4.0\ \text{V}}{0.0016\ \text{A}} = 2500\ \Omega$ MP3 dependent on MP1 or MP2	**3**
17(c)	An explanation that makes reference to the following points: • This is because there is a change of flux (linkage) as the meter is moved	 **(1)**		**4**

	• An emf is induced which will produce a current in the coil (as both ends of the coil are connected) **(1)** • Current-carrying conductor within a magnetic field experiences a force **(1)** • These forces oppose the coil's motion (reducing it) **(1)**		

(Total for Question 17 = 13 marks)

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