Pearson Edexcel

Mark Scheme (Results)

Summer 2023

Pearson Edexcel International Advanced Subsidiary Level In Physics (WPH14)

Paper 01

Unit 4: Physics Futher Mechanics, Fields and Particles

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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 schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate.

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. Units will be bracketed on the mark scheme in this case, e.g. 7.2 (m).

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.

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	Answer	Mark
1	The only correct answer is **D** because the emission of electrons from a heated filament is called thermionic emission. **A** is not correct because the emission of electrons from a heated filament is not called annihilation **B** is not correct because the emission of electrons from a heated filament is not called ionisation **C** is not correct because the emission of electrons from a heated filament is not called photoelectric effect	1
2	The only correct answer is **B** because the charge stored on the capacitor in coulomb is given by $2.2 \times 10^{-4} \times 6$ **A** is not correct because the charge stored on the capacitor in coulomb is not given by $0.5 \times 2.2 \times 10^{-4} \times 6$ **C** is not correct because the charge stored on the capacitor in coulomb is not given by $\frac{0.5 \times 2.2 \times 10^{-4}}{6}$ **D** is not correct because the charge stored on the capacitor in coulomb is not given by $\frac{2.2 \times 10^{-4}}{6}$	1
3	The only correct answer is **B** because after emission the proton number is 18 and the nucleon number is 38 **A** is not correct because after emission the proton number is 18 and the nucleon number is 38 **C** is not correct because after emission the proton number is 18 and the nucleon number is 38 **D** is not correct because after emission the proton number is 18 and the nucleon number is 38	1
4	The only correct answer is **A** because impulse has the units of mass × velocity **B** is not correct because this is not units of mass × velocity **C** is not correct because N is not a base unit **D** is not correct because N is not a base unit	1
5	The only correct answer is **D** because this is a requirement for creating new particles rather than investigating structure **A** is not correct because this is a reason why particles with high energy are required **B** is not correct because this is a reason why particles with high energy are required **C** is not correct because this is a reason why particles with high energy are required	1
6	The only correct answer is **A** because a neutrino is a fundamental particle **B** is not correct because a neutron is not a fundamental particle **C** is not correct because a pion is not a fundamental particle **D** is not correct because a proton is not a fundamental particle	1
7	The only correct answer is **B** because the mass in kg is given by $\frac{6.5 \times 1.6 \times 10^{-13}}{(3 \times 10^{8})^2}$ **A** is not correct because this does not take account of the M in MeV **C** is not correct because multiplication and division are reversed **D** is not correct because multiplication and division are reversed	1
8	The only correct answer is **C** because there is insufficient evidence to draw this conclusion **A** is not correct because this is a valid conclusion **B** is not correct because this is a valid conclusion **D** is not correct because this is a valid conclusion	1

9	The only correct answer is **B** **A** is not correct because there should be an antineutrino and not a neutrino **C** is not correct because charge is not conserved **D** is not correct because charge is not conserved	**1**
10	The only correct answer is **A** **B** is not correct because the length of the magnet is the length of wire perpendicular to the field **C** is not correct because the force is into the page **D** is not correct because the force is into the page	**1**

Question Number	Answer		Mark
11	Meson $\bar{c}$ and one quark from cdsu Charge correct for quark-antiquark combination Baryon 3 quarks from cdsu Charge correct for three-quark combination Correct 5 quarks used once each such that meson and baryon charges are equal and opposite ($\bar{c}$ d and csu **or** $\bar{c}$ s and cdu) (MP5 dependent on MP1, 2, 3 and 4)	 **(1)** **(1)** **(1)** **(1)** **(1)**	5
	Total for question 11		**5**

Question Number	Answer		Mark
12(a)	Equates $F = \frac{mv^2}{r}$ and $F = BQv$ Substitutes $p = mv$ with suitable algebra to arrive at $r = \frac{p}{BQ}$ <u>Example of derivation</u> $\frac{mv^2}{r} = BQv$ $\frac{mv}{r} = BQ$ $\frac{p}{r} = BQ$ $r = \frac{p}{BQ}$	**(1)** **(1)**	**2**
12(b)	Use of conversion factor from eV to J Use of $E_k = \frac{p^2}{2m}$ **Or** Use of $E_k = ½\, mv^2$ **and** $p = mv$ Use of $r = \frac{p}{BQ}$ $B = 3.5$ T <u>Example of calculation</u> $E = 5.4 \text{ MeV} \times 10^6 \times 1.6\times10^{-19}$ C $= 8.64\times10^{-13}$ J $8.64\times10^{-13} \text{ J} = \frac{p^2}{2 \times 6.64\times 10^{-27}\text{kg}}$ $p = 1.07 \times 10^{-19}$ Ns $0.096 \text{ m} = 1.07 \times 10^{-19} \text{ Ns} / B \times 2 \times 1.6\times10^{-19}$ C $B = 3.48$ T	**(1)** **(1)** **(1)** **(1)**	**4**
	Total for question 12		**6**

Question Number	Answer	Mark
13(a)	The particles are accelerated by an electric field in the gaps **(1)** The a.c. frequency is constant so the particles spend the same time in the tubes/gaps **(1)** (This is achieved by) increasing length of drift tubes **Or** (This is achieved by) increasing length of gaps **(1)** The (a.c) polarity changes so the (electric) field is in the same direction when the particle is in the gaps **Or** The (a.c.) polarity changes so it is always accelerating the particles **(1)**	**4**
13(b)	The particles experience a force at right angles to their motion/path/velocity. **(1)** Which causes centripetal acceleration/force **Or** Which causes circular motion **(1)**	**2**
	Total for question 13	**6**

Question Number	Answer		Mark
14(a)	Use of trigonometrical function for x component of alpha momentum after collision **Or** Use of trigonometrical function for y component of alpha momentum after collision	**(1)**	
	Applies conservation of momentum in x direction **Or** Applies conservation of momentum in y direction	**(1)**	
	Applies trigonometry to calculate final angle for proton	**(1)**	
	Applies trigonometry or Pythagoras to calculate magnitude	**(1)**	
	Angle = 17.0(°)	**(1)**	
	Magnitude = 4.9×10^{-20} (N s)	**(1)**	**6**
	<u>Example of calculation</u> x component of alpha after = 8.06×10^{-20} Ns × cos10.2° = 7.93×10^{-20} Ns y component of alpha after = 8.06×10^{-20} Ns × sin10.2° = 1.43×10^{-20} Ns x component of proton = 1.26×10^{-19} Ns – 7.93×10^{-20} Ns = 4.67×10^{-20} Ns y component of proton = 1.43×10^{-20} Ns tan θ = 1.43×10^{-20} Ns ÷ 4.67×10^{-20} Ns = 0.31 θ = 17.0° $p^2 = (4.67 \times 10^{-20}\text{ Ns})^2 + (1.43 \times 10^{-20}\text{ Ns})^2$ $p = 4.88 \times 10^{-20}$ N s		
14(b)	Use of $E_k = \frac{p^2}{2m}$ **Or** Use of $E_k = ½ mv^2$ **and** $p = mv$	**(1)**	
	Correct calculation of one kinetic energy (e.c.f from (a))	**(1)**	
	Correct calculation of all kinetic energies (e.c.f from (a))	**(1)**	
	Conclusion consistent with correctly calculated values of kinetic energy	**(1)**	**4**
	<u>Example of calculation</u> $E_k = \frac{(4.88 \times 10^{-20}\text{ N s})^2}{2 \times 1.67 \times 10^{-27}\text{kg}} = 7.13 \times 10^{-13}$ J (proton after) $E_k = \frac{(8.06 \times 10^{-20}\text{ N s})^2}{2 \times 6.64 \times 10^{-27}\text{kg}} = 4.89 \times 10^{-13}$ J (alpha after) $E_k = \frac{(1.26 \times 10^{-19}\text{ N s})^2}{2 \times 6.64 \times 10^{-27}\text{kg}} = 1.20 \times 10^{-12}$ J (initial alpha) 7.13×10^{-13} J + 4.89×10^{-13} J = 1.2×10^{-12} J = initial alpha kinetic energy, so it is elastic		
	Total for question 14		**10**

Question Number	Answer		Mark
15(a)(i)	States $T = 0.16$ s	**(1)**	
	Use of $\omega = 2\pi / T$	**(1)**	
	$\omega = 39$ (radian s^{-1})	**(1)**	**3**
	<u>Example of calculation</u> $T = 0.16$ s $\omega = 2\pi / 0.16$ s $\omega = 39.3$ radian s^{-1}		
15(a)(ii)	Maximum force read from graph ($F = 0.63$ N) (accept 0.62 N to 0.64 N)	**(1)**	
	Use of $F = m\,\omega^2\, r$	**(1)**	
	$r = 0.044$ (m) (e.c.f from (a)(i))	**(1)**	
	86 mm is 2 × 0.043 m, so 0.086 m was the diameter in mm	**(1)**	**4**
	<u>Example of calculation</u> $0.63 \text{ N} = 0.0095 \text{ g} \times (39 \text{ radian s}^{-1})^2 \times r$ $r = 0.044$ m (Show that value gives 0.041)		
15(b)*	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.

Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points	Max linkage mark available	Max final mark
6	4	2	6
5	3	2	5
4	3	1	4
3	2	1	3
2	2	0	2
1	1	0	1
0	0	0	0

The following table shows how the marks should be awarded for structure and lines of reasoning.

	Number of marks awarded for structure of answer and sustained line of reasoning
Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2
Answer is partially structured with some linkages and lines of reasoning	1
Answer has no linkages between points and is unstructured	0

Guidance on how the mark scheme should be applied: The mark for indicative content should be added to the mark for lines of reasoning. For example, an answer with five indicative marking points which is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning). If there are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).

	Indicative content: IC1: Magnitude of centripetal force is constant since speed is constant IC2: Centripetal force on car at bottom is normal contact force minus weight ($F = N - W$ **or** $N = F + W$) IC3: When car is at bottom force is maximum IC4: Centripetal force on car at top is normal contact force plus weight ($F = N + W$ **or** $N = F - W$) IC5: When car is at top force is minimum IC6: At 0.04 s it is at the bottom and at 0.12 s it's at the top	**6**
	Total for question 15	**13**

Question Number	Answer		Mark
16(a)	(Wires) cut lines of magnetic flux **Or** flux linkage (with coil) changing Induces emf	 **(1)** **(1)**	**2**
16(b)	Use of $A = \pi(d/2)^2$ Applies knowledge of flux = flux density × area Flux = 8.8×10^{-5} (Wb) (at least 2 s.f) Example of calculation $A = \pi \times (0.025\text{ m} / 2)^2$ $= 4.9 \times 10^{-4}\text{ m}^2$ $\varphi = 0.18\text{ T} \times 4.9 \times 10^{-4}\text{ m}^2$ $= 8.84 \times 10^{-5}\text{ Wb}$	**(1)** **(1)** **(1)**	**3**
16(c)	Determine maximum gradient of graph Use of flux linkage = $N\varphi$ Use of $\varepsilon = dN\varphi / dt$ $V = 2.3$ V (range rounds – 2.2 V to 2.6 V) Example of calculation max gradient = $4.62 \times 10^{-4}\text{ Wb s}^{-1}$ max $V = 5000 \times 4.62 \times 10^{-4}\text{ Wb s}^{-1} = 2.3\text{ V}$	**(1)** **(1)** **(1)** **(1)**	**4**
16(d)	By Lenz's law, current/e.m.f./field/force produced is so as to oppose the cause of the current/e.m.f. Force on wire due to interaction of induced current and field Force to left, so, by (Fleming) LHR… … current into page and student is correct (dependent on MP3)	**(1)** **(1)** **(1)** **(1)**	**4**
	Total for question 16		**13**

Question Number	Answer		Mark
17(a)	At least 4 radial straight lines, from surface of sphere Equal spacing Arrows outward	(1) (1) (1)	3
17(b)(i)	Use of $V = \frac{Q}{4\pi\varepsilon_0 r}$ $Q = 1.1 \times 10^{-8}$ (C) Example of calculation $5000 \text{ V} = 8.99 \times 10^9 \text{ Nm}^2\text{C}^{-2} \times \frac{Q}{0.02 \text{ m}}$ $Q = 1.1 \times 10^{-8}$ C	(1) (1)	2
17(b)(ii)	Use of $E = V/d$ Use of $F = EQ$ $F = 5.2 \times 10^{-4}$ N (e.c.f from (b)(i)) Example of calculation $E = 5000 \text{ V} \div 0.105 \text{ m} = 47\,600 \text{ V m}^{-1}$ $F = 47\,600 \text{ V m}^{-1} \times 1.1 \times 10^{-8}$ C $F = 5.24 \times 10^{-4}$ N	(1) (1) (1)	3
17(b)(iii)	Use of $W = mg$ Use of suitable trigonometry, such as $\tan\theta = F/W$ $\theta = 1.1(°)$ (e.c.f from (b)(i) and (b)(ii)) Example of calculation $W = 0.0027 \text{ kg} \times 9.81 \text{ N kg}^{-1} = 0.0265$ N $\tan\theta = 5.24 \times 10^{-4} \text{ N} / 0.0265 \text{ N} = 0.0198$ $\theta = 1.13°$	(1) (1) (1)	3
17(c)	Use of $F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$ with $Q_1 = Q_2 = 1.2 \times 10^{-8}$ C $r = 0.051$ m Example of calculation 5.0×10^{-4} N $= \frac{8.99 \times 10^9 \text{ Nm}^2\text{C}^{-2} \times 1.2 \times 10^{-8} \text{ C} \times 1.2 \times 10^{-8} \text{ C}}{r^2}$ $r = 0.051$ m	(1) (1) (1)	3
	Total for question 17		**14**

Question Number	Answer	Mark
18(a)	Draws best fit straight line on graph **(1)** Use of two corresponding pairs of values of I and t **(1)** Use of gradient = – 1 / CR **(1)** $C = 2.17 \times 10^{-5}$ (F) (rounds to 2.2×10^{-5}) **(1)** **Or** Draws best fit straight line on graph **(1)** Use of two corresponding pairs of values of I and t **(1)** Use of $\ln I = \ln I_0 - t / CR$ **(1)** $C = 2.17 \times 10^{-5}$ (F) (rounds to 2.2×10^{-5}) **(1)** <u>Example of calculation</u> Gradient = $-0.189\ \text{s}^{-1}$ $0.191\ \text{s}^{-1} = 1 / C \times 240\,000\ \Omega$ $C = 2.17 \times 10^{-5}$ F	4
18(b)(i)	Use of $\Delta E_{grav} = mg\Delta h$ **(1)** Use of $E_k = ½ mv^2$ and conservation of energy **(1)** $v = 0.46\ \text{m s}^{-1}$ **(1)** <u>Example of calculation</u> $E_{grav} = 0.028\ \text{kg} \times 9.81\ \text{N kg}^{-1} \times 0.011\ \text{m} = 3.02 \times 10^{-3}$ J $3.02 \times 10^{-3}\ \text{J} = ½ \times 0.028\ \text{kg} \times v^2$ $v = 0.464\ \text{m s}^{-1}$	3
18(b)(ii)	Use of $V = V_0\, e^{-t/CR}$ **(1)** **Or** Use of $\ln V = \ln V_0 - t / CR$ $t = 1.4 \times 10^{-4}$ s **(1)** <u>Example of calculation</u> $\ln (5.43\ \text{V} / 6.18\ \text{V}) = - t / 2.2 \times 10^{-5}\ \text{F} \times 49\ \Omega$ $t = 1.39 \times 10^{-4}$ s	2
18(b)(iii)	Use of $W = mg$ **(1)** Use of $p = mv$ **(1)** Use of $F\,\Delta t = \Delta p$ **(1)** $F = 93$ N which is (much) more than the weight of sphere A, so the suggestion is incorrect (e.c.f from (b)(i) and (b)(ii)) **(1)** <u>Example of calculation</u> $W = mg$ $= 0.028\ \text{kg} \times 9.81\ \text{N kg}^{-1}$	4

	= 0.275 N p = 0.028 kg × 0.464 m s^{-1} = 0.013 N s F = 0.013 N s / 1.39 × 10^{-4} s = 93 N	
	Total for question 18	**13**

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