Mark Scheme (Results)

January 2025

Pearson Edexcel International Advanced Level in Physics (WPH14)
Paper 01 Further 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 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. 'resonance'

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 placing brackets around the unit.

3. Significant figures

3.1 Use of too many significant figures in the theory questions will not 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 be penalised by one mark (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 **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.

4.2 If a 'show that' question is worth 2 marks, then both marks will be available for a reverse working. If the question is worth 3 marks then only 2 marks will be available.

4.3 The mark scheme will show a correctly worked answer for illustration only.

5. Quality of Written Expression

5.1 Questions that asses the ability to show a coherent and logically structured answer are marked with an asterisk.

5.2 Marks are awarded for indicative content and for how the answer is structured.

5.3 Linkage between ideas, and fully-sustained reasoning is expected.

Question Number	Answer	Mark
1	**The only correct answer is A** $\left(\frac{40 \times 2\pi}{360}\right)$ B is not correct because it does not equal 40º C is not correct because it does not equal 40º D is not correct because it does not equal 40º	**1**
2	**The only correct answer is B** (pion) A is not correct because a photon is a quantum of electromagnetic radiation C is not correct because a positron is a lepton D is not correct because a proton is a baryon	**1**
3	**The only correct answer is B** $\left(\frac{8.99 \times 10^{9} \times (8.0 \times 10^{-6})^{2}}{0.020^{2}}\right)$ A is not correct because distance is not squared, and charge is not squared C is not correct because distance is not squared D is not correct because charge is not squared	**1**
4	**The only correct answer is D** (same mass, different lepton number) A is not correct because the positron has a different lepton number and same baryon number as the electron B is not correct because the positron has a different lepton number C is not correct because the positron has the same baryon number as the electron	**1**
5	**The only correct answer is A** (Strong electrostatic forces act on the alpha particles.) B is not correct because this does not explain large angle deflection C is not correct because this does not explain large angle deflection D is not correct because this does not explain large angle deflection	**1**
6	**The only correct answer is C** (more turns in coil Q, closer together) A is not correct because fewer turns in Q will reduce e.m.f. B is not correct because the two coils further apart and fewer turns in Q will reduce e.m.f. D is not correct because two coils further apart will reduce e.m.f.	**1**
7	**The only correct answer is D** $(2 \times 9.11 \times 10^{-31} \times (3 \times 10^{8})^{2})$ A is not correct because this does not consider the mass of the positron B is not correct because this uses the mass of a single proton / antiproton C is not correct because this gives uses the mass of a proton / antiproton	**1**

8	**The only correct answer is D** (The particle experiences a centripetal force.) A is not correct because the direction of the magnetic field is not given B is not correct because there is no change in radius C is not correct because there is no change in radius	**1**
9	**The only correct answer is B** (The area under the graph from 0.5 m to infinity.) A is not correct because area under the graph is incorrect C is not correct because the gradient does not give electric potential D is not correct because E at 0.5m divided by 0.5m does not give electric potential	**1**
10	**The only correct answer is A** $\left(\frac{1}{8}\right)$ B is not correct because the p.d. hasn't been squared C is not correct because the ratio is inverted, and the p.d. hasn't been squared D is not correct because the ratio is inverted	**1**

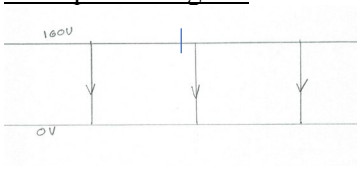
Question Number	Answer		Mark
11	Lepton number: $0 + 0 \rightarrow 0 + 0 - 1 + 1$ (0 on each side so conserved)	**(1)**	
	Baryon number: $1 + 1 \rightarrow 1 + 1 + 0 + 0$ (2 on each side so conserved)	**(1)**	
	Charge: $+1 + 1 \rightarrow +1 + 0 + 1 + 0$ (+2 (e) on both sides so conserved)	**(1)**	**3**
	Total for question 11		**3**

Question Number	Answer		Mark
12(a)	Use of $V = \frac{Q}{4\pi\varepsilon_0 r}$ (Allow use of $V = \frac{kQ}{r}$)	**(1)**	
	$Q = 4.38 \times 10^{-7}$ (C)	**(1)**	**2**
	Example of calculation $Q = 1.75 \times 10^4$ V $\times 22.5 \times 10^{-2}$ m $\times 4\pi \times 8.85 \times 10^{-12}$ F m^{-1} $= 4.38 \times 10^{-7}$ C		
12(b)	Use of $E = \frac{Q}{4\pi\varepsilon_0 r^2}$ (Allow use of $E = \frac{kQ}{r^2}$)	**(1)**	
	E = 37000 V m^{-1} allow ecf from (a)	**(1)**	**2**
	Example of calculation $E = \frac{4.38 \times 10^{-7}\text{C}}{4\pi \times 8.85 \times 10^{-12}\text{ F m}^{-1}\ (32.5 \times 10^{-2}\text{ m})^2} = 37300\text{ V m}^{-1}$		
	Total for question 12		**4**

Question Number	Answer		Mark
13	Use of $F = BIl\sin\theta$	**(1)**	
	Component of magnetic flux density calculated using cos(20°) or sin(70°)	**(1)**	
	F = 2.8 N	**(1)**	**3**
	Example of calculation $B = 48 \times 10^{-6} \sin(70°) = 45.1 \times 10^{-6}$ T $F = 45.1 \times 10^{-6}$ T $\times 700$ A $\times 90$ m $= 2.84$ N		
	Total for question 13		**3**

Question Number	Answer		Mark
14(a)	The (metal in the) filament is heated (by the current)	**(1)**	
	The electrons are released by <u>thermionic emission</u>	**(1)**	**2**
14(b)	Use of $p = \frac{h}{\lambda}$	**(1)**	
	Use of $E_k = \frac{p}{2m}^2$ **Or** p=mv and $E_k = \frac{1}{2}mv^2$	**(1)**	
	Use of $V = \frac{w}{Q}$	**(1)**	
	$V = 2100$ V	**(1)**	**4**
	<u>Example of calculation</u> $p = \frac{6.63 \times 10^{-34}\ \text{J s}}{2.65 \times 10^{-11}\ \text{m}} = 2.50 \times 10^{-23}\ \text{kg m s}^{-1}$ $E_k = \frac{(2.50 \times 10^{-23}\ \text{kg m s}^{-1})^2}{2 \times 9.11 \times 10^{-31}\ \text{kg}} = 3.44 \times 10^{-16}\ \text{J}$ $V = \frac{3.44 \times 10^{-16}\ \text{J}}{1.6 \times 10^{-19}\ \text{C}} = 2147\ \text{V}$		
	Total for question 14		**6**

Question Number	Answer		Mark
15(a)(i)	Use of $T = \frac{2\pi}{\omega}$ ω = 147 (rad s^{-1}) Example of calculation $T = \frac{60\text{ s}}{1400}$ = 0.0429 s $\omega = \frac{2\pi}{0.429\text{ s}}$ = 146.6 (rad s^{-1})	**(1)** **(1)**	**2**
15(a)(ii)	Use of $a = r\omega^2$ $a = 4.9 \times 10^3$ m s^{-2} ecf from (a)(i) (show value that gives 5100 m s^{-2}) Example of calculation $a = 0.225\text{ m} \times (147\text{ rad s}^{-1})^2 = 4862\text{ m s}^{-2}$	**(1)** **(1)**	**2**
15(b)(i)	One weight force in each diagram, vertically downwards and labelled weight, *W* or *mg* One reaction force vertically upwards on first diagram **and** one reaction force vertically downwards on second diagram and labelled reaction, *R*, or *N*.	**(1)** **(1)**	**2**
15(b)(ii)	The weight is constant, **and** reaction force is minimum at top and maximum at bottom. At the top $F_c = R + W$ At the bottom $F_c = R - W$	**(1)** **(1)** **(1)**	**3**
15(b)(iii)	(water continues in a straight line), at a tangent to the surface of the drum	**(1)**	**1**
	Total for question 15		**10**

Question Number	Answer		Mark
16(a)	At least three equi-spaced vertical parallel lines touching the wires	**(1)**	**2**
	Arrows towards bottom plate [Ignore curved lines at edges of plates]	**(1)**	
	Example of diagram 		
16(b)	Use of $\rho = \frac{m}{V}$	**(1)**	**5**
	Use of $w = mg$	**(1)**	
	Use of $E = \frac{V}{d}$	**(1)**	
	Use of $E = \frac{F}{Q}$	**(1)**	
	Q = 5e, so the charge on the oil drop was a whole number multiple of the electronic charge.	**(1)**	
	Example of calculation $m = \rho V = 920\ \text{kg m}^{-3} \times 5.00 \times 10^{-19}\ \text{m}^3 = 4.60 \times 10^{-16}\ \text{kg}$ $w = mg = 4.60 \times 10^{-16}\ \text{kg} \times 9.81\ \text{N kg}^{-1} = 4.51 \times 10^{-15}\ \text{N}$ $E = \frac{V}{d} = \frac{85\ \text{V}}{1.5 \times 10^{-2}\ \text{m}} = 5.67 \times 10^{3}\ \text{V m}^{-1}$ $Q = \frac{F}{E} = \frac{4.51 \times 10^{-15}\ \text{N}}{5.67 \times 10^{3}\ \text{N C}^{-1}} = 7.96 \times 10^{-19}\ \text{C}$ $N = \frac{7.96 \times 10^{-19}\ \text{C}}{1.6 \times 10^{-19}\ C} = 4.97$		
	Total for question 16		**7**

Question Number	Answer		Mark
17(a)	Spiral path (of increasing radius) in the Dees (allow straight line in the gap)	**(1)**	
	Anticlockwise spiral (MP2 dependent on MP1)	**(1)**	**2**
17(b)	Use of $f = \frac{Bq}{2\pi m}$	**(1)**	
	Use of $T = 1/f$	**(1)**	
	$T = 6.0 \times 10^{-8}\text{s}$	**(1)**	**3**
	Example calculation: $f = \frac{0.55 \times 1.6 \times 10^{-19}}{2\pi \times 1.67 \times 10^{-27}} = 8.39 \times 10^{6}\text{Hz}$ $T = \frac{1}{8.39 \times 10^{6}} = 1.19 \times 10^{-7}\text{s}$ Time in one Dee $\frac{1.19 \times 10^{-10}\text{s}}{2} = 5.96 \times 10^{-8}\text{s}$		

***17(c)**

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.

IC points	IC mark	Max linkage mark	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

Indicative content

IC1 (p.d. creates an) electric field between the dees

IC2 Electric field/force accelerates protons

IC3 Magnetic (field gives a) force at right angles to protons' path

IC4 Protons follows a circular path (whilst in dees)
Or protons experience a centripetal force.

IC5 p.d./polarity (of dees) switches every half cycle
Or p.d./polarity switches while protons are in the dee

IC6 (So) opposite side of the dee is always oppositely charged (to the protons) so protons accelerate repeatedly

6

Total for question 17 **11**

Question Number	Answer		Mark
18(a)	The magnets/poles are moved relative to the coil/reader	**(1)**	
	This causes a change in flux linkage with the coil **Or** This causes the coil to cut lines of flux	**(1)**	
	An <u>e.m.f.</u> is <u>induced</u> across the coil	**(1)**	
	The (north/south) pole affects the direction of the e.m.f. **Or** the sensor will register positive and negative p.d. as the polarity of the magnetic field changes.	**(1)**	**4**
18(b)	Use of $\frac{dA}{dt} = Lv$	**(1)**	
	Use of flux linked with one turn of coil $\phi = \text{BA}$	**(1)**	
	Use of $\mathcal{E} = -\frac{\delta(N\phi)}{\delta t}$	**(1)**	
	$\varepsilon = 1.65 \times 10^{-6}\,(\text{V})$	**(1)**	
	$1.65 \times 10^{-6}\,(\text{V}) > 1.5 \times 10^{-6}\,(\text{V})$ so can detect the direction of the emf Or Comparison of their calculated value with $1.5 \times 10^{-6}\,(\text{V})$ and conclusion consistent with comparison	**(1)**	**5**
	<u>Example of calculation</u> $\varepsilon = -\frac{d(N\phi)}{dt} = \frac{d(NBA)}{dt}$ $\varepsilon = \frac{25 \times 24 \times 10^{-6}\ T \times 0.090\ \text{m} \times 0.98 \times 10^{-3}\ \text{m}}{0.032\ \text{s}} = 1.65 \times 10^{-6}\ \text{V}$ $1.65 \times 10^{-6}\,(\text{V}) > 1.5 \times 10^{-6}\,(\text{V})$ so can detect the direction of the emf		
	Total for question 18		**9**

Question Number	Answer		Mark
19(a)	The rubber strip deforms (when the cars collide)	**(1)**	
	Increasing the time taken for the change in momentum of the car **Or** increasing the time for the collision	**(1)**	
	So since $F\Delta t$ is equal to change in momentum, the force is reduced	**(1)**	**3**
19(b)	Use of $p = mv$	**(1)**	
	Resolves momentum/velocity into components	**(1)**	
	Applies conservation of momentum	**(1)**	
	Use of $E_k = ½ mv^2$ **Or** $E_k = \frac{p^2}{2m}$	**(1)**	
	Initial E_k = 940 J **and** final E_k = 860 J	**(1)**	
	Initial E_k is not equal to final E_k, so collision is inelastic **Or** Comparison of their calculated values of initial E_k and final E_k with correct conclusion	**(1)**	**6**
	<u>Example of calculation</u> Initial momentum Car A= $2.19\ \text{m s}^{-1} \times 390\ \text{kg} = 854\ \text{kg m s}^{-1}$ Final momentum Car A along original direction $= 390\ \text{kg} \times 1.21\ \text{m s}^{-1} \times \cos(48^\circ) = 315.8\ \text{kg m s}^{-1}$ Momentum conservation along original direction $(854 - 315.8)\ \text{kgms}^{-1} = 360\text{kg}\ v_B \cos 33°$ $v_B = \frac{(854.0-315.8)(\text{kg m s}^{-1})}{301.9\ \text{kg}} = 1.78\ \text{m s}^{-1}$ Initial $E_K = \frac{1}{2} 390\ \text{kg} \times (2.19\ \text{m s}^{-1})^2 = 935\ \text{J}$ Final $E_K = \frac{1}{2} 360\ \text{kg} \times (1.78\ \text{m s}^{-1})^2 + \frac{1}{2} 390\ \text{kg} \times (1.21\text{m s}^{-1})^2$ Final $E_K = 572\ \text{J} + 285\ \text{J} = 857\ \text{J}$		
	Total for question 19		**9**

Question Number	Answer		Mark
20(a)(i)	Initially the current in the circuit is a maximum	**(1)**	
	The p.d. across the capacitor increases (as the capacitor charges)	**(1)**	
	The current in the circuit decreases because the p.d. across resistor decreases	**(1)**	
	When the capacitor is fully charged, the current is 0 because the p.d. across the resistor is 0 **Or** Capacitor is fully charged when p.d. across the capacitor equals p.d. across the supply, and the current is 0	**(1)**	**4**
20(a)(ii)	Axes labelled with *I* and *t*, exponential decreasing curve starting at y axis	**(1)**	
	Use of $I = V/R$	**(1)**	
	I_0 = 0.064 mA and marked on the current axis (at time = 0)	**(1)**	**3**
	<u>Example of calculation</u> $I_0 = 8\text{V} / 125 \times 10^3\ \Omega = 0.064$ mA		
20(b)(i)	Use of time constant = *RC*	**(1)**	
	58.8(s)	**(1)**	**2**
	<u>Example of calculation</u> Max value = 470×10^{-6} F × $125 \times 10^3\ \Omega$ = 58.75(s)		
20(b)(ii)	3 minutes is about 3*RC* **Or** Use of $V = V_0 e^{-t/RC}$ ecf (20 (b) (i))	**(1)**	
	Percentage reduction = 1/e in one time constant	**(1)**	
	Or % reduction $= \frac{V}{V_0} \times 100$	**(1)**	**3**
	The potential difference will be reduced to 5%		
	<u>Example of calculation</u> $1/e^3 = 0.0498$ $0.0498 \times 100 = 4.98\%$		

20(c)	$V_R + V_C = 8$ V	**(1)**	
	$V = 4.0$ V	**(1)**	
	Use of $\ln V = \ln V_0 - \frac{t}{RC}$	**(1)**	
	$t = 41$ s Example of calculation $\frac{4}{8} = e^{-\frac{t}{59\text{ s}}}$ $t = -59\text{ s} \ln(\frac{1}{2})$ $t = 40.9$ s $V = 4.00$ V	**(1)**	**4**
20(d)	charge stored in each capacitor is less than the original value	**(1)**	
	(because) the potential difference is shared between the capacitors	**(1)**	**2**
	Total for question 20		**18**

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