Pearson

Mark Scheme (Results)

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Pearson Edexcel
International Adavanced Level
in Physics (WPH04)
Paper 01 Physics on the Move

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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.

For example:

(iii)	<u>Horizontal force of hinge on table top</u> 66.3 (N) or 66 (N) **and** correct indication of direction [no ue] [Some examples of direction: acting from right (to left) / to the left / West / opposite direction to horizontal. May show direction by arrow. Do not accept a minus sign in front of number as direction.]	✓	**1**

This has a clear statement of the principle for awarding the mark, supported by some examples illustrating acceptable boundaries.

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.
   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 Incorrect use of case e.g. 'Watt' or 'w' will **not** be penalised.
   2.3 There will be no unit penalty applied in 'show that' questions or in any other question where the units to be used have been given, for example in a spreadsheet.
   2.4 The same missing or incorrect unit will not be penalised more than once within one question (one clip in epen).
   2.5 Occasionally, it may be decided not to penalise a missing or incorrect 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.
   2.6 The mark scheme will indicate if no unit error penalty is to be applied by means of [no ue].

3. **Significant figures**
   3.1 Use of an inappropriate number of significant figures in the theory papers will normally only be penalised in 'show that' questions where use of too few significant figures has resulted in the candidate not demonstrating the validity of the given answer.
   3.2 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}

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.
   - 4.6 Example of mark scheme for a calculation:

<u>'Show that' calculation of weight</u>

Use of L × W × H ✓

Substitution into density equation with a volume and density ✓

Correct answer [49.4 (N)] to at least 3 sig fig. [No ue] ✓
[If 5040 g rounded to 5000 g or 5 kg, do not give 3rd mark; if conversion to kg is omitted and then answer fudged, do not give 3rd mark] **3**
[Bald answer scores 0, reverse calculation 2/3]

Example of answer:
80 cm × 50 cm × 1.8 cm = 7200 cm^3
7200 cm^3 × 0.70 g cm^{-3} = 5040 g
5040 × 10^{-3} kg × 9.81 N/kg
= 49.4 N

5. **Quality of Written Communication**
   - 5.1 Indicated by QoWC in mark scheme. QWC – Work must be clear and organised in a logical manner using technical wording where appropriate.
   - 5.2 Usually it is part of a max mark, the final mark not being awarded unless the QoWC condition has been satisfied.

6. **Graphs**
   - 6.1 A mark given for axes requires both axes to be labelled with quantities and units, and drawn the correct way round.
   - 6.2 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.
   - 6.3 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.
   - 6.4 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 C** ***A*** *is not correct as, this increases the atomic number and mass number by 4 and 2 respectively.* ***B*** *is not correct as this increases the atomic number and mass number by 2 and 4 respectively.* ***D*** *is not correct as This decreases the atomic number and mass number by 4 and 2 respectively.*	**(1)**
2	**The only correct answer is C** ***A*** *is not correct as an electron is a lepton.* ***B*** *is not correct as a neutrino is a lepton.* ***D*** *is not correct as a positron is the antiparticle of an electron so it is a lepton.*	**(1)**
3	**The only correct answer is D** ***A*** *is not correct as another correct possibility is* $\frac{1}{2}CV^2$ *, but this answer is just* $\frac{1}{2}CV$*.* ***B*** *is not correct as the quantities in the numerator and denominator have been reversed.* ***C*** *is not correct as this is superficially similar to* $\frac{1}{2}CV^2$ *, but the wrong term is squared*	**(1)**
4	**The only correct answer is C** ***A*** *is not correct as the statement is true. The inward spiral is due to a decrease in momentum, since* $r = p/BQ$ *and B and Q are unchanged, so this must be linked to a decrease in energy.* ***B*** *is not correct as the statement is true. Using knowledge of particle tracks we know that the radius of the track is decreasing with time, so the particle enters the picture from the left. As it is positively charged, this is the direction of the current. The direction of the spiral shows us the direction of the force acting on the particle. Using Fleming's left hand rule, the field must be acting into the page.* ***D*** *is not correct as the statement is true since we know from the inward spiral that the momentum is decreasing.*	**(1)**
5	**The only correct answer is B** ***A*** *is not correct as this is the time for the potential difference to decrease to 1/2 of its initial value* ***C*** *is not correct as this is the time for the potential difference to decrease to 1/ln 2 of its initial value* ***D*** *is not correct as this is the time for the potential difference to decrease to 1/ln e of its initial value*	**(1)**

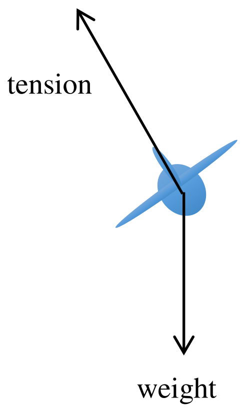
6	**The only correct answer is D** ***A*** *is not correct as The first composition would be a meson, not a baryon, and the second composition has too many quarks for a meson.* ***B*** *is not correct as The first composition is possible for a baryon, but the second composition has 2 quarks rather than a quark and an antiquark.* ***C*** *is not correct as This shows a possible meson in the baryon column and vice versa*	**(1)**
7	**The only correct answer is B** ***A*** *is not correct as this is* $C^2\ m^2 / N$*, which would require* $\varepsilon_0 = Q_1 Q_2 r^2 / 4\pi F$ ***C*** *is not correct as this is* $m^2 / N\ C^2$ *, which would require* $\varepsilon_0 = r^2 / Q_1 Q_2\ 4\pi F$ ***D*** *is not correct as this is* $N / C^2\ m^2$ *, which would require* $\varepsilon_0 = F / r^2\ Q_1 Q_2\ 4\pi$	**(1)**
8	**The only correct answer is B** ***A*** *is not correct as this shows both charge and current decreasing, which would be correct for discharging but not charging.* ***C*** *is not correct as this shows both charge and current increasing, which is not possible in the circuit shown.* ***D*** *is not correct as this shows current increasing and charge decreasing, which is not possible in the circuit shown*	**(1)**
9	**The only correct answer is C** ***A*** *is not correct as this would suggest zero force acting on the sphere with +Q charge but a larger force on the other sphere, therefore not equal and opposite.* ***B*** *is not correct as this suggests a greater force acting on the 10Q sphere, therefore not equal and opposite.* ***D*** *is not correct as this suggests a lesser force acting on the 10Q sphere, therefore not equal and opposite.*	**(1)**
10	**The only correct answer is B** ***A*** *is not correct as this is the fraction of 360° multiplied by π only.* ***C*** *is not correct as this is an incorrect arrangement of the correct numbers.* ***D*** *is not correct as this is an incorrect arrangement of the numbers in part A.*	**(1)**
	Total for multiple choice questions	**10**

Question Number	Answer	Mark
11(a)	Correct charges used: π^+, μ^- **Or** π^-, μ^+ (Accept 0 charge for antineutrino) **(1)** Example of equation $K^0 \rightarrow \pi^+ + \mu^- + \bar{\nu}_\mu$	**1**
11(b)	Correct, uncontradicted reference to fundamental particles: E.g., Electron is not made of any other particles **Or** the electron is fundamental **Or** the electron has no internal structure **Or** Protons/neutrons are not fundamental **(1)** Protons/neutrons are baryons **Or** electrons are leptons **(1)** Proton/neutron/baryon made of 3 quarks (accept the individual quark combinations of proton and neutron) **(1)**	**3**
	Total for question 11	**4**

Question Number	Answer	Mark
12	See $F_E = Eq$ and $E = V/d$ **(1)** Combine to obtain $F_E = qV/d$ **(1)** See $F_B = Bqv$ **(1)** Equates F_E and F_B and rearranges **(1)** Example of derivation $E = V/d$ and $F_E = Eq$ So $F_E = q\ V/d$ $F_B = Bqv$ $F_E = F_B$ So $Bqv = q\ V/d$ Therefore $v = V/dB$	**4**
	Total for question 12	**4**

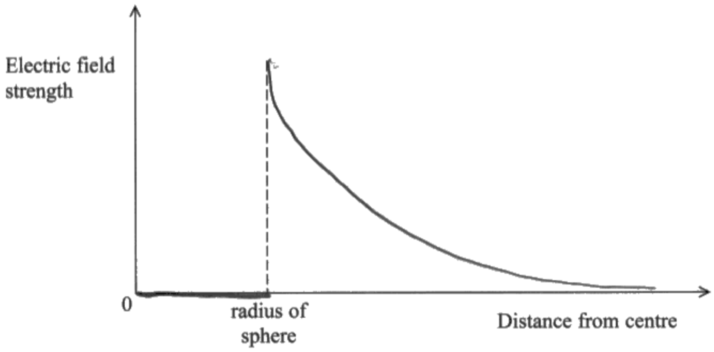
Question Number	Answer		Mark
13(a)	Use of $p = mv$	**(1)**	
	Use of $\times \sin 30.0°$ or $\times \sin 10.9°$ for vertical **Or** Use of $\times \cos 30.0°$ or $\times \cos 10.9°$ for horizontal	**(1)**	
	Use of principle of conservation of momentum	**(1)**	
	$v = 5.24 \times 10^6$ (m s^{-1})	**(1)**	**4**
	<u>Example of calculation</u> $p_\alpha = 4u \times 6.93 \times 10^6$ m s^{-1} = $2.77u \times 10^7$ kg m s^{-1} Component of p_α in vertical direction = ($2.77u \times 10^7$ kg m s^{-1} $\times \sin 30.0°$) = $1.39u \times 10^7$ kg m s^{-1} Momentum before = momentum after, so vertical component of p_α + vertical component of $p_N = 0$ Component of p_N in vertical direction = ($14u \times v \times \sin 10.9°$) = $1.39u \times 10^7$ kg m s^{-1} $v = 5.24 \times 10^6$ m s^{-1}		
13(b)	Use of $E_k = ½ mv^2$ (ecf v from (a))	**(1)**	
	Initial $E_k = 2.88u \times 10^{14}$ (J) **Or** $E_k = 4.78 \times 10^{-13}$ (J)	**(1)**	
	Calculation of final $E_k = 2.88u \times 10^{14}$ (J) **Or** $E_k = 4.78 \times 10^{-13}$ (J) **and** statement that E_k conserved so it is elastic	**(1)**	**3**
	<u>Example of calculation</u> $E_k = ½ mv^2$ Before: $E_k = ½ \times 4u \times (1.2 \times 10^7 \text{ m s}^{-1})^2 = 2.88u \times 10^{14}$ J (= 4.78×10^{-13} J) After: α, $E_k = ½ \times 4u \times (6.93 \times 10^6 \text{ m s}^{-1})^2 = 9.62u \times 10^{13}$ J N, $E_k = ½ \times 14u \times (5.24 \times 10^6 \text{ m s}^{-1})^2 = 1.92u \times 10^{14}$ J Total = $2.88u \times 10^{14}$ J (= 4.78×10^{-13} J), so kinetic energy conserved		
	Total for question 13		**7**

Question Number	Answer	Mark
14(a)	Use of $\Delta E = c^2\Delta m$ **(1)** with $\Delta m = 2m_e$ **(1)** Use of $c = f\lambda$ and $E = hf$ **Or** Use of $E = hc/\lambda$ **(1)** $\lambda = 1.2 \times 10^{-12}$ m **(1)** <u>Example of calculation</u> $\Delta E = (3.00 \times 10^8 \text{ m s}^{-1})^2 \times 2 \times 9.11 \times 10^{-31}$ kg $\Delta E = 1.64 \times 10^{-13}$ J $f = 1.64 \times 10^{-14} \text{ J} \div 6.63 \times 10^{-34}$ J s $= 2.47 \times 10^{20}$ Hz $\lambda = 3 \times 10^8 \text{ m s}^{-1} \div 2.47 \times 10^{20}$ Hz $\lambda = 1.2 \times 10^{-12}$ m	**4**
14(b)	Initial charge is zero, so final charge must be zero **Or** charge would not be conserved **(1)**	**1**
14(c)	Energy of electron reduces through collisions/ionisations **Or** electron is absorbed by an atom/ion/nucleus **(1)** Positron will meet an electron and annihilate **(1)**	**2**
	Total for question 14	**7**

Question Number	Answer		Mark
15(a)(i)	*W/mg/*weight – labelled arrow downwards *T/*tension only – labelled arrow parallel to string on diagram (Maximum mark available reduced by one for each incorrect force) <u>Example of diagram</u> 	**(1)** **(1)**	**2**
15(a)(ii)	Use of $v = \omega r$ $v = 1.5 \text{ m s}^{-1}$ <u>Example of calculation</u> $v = 2\pi \times 36 \times 0.4 \text{ m} / 60 \text{ s}$ $v = 1.51 \text{ m s}^{-1}$	**(1)** **(1)**	**2**
15(a)(iii)	$T\cos\theta = mg$ $T\sin\theta = mv^2/r$ **Or** $T\sin\theta = mr\omega^2$ $\tan\theta = v^2/rg$ **Or** $\tan\theta = r\omega^2/g$	**(1)** **(1)** **(1)**	**3**

15(b)	**Either** Video and playback Viable method to measure maximum angle from video **Or** Viable method to measure diameter of rotation and length of string use of correct trigonometry to calculate angle **Or** Viable method to measure diameter of rotation and height of point of suspension above aeroplane use of correct trigonometry to calculate angle **Or** Viable method to measure rotational period and radius/diameter of rotation Calculation of angle using appropriate formulae **Or** Viable method to measure speed and radius/diameter of rotation Calculation of angle using appropriate formulae	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**2**
	Total for question 15		**9**

Question Number	Answer		Mark
***16(a)**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) Protons accelerated by electric field between the dees **Or** Protons accelerated by potential difference across the gap The magnetic field is perpendicular to proton motion This causes a centripetal acceleration/force for a circular path The p.d./field/polarity (across the gap between the dees) has reversed when the proton reaches the gap again **Or** The p.d./field/polarity (across the gap between the dees) reverses while the proton is in the dee (Each successive half-circle) path of the proton has a larger radius with greater speed/momentum/energy	 **(1)** **(1)** **(1)** **(1)** **(1)**	**5**
16(b)(i)	Use of eV conversion using 1.6×10^{-19} C Use of $E_k = p^2/2m$ $p = 1.03 \times 10^{-19}$ (N s) Example of calculation 20×10^6 eV $\times 1.6 \times 10^{-19}$ C $= 3.2 \times 10^{-12}$ J $p = \sqrt{(2 \times 1.67 \times 10^{-27} \text{ kg} \times 3.2 \times 10^{-12} \text{ J})}$ $= 1.03 \times 10^{-19}$ N s	**(1)** **(1)** **(1)**	**3**
16(b)(ii)	Use of $r = p/BQ$ (ecf from b)(i)) $r = 1.6$ m Example of calculation $r = 1.03 \times 10^{-19}$ N s $\div (0.41 \text{ T} \times 1.6 \times 10^{-19} \text{ C})$ $r = 1.57$ m	**(1)** **(1)**	**2**
16(b)(iii)	Use of $\lambda = h/p$ (ecf from (b)(i)) $\lambda = 6.4 \times 10^{-15}$ m comparison of their wavelength with diameter and appropriate comment on suitability, e.g. λ smaller than diameter, so suitable Example of calculation $\lambda = 6.63 \times 10^{-34}$ J s $\div 1.03 \times 10^{-19}$ N s $\lambda = 6.4 \times 10^{-15}$ m	**(1)** **(1)** **(1)**	**3**
	Total for question 16		**13**

Question Number	Answer		Mark
17(a)(i)	Resultant force on a charge would be zero **Or** there is no charge inside the sphere **Or** there is no field inside the sphere	**(1)**	**1**
17(a)(ii)	Concave curve starting from radius of sphere, not reaching axis Line along x axis inside radius of sphere (accept no line for this part if graph sketched in the part after the dashed line at the radius) <u>Example of graph</u> 	**(1)** **(1)**	**2**
17(b)(i)	Use of $C = 4\pi\varepsilon_0 r$ Use of $C = Q/V$ $V = 1.1 \times 10^5$ V <u>Example of calculation</u> $C = 4\pi \times 8.85 \times 10^{-12}$ F m^{-1} $\times 0.12$ m $= 1.33 \times 10^{-11}$ F $V = 1.5 \times 10^{-6}$ C / 1.33×10^{-11} F $= 1.1 \times 10^5$ V	**(1)** **(1)** **(1)**	**3**
17(b)(ii)	Use of $Q = Q_0 e^{-t/RC}$ (ecf C from (b)(i)) with correct $Q = 0.3 \times Q_0$ $t = 15$ s <u>Example of calculation</u> $0.3 \times Q_0 = Q_0 e^{-t/RC}$ $\ln(0.3) = -t / (9.1 \times 10^{11}\ \Omega \times 1.33 \times 10^{-11}$ F) $t = 14.6$ s	**(1)** **(1)** **(1)**	**3**
	Total for question 17		**9**

Question Number	Answer		Mark
18(a)	Correctly describes direction e.g. current from C to A **Or** current flows CABD (could start with any letter) **Or** current flows anticlockwise **Or** current is out of the page at A **Or** current is into the page at B By (Fleming's) left hand rule **Or** by FLHR/LHR	 **(1)** **(1)**	**2**
18(b)	Use of $F = BIl$ $F = 0.033$ N Example of calculation $F = 0.074 \text{ T} \times 0.29 \text{ A} \times 0.048 \text{ m} \times 32$ $F = 0.033$ N	**(1)** **(1)**	**2**
***18(c)(i)**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) Change in flux linkage as coil turns **Or** wires in coil cut lines of magnetic flux/field This induces an e.m.f. By Lenz's law, the induced e.m.f. is in the opposite direction to the applied potential difference	 **(1)** **(1)** **(1)**	**3**
18(c)(ii)	See $\varphi = BA$ (accept $\varepsilon = BA/t$ or $\varepsilon = BAN/t$) Produces correct expression for area Use $\varepsilon = \mathrm{d}\varphi/\mathrm{d}t$ leading to $\varepsilon = Blv$ Examples of derivation $\varphi = BA$ $\varphi = Bls$ $\varepsilon = \mathrm{d}\varphi/\mathrm{d}t = Bls/t$ $\varepsilon = Blv$ $\varphi = BA$ $s = vt$ so $A = lvt$ so $BA = Blvt$ $\varepsilon = \mathrm{d}\varphi/\mathrm{d}t = Blvt/t = Blv$	**(1)** **(1)** **(1)**	**3**
18(c)(iii)	Use of $\varepsilon = Blv$ Use of $v = 2\pi r/t$ **Or** use of $v = \omega r$ **and** $\omega = 2\pi/t$ $\varepsilon = 0.077$ V (Use of $\varepsilon = BAN/t$ leading to an answer of $\varepsilon = 0.025$ V gains one mark) Example of calculation $v = 2\pi \times 0.012 \text{ m} \times 9 / 1 \text{ s}$ $= 0.68 \text{ m s}^{-1}$ $\varepsilon = 0.074 \text{ T} \times 0.048 \text{ m} \times 32 \times 0.68 \text{ m s}^{-1}$ $= 0.077$ V	**(1)** **(1)** **(1)**	**3**

18(c)(iv)	Angle of wire's velocity to field varies (from 90° to zero) as it rotates **Or** Coil is out of the magnetic field for part of the cycle **Or** The angle of the coil to the magnetic field varies as it rotates **Or** The wire cuts the magnetic flux in the opposite direction (every half turn) **(1)** Rate of change of flux varies (from maximum to zero) **(1)**	**2**
18(d)	Use of a data logger **(1)** Connected to a current sensor in series **(1)**	**2**
	Total for question 18	**17**

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