Mark Scheme (Results)

Summer 2017

Pearson Edexcel International Advanced 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.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:

- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

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) Horizontal force of hinge on table top

66.3 (N) or 66 (N) **and** correct indication of direction [no ue] ✓ **1**
[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.]

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. 'resonance'

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 $g = 10 \text{ m s}^{-2}$ 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]
[Bald answer scores 0, reverse calculation 2/3] **3**

Example of answer:

$80 \text{ cm} \times 50 \text{ cm} \times 1.8 \text{ cm} = 7200 \text{ cm}^3$

$7200 \text{ cm}^3 \times 0.70 \text{ g cm}^{-3} = 5040 \text{ g}$

$5040 \times 10^{-3} \text{ kg} \times 9.81 \text{ N/kg}$

$= 49.4 \text{ N}$

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.

6.5 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	**A - muon**	**1**
	Incorrect Answers: B – a neutron is not a lepton C – a pion is not a lepton D – a proton is not a lepton	
2	**B – into the page**	**1**
	Incorrect Answers: A – treats direction of electron travel as direction of current C – not perpendicular to page D – not perpendicular to page	
3	**C – resultant force**	**1**
	Incorrect Answers: A – acceleration is the gradient of a velocity-time graph B – kinetic energy could be determined from the area under a force-displacement graph D – speed is the gradient of a distance-time graph	
4	**D**	**1**
	Incorrect Answers: A – this would increase wavelength B – this would increase wavelength C – this would not affect wavelength	
5	**D – rest mass**	**1**
	Incorrect Answers: A – charge is always conserved B – energy is always conserved C – momentum is always conserved	
6	**C – 5 V m^{-1}**	**1**
	Incorrect Answers: Correct method: electric field strength = 0.2 V ÷ 0.04 m = 5 V m^{-1} A – uses the separation in units of cm B – uses the distance to the halfway point in cm D – uses the distance to the halfway point	

Question Number	Answer		Mark
11 (a)(i)	Use of $v = 2\pi r/T$ **Or** Use of $v = 2\pi rf$ **Or** Use of $v = \omega r$ and $\omega = 2\pi/T$ $v = 35.2$ (m s^{-1}) <u>Example of calculation</u> $v = 2\pi \times 0.240$ m / (60 / 1400) s $v = 35.2$ m s^{-1}	(1) (1)	**2**
11 (a)(ii)	Use of $F = mv^2/r$ **Or** $F = m\omega^2 r$ $F = 7.2$ N (allow full ecf for answer in a) ('Show that' value gives 7.1 N) <u>Example of calculation</u> $F = 0.0014$ kg $\times$ (35.2 m $s^{-1})^2$ / 0.240 m $F = 7.23$ N	(1) (1)	**2**
11 (b)	Water has no resultant/centripetal force **Or** The clothes experience a centripetal force from the drum **Or** The clothes experience a resultant force towards the centre of the drum Water continues its motion in a straight line **Or** Water leaves drum along a tangent	(1) (1)	**2**
	Total for question 11		**6**

Question Number	Answer		Mark
12 (a)	Use of $p = mv$ Use of principle of conservation of momentum (momentum lost by DART = momentum gained by asteroid) $m = 4.7 \times 10^9$ (kg) <u>Example of calculation</u> $p = 300 \text{ kg} \times 6250 \text{ m s}^{-1}$ $= 1\,875\,000 \text{ kg m s}^{-1}$ Δp for asteroid $= 1\,875\,000 \text{ kg m s}^{-1}$ $m = 1\,875\,000 \text{ kg m s}^{-1} / 0.0004 \text{ m s}^{-1}$ $m = 4.7 \times 10^9$ kg	(1) (1) (1)	**3**
12 (b)	Use of tan θ with momentum of DART and momentum of asteroid **Or** use of tan θ with change in velocity of asteroid and original velocity of asteroid $\theta = 0.14°$ (allow ecf from (a)) <u>Example of calculation</u> tan θ = change in velocity of asteroid ÷ original velocity of asteroid $\tan\theta = 0.0004 \text{ m s}^{-1} / 0.16 \text{ m s}^{-1}$ $\tan\theta = 2.5 \times 10^{-3}$ $\theta = 0.14°$	(1) (1)	**2**
	Total for question 12		**5**

Question Number	Answer		Mark
13(a)	Use of $F = \frac{kQ_1Q_2}{r^2}$ $F = 3.6 \times 10^{-4}$ N <u>Example of calculation</u> $F = 8.99 \times 10^{9}$ N m^{2} C^{-2} $\times 3.1 \times 10^{-9}$ C $\times 2.4 \times 10^{-8}$ C $\div (0.043$ m$)^{2}$ $F = 3.6 \times 10^{-4}$ N	(1) (1)	 **2**
13(b)(i)	Electric field strength is the force per unit (positive) charge	(1)	**1**
13(b)(ii)	At X, a positive charge experiences a force due to A away from A **Or** At X, the electric field due to A is in the direction AX At X, a positive charge experiences a force due to B towards B **Or** At X, the electric field due to B is in the direction XB Statement that the components in the direction perpendicular to AB are all balanced by components in the opposite direction (Resultant) force is in the direction AB **Or** the (resultant) field is in the direction AB	 (1) (1) (1) (1)	 **4**
	Total for question 13		**7**

Question Number	Answer		Mark
14 (a)	The capacitor would discharge **Or** Charge would be able to flow from the capacitor	(1)	**1**
14(b)(i)	**Either** Determine time constant, e.g. intercept of tangent at start with x axis Use of $t = RC$ $C = 9.6 \times 10^{-7}$ F **Or** Determine time for charge to fall to 1/e (37%) Use of time for charge to fall $t = RC$ $C = 9.6 \times 10^{-7}$ F **Or** Determine time for charge to fall to ½ its original value Use of time for charge to fall $t = RC \ln 2$ $C = 9.4 \times 10^{-7}$ F **Or** Take two sets of coordinates from the graph Use of $Q = Q_0 e^{-t/RC}$ $C = 9.6 \times 10^{-7}$ F (Accept answers in range 8.7×10^{-7} F to 9.7×10^{-7} F) <u>Example of calculation</u> $4.4\ \text{s} = 4.6 \times 10^{6}\ \Omega \times C$ $C = 9.6 \times 10^{-7}$ F	(1) (1) (1) (1) (1) (1) (1) (1) (1) (1) (1) (1)	**3**
14(b)(ii)	Use of $C = Q/V$ and $W = ½\, QV$ **Or** see $W = ½\, Q^2/C$ $W = 1.6 \times 10^{-9}$ J <u>Example of calculation</u> $W = ½\, QV$ and $C = Q/V$ so $W = ½\, Q^2/C$ $= ½\, (5.5 \times 10^{-8}\ \text{C})^2 / 9.6 \times 10^{-7}$ F $= 1.6 \times 10^{-9}$ J	(1) (1)	**2**
14 (c)	p.d. must become equal across both $Q = CV$, so if C greater, Q will be greater	(1) (1)	**2**
14(d)	To obtain sufficient data points **Or** can take measurements simultaneously **Or** can obtain more readings for a given time	(1)	**1**
	Total for question 14		**9**

Question Number	Answer		Mark
15 (a)	Lines of magnetic flux cut through coil of wire **Or** this causes a change in flux (linkage) for the coil Reference to electromagnetic induction, e.g. This induces an emf There is a complete/closed circuit (so there is a current in the coil)	(1) (1) (1)	**3**
15 (b)	Statement of Lenz's law in terms of induced e.m.f. or current The (induced) current in the coil produces a magnetic field to oppose motion So there is a force on the magnet in the opposite direction to its motion As work = force × distance, work is done as the magnet moves	(1) (1) (1) (1)	**4**
15 (c)	The current changes direction **Or** an alternating current is produced So without diode the battery charges and discharges **Or** the diode cuts out alternate half cycles so preventing the discharge **Or** a battery needs d.c. to charge and the diode produces d.c.	(1) (1)	**2**
	Total for question 15		**9**

Question Number	Answer		Mark
16(a)	Uses energy units = kg m^2 s^{-2} Uses momentum units = kg m s^{-1} multiplied by m s^{-1} Convincing algebra to show units for each term the same Use of units for *E*, mc^2 and pc acceptable as this is dimensionally correct	(1) (1) (1)	**3**
16(b)	States if $v = 0$ then $p = 0$ **Or** See $E^2 = m^2c^4$ $E=mc^2$ (dependent mark)	(1) (1)	**2**
16(c)	$E^2 = p^2c^2$, take square root ($\rightarrow E = pc$) Use of mc^2 for electron **Or** Use of m^2c^4 for electron Use of conversion factor of 1.6×10^{-19} C (for J to eV or eV to J) Compares correct values for electron: 0.26 $(\text{MeV})^2 << 2.0 \times 10^9$ $(\text{MeV})^2$ **Or** E^2 is 7.8×10^9 times bigger **Or** 6.7×10^{-27} $J^2 << 5.2 \times 10^{-17}$ J^2 **Or** 8.2×10^{-14} J $<< 7.2 \times 10^{-9}$ J **Or** 0.51 MeV $<<$ 45 GeV **Or** E is 8.8×10^4 times bigger <u>Example of calculation</u> $mc^2 = (9.11 \times 10^{-31}\text{ kg}) \times (3 \times 10^8\text{ m s}^{-1})^2) = 8.2 \times 10^{-14}$ J 8.2×10^{-14} J / 1.6×10^{-19} C = 0.51 MeV $m^2c^4 = 6.7 \times 10^{-27}\text{ J}^2 = 0.26\ (\text{MeV})^2$ $(45\text{ GeV})^2 = (45000\text{ MeV})^2 = 2.0 \times 10^9\ (\text{MeV})^2 = 5.2 \times 10^{-17}\text{ J}^2$ (7.8×10^9 times bigger)	(1) (1) (1) (1)	**4**
	Total for question 16		**9**

Question Number	Answer	Mark
17(a)	to ensure a single path for the alpha particles **Or** otherwise alpha particles would travel in all directions **Or** to act as a collimator (1) (because) alpha particles are absorbed by lead (1) (lead absorbs alpha particles travelling in directions other than towards the foil gets both marks)	**2**
***17(b)**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) **Conclusion 1** Observation **-** most of the alpha particles were undeflected **Or** most of the alphas went straight through (1) from this they could conclude – that most did not get near enough to any matter to be affected (1) **Conclusion 2** Observation - a few particles were deflected (by small angles) (1) from this they could conclude – only a few particles came close enough to charge to be affected (1) **Conclusion 3** Observation - a very small proportion of alpha particles were deflected through more than 90° (1) from this they could conclude that the nucleus must have mass much greater than the alpha particle mass in order to cause this deflection (1)	**6**
17(c)	Top: 4, 222 (1) Bottom: 2, 86 (1)	**2**
17(d)	Use of $E_k = ½\, mv^2$ (1) Use of $W = QV$ (1) $V = 2.33 \times 10^6$ V = 2.33 MV (1) <u>Example of calculation</u> Use of $E_k = ½\, mv^2 = ½ \times 4.00 \times 1.66 \times 10^{-27}$ kg $\times (1.50 \times 10^7 \text{ m s}^{-1})^2$ $= 7.47 \times 10^{-13}$ J Use of $V = 7.47 \times 10^{-13}$ J $\div (2 \times 1.6 \times 10^{-19}$ C) $= 2.33 \times 10^6$ V = 2.33 MV	**3**
	Total for question 17	**13**

Question Number	Answer	Mark
***18(a)**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) There is a current in the aluminium (because sheet completes circuit) (1) There is a force (on aluminium) due to the current perpendicular to field (1) Equal and opposite force on motor from aluminium (1) (Unbalanced) force, so motor <u>accelerates</u> (1)	**4**
18(b)(i)	Millimetre scale: uncertainty in individual measurement ± 1 mm (accept ± 0.5 mm) **Or** Protractor: uncertainty ± 1° (accept ± 0.5°) (1) Percentage uncertainty for protractor ± 67 % (accept 33%) (1) Ruler percentage uncertainty 0.13% + 4.76% = ± 4.9 % for sin θ **Or** calculate max and min values of sin θ giving uncertainty of 5 % (1)	**3**
18(b)(ii)	Use of $W = mg$ (1) Resolve forces (see $F = W \sin\theta$) (1) F = 0.018 N (1) **Or** Use of $\Delta E_{grav} = mg\Delta h$ (1) Use of change of gpe = force × distance (1) F = 0.018 N (distance used is distance along sheet to award this mark) (1) <u>Example of calculation</u> $W = mg$ = 0.0694 kg × 9.81 N kg^{-1} = 0.681 N F = 0.681 N × sin 1.5° = 0.0178 N (using 2.1/79 as sin θ the answer is 0.0181 N)	**3**
18(b)(iii)	Use of $F = BIl$ (ecf from (b)(ii)) (1) B = 0.071 Wb m^{-2} **Or** B = 0.071 T (1) <u>Example of calculation</u> 0.0178 N = B × 3.4 A × 0.074 m B = 0.0707 Wb m^{-2}	**2**
	Total for question 18	**12**

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