Mark Scheme (Results)

January 2021

Pearson Edexcel International Advanced Level In Physics (WPH14/01)
Paper 1: Unit 4: Further Mechanics, Fields and Particles

Edexcel and BTEC Qualifications

Edexcel and BTEC qualifications are awarded by Pearson, the UK's largest awarding body. We provide a wide range of qualifications including academic, vocational, occupational and specific programmes for employers. For further information visit our qualifications websites at www.edexcel.com or www.btec.co.uk. Alternatively, you can get in touch with us using the details on our contact us page at www.edexcel.com/contactus.

Pearson: helping people progress, everywhere

Pearson aspires to be the world's leading learning company. Our aim is to help everyone progress in their lives through education. We believe in every kind of learning, for all kinds of people, wherever they are in the world. We've been involved in education for over 150 years, and by working across 70 countries, in 100 languages, we have built an international reputation for our commitment to high standards and raising achievement through innovation in education. Find out more about how we can help you and your students at: www.pearson.com/uk

January 2021
Publications Code WPH14_01_2101_MS

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) 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 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:

'Show that' calculation of weight

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 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. 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 D because work done is a scalar quantity and the product of two vector quantities, but not itself a vector quantity** A electric field strength is a vector quantity B impulse C magnetic flux density	**(1)**

Question number	Answer	Mark
2	**The only correct answer is D because $E_K = p^2 / 2m$ and doubling momentum increase E_K by a factor of 4 and halving the mass increase E_K by a factor of 2, so the overall change is an increase by a factor of 8.** A $E_K = p^2 / 2m$ and doubling momentum increase E_K by a factor of 4 and halving the mass increase E_K by a factor of 2, so the overall change is an increase by a factor of 8, not a decrease by a factor of 8 B $E_K = p^2 / 2m$ and doubling momentum increase E_K by a factor of 4 and halving the mass increase E_K by a factor of 2, so the overall change is an increase by a factor of 8, not a decrease by a factor of 2 C $E_K = p^2 / 2m$ and doubling momentum increase E_K by a factor of 4 and halving the mass increase E_K by a factor of 2, so the overall change is an increase by a factor of 8, not an increase by a factor of 2	**(1)**

Question number	Answer	Mark
3	**The only correct answer is A** (118, 176) because 118 is the proton number and the nucleon number is 118 + 176 = 294 B the correct answer is (118, 176) C the correct answer is (118, 176) D the correct answer is (118, 176)	**(1)**

Question number	Answer	Mark
4	**The only correct answer is D** $\frac{3.17 \times 10^{-27} \times (3.00 \times 10^{8})^2}{10^9 \times 1.6 \times 10^{-19}}$ A the correct answer is $\frac{3.17 \times 10^{-27} \times (3.00 \times 10^{8})^2}{10^9 \times 1.6 \times 10^{-19}}$ B the correct answer is $\frac{3.17 \times 10^{-27} \times (3.00 \times 10^{8})^2}{10^9 \times 1.6 \times 10^{-19}}$ C the correct answer is $\frac{3.17 \times 10^{-27} \times (3.00 \times 10^{8})^2}{10^9 \times 1.6 \times 10^{-19}}$	**(1)**

Question number	Answer	Mark
5	**The only correct answer is C because the charge is increasing while the current is decreasing** A this shows charge decreasing B this shows charge decreasing and current increasing D this shows current increasing	**(1)**

Question number	Answer	Mark
6	**The only correct answer is C because the force on a positive charge will cause an initial force to the left, the force on a negative charge will cause an initial force to the right and a muon has a greater mass than a positron so it has less curvature.** A shows the particles curving in the wrong direction B shows the particles curving in the wrong direction D shows a muon curving more than a positron	**(1)**

Question number	Answer	Mark
7	**The only correct answer is B because the field strength due to 2 microcoulomb is** $\frac{2 \times 10^{-6}}{4\pi\varepsilon_0(0.4)^2}$ **and field strength due to 3 microcoulomb is** $\frac{3 \times 10^{-6}}{4\pi\varepsilon_0(0.8)^2}$ **and they are in opposite directions** A assumes the fields are in the same direction C uses the distance from the wrong charge in each case and assumes the fields are in the same direction D uses the distance from the wrong charge in each case	**(1)**

Question number	Answer	Mark
8	**The only correct answer is A because *I* = *F* / *Bl* and FLHR gives the direction from X to Y** B the direction is from Y to X C this is *Bl* / *F* D this is *Bl* / *F* in the wrong direction	**(1)**

Question number	Answer	Mark
9	**The only correct answer is D because the direction of the field is upwards and the potential increases going downwards, towards positive** A the field is in the wrong direction B the field is in the wrong direction D the potential is increasing going upwards	**(1)**

Question number	Answer	Mark
10	**The only correct answer is B because gradient = −1/*CR* , so *C* =** $-\frac{1}{(\text{gradient} \times R)}$ A the correct answer is $-\frac{1}{(\text{gradient} \times R)}$ C the correct answer is $-\frac{1}{(\text{gradient} \times R)}$ D the correct answer is $-\frac{1}{(\text{gradient} \times R)}$	**(1)**

Question number	Answer		Mark
11(a)	• Use of $Q = CV$ • $Q = 3.8 \times 10^{-4}$ C <u>Example of equation</u> $Q = 32 \times 10^{-6}$ F × 6.0 V × 2 $= 3.84 \times 10^{-4}$ C	1 1	**(2)**
11(b)	• Use of $W = ½\, CV^2$ **or** $W = ½\, QV$ **or** $W = ½\, Q^2/C$ • $W = 1.2 \times 10^{-3}$ J [ecf for *Q*, *C*, *V* from part a] <u>Example of equation</u> $Q = ½ \times 32 \times 10^{-6}$ F × (6.0 V)^2 × 2 $= 1.15 \times 10^{-3}$ J	1 1	**(2)**
	Total for Question 11		**4**

Question number	Answer		Mark
12	• Calculate period = 60 s / 600 = 0.10 s **or** calculate f = 600 / 60 s = 10 Hz • Use of $\omega = 2\pi / T$ **or** $v = 2\pi r / T$ **or** $\omega = 2\pi f$ **or** $v = 2\pi f r / T$ • Use of $F = m\omega^2 r$ **or** $F = mv^2/r$ • Add weight to identified centripetal force • Answer = 11.5 N <u>Example of equation</u> period = 60 s / 600 = 0.10 s $v = 2\pi \times 0.24$ m / 0.10 s = 15.1 m s^{-1} F = 0.012 kg × (15.1 m s^{-1})^2 / 0.24 m = 11.37 N $W = mg$ = 0.012 kg × 9.81 m s^{-2} = 0.12 N Maximum normal contact force = 11.37 N + 0.12 N = 11.49 N	1 1 1 1 1	(5)
	Total for Question 12		5

Question number	Answer		Mark
13(a)	• Mass of products is less than mass of antineutron **Or** particles have kinetic energy after decay • Where mass difference and the kinetic energy are related by $\Delta E = c^2 \Delta m$	1 1	(2)
13(b)	• Conservation of charge (because same before and after) • Antineutron charge = 0; charge of antiproton = –1, positron = 1, neutrino = 0; total charge after = 0 • Conservation of baryon number (because same before and after) • Antineutron baryon number = –1; Antiproton baryon number =–1, positron = 0, neutrino = 0 Total baryon number after =–1 • Conservation of lepton number (because same before and after) • Antineutron lepton number = 0; Antiproton lepton number = 0, positron = –1, neutrino = 1 Total lepton number after = 0	1 1 1 1 1 1	(6)
	Total for Question 13		8

Question number	Answer		Mark
14(a)	• The speed of the muon is very close to the speed of light • Calculate distance travelled at 0.994 *c* in the average lifetime (without relativistic effects) = 656 m **Or** Calculate the time to travel 1600 m at 0.994c = 5.4 x 10^{-6} s • Comparative comment about calculated value and situation if no relativistic effects • Comment about lifetime linked to relativistic effects **Or** Comment about time of flight linked to relativistic effects • Reason why most reach the ground	1 1 1 1 1	**(5)**
14(b)	• Muons are leptons **Or** Muons are fundamental/elementary particles • but mesons are made of quarks **Or** mesons are made of quark-antiquark	1 1	**(2)**
	Total for Question 14		**7**

Question Number	Answer	Mark
*15a	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

- <u>Magnetic field</u> perpendicular to velocity of particles
- Magnetic force on particles perpendicular to velocity
- Particles experience centripetal acceleration/force so they undergo circular motion
- Alternating potential difference between dees changes direction while particle in dees
- Particle accelerated by <u>electric field</u> between dees
- (Electric) field in correct direction so that force on particle further increases speed

(6)

15b	• Apply factor of 1.6×10^{-19} C for energy unit conversion • Use of $E_k = p^2 / 2m$ • Use of $r = p / Bq$ • $B = 1.2$ T <u>Example of calculation</u> $E_K = 16 \times 10^6 \times 1.6 \times 10^{-19}$ C $= 2.56 \times 10^{-12}$ J 2.56×10^{-12} J $= p^2 / 2 \times 6.6 \times 10^{-27}$ kg $p = 1.8 \times 10^{-19}$ N s 0.47 m $= 1.8 \times 10^{-19}$ N s / $B \times 2 \times 1.6 \times 10^{-19}$ C $B = 1.2$ T	**1** **1** **1** **1**	**(4)**
	Total for Question 15		**10**

Question number	Answer		Mark
16(a)	• Varying current, so varying magnetic field • Change in flux linkage with plasma (loop) **Or** magnetic field lines cut plasma (loop) • Emf induced • Plasma makes a complete circuit, so current (in plasma)	1 1 1 1	**(4)**
16 (b)(i)	• Use of $R = \rho l/A$ • $R = 1.89 \times 10^{-7}$ (Ω) Example of calculation $R = 3.30 \times 10^{-8}\ \Omega\ \text{m} \times 13.2\ \text{m} / 2.30\ \text{m}^2$ $= 1.89 \times 10^{-7}\ \Omega$	1 1	**(2)**
16(b)(ii)	• Use $\varepsilon = \text{d}\phi / \text{d}t$ • Use of $I = V/R$ [ecf for R] • Use of $P = IV$ **Or** Use of $P = I^2 R$ [Use of $P = V^2 / R$ for MP2&3] • P = 2.42 MW Example of calculation $\varepsilon = 16.9\ \text{Wb} / 25.0\ \text{s}$ $= 0.676\ \text{V}$ $I = 0.676\ \text{V} / 1.89 \times 10^{-7}\ \Omega = 3.58\ \text{MA}$ $P = 3.58\ \text{MA} \times .676\ \text{V}$ $= 2.42\ \text{MW}$	1 1 1 1	**(4)**
	Total for Question 16		**10**

Question number	Answer		Mark
17(a)	• Use of $\Delta p = m\Delta v$ • Use of $F\Delta t = \Delta p$ • $F = 0.14$ N <u>Example of calculation</u> $p = 0.11 \text{ kg} \times 0.35 \text{ m s}^{-1}$ $= 0.039 \text{ kg m s}^{-1}$ $0.039 \text{ N s} = F \times 0.28 \text{ s}$ $F = 0.14$ N	1 1 1	**(3)**
17 (b)(i)	• Use of $p = mv$ • Use of correct components of p • Use of conservation of momentum • Speed = 0.26 m s^{-1} <u>Example of calculation</u> Momentum for puck 1 after collision = $0.11 \text{ kg} \times 0.28 \text{ m s}^{-1}$ $= 0.031 \text{ kg m s}^{-1}$ component of momentum of puck 1 in the direction perpendicular to the initial velocity of puck 1 = $0.031 \text{ kg m s}^{-1} \times \sin 49°$ $= 0.023 \text{ kg m s}^{-1}$ component of momentum of puck 1 in the direction perpendicular to the initial velocity of puck 1 = component of momentum of puck 2 in the direction perpendicular to the initial velocity of puck 1 $0.023 \text{ kg m s}^{-1} = p \times \sin 43°$ $p = 0.034 \text{ kg m s}^{-1}$ $v = 0.034 \text{ kg m s}^{-1} / 0.13 \text{ kg}$ $v = 0.26 \text{ m s}^{-1}$	1 1 1 1	**(4)**
17(b)(ii)	• Use of $E_k = \frac{1}{2} m v^2$ • A correct value of E_k [ecf for v_2] • Comparison of kinetic energy before and after collision and conclusion that kinetic energy before collision is different to kinetic energy after collision, so it is not an elastic collision [accept inelastic] **Or** Comparison of kinetic energy before and after collision and conclusion that so kinetic energy is not conserved, so it is not an elastic collision [accept inelastic] <u>Example of calculation</u> Before collision $E_k = \frac{1}{2} m v^2 = \frac{1}{2} \times 0.11 \text{ kg} \times (0.41 \text{ m s}^{-1})^2$ $= 0.0092$ J After collision $E_k = \frac{1}{2} m v^2 = \frac{1}{2} \times 0.11 \text{ kg} \times (0.28 \text{ m s}^{-1})^2$ $= 0.0043$ J $E_k = \frac{1}{2} m v^2 = \frac{1}{2} \times 0.13 \text{ kg} \times (0.26 \text{ m s}^{-1})^2$ $= 0.0044$ J Total after = 0.0087 J $0.0092 \text{ J} > 0.0087 \text{ J}$	1 1 1	**(3)**
17(c)	• The assumption is that no (resultant) external forces act • Because if external forces act there will be acceleration, so the final momentum will be different than otherwise **Or** if external forces act there will be an (additional) impulse, so the change in momentum will be different	1 1	**(2)**

	Total for Question 17	12

Question number	Answer		Mark
18(a)	• Use of $E_k = ½\, m\, v^2$ • Use of $V = Q / 4\pi\varepsilon_0 r$ and $W = QV$ • Use of $F = Q_1 Q_2 / 4\pi\varepsilon_0 r^2$ • Use of $F = ma$ • $a = 4.2 \times 10^{27}$ m s^{-2} <u>Example of calculation</u> $E_k = ½ \times 6.64 \times 10^{-27}$ kg $\times (1.74 \times 10^7$ m s$^{-1})^2$ $= 1.01 \times 10^{-12}$ J $1.01 \times 10^{-12}\ \text{J} = \frac{2 \times 1.6 \times 10^{-19}\ \text{C} \times 79 \times 1.6 \times 10^{-19}\ \text{C}}{4 \times \pi \times 8.85 \times 10^{-12}\ \text{F m}^{-1} \times r}$ $r = 3.60 \times 10^{-14}$ m $F = \frac{2 \times 1.6 \times 10^{-19}\ \text{C} \times 79 \times 1.6 \times 10^{-19}\ \text{C}}{4 \times \pi \times 8.85 \times 10^{-12}\ \text{F m}^{-1} \times (3.60 \times 10^{-14}\ \text{m})^2}$ $= 28.1$ N $a = 28.1\ \text{N} / 6.64 \times 10^{-27}$ kg $a = 4.23 \times 10^{27}$ m s^{-2}	1 1 1 1 1	(5)
18(b)	• alpha particle does not ever have zero speed/ke • so not all of the energy has been transferred from the kinetic energy store to the electric potential energy store • it is not as close to the nucleus **Or** minimum r is greater • so (max) force is less, so (max) acceleration is less	1 1 1 1	(4)
	Total for Question 18		**9**

Question Number	Answer		Mark
19(a)(i)	• See mass = $4\pi r^3 \rho / 3$ • See $6\pi\eta v r = 4\pi r^3 \rho g / 3$ • Suitable algebra	1 1 1	(3)
19(a)(ii)	• Use of $r = \sqrt{\frac{9\eta v}{2\rho g}}$ • $r = 2.2 \times 10^{-6}$ m <u>Example of calculation</u> $r = \sqrt{(9 \times 1.86 \times 10^{-5} \text{ Pa s} \times 5.35 \times 10^{-4} \text{ m s}^{-1} / 2 \times 904 \text{ kg m}^{-3} \times 9.81 \text{ N kg}^{-1})}$ $= 2.247 \times 10^{-6}$ m	1 1	(2)
19(a)(iii)	• Use of $W = mg$ • Use of $E = V / d$ • Use of $F = EQ$ • $Q = 4.8 \times 10^{-19}$ C <u>Example of calculation</u> $W = 3.03 \times 10^{-14} \text{ kg} \times 9.81 \text{ N kg}^{-1}$ $= 2.97 \times 10^{-13}$ N $E = 9910 \text{ V} / 0.016 \text{ m}$ $= 619\,000 \text{ V m}^{-1}$ $2.97 \times 10^{-13} \text{ N} = 619\,000 \text{ V m}^{-1} \times Q$ $Q = 4.8 \times 10^{-19}$ C	1 1 1 1	(4)
19(b)	• The maxima are integer multiples of 1.6×10^{-19} C **Or** The peaks are at intervals of 1.6×10^{-19} C • The spread about the maxima is small • This could be due to experimental error, so the statement is supported	1 1 1	(3)
19(c)	• (Since $r = \sqrt{\frac{9\eta v}{2\rho g}}$,) if the viscosity is too small, then (calculated) r will be too small • Therefore the value used as the mass/weight of the droplet (to balance the upward electrical force) must be too small • The electrical force will be smaller, so the charge will be smaller **Or** • If the charge is smaller, the electrical force is smaller • Therefore the value used as the mass/weight of the droplet (to balance the upward electrical force) must be too small • (Since $r = \sqrt{\frac{9\eta v}{2\rho g}}$,) if the (calculated) r is too small, it is because viscosity is too small	1 1 1	(3)
	Total for Question 19		**15**