Pearson
Edexcel

Mark Scheme (Results)

January 2020

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.

For example:

(iii) Horizontal force of hinge on table top

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. ‘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	C	(1)

Question number	Answer	Mark
2	B	(1)

Question number	Answer	Mark
3	B	(1)

Question number	Answer	Mark
4	A	(1)

Question number	Answer	Mark
5	B	(1)

Question number	Answer	Mark
6	D	(1)

Question number	Answer	Mark
7	C	(1)

Question number	Answer	Mark
8	D	(1)

Question number	Answer	Mark
9	C	(1)

Question number	Answer	Mark
10	D	(1)

Question number	Answer	Mark
11	- Mo correct (1) - Deuterium correct (1) - Neutrons correct (1) Example of equation $^{96}_{42}\mathrm{Mo} + {}^{2}_{1}\mathrm{H} \rightarrow {}^{95}_{43}\mathrm{Tc} + 3\ {}^{1}_{0}\mathrm{n}$	**(3)**
	Total for question 13	**3**

Question number	Answer	Mark
12	- Neutrons/Protons are baryons (1) - Baryons/Neutrons/Protons made of 3 quarks (or 3 antiquarks) (1) - Mesons made of quark and antiquark (1) - Electrons/muons are leptons (1) - p/n/e first generation **Or** muon 2nd generation (1) - Leptons/electron/muon/quarks fundamental **Or** proton/neutron/mesons not fundamental (1)	**(6)**
	Total for question 12	**6**

Question number	**Answer**	**Mark**
13(a)	• Use of $E_{el} = ½F\Delta x$ (1) • W = 0.12 (J) (1) Example of calculation W = 0.5 × 14 N × 0.017 m W = 0.119 J	**(2)**
13 (b)	• Use of $E_{grav} = mgh$ (1) • Use of elastic potential energy = ½ mv^2 **Or** Use of grav potential energy = ½ mv^2 (1) • v_{head} = 6.1 (m s^{-1}) **Or** v_{toy} = 5.4 (m s^{-1}) (ecf from (a)) (1) • Use of $p = mv$ (1) • P_{head} = 0.039 (kg m s^{-1}) and p_{toy} = 0.039 (kg m s^{-1}) and conclusion that momentum is conserved **Or** P_{head} = 0.039 (kg m s^{-1}) and p_{toy} = (0.039 kg m s^{-1}) and conclusion that momentum before = momentum after (1) Example of calculation For head, max ke = E_{el} of spring ½ × 0.0064 kg × v^2 = 0.119 J max speed of head = 6.10 m s^{-1} max momentum of head = 0.0064 kg × 6.1 m s^{-1} p_{head} = 0.039 kg m s^{-1} E_{grav} = 0.0072 kg × 9.81 N kg^{-1} × 1.5 m = 0.106 J For whole toy, initial ke = 0.106 J ½ × 0.0072 kg × v^2 = 0.106 J For whole toy, initial v = 5.42 m s^{-1} For whole toy, initial momentum = 0.0072 kg × 5.42 m s^{-1} = 0.039 kg m s^{-1}	**(5)**
13 (c)	• Calculate E_K values or identify from part (a) and (b) (0.12 J before and 0.11 J after) (ecf) (1) • Conclude (kinetic energy is) not conserved because energy before is greater than energy after (1) (accept a conclusion consistent with their answers) Example of calculation Head ke = ½ × 0.0064 kg × (6.1 m s^{-1})^2 = 0.119 J Whole toy ke = ½ × 0.0072 kg × (5.42 m s^{-1})^2 = 0.106 J	**(2)**
	Total for question 13	**9**

Question Number	Answer		Mark
14(a)	• Use of $F = mv^2/r$ • v = 9.78 (m s^{-1}) (3 sf) **Or** d = 29.6 (m) (3 sf) **Or** centripetal force = 1170 (N) (3 sf) (accept r = 14.8 (m)) (3 sf) <u>Example of calculation</u> 1180 N = 185 kg × v^2/ 15 m v = 9.78 m s^{-1}	**(1)** **(1)**	**(2)**
14(b) (i)	• State $R \sin \theta = mv^2/r$ • State $R \cos \theta = mg$ • Divide $R \sin \theta$ by $R \cos \theta$ and use $d/2$ **Or** • Vector diagram with normal contact force as hypotenuse • Divide mv^2/r by mg • Substitute $r = d/2$	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**(3)**
14(b)(ii)	• Use of $\tan \theta = 2v^2 / gd$ • Angle = 33° <u>Example of calculation</u> $\tan \theta = 2 \times (9.72 \text{ m s}^{-1})^2 / 9.81 \text{ N kg}^{-1} \times 30 \text{ m} = 0.642$ $\theta = 32.7°$	**(1)** **(1)**	**(2)**
14 (c)	Max 2 points • Higher speeds can be used • A smaller track can be used • The kart is less likely to skid • The (maximum) centripetal force is larger	 **(1)** **(1)** **(1)** **(1)**	**(2)**
	Total for Question 14		**9**

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<table>
<tr><th>Question number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>15(a)</td><td>• So no collisions with air molecules (1)
Or
• So the air doesn’t stop alpha particles from reaching the detector (1)</td><td>(1)</td></tr>
<tr><td>15 (b)*</td><td>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.
<table>
<tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th><th>Max linkage mark available</th><th>Max final mark</th></tr>
<tr><td>6</td><td>4</td><td>2</td><td>6</td></tr>
<tr><td>5</td><td>3</td><td>2</td><td>5</td></tr>
<tr><td>4</td><td>3</td><td>1</td><td>4</td></tr>
<tr><td>3</td><td>2</td><td>1</td><td>3</td></tr>
<tr><td>2</td><td>2</td><td>0</td><td>2</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>1</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td></tr>
</table>

The following table shows how the marks should be awarded for structure and lines of reasoning.</td><td>(6)</td></tr>
</table>

	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:

- Most alpha particles passed straight through the gold foil
- Some alpha particles were deflected by small angles
- Either model would predict small or zero deflections because in the nuclear model the atom is mostly empty space and in the 'pudding' model matter is too spread out
- A few proportion of alpha particles were deflected by more than 90°
- This did not fit the plum pudding model as this deflection requires a high concentration of charge (to provide a large force)
  Or
  This could only be explained by the nuclear model as this deflection requires a high concentration of charge to (provide a large force)
- This did not fit the plum pudding model as this deflection requires a high concentration of mass (so that the alpha particle is deflected and not the gold nucleus)
  Or
  This could only be explained by the nuclear model as this deflection requires a high concentration of mass (so that the alpha particle is deflected and not the gold nucleus)

	Total for question 15	7

Question number	Answer	Mark
16 (a)	- Negative because the direction of field is direction of force on a positive charge **Or** Field downwards means negatively charged Earth and negative repels negative **Or** Negative because the force is in the opposite direction to the electric field (1)	**(1)**
16 (b)	- Use of $F = EQ$ (1) - Use of $W = mg$ (1) - $F - W$ to determine resultant force (1) - Use of $F = ma$ (1) - $a = 2.2 \text{ m s}^{-2}$ (1) Example of calculation $F = 120 \text{ V m}^{-1} \times 3.00 \times 10^{-7} \text{ C} = 3.60 \times 10^{-5} \text{ N}$ $W = 3.00 \times 10^{-6} \text{ kg} \times 9.81 \text{ N kg}^{-1} = 2.94 \times 10^{-5} \text{ N}$ Resultant force = $3.60 \times 10^{-5} \text{ N} - 2.94 \times 10^{-5} \text{ N} = 6.57 \times 10^{-6} \text{ N}$ $a = 6.57 \times 10^{-6} \text{ N} \div 3.00 \times 10^{-6} \text{ kg}$ $= 2.19 \text{ m s}^{-2}$	**(5)**
16 (c)	- Use of $E = Q/4\pi\varepsilon_0 r^2$ **Or** Use of $E = kQ/r^2$ (1) - Use of $A = 4\pi r^2$ (1) - Charge = 1.1×10^{-9} C (m^{-2}) (1) Example of calculation $E = kQ/r^2$ $120 \text{ V m}^{-1} = 8.99 \times 10^9 \text{ N m}^2 \text{ C}^{-2} \times Q / (6.4\times 10^6 \text{ m})^2$ $Q = 5.47 \times 10^5 \text{ C}$ $Q/A = 5.47 \times 10^5 \text{ C} / 4\pi \times (6.4\times10^6 \text{ m})^2$ $= 5.47 \times 10^5 \text{ C} / 5.15 \times 10^{14} \text{ m}^2$ $= 1.1 \times 10^{-9} \text{ C m}^{-2}$	**(3)**
	Total for question 16	**9**

Question number	**Answer**	**Mark**
17(a)	• Use ratio of resistors to determine initial p.d. across LED or final p.d. across capacitor **Or** Use of $I = V/R$ to determine initial current and final current (1) • Use of $V = V_0 e^{\frac{-t}{RC}}$ **Or** Use of $I = I_0 e^{\frac{-t}{RC}}$ (1) • C = 0.56 F (1) • Need to choose 0.58 F so it doesn't take less than the required time (1) <u>Example of calculation</u> Initial p.d. across LED = 12 V × 340 Ω/(860 Ω + 340 Ω) = 3.4 V V across LED proportional to V across capacitor $1.4 \text{ V} = 3.4 \text{ V } e^{-(10 \times 60 \text{ s} / 1200 \, \Omega \times C)}$ • C = 0.56 F	**(4)**
17 (b)	• From the graph, as p.d. decreases the resistance increases (1) • Therefore the time constant increases (1) • The light will take longer to switch off (1)	**(3)**
17(c)	• The capacitor is an energy store (1) • The overall charge on the capacitor is zero (1) • The capacitor separates charge (1)	**(3)**
	Total for question 17	**10**

Question Number	**Answer**	**Mark**
18(a)	• (Rotating coil in field causes) changing (magnetic) flux linkage with coil **(1)** **Or** wires/coils cut lines of (magnetic) flux **(1)** • E.m.f. induced **(1)** • Complete circuit, so current in circuit • p.d./current produced changes in direction (as opposite parts of the coil switch sides), so LED only shines when current is flowing in one direction **(1)**	**(4)**
18(b)(i)	• Period doubled **(1)** • Amplitude halved **(1)**	**(2)**
18(b)(ii)	• (Half angular velocity) so takes twice as long to turn so period doubled **(1)** • (Half angular velocity) so rate of change of flux halved so e.m.f halved **(1)**	**(2)**
18(b)(iii)	• Use of $\varphi = BA$ **(1)** • Period (from graph) = 0.2 s **(1)** • Use of $\varepsilon = N \, \mathrm{d}\varphi / \mathrm{d}t$ **(1)** • N = 400 turns **(1)** Example of calculation $3.2 \text{ V} = N \times 0.083 \text{ T} \times 0.0048 \text{ m}^2 / 0.25 \times 0.2 \text{ s}$ $N = 402$	**(4)**
	Total for question 18	**12**

Question Number	Answer	Mark
19(a)(i)	• Use of $r = p/Bq$ and $p = mv$ **Or** Use of $F = Bqv$ and $F = mv^2/r$ **(1)** • Use of $v = 2\pi r/t$ **(1)** • Algebra leading to $t = 2\ m\ \pi\ /Bq$ **(1)** <u>Example of derivation</u> $r = p/Bq$ $p = mv$ so $r = mv/Bq$ $v = 2\pi r/t$ so $r = m2\pi r\ /Bqt$ Therefore $t = 2\ m\ \pi\ /Bq$	**(3)**
19(a)(ii)	• Time independent of speed **Or** Time independent of radius **(1)** • So particles take constant time to complete circular path **Or** so particles spend the same time in each dee **(1)** • So a fixed frequency can be used for the p.d. **(1)** • because the p.d./field across the gap will be in the correct direction to increase the speed of the particles as they cross each time **(1)**	**(4)**
19(b)	• Use of $t = 2\pi m/Bq$ **(1)** • Use of $E_K = ½\ mv^2$ **(1)** • Use of $W = QV$ **(1)** • Total energy / accelerating p.d. for number of passes **(1)** • 1.9×10^{-6} s **(1)** <u>Example of calculation</u> $t = 2\pi \times 1.67 \times 10^{-27}$ kg / 1.6 T × 1.6×10^{-19} C $= 4.1 \times 10^{-8}$ s $E_K = ½ \times 1.67 \times 10^{-27}$ kg × $(1.5 \times 10^6)^2$ $= 1.88 \times 10^{-13}$ J $= 1.88 \times 10^{-13}$ J ÷ 1.6×10^{-19} C = 1.17×10^6 eV No of passes = 1.17×10^6 eV ÷ 13 000 eV = 90.3 2 passes per cycle, so 45.2 cycles $45.2 \times 4.1 \times 10^{-8}$ s = 1.85×10^{-6} s (or use 45.5 or 46)	**(5)**
19(c)	• High energy so particles have high momentum **(1)** • High momentum so that (de Broglie) wavelength is small **(1)** • Studying nucleons requires wavelengths of the order of nucleon size **(1)**	**(3)**
	Total for question 19	**15**

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