Pearson
Edexcel

Mark Scheme (Results)

June 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:

<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 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	B The only correct answer is **B** because the components of the fields due to Y and Z along the direction of the line between Y and Z are equal and opposite and the component of the fields from each of Y and Z perpendicular to the line from Y to Z are both down the page, so the resultant is down the page A is not the correct answer because the components of the fields due to Y and Z along the direction of the line between Y and Z are equal and opposite and there is no resultant component in that direction C is not the correct answer because the components of the fields due to Y and Z along the direction of the line between Y and Z are equal and opposite and there is no resultant component in that direction D is not the correct answer because it is up the page	**(1)**

Question number	Answer	Mark
2	D The only correct answer is **D** because conservation of lepton number is violated because there should be an electron anti-neutrino rather than an electron neutrino A is not the correct answer because baryon number is conserved B is not the correct answer because charge is conserved C is not the correct answer because the equation does not give an indication of kinetic energy and the mass-energy for the products is not more than for the neutron	**(1)**

Question number	Answer	Mark
3	D The only correct answer is **D** because the charge stored on a capacitor = CV and all of the capacitors have the same p.d. of V, so doubling C doubles charge and having two capacitors doubles it again to $4Q$ A is not the correct answer because it is not $4Q$ B is not the correct answer because it is not $4Q$ C is not the correct answer because it is not $4Q$	**(1)**

Question number	Answer	Mark
4	C	**(1)**

	The only correct answer is **C** because all of the answers are dimensionally correct, but only C is in base units A is not the correct answer because C and V are not base units B is not the correct answer because C and J are not base units D is not the correct answer because C is not a base unit	

Question number	Answer	Mark
5	D The only correct answer is **D** because the component of momentum perpendicular to the surface is $mv\sin\theta$ so the change in momentum is $2mv\sin\theta$ and the time is t and force = change in momentum divided by time A is not the correct answer because it does not take account of the angle B is not the correct answer because it does not take account of the angle C is not the correct answer because it is only half of the correct value	**(1)**

Question number	Answer	Mark

6	C The only correct answer is **C** because $E = V/d$ and $F = Eq$ and $W = mg$, so $Vq/d = mg$ A is not the correct answer because it is not mgd/V B is not the correct answer because it is not mgd/V D is not the correct answer because it is not mgd/V	**(1)**

Question number	Answer	Mark
7	C The only correct answer is **C** because the force is into the page A is not the correct answer because it is in the plane of the page B is not the correct answer because it is in the plane of the page D is not the correct answer because it is out of the page	**(1)**

Question number	Answer	Mark
8	C The only correct answer is **C** because doubling one charge doubles force, so doubling both charges increases the force by a factor of 4, and doubling the distance decreases the force by a factor of 4, so the force is unchanged A is not the correct answer because the force is changed B is not the correct answer because the force is changed D is not the correct answer because the force is changed	**(1)**

Question number	Answer	Mark
9	C The only correct answer is **C** because angular velocity = angular displacement / time, which is 33 revolutions multiplied by 2π radians divided by 60 seconds A is not the correct answer because it is not $33 \times 2\pi / 60$ B is not the correct answer because it is not $33 \times 2\pi / 60$ D is not the correct answer because it is not $33 \times 2\pi / 60$	**(1)**

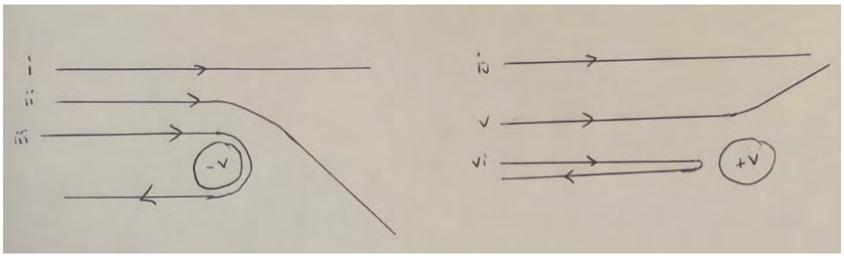
Question number	Answer	Mark
10	A The only correct answer is A because at X, by Lenz's law, the force produced by the current will oppose the change creating it, so it will create a north-seeking pole to produce an upward force on the north-seeking pole of magnet and at Y it will create a north seeking pole to produce an upward force on the south seeking pole of the magnet	**(1)**

	B is not the correct answer because the pole at Y is south C is not the correct answer because the pole at X is north D is not the correct answer because the poles at both X and Y are south	

Question number	Answer		Mark
11	• Use of $F = BIl$ • Use of moment = Fx • Applies component = $F\cos20°$ or $F\sin70°$ • Moments = 7.9×10^{-3} N m <u>Example of equation</u> $F = 0.07$ T × 6.9 A × 0.05 m × 10 = 0.24 N Moment = 2 × 0.24 N × sin70° × (0.035 m)/2 = 7.9×10^{-3} N m	1 1 1 1	**(4)**
	Total for question 11		**4**

Question number	Answer		Mark
12 (a)	annihilation	1	**(1)**
12 (b)	• Use of $\Delta E = c^2 \Delta m$ • Use $E = hf$ • Use of $c = f\lambda$ • $\lambda = 2.4 \times 10^{-12}$ m <u>Example of equation</u> $\Delta E = (3.00 \times 10^8 \text{ m s}^{-1})^2 \times 2 \times 9.11 \times 10^{-31}$ kg $f = 1.64 \times 10^{-13}$ J / 6.63×10^{-34} J s × 2 $\lambda = 3.00 \times 10^8$ m s^{-1} / 1.24×10^{20} Hz $\lambda = 2.42 \times 10^{-12}$ m	1 1 1 1	**(4)**
	Total for question 12		**5**

Question number	Answer		Mark
13	**Maximum 4 marks**		
	Similarities – Max 3 marks		
	• Zweig model, baryon 3 aces and standard model baryon 3 quarks, so similar	1	
	• Zweig model, meson 2 aces and standard model meson 2 quarks, so similar	1	
	• Zweig model, number of aces same as lepton and standard model quarks same as leptons, so similar	1	
	• Zweig model, aces have fractional charge and standard model quarks have fractional charge, so similar	1	
	• Zweig model, aces are fundamental and standard model quarks are fundamental, so similar	1	
	• Zweig model, aces have baryon number 1/3 and standard model quarks have baryon number 1/3, so similar	1	
	Differences – Max 3 marks		
	• Zweig model, meson 2 aces but standard model meson quark antiquark, so different	1	
	• Zweig model, 4 aces in total but standard model 6 quarks in total, so different	1	
	• Zweig model, 4 leptons in total and standard model 6 leptons, so different	1	
	• Zweif model, no anti-aces but standard model has anti-quarks, so different	1	**(4)**
	Total for question 13		**4**

Question number	Answer		Mark
14(a)	• Only a few particles were deflected • So only a few came close enough to be deflected (so the charge must occupy a small volume)	1 1	(2)
14 (b)	 **Max 3** • Alpha particles close to a –ve nucleus would experience a force towards it and be deviated slightly (ii) • Alpha particles close to a +ve nucleus would experience a force away from it and be deviated slightly (v) • Alpha particles very close to a –ve nucleus would experience a force towards it and be deviated right around it and back again (iii) • Alpha particles approaching a +ve nucleus directly would experience a force away from it and be deviated right back again (vi) **And** • All of the possible observed paths can be explained by both types of nucleus, so the suggestion is correct	1 1 1 1 1	(4)
14 (c)	• Calculates E_K in J • Use of $V = kq_1/r$ **Or** $E_{pot} = kq_1q_2/r$ • $r = 3.6 \times 10^{-14}$ m <u>Example of calculation</u> $E_K = (6.29 \times 10^6)$ eV $\times 1.6 \times 10^{-19}$ C $= 1.01 \times 10^{-12}$ J 1.01×10^{-12} J $= 8.99 \times 10^9 \times 2 \times 1.6 \times 10^{-19}$ C $\times 78 \times 1.6 \times 10^{-19}$ C /r $r = 3.6 \times 10^{-14}$ m	1 1 1	(3)
	Total for question 14		9

<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>15(a)</td><td>

- Use of $W = F_{ave} \times x$ **(1)**
- $W = 0.47$ J **(1)**

<u>Example of calculation</u>
$W = 0.5(2.6 \text{ N} + 9.6 \text{ N}) \times 0.5 \times \pi \times 0.049 \text{ m}$
$W = 0.47$ J
</td><td>2</td></tr>
<tr><td>*15(b) (i)</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.

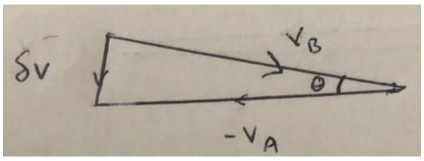
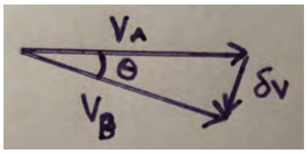
<table>
<tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th><th>Max linkage mark available</th><th>Max final mark</th></tr>
<tr><td>6</td><td>4</td><td>2</td><td>6</td></tr>
<tr><td>5</td><td>3</td><td>2</td><td>5</td></tr>
<tr><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>

	<table><tr><td></td><td>Number of marks awarded for structure of answer and sustained line of reasoning</td></tr><tr><td>Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr><tr><td>Answer is partially structured with some linkages and lines of reasoning</td><td>1</td></tr><tr><td>Answer has no linkages between points and is unstructured</td><td>0</td></tr></table> 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: • (Aternating p.d. produces) alternating current in input coil • (Alternating/varying current produces) a varying magnetic field in core **Or** (Alternating/varying current produces) a varying magnetic field in second coil • There is a change in magnetic flux linkage with (second) coil • <u>E.m.f.</u> <u>induce</u>d • Complete circuit, so current in capacitor circuit • Diode produces direct current		
15(b)(ii)	• Evidence of attempt to determine maximum gradient of graph • Use of emf = $NA\,dB/dt$ • Max emf = 610 V <u>Example of calculation</u> Gradient = 1030 T s^{-1} Emf = 1030 T s^{-1} × 1700 × 3.5 × 10^{-4} m^2 = 613 V	**(1)** **(1)** **(1)**	**3**
15 (c)	• Calculate V_0 / e • Read time constant from graph = (4.5 s) • Use of time constant = RC • Use of $W = ½ CV^2$ • W = 270 J which is greater than 0.47 J, so the electrical method stores the most energy **OR** • Draws tangent to line at t = 0 s	**(1)** **(1)** **(1)** **(1)** **(1)**	**5**

	• Read time constant value off graph (= 4.5 s) • Use of time constant = RC • Use of $W = ½ CV^2$ • W = 270 J which is greater than 0.47 J, so the electrical method stores the most energy **OR** • record a pair of values of V and t from graph • Use of $V = V_0 e^{-\frac{t}{RC}}$ • Convert to correct logarithmic form • Use of $W = ½ CV^2$ • W = 270 J which is greater than 0.47 J, so the electrical method stores the most energy **OR** • $V_0 / 2 = V_0 e^{-t½/RC}$ • $RC = t_{½} / \ln 2$ • Records time for V to decrease to ½ (= 3.1 s) • Use of $W = ½ CV^2$ • W = 270 J which is greater than 0.47 J, so the electrical method stores the most energy <u>Example of calculation</u> V_0 / e = 600 V / e = 221 V Time constant = 4.5 s 4.5 s = 3000 Ω × C $C = 1.5 \times 10^{-3}$ F $W = ½ \times 1.5 \times 10^{-3} \text{ F} \times (600 \text{ V})^2$ = 270 J	
	Total for Question 15	**16**

s

Question number	Answer		Mark
16(a)	• Correct vector diagram showing velocity change • Small angle, so $\delta\theta = \delta v / v$ • Use of $\delta\theta / \delta t = \omega$ and $v = R\omega$ • Algebra to show $\delta v / \delta t = v^2 / R$ <u>Example of derivation</u>  Small angle, so $\delta\theta = \delta v / v$ $\delta\theta = \omega\delta t$ $\delta\theta = v\delta t / R$ $v\delta t / r = \delta v / v$ $\delta v / \delta t = v^2 / R$	1 1 1 1	**4**
16 (b)(i)	• Free-body force diagram showing tension and weight only	1	**1**
16(b)(ii)	• Use of $T \cos \theta = mg$ • Use of $T \sin \theta = m\omega^2 r$ • Use of $\omega = 2\pi/T$ • Time for 4 rotations is 3.2 s <u>Example of calculation</u> $T \cos 19° = 0.0052 \text{ kg} \times 9.81 \text{ N kg}^{-1}$ $T = 0.054$ N $0.054 \text{ N} \times \sin 19° = 0.0052 \text{ kg} \times \omega^2 \times 0.054 \text{ m}$ $\omega = 7.9 \text{ radian s}^{-1}$ $t = 4 \times (2\pi/7.9 \text{ radian s}^{-1})$ = 3.2 (s)	1 1 1 1	**4**
16(b)(iii)	• If vertical, zero horizontal component **Or** must be at an angle for a horizontal component • Must have resultant horizontal component for circular motion, so first student incorrect • If at an angle the radius is greater than before • Since ω the same and r increased, $F = m\omega^2 r$ increased **Or** Since ω the same and r increased, v must increase, so $F = mv^2/r$ increased • Component of tension must be greater so a greater angle is required and the second student is correct	1 1 1 1 1	**5**
	Total for question 16		**14**

Question number	Answer		Mark
17(a)	• They are uncharged **Or** they do not cause ionisation	1	**1**
17 (b)(i)	${}^{220}_{86}\text{Rn} \rightarrow {}^{212}_{82}\text{Pb} + 2\ {}^{4}_{2}\alpha$ • Nucleon numbers for Pb and α correct • Proton numbers for Rn and α and number of α correct	1 1	**2**
17(b)(ii)	• Momentum vectors in directions of track 1 and 2 shown tip to tail • Momentum vector for lead completes closed triangle	1 1	**2**
17(b)(iii)	• Use of $p = mv$ • Use of $p_h = p \cos \theta$ • Use of $p_v = p \sin \theta$ • Use of conservation of momentum • Use of Pythagoras (for momentum magnitude) • Velocity magnitude = 5.8×10^5 m s^{-1} <u>Example of calculation</u> Momentum for 1st alpha = 6.64×10^{-27} kg × 1.74×10^7 m s^{-1} = 1.155×10^{-19} kg m s^{-1} Momentum for 2nd alpha = 6.64×10^{-27} kg × 1.81×10^7 m s^{-1} = 1.20×10^{-19} kg m s^{-1} 'vertical' component of 2nd alpha = 1.20×10^{-19} kg m s^{-1} × cos 60° = 6.01×10^{-20} kg m s^{-1} 'horizontal' component of 2nd alpha = 1.04×10^{-19} kg m s^{-1} Total 'vertical' component of lead momentum = 1.17×10^{-19} kg m s^{-1} + 6.01×10^{-20} kg m s^{-1} = 1.77×10^{-19} kg m s^{-1} $(p_{Pb})^2 = (1.77 \times 10^{-19}\text{ kg m s}^{-1})^2 + (1.04 \times 10^{-19}\text{ kg m s}^{-1})^2$ $p_{Pb} = 2.04 \times 10^{-19}$ kg m s^{-1} $v = 2.04 \times 10^{-19}$ kg m s^{-1} / 3.52×10^{-25} kg $v = 5.80 \times 10^5$ m s^{-1}	1 1 1 1 1 1	**6**
17 (c)	• There is a gap between the start of the two tracks • The atom/ion/nucleus produced after alpha decay would recoil in the opposite direction before emitting the next alpha • So we can tell that the track on the right was produced by the first alpha **Or** • The track on the right is thicker (than the track on the left) • This means that the track has had a longer time in which to disperse • So we can tell that the track on the right was produced by the first alpha	1 1 1 1 1 1	**3**
	Total for question 17		**14**

Question number	Answer		Mark
18(a)	• Thermionic emission • Electrons in the heated metal gain energy and leave the surface	1 1	 **2**
18 (b) (i)	• Use of $E_k = ½ mv^2$ • Use of 1.6×10^{-19} C to convert eV to J or J to eV • Energy = 7.6×10^{-13} J (Accept 4.7 MeV) <u>Example of calculation</u> $E_k = 0.5 \times 9.11 \times 10^{-31}$ kg $\times (2.5 \times 10^6$ m s$^{-1})^2$ $= 2.8 \times 10^{-18}$ J Additional $E_k = 59 \text{ x } 80 \times 10^3$ V $\times 1.6 \times 10^{-19}$ C $= 7.55 \times 10^{-13}$ J	1 1 1	 **3**
18 (b) (ii)	• As the electrons approach the speed of light there is no appreciable increase in speed • v is constant and the electrons spend the same time in(/between) drift tubes, so $s = vt$ must be constant	1 1	 **2**
18 (c)	• Waves travelling in opposite direction (meet and) superpose/interfere **Or** a wave and a reflected wave (meet and) superpose/interfere • At points where waves in antiphase destructive interference takes place **Or** At points where waves in phase constructive interference takes place • Zero/minimum amplitude at points where destructive interference takes place **Or** Maximum amplitude at points where constructive interference takes place **Or** Nodes at points where destructive interference takes place **Or** Antinodes at points where constructive interference takes place	1 1 1	 **3**

18 (d)	• Use of 1.6×10^{-19} C to convert eV to J • Use of $E_k = p^2 / 2m$ • Use of $r = p/BQ$ • $B = 0.0028$ T Example of calculation (2.5×103) eV $\times 1.6 \times 10^{-19}$ C $= p^2 / 2 \times 9.11 \times 10^{-31}$ kg $p = 2.70 \times 10^{-23}$ kg m s^{-1} $B = 2.70 \times 10^{-23}$ kg m s^{-1}/0.061 m $\times 1.60 \times 10^{-19}$ C $B = 0.0028$ T	1 1 1 1	**4**
	Total for question 18		14