Pearson

Mark Scheme (Results)

Summer 2022

Pearson Edexcel GCE
in Physics (9PH0)
Paper 01 Advanced Physics I

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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 schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear

  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter

  iii) organise information clearly and coherently, using specialist vocabulary when appropriate.

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.

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 e.g. '**and**' when two pieces of information are needed for 1 mark.
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 This does not apply in 'show that' questions or in any other question where the units to be used have been given, for example in a spreadsheet.
2.3 The mark will not be awarded for the same missing or incorrect unit only once within one clip in epen.
2.4 Occasionally, it may be decided not to insist on a 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.
2.5 The mark scheme will indicate if no unit error is to be applied by means of [no ue].

3. Significant figures

3.1 Use of too many significant figures in the theory questions will not be prevent a mark being awarded if the answer given rounds to the answer in the MS.
3.2 Too few significant figures will mean that the final mark cannot be awarded in 'show that' questions where one more significant figure than the value in the question is needed for the candidate to demonstrate the validity of the given answer.
3.3 The use of one significant figure might be inappropriate in the context of the question e.g. reading a value off a graph. If this is the case, there will be a clear indication in the MS.
3.4 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 mean that one mark will not be awarded. (but not more than once per clip). Accept 9.8 m s^{-2} or 9.8 N kg^{-1}
3.5 In questions assessing practical skills, a specific number of significant figures will be required e.g. determining a constant from the gradient of a graph or in uncertainty calculations. The MS will clearly identify the number of significant figures required.

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.

Question Number	Acceptable answers	Additional guidance	Mark
1	**The only correct answer is A** *B is not correct because an electron has a much smaller mass* *C is not correct because a neutron has no charge* *D is not correct because a positron has a much smaller mass and is positive*		**1**
2	**The only correct answer is B** *A is not correct because this is not dimensionally correct* *C is not correct because* $E_k/2p = v/4$ *D is not correct because this is not dimensionally correct*		**1**
3	**The only correct answer is D** *A is not correct because the acceleration in the vertical plane is g* *B is not correct because the horizontal component of velocity is constant* *C is not correct because of* $v = 0 - at$ *gives* $t = v / g$		**1**
4	**The only correct answer is D** *A is not correct because the process described is the thermionic effect* *B is not correct because the process described is the thermionic effect* *C is not correct because the process described is the thermionic effect*		**1**
5	**The only correct answer is D** *A is not correct because FLHR gives the direction as OQ* *B is not correct because FLHR gives the direction as OQ* *C is not correct because FLHR gives the direction as OQ*		**1**
6	**The only correct answer is C** *A is not correct because the E is equal to − gradient of the graph of V against r* *B is not correct because the E is equal to − gradient of the graph of V against r* *D is not correct because the E is equal to − gradient of the graph of V against r*		**1**

7	**The only correct answer is C** *A is not correct because charge is a scalar quantity* *B is not correct because mass is a scalar quantity* *D is not correct because time is a scalar quantity*		**1**
8	**The only correct answer is A** *B is not correct because field direction is correct but equipotential lines will become further apart as distance increases as* $V \propto 1/r$ *C is not correct because field direction is incorrect* *D is not correct because field direction is incorrect*		**1**
9	**The only correct answer is A** *B is not correct because the charge on an Au nucleus is* $79 \times 1.6 \times 10^{-19} C$ *C is not correct because the charge on an alpha particle is* $2 \times 1.6 \times 10^{-19} C$ *D is not correct because the charges have not been converted to C*		**1**
10	**The only correct answer is B** *A is not correct because it is a correct conclusion* *C is not correct because it is a correct conclusion* *D is not correct because it is a correct conclusion*		**1**

(Total for Multiple Choice Questions = 10 marks)

Question Number	Acceptable answers	Additional guidance	Mark
11(a)	• Determines vertical height gained per second **(1)** • Use of $\Delta E_{grav} = mg\Delta h$ **(1)** • Use of $\Delta W = F \times \Delta s$ and $P = W/t$ **(1)** • Power = 210 W **(1)** Alternative method based on resolving forces • resolves weight along slope **(1)** • determines total force along the slope **(1)** • Use of $\Delta W = F \times \Delta s$ and $P = W/t$ **(1)** • Power = 210 W **(1)**	Example of calculation $P = 18\text{ N} \times 2.8\text{ m} + 60\text{ kg} \times 9.81\text{ N kg}^{-1} \times 2.8\text{m} \times \sin 5.7$ $P = 50.4 + 163.7$ $P = 214$ W Alternative based on resolving forces $W\sin\theta = 60\text{ kg} \times 9.81\text{ Nkg}^{-1} \times \sin 5.7 = 58.5\text{ N}$ Total force down slope = 58.5 N + 18 N = 76.5 N Power is work done per second = 76.5 N × 2.8 m s^{-1} = 214 W	4
11(b)	• Use of $P = I^2R$ **(1)** • resistance = 0.095 Ω **(1)**	Example of calculation $55\text{ W} = 24^2\text{ A}^2 \times R$ I = 0.095 Ω	2

(Total for Question 11 = 6 marks)

Question Number	Acceptable answers	Additional guidance	Mark
12a	• Opposite horizontal force, labelled friction/resistance/drag **(1)** • Vertically downward force labelled *W*/weight/*mg* **(1)** • Vertically upwards force labelled *R*/Reaction/*N*/Normal (contact force) **(1)**	ignore extra words such as ..of bicycle	**3**
12 b(i)	• straight line starting on *v* axis with negative gradient **(1)** • intercept on *t* axis marked 5.2 with unit s **(1)**		**2**
12b(ii)	• Use of $s = \frac{(u+v)t}{2}$ with $v = 0$ **(1)** • Use of another SUVAT equation to determine *a* **(1)** • Use of $F = ma$ **(1)** • Resistance = 16 N **(1)** **Or** • Use of area = base × height / 2 **(1)** • Use of acceleration is gradient of line **(1)** • Use of $F = ma$ **(1)** • Resistance = 16 N **(1)** **Or** • Use of $s = (u + v)t/2$ with $v = 0$ • Use $E_k = ½ mv^2$	<u>Example of calculation</u> Using SUVAT eg $7.8 \text{ m} = (u + 0)5.2 \text{ s}/2$ $u = 3.0 \text{ m s}^{-1}$ $7.8 \text{ m} = 3.0 \text{m s}^{-1} \times 5.2 \text{ s} + \frac{1}{2} a\, 5.2^2 \text{ s}^2$ $a = (–)0.58 \text{ m s}^{-2}$ Using area under graph $\text{Area} = 7.8 \text{ m} = v \times \frac{5.2 \text{ s}}{2}$ $v = 3.0 \text{ m s}^{-1}$ $a = \text{gradient} = \frac{3.0 \text{ m s}^{-1}}{5.2 \text{ s}}$ $a = (–)0.58 \text{ m s}^{-2}$ $F = 28 \text{ kg} \times 0.58 \text{ m } s^{-2}$ $F = 16.2 \text{ N}$	**4**

	• Use of $W = F\Delta s$ • Resistance = 16 N		

(Total for Question 12 = 9 marks)

Question Number	Acceptable answers		Additional guidance	Mark
13	• Measures angle at 52° +/- 2 ° • Uses $F = ma$ horizontally • Resolves forces vertically • Uses $a = v^2 / r$ **Or** $a = r\omega^2$ • Calculates the 51° and reaches a consistent conclusion	**(1)** **(1)** **(1)** **(1)** **(1)**	Accept angle calculate from measured dimensions and trigonometry. <u>Example of calculation</u> $T\sin\theta = \frac{mv^2}{r}$ $T\cos\theta = mg$ $\tan\theta = \frac{v^2}{rg}$ $\tan\theta = (3.8)^2 (\text{m s}^{-1})^2 / 1.2 \text{ m} \times 9.81 \text{ m s}^{-2}$ $\theta = 50.8°$	**5**

(Total for Question 13 = 5 marks)

Question Number	Acceptable answers	Additional guidance	Mark
14a(i)	• Frequency = 50 Hz **(1)**	Example of calculation $f = \frac{1}{0.02\ \text{s}} = 50\ \text{Hz}$	**1**
14a(ii)	• Root mean square potential difference = 2.8 V **(1)**	Example of calculation $V_{rms} = \frac{4}{\sqrt{2}} = 2.83\ \text{V}$	**1**
14b(i)	An answer which makes reference to: • Diode only lets current through in one direction **(1)** • (In positive half cycle of input) D2 and D4 conduct **Or** In positive half cycle of input D2 conducts **Or** (In negative half cycle of input) D3 and D1 conduct **(1)** **Or** negative half cycle D3 conducts • Current towards X **Or** down through *R* **Or** X to Y **(1)**		**3**
14b(ii)	• Read off corresponding values of *V* and *t* from graph **(1)** • Use of $lnV = lnV_o - \frac{t}{RC}$ **(1)** • $C = 3.5 \times 10^{-5}$ F **(1)** range 2.7×10^{-5} F to 3.5×10^{-5} F Alternate method • Use of $I = V/R$ • Use of $Q = It$ and $C = \Delta Q/\Delta V$ • $C = 2.7 \times 10^{-5}$ F to 3.5×10^{-5} F	eg this can be any *t* (in ms) and corresponding *V* Example of calculation $ln3.5 = ln4 - \frac{0.008\ \text{s}}{2200\ \Omega\ \times C}$ $C = 2.7 \times 10^{-5}$ F Alternate: $I = 3.8\ \text{V} / 2.2\ \text{k}\Omega = 1.73\ \text{mA}$ $Q = 1.73\ \text{mA} \times 8\ \text{ms} = 13.8 \times 10^{-6}$ C $C = 13.8 \times 10^{-6}\ \text{C} / 0.4\ \text{V} = 3.4 \times 10^{-5}$ F	**3**

(Total for Question 14 = 8 marks)

<table>
<tr><th>Question Number</th><th>Acceptable answers</th><th>Additional guidance</th><th>Mark</th></tr>
<tr><td>*15 (a)</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.

Indicative content:

IC1: set of (metal drift) tubes (in a line)

IC2: electrons accelerated by electric field/potential difference

IC3: acceleration takes place in the gaps between tubes

IC4: adjacent tubes connected to opposite terminals of a power supply or opposite charge/polarity

IC5: power supply/p.d./electric field is alternating (so that as electron emerges from one tube the next tube is positive)

IC6: time spent in each tube must be the same so as the electrons travel faster the tubes must be longer / gaps between get longer</td><td><table>
<tr><th>IC points</th><th>IC mark</th><th>Max linkage mark availabl e</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>
IC points 1 and 4 may be awarded with well-drawn diagram

IC6 accept reference to distance between centres/ends of tubes must increase to give a fixed alternating frequency</td><td>6</td></tr>
<tr><td>15 (b)</td><td>• High energy electrons will have a short (de Broglie) wavelength (1)

• The wavelength needs to be comparable/smaller than proton size (1)</td><td></td><td>2</td></tr>
</table>

15 (c)(i)	• units eV (energy) base units: kg m^2 s^{-2} **Or** base units of momentum: kg m s^{-1} **(1)** • divide energy by units of speed (c) m s^{-1} gives kg m s^{-1} which are units of momentum Or multiply units of momentum by speed (c) m s^{-1} to give units of energy kg m^2 s^{-2} **(1)**		**2**
15(c)(ii)	• resolves a y-component or x-component of electron momentum **(1)** • applies momentum conservation in x-direction or y-direction **(1)** • comparison of total momentum after **Or** momentum of proton after plus comment **(1)** Alternative: • draws a vector triangle • Uses cosine rule • Calculates angle from three sides = 20.4°	<u>Example of calculation</u> p_y = 9.1 (GeV/c)sin20 = 3.1 GeV/c p_x = 9.1 (GeV/c)cos20 = 8.55 GeV/c p_x of proton = 20 (GeV/c) - 8.55 (GeV/c) = 11.45 GeV/c $p_{\text{proton}} = \sqrt{3.1^2 + 11.45^2}$ = 11.86 GeV/c Alternative: p_y = 9.1 (GeV/c)sin20 = 3.1 GeV/c=11.9(GeV/c)sinØ Ø = 15.2 So total p after = 11.9 GeV/c cos 15.2 + 9.1 (GeV/c)cos20 = 11.5 + 8.55 = 20.05 GeV/c	**3**
15(c)(iii)	• (total) kinetic energy not conserved **(1)**		**1**

(Total for Question 14 = 14 marks)

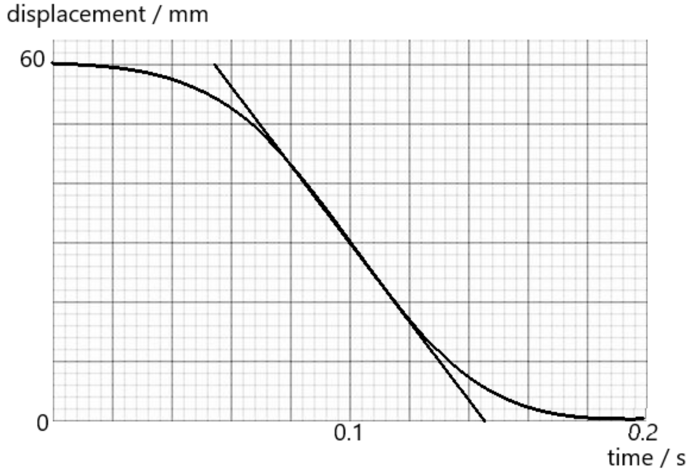
Question Number	Acceptable answers	Additional guidance	Mark
16(a)(i)	• change in magnetic flux (linkage as motor rotates) **Or (**copper disc is) cutting magnetic flux/field **(1)** • therefore there is an induced e.m.f. (according to Faraday's law) **(1)**	Accept flux linkage for magnetic flux	**2**
16(a)(ii)	• copper disc rotates in the same direction **(1)** • because it reduces the rate of magnetic flux change **(1)** • so as to oppose the change that produces it **(1)**	Accept induced current produces magnetic fields **Or** force on current in a magnetic field for MP2 Accept alternatives to flux as in a(i)	**3**
16(b)	• convert to radians **(1)** • $\omega = 52 \text{ rad s}^{-1}$ **(1)**	Example of calculation $\omega = \frac{500 \times 2\pi}{60}$ $\omega = 52.4$ radians s^{-1}	**2**
16(c)	• The relationship between ω and turning effect is (approximately) proportional **(1)** • As speed increases rate of change/cut of magnetic flux increases **(1)** • this increases the induced current in the copper disc **(1)** • this will lead to an increase in force (on the copper disc as it is within a magnetic field/flux) **(1)**	Accept attempt to find a constant ratio and relevant conclusion Accept alternatives to flux as in a(i) accept ref. to emf rather than current Dependent on MP2 or 3	**4**

(Total for Question 16 = 11 marks)

Question Number	Acceptable answers		Additional guidance	Mark
17 (a)	• Correct equation ignoring charges Charge on pion + (1)	**(1)** **(1)**	$p + p \rightarrow p + n + \pi^+$	**2**
17 (b)	• p : u u d • n : u d d • π : u $\bar{d}$	**(1)** **(1)** **(1)**	Accept labelled $\pi-$: $\bar{u}$ d	**3**
17(c)	• Convert eV to J • Convert J to kg • mass = 2.5×10^{-28} (kg)	**(1)** **(1)** **(1)**	<u>Example of calculation</u>: $m = \frac{140\,(\text{MeV/c}^2) \times 1.6 \times 10^{-13}\,\text{J MeV}^{-1}}{(3 \times 10^8)^2\,(\text{m s}^{-1})^2}$ $m = 2.49 \times 10^{-28}$ (kg)	**3**
17(d)	• extra mass after collision is the mass of pion **Or** energy must be conserved so E_k is required for pion • According to $\Delta E = c^2 \Delta m$ (if extra mass is pion) then ΔE required is 140 MeV **Or** extra mass is 140 MeV/c^2 so E required is 140 MeV • Momentum conservation means that the (three) resulting particles after the collision must have some momentum/E_k • The incoming proton needs 140 MeV plus the E_k of the product particles so statement is inaccurate	**(1)** **(1)** **(1)** **(1)**		**4**

(Total for Question 17 = 12 marks)

Question Number	Answer	Additional Guidance	Mark
18(a)	• Use of Area = width × thickness **(1)** • Use of $R = \frac{\rho l}{A}$ **(1)** • thickness = 9.4×10^{-4} m **(1)**	<u>Example of calculation</u>: $$12 \times 10^3 \Omega = \frac{0.49\ \Omega\ \text{m} \times 0.115\ \text{m}}{0.0050\ \text{m} \times t}$$ thickness = 9.4×10^{-4} m	3
18(b)(i)	• uses ratio of lengths to determine p.d. across potentiometer **(1)** • V = 9.6 (V) **(1)**	<u>Example of calculation:</u> p.d. across potentiometer = $\frac{115\ \text{mm}}{60\ \text{mm}} \times 5$ V = 9.6 V	2
18(b)(ii)	• determines p.d. across *R* **(1)** • apply $V = IR$ to potentiometer to determine current **(1)** **Or** uses ratio of resistances = ratio of p.d.s • $R = 3000\ \Omega$ **(1)**	<u>Example of calculation:</u> current in circuit = $\frac{9.6\ \text{V}}{12000\ \Omega}$ = 8.0×10^{-4} A p.d. across *R* = 12 – 9.6 = 2.4 V $$R = {}^{2.4\ \text{V}}/_{8.0 \times 10^{-4}\ \text{A}}$$ R = 3000 Ω (show that value gives 2400 Ω)	3
18(b)(iii)	• A battery has internal resistance **(1)** • There is a p.d. across the internal resistance **(1)** • Terminal p.d. less (than e.m.f.) **(1)** **Or** refers to $V = E - Ir$	Accept "lost volts" for MP2 *V* must be the subject	3

18(b)(iv)	• tangent drawn on the curve **(1)** • uses a triangle base of at least 0.06 s **(1)** • attempt to find a gradient **(1)** • velocity = 0.68 m s^{-1} so velocity not exceeded **(1)** allow range from to 0.60 m s^{-1} to 0.80 m s^{-1}	MP2 dependent on MP1  v = gradient = $\frac{60\ \text{mm}}{0.144 - 0.056}$ v = 682 mm s^{-1}	4

(Total for Question 18 = 15 marks)

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