Mark Scheme

Summer 2018

Pearson Edexcel GCE Level 3
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) orga
  nise information clearly and coherently, using specialist vocabulary when appropriate.

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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.

1. Quality of Written Communication

1.1 Indicated by QoWC in mark scheme. QWC – Work must be clear and organised in a logical manner using technical wording where appropriate.

1.2 Usually it is part of a max mark, the final mark not being awarded unless the QoWC condition has been satisfied.

2. Graphs

2.1 A mark given for axes requires both axes to be labelled with quantities and units, and drawn the correct way round.

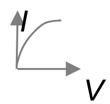
2.2 Sometimes a separate mark will be given for units or for each axis if the units are complex. This will be indicated on the mark scheme.

2.3 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.

2.4 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	Acceptable answers	Additional guidance	Mark
1	**The only correct answer is D** A *is not correct because as it is 2A + 1A* B *is not correct because 2A +2A* C *is not correct because 2A + 3A*	6 A	**1**
2	**The only correct answer is A** B *is not correct because V decreases as I decreases* C *is not correct because I decreases as R increases* D *is not correct because I decreases as R increases*	decreases decreases	**1**
3	**The only correct answer is C** A *is not correct because acceleration* ***is*** *0* as *v* constant B *is not correct because there* ***is*** *a resistive force opposing weight* D *is not correct because there* ***is*** *a weight*	There is a resultant force acting on the object.	**1**
4	**The only correct answer is B** A *is not correct because R decreases as more conduction electrons* C *is not correct because lattice vibrations not affected* D *is not correct because lattice vibrations not affected*	It increases because there is an increase in the number of conduction electrons.	**1**
5	**The only correct answer is C** A *is not correct because it shows constant resistance* B *is not correct because it shows decreasing resistance* D *is not correct because it shows an I independent of V*		**1**
6	**The only correct answer is A** B *is not correct because these are base units of force* C *is not correct because these are not base units* D *is not correct because these are not base units*	kg m s^{-1}	**1**

7	**The only correct answer is B** A *is not correct because this is a uniform field so F constant* C *is not correct because this is a uniform field so F constant* D *is not correct because this is a uniform field so F constant*	F	**1**
8	**The only correct answer is B** A *is not correct because it is 3 divided by 2* C *is not correct because it is 3 x root 2* D *is not correct because it is* 3^2	2.1 A	**1**
9	**The only correct answer is B** A *is not correct because a cyclotron uses a magnetic field* C *is not correct because a LINAC uses an electric field* D *is not correct because a LINAC does not use a magnetic field*	Cyclotron accelerated	**1**
10	**The only correct answer is C** A *is not correct because lepton number is not conserved* B *is not correct because charge conservation is not obeyed* D *is not correct because charge conservation is not obeyed*	$p \rightarrow n + \beta^+ + \nu$	**1**

(Total for Multiple Choice Questions = 10 marks)

Question Number	Acceptable answers	Additional Guidance	Mark
11a	• Use of $R = \frac{\rho l}{A}$ **(1)** • Use of area formula with correct value of radius **(1)** • $R = 8.9\ \Omega$ **(1)**	Use of: any dimensionally correct substitutions eg using a diameter squared Accept R=8.62 as due to rounding Area Example of calculation: $R = 1.12 \times 10^{-6}\ \Omega\,m \times 1m / \pi(0.2\times10^{-3})^2\ m^2$	**3**
11bi	• As resistance increases with length of wire **(1)** • potential (difference) proportional to length of wire **(1)**	Alt to MP1: Current same through whole length of wire and $V=IR$	**2**
11bii	• Use of ratio of lengths = ratio of potentials **(1)** • Potential at P = 1.13 V **(1)**	Alternative method uses ratio of resistances. Example of calculation: $= \frac{75.0}{100} \times 1.50$ $= 1.125\text{V}$	**2**
11(c)	**Either** • Calculates current correctly using $I=V/R$ **(1)** • $R = 1.10\ \Omega$ **(1)** **Or** • Use of ratios of lengths = ratios of resistances **(1)** • $R = 1.10\ \Omega$ **(1)** **Or** • Use ratio of resistances = ratio of p.d.s **(1)** • $R = 1.10\ \Omega$ **(1)**	Show that value gives 1.2 Ω Example of calculation: $I = \frac{1.125}{3.30} = 0.34A$ $R = \frac{0.375}{0.34} = 1.1\Omega$ Or $\frac{R}{3.30} = \frac{25}{75}$	**2**

(Total for Question 11 = 9 marks)

Question Number	Acceptable Answers	Additional Guidance	Mark

***12** — Mark: 6

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.

IC points	IC mark	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**

Indicative content:

- (Maximum/Initial) current is equal to battery emf divided by *R*
  Or current as switch closed
  Or current as complete circuit
  Or current due to battery
- Coil rotates
- (movement of) coil "cuts/changes" (magnetic) flux (linkage) / field
- Which induces an emf (according to Faraday's law)
- Opposes original emf/current according to Lenz's law
  Or current reduced as effect opposes change
- The faster the coil rotates the larger this (back) emf/effect the smaller the current

Additional guidance:
ic3 needs a link to coil moving
ic4 depends on ic3

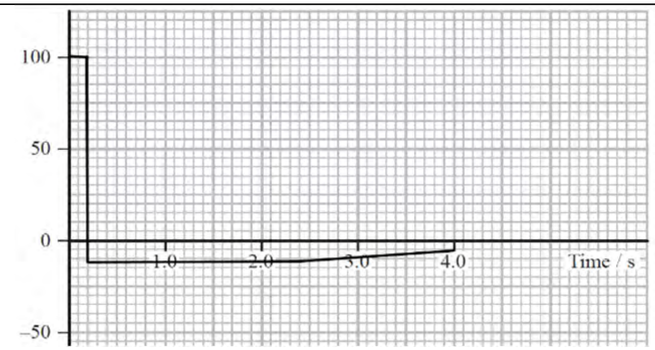
(Total for question 12 = 6 Marks)

Question Number	Acceptable answers	Additional guidance	Mark
13 (a)	• Take a correct moment about pivot P **(1)**	eg T.6.cos20 or sin70	**4**

	• Converts the mass to weight of beam ie ×9.81 seen **(1)** • Appreciates centre of mass 0.5 m from P **(1)** • T = 25 kN **(1)**	If cos20's are absent from both sides of equation then can still credit 4 marks Example of Calculation: $T \times 6(\text{m}) \times \cos 20 = 3.05 \times 10^4(\text{kg}) \times 9.81(\text{ms}^{-2}) \times 0.5(\text{m}) \times \cos 20$ $T = 24.9\text{kN}$	
13 (b)	• Use of $\Delta E_{\text{grav}} = mg\Delta h$ **(1)** • convert for a unit time, e.g. day or second ie W **(1)** • Calculation of energy input provided by coal in unit time **(1)** • Use of Efficiency = energy output/energy input **(1)** **Or** in terms of power • Efficiency = 1.5 % so not correct **(1)**	(allow reverse argument starting with 10% efficiency for full credit) Example of calculation: $\Delta E_{grav} = 2500 \times 9.81 \times 12$ $\Delta E_{grav} = 294\text{kJ}$ per minute $\Delta E_{grav} = 294\text{kJ} \times 60 \times 24$ $\Delta E_{grav} = 424\text{MJ}$ per day energy input = 1250 × 22.3 MJ Efficiency = 424 MJ/ 27900 MJ = 1.5%	**5**

(Total for Question 13 = 9 marks)

Question Number	Acceptable Answers	Additional Guidance	Mark
14 (a)	• Attempts to find area under graph **(1)** • Height = 19 m **(1)**	Range for base of triangle between 1.8 and 2s to recognise area Example of calculation: Area = $\frac{1}{2} \times 1.9\text{s} \times 20\text{ms}^{-1}$	**2**

	Alternative: • Use equations of motion to Height = 19 m **(2)**	= 19 m	
14 (b)	• Positive value of acceleration for first 0.2 s **(1)** • Constant at 100 m s^{-2} **(1)** • Negative value of acceleration up to 4 s **(1)** • Initially at -12 m s^{-2} (value between -10 and -15 on graph) **(1)** • Negative value reducing in magnitude in last 1.0 s to 2.0 s (can be a step change) **(1)**	 	**5**

(Total for Question 14 = 7 marks)

Question Number	Acceptable Answers	Additional guidance	Mark
15a	• fundamental – quarks and leptons **(1)** • Baryons made of 3 q **(1)** • Mesons made of quark and antiquark **(1)**	MP2 and 3 could be given for a named particle and its quark composition	**5**

	• 6 quark **Or** 6 leptons **(1)** • Each particle has an antiparticle **(1)**	Can be inferred if either set named	
15b	• Use of $\Delta E = \Delta mc^2$ **(1)** • Conversion of J to eV **(1)** • mass = 120 GeV/c^2 **(1)**	Example of calculation: $E = 2.2\times10^{-25}\,\text{kg}\times(3.0\times10^{8})^2(\text{ms}^{-1})^2$ $E = 1.98\times10^{-8}\,\text{J}$ $E = 1.98\times10^{-8}\,\text{J}\div1.6\times10^{-19}\,\text{JeV}^{-1}$ $E = 124\times10^{9}\,\text{eV}$	**3**
15c(i)	• Energy (of protons) converted to mass (of Higgs) **Or** Energy is required to overcome electrostatic repulsion between protons **(1)** • Reference to $E = mc^2$ (can be written in any form) **(1)** • Because c^2 is very large (E must be large) **Or** Higgs particle is massive so needs a lot of energy to create it **(1)**	Alternative based on numerical values: Observation that Higgs mass is 120 GeV/c^2 This requires an energy of at least 120 GeV Each beam of protons would need an energy of at least 60 GeV	**3**
15c(ii)	• Use of circumference = $2\pi r$ **(1)** • Use of $p = Bqr$ **(1)** • p = 5.7 × 10^{-15} Ns **(1)**	Example of calculation: $r = 27000\div2\pi$ $r = 4300\,\text{m}$ $p = 8.3\text{T}\times1.6\times10^{-19}\,\text{C}\times4300\text{m}$ $p = 5.7\times10^{-15}\,\text{Ns}$	**3**

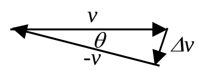
Question Number	Acceptable Answers	Additional guidance	Mark
15ciii	0 **(1)**	zero	**1**
15d	• High speeds **Or** relativistic **(1)** • Mass (of proton) increases • **Or** this equation is only valid at non-relativistic speeds **(1)**	Alt: speeds close to speed of light	**2**

(Total for Question 15 = 17 marks)

Question number	Acceptable Answers	Additional guidance	Mark
16a	• At least 4 radial lines **(1)** • arrow pointing outwards **(1)** • straight, symmetrical and equally distributed **(1)**	Ignore dotted lines	**3**
16b	• tangent at correct point **(1)** • triangle with base at least 0.4 m **(1)** • 5.3×10^{6} (Vm^{-1}) (range 4.9×10^{6} to 6.1×10^{6}) **(1)**	Example of calculation: Gradient = 3200000 / 0.6 $E = 5.3 \times 10^{6}$ V m^{-1}	

	• So would ionise as value greater than 3×10^6 **(1)** Alternative: • **C**orrect value of V at 30 cm **(1)** • Use of $E = k\frac{Q}{r^2}$ and $V = k\frac{Q}{r}$ **(1)** • 5.3×10^6 (Vm^{-1}) **(1)** • So would ionise as value greater than 3×10^6 **(1)**	MP4 to be consistent with calculated value $V = 1.6 \times 10^6$ V m^{-1}	**4**
16c	**Maximum 3 marks** • There cannot be a p.d. across his body **(1)** • Electric field strength inside cage is zero **(1)** • As no potential gradient **(1)** • Current/electrons/charge would conduct through suit **Or** the current would not pass through body **(1)**	Accept reference to Faraday cage for MP2	**3max**

(Total for Question 16 = 10 marks)

Question mark	Acceptable Answers	Additional Guidance	Mark
17a	• vector velocities at two positions as part of a triangle and third side identified as Δv **(1)** • Acceleration $a = \Delta v/t$ (i) **(1)** • Use of trigonometry: $\Delta v/v \approx \sin\theta \approx \theta$ for small angles (ii) **(1)** • Use of $v = r\theta/t$ (iii) **(1)** • Combine i, ii, iii to final equation **(1)** **OR** • Diagram shows components of v with angle turned through **(1)** • Acceleration $= 2v\sin\theta/t$ **(1)** • Use of trigonometry: $\Delta v/v \approx \sin\theta \approx \theta$ for small angles **(1)** • $t = r2\theta/v$ and 2s cancel **(1)** • Simplify to final equation **(1)**	<u>Example of diagram</u>  Ignore arrow directions Combine (i) and (ii) $a = v\theta/t$ Substitute for θ using (iii) a = $\frac{v}{t} \times \frac{vt}{r}$ then "t"s cancel Allow other fully correct methods	5
17b(i)	• Correct conversion to angle in radians **(1)** • $\omega = 5.2$ (rad s^{-1}) **(1)**	<u>Example of calculation</u> $\omega = 50 \times 2\pi / 60$ s $= 5.24 \text{ rad s}^{-1}$	**2**
17b(ii)	• Reference to $F = mr\omega^2$ **(1)** • appreciation that r is large **Or** (the equipment) has a **high** (linear) velocity **(1)**	Alt: mass (of equipment) could be large	**2**
17b(iii)	• use of $r\omega^2$ **(1)** • $a = 25g$ **and** appropriate comment **(1)**	Show that value gives 22.5g Allow reverse argument starting with 25g to ω=5.28 rad s^{-1} <u>Example of calculation</u> a = 8.8 (m) x 5.24^2 (rad s^{-1})^2 a = 238 (m s^{-2}) ÷9.81 (m s^{-2}) = 24.6× g	**2**

(Total for Question 17 = 11 marks)

Question Marks	Acceptable Answers		Additional guidance	Mark
18a	• Magnet accelerates ball Or magnet increases ball's KE • Momentum is conserved in the collision(s) • (Since collisions are elastic) KE conserved so third ball moves off with the same velocity/KE as incoming ball hit magnet with	**(1)** **(1)** **(1)**	Marks can be gained by discussing either set of balls	3
18bi	• Use of $W = \frac{1}{2}CV^2$ • $W =$ 45 μJ	**(1)** **(1)**	<u>Example of calculation</u> $W = \frac{1}{2} 40\mu F \times (1.5\ V)^2$ $W =$ 45 μJ Alt: Use $Q = CV$ then $E = QV/2$ for MP1	2
18bii	• Use of $V = V_o e^{-t/RC}$ • Time = 0.14 (s)	**(1)** **(1)**	<u>Example of calculation</u> $0.5 = e^{-t/5000 \times 40 \times 10^{-6}}$ $\ln 0.5 = -t / 0.2$ $t = 0.14 s$	2
18biii	• Use of speed = d/t • Speed = 3.6 ms^{-1} Allow ecf from ii	**(1)** **(1)**	Show that value gives 5.0 ms^{-1} <u>Example of calculation</u> $v = 0.5 m / 0.14 s$ = 3.6 ms^{-1}	2
18biv	• use of $s = \frac{at^2}{2}$ • s = 9 cm + comment that foil is not broken at its centre (comment consistent with calculation) Allow ecf from ii	**(1)** **(1)**	Show that value gives 0.049 m <u>Example of calculation</u> $s = \frac{9.81\ ms^{-2} \times 0.14^2\ s}{2}$ = 0.094 m	2

(Total for Question 18 = 11 marks)

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